GRIGORE T. POPA UNIVERSITY OF MEDICINE AND PHARMACY IASI

HABILITATION THESIS

TECHNOLOGICAL PERSPECTIVES ON THE POSSIBILITIES AND LIMITS OF ACHIEVING REMOVABLE DENTURES

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Contents

Abreviations

AAPHD- American Association of Public Health Dentistry
ADA –American Dental Association
ADP- Academy of Denture Prosthetics
AgNPs- Silver nanoparticles
AFM-Atomic Force Microscopy
AI- Artificial Intelligence
AR-Artificial Reality
CAD- Computer Aided Design
CAM- Computer Aided Manuifacturing
CBCT- Cone Beam Computer Tomography
CD- Complete Denture
CFU- Colony-Forming Units
DCS- Differential Scanning Calorimetry
EBM- Electron Beam Melting
HCR- Heta Curing Resin
FEA- Finite Element Analysis
IT- Information Technology
ML- Machine Learning
MMA- Methyl methacrylate
NIDR- National Institute of Dental Research
OM-Optical Microscopy
OSHA- Occupational Safety and Health Administration
PEEK- Polyetheretherketone
PMMA- Poly Methyl methacrylate
RP- Rapid Prototyping
SCR- Self-Curing Resin
SEM-Scanning Electrone Microscope
SLM– Selective Laser Melting
SLS- Selective Laser Sintering
TGN- Total Germs Number
VR -Virtual Realitity

ABSTRACT

The habilitation thesis, which summarizes my postdoctoral professional, academic and scientific activity, is framed in three major sections, according to the CNATDCU recommendations: Section I - Scientific achievements in the post-doctoral period; Section II - Future plans of development on scientific and academic career; Section III - Bibliographic references.

The paper entitled "Technological perspectives on the possibilities and limits of achieving removable dentures" reflects the overview of my concerns in the fields of technologies and materials for removable dentures, as well as the possibilities of optimizing their biomechanical parameters.

Before the first section I made a short presentation of the professional, academic and scientific achievements of my entire teaching career, started in 1994.

After finishing my doctoral studies, I continued my research, broadening my area of interest on other types of prosthetic constructions and thus outlined the subsequent study directions, on which I focused since 2005 to the present: possibilities for optimizing the bio-mechanical properties of inlay type prostheses, optimizing the structure and quality of materials used in fixed prosthetic realization, possibilities to optimize the characteristics of acrylic removable ptoteseses, the economic aspects in the practice of dentistry, possibilities and limits of cross-infection control.

The habilitation thesis sums up the research on the increase of the performances of the acrylic resins used in the realization of mobile prostheses and the optimization of the activity in the dental laboratory.

Section I systematizes the postdoctoral scientific researches on which I focused in the 16 years of academic activity and is structured on three research fields. This section of the thesis contains the most relevant articles from my scientific activity, indexed in the Web of Science Core Collection and in international databases.

The first chapter *of this section, entitled "Research on the characteristics and biomechanical behavior of acrylic resins for full dentures*" includes researches specific to the field of Prosthesis and Dental Materials Technology, preceded by an introductory section, which details the latest and most relevant information on these topics.

The first direction of study is represented by researches on the characteristics and biomechanical behavior of acrylic resins for full dentures, following the behavior of these materials, after their optimization with silver nanoparticles, in order to prevent prosthetic stomatitis

The second research direction analyzes the effect of silver nanoparticles incorporation on structure and surface of the acrylic dental resins; knowing that the structure and surface quality of prosthetic constructions influence the adaptation and longevity of removable dentures, the studies aimed to analyze whether the introduction of silver nanoparticles, a procedure widely agreed by practitioners, significantly changes the structure and implicit behavior of acrylic resins.

The third direction focused on analyzing the surface characteristics of conventional dental acrylic resins, self-cured and heat- cured, depending on the finishing and polishing technique. The conclusions of the studies offer practical solutions to dental technicians, guiding them in choosing the optimal method and tools for processing, depending on the type of resin.

In the second chapter *entitled "Possibilities and limits of cross-infection control in the dental laboratory"* I followed three directions of research, preceded by an update of the latest information in the literature on this extremely current issue.

The first direction of research is represented by researches on the knowledge and implementation of measures to control cross-infection in the dental laboratory. In order to conduct a study on the sources of contamination and the possibility of eliminating the risk of cross-infection, I analyzed the extent to which the notions of cross-infection prophylaxis are known and applied by dental technicians; the results and conclusions subsequently guide us to the other directions of research.

The second research direction approached the analysis of the concentration of powders and the degree of their microbial contamination in the dental laboratory, as a result of the different stages of prostheses processing

The third direction of research aims to analyze the possibilities of microbial contamination ofremovable prostheses after processing, depending on the tools and pastes used for finishing.

The third chapter entitled "*Technological possibilities for full dentures realization"* is also preceded by an introductory section which presents the conventional and modern methods used to make full dentures, as well as the advantages and disadvantages of the materials used in the technologies for these prosthetic constructions, longevity of these prostheses and the possibilities for a correct restoration of dento-maxillary system functions.

The first research direction is represented by studies on the main technologies for complete dentures, analyzing which are the methods most frequently used in practice for the realization of these devices.

The second research direction follows the analysis of the mechanical parameters of the complete dentures realized by different polymerization technologies. The polymerization mechanism influences the mechanical characteristics and the biological behavior of the acrylic resins. Our researches allowed the systematization of the optimal polymerization conditions, in order to obtain removable dentures with optimal parameters.

*The third direction f*ocused on the „*Students' attitude regarding the implementation of digital technologies in current dental practice”*. All modern prosthetic restorations have a lot of advantages, but there are also many disadvantages which must be well known, in order to choose a correct therapeutic solution. To this end, our studies focused on analyzing the opinions of students from Dental Technician Specialization, on the implementation of digital technologies in dental laboratory activity, as well as the impact that these methods could have on the current practice.

Section II presents future research directions, both scientifically and academically. In this sense, on the one hand, I want to continue the topic already addressed, specific to the discipline of Prosthesis Technology, and on the other hand, I want to approach new, innovative directions that allow interdisciplinary research in national and international teams.

The analysis of the characteristics of the materials and technologies for the realization of dental prostheses will remain an important concern in the future, aiming at consolidating the existing research core, expanding interdisciplinary collaborations, creating a high-performance research center for digital technologies and creating a defectoscopy center.

In this section I have highlighted the strategies and projects on the activity with future PhD students, detailing the research topics that can be addressed by them, namely: experimental research on fatigue and wear resistance of resins enriched with silver nanoparticles, methods of application and preparation of silver nanoparticles for resin optimization and microbial adhesion to the bases of prostheses made of resins optimized with silver nanoparticles; in vitro studies are useful for initiating clinical research on the analysis of changes in the external surface and color of acrylic full dentures nanoparticles enriched, as well as research on the possibilities of reducing inflammation of the oral mucosa to full dentures wearers.

Other research directions that will be developed are represented by comparative studies on digital and conventional technologies for the realization of complete prostheses and research on the possibilities of using digital technologies in the different laboratory stages.

Section III includes a list of the main reference works that have been consulted in order to elaborate the habilitation thesis.

Rezumat

Teza de abilitare, care rezumă activitatea mea profesională, academică și științifică, postdoctorală este încadrată în trei mari secțiuni, conform recomandărilor CNATDCU: Secțiunea I – Realizări științifice din perioada post-doctorală; Secțiunea II – Planuri viitoare în activitatea profesională, academică și științifică; Secțiunea III – Referințe bibliografice.

Lucrarea intitulată „Technological aspects in the removable dentures realization" reflectă preocupările mele de cercetare în domeniul tehnologiilor și materialelor de realizare a protezelor mobile, precum si interesul privind posibilitățile de optimizare a parametrilor biomecanici ai acestor.

Înainte de prima secţiune am realizat o scurtă prezentare a realizărilor profesionale, academice şi ştiinţifice din întreaga mea carieră didactică, începută în anul 1994.

După terminarea studiilor doctorale, mi-am continuat cercetările, lărgindu-mi aria de interes asupra altor tipuri de construcții protetice și am schițat astfel direcțiile de studiu ulterioare, pe care m-am concentrat din 2005 până în prezent: posibilități de optimizare a proprietăților biomecanice ale incrustațiilor intratisulare, optimizarea structurii și calității materialelor utilizate în realizarea lucrărilor protetice fixe, posibilități de optimizare a caracteristicilor protezelor acrilice mobile, aspectele economice în practica medicinei dentare, posibilități și limite de control al infecțiilor încrucișate.

Teza de abilitare sumează cercetările asupra creşterii performanțelor rășinilor acrilice utilizate în realizarea protezelor mobile și optimizarea activității în laboratorul de tehnică dentară.

Secţiunea I sistematizează cercetările ştiinţifice postdoctorale asupra cărora m-am concentrat în cei 16 ani de activitate didactică și academică și este structurată pe trei domenii de cercetare. Această secțiune a tezei cuprinde cele mai relevante articole din activitatea mea științifică, indexate în Web of Science Core Collection și în baze de date internaționale.

Primul capitol al acestei secțiuni, intitulat „*Research on the characteristics and biomechanical behavior of acrylic resins for full dentures"*cuprinde cercetări specifice domeniului Tehnologiei Protezelor și Materialelor dentare, fiind precedat de o secțiune introductivă, care detaliază cele mai noi și relevante informații din literatura de specialitate cu privire la aceste teme.

Prima direcție de cercetare este reprezentata de cercetări asupra caracteristicilor si comportamentului biomecanic al rășinilor acrilice utilizate pentru realizarea protezelor mobile totale, urmărind comportamentul acestor materiale, după introducerea în structural lor a nanoparticulelor de argint, în scopul prevenirii stomatopatiilor paraprotetice.

A doua direcție de cercetare analizeaza efectul încorporării nanoparticulelor de argint asupra structurii și suprafeței rășinilor acrilice; cunoscând faptul că structura și calitatea suprafeței unei construcții protetice influențează adaptarea și longevitatea protezelor mobile, studiile realizate și-au propus să analizeze dacă introducerea nanoparticulelor de argint, procedeu foarte agreat de practicieni, modifică semnificativ structura și, implicit, comportamentul în timp al rășinilor acrilice

Cea de a treia direcție a tezei s-a axat pe analizarea caracteristicilor suprafețelor rășinilor acrilice convenționale, autopolimerizabile și termopolimerizabile, în functie de tehnica de finisare și lustruire. Cocluziile studiilor oferă soluții practice tehnicienilor dentari, ghidându-i în alegerea metodei și instrumentarului optim de prelucrare, coroborate cu tipul de rășină utilizat.

În al doilea capitol intitulat ” *Possibilities and limits of cross-infection control in the dental laboratory*” am urmărit trei direcții de cercetare, precedate de o aducere la zi a ultimelor informații din literatura de specialitate referitoare la aceasta problematică extrem de actuală.

Prima direcție de cercetare este reprezentată de cercetări privind cunoașterea și implementarea măsurilor de control a infecției încrucișate în laboratorul dentar. In vederea realizării unui studiu privind sursele de contaminare și posiblitatea eliminării riscului infecției încrucișate, am analizat măsura in care noțiunile profilactice sunt cunoscute și aplicate de către tehnicienii dentari; rezultatele și concluziile obținute m-au ghidat ulterior spre celelalte direcții de cercetare.

A doua direcție de cercetare a abordat analizarea concentrației de pulberi nocive și gradul de contaminarea microbiană a acestora în laboratorul de tehică dentară, rezultate ca urmare a diferitelor etape de prelucrare a protezelor.

Cea de a treia direcție de cercetare vizează analizarea posibilităților de contaminare microbiană a protezelor mobile după prelucrare, în funcție de instrumentarul și pastele folosite pentru finisare..

Cel de al treilea capitol intitulat "Technological possibilities for full dentures realization" este, de asemenea, precedat de o secțiune introductivă care prezintă metodele convenționale și moderne de realizare a protezelor totale, precum și avantajele și dezavantajele materialelor utilizate în tehnologiile de realizare a acestor construcții protetice, longevitatea acestor proteze și posibilitățile de refacere corectă a funcțiilor aparatului dento-maxilar

Prima direcție de cercetare este reprezentată de studii privind principalele tehnologii utilizate pentru realizarea protezele totale, analizând care sunt metodele mai frecvent utilizate în practică pentru realizarea acestor lucrări protetice.

A doua direcție de cercetare este reprezentată de o analiză a parametrilor mecanici ai protezelor acrilice realizate prin diferite tehnologii de polimerizare. Mecanismul de polimerizare influențează caracteristicile mecanice și comportamentul biologic al rășinilor acrilice, iar cercetările noastre au permis sistematizarea condițiilor optime de polimerizare, pentru a obține lucrări protetice mobile cu parametri biomecanici optimi.

A treia direcție se intitulează *„Students' attitude regarding the implementation of digital technologies in current dental practice”.*

Toate restaurările protetice moderne au o mulțime de avantaje, dar există și o serie de dezavantaje, care trebuie cunoscute, în vederea alegerii unei soluții terapeutice corectă.

În acest scop, studiile s-au concentrat pe analiza opiniilor studenților de la Specializarea Tehnică dentară, cu privire la implementarea tehnologiilor digitale în activitatea de laborator, precum și impactul pe care aceste metode l-ar putea avea asupra activității practice curente.

Secţiunea II prezintă direcţiile viitoare de cercetare, atât din punct de vedere ştiinţific, cât şi academic. În acest sens mi-am propus, pe de o parte, continuarea tematicii deja abordate, specifice disciplinei Tehnologia Protezelor Dentare și, pe de altă parte, doresc să abordez direcţii noi, inovatoare, care să permită cercetări interdisciplinare în cadrul unor proiecte naţionale şi internaţionale.

Analizarea caracteristicilor materialelor si tehnologiilor de realizare a protezelor dentare va ramane o preocupare importantă și în viitor, urmărind consolidarea nucleului de cercetare existent, extinderea colaborărilor interdisciplinare, crearea unui centru performant de cercetare pentru tehnologii digitale și crearea unui centru de defectoscopie.

În această secţiune am subliniat strategiile și proiectele privind activitatea cu viitorii doctoranzi, detaliind temele de cercetare care pot fi abordate de către aceștia, și anume: cercetări experimentale privind rezistența la oboseală și uzură a rășinilor îmbogățite cu nanoparticule de argint, metodele de aplicare și preparare a nanoparticulelor de argint destinate optimizarii rășinilor și aderența microbiană la bazele protezelor realizate din rășini optimizate cu nanoparticule de argint; studiile in vitro sunt utile pentru inițierea unor cercetări clinice privind analizarea modificarilor suprafeței extene și a culorii protezelor totale din rășini acrilice optimizate cu nanoparticule, precum și cercetări privind posibilitățile de reducere a inflamațiilor mucoasei orale la purtătorii de protezele totale din aceste materiale.

Alte direcții de cercetare care vor fi dezvoltate sunt reprezentate de studii comparative privind tehnologiile digitale și convenționale de realizare a protezelor mobile totale și cercetări asupra posibilităților de utilizare a tehnologiilor digitale în diferitele etape de laborator.

Secţiunea III include o listă a principalelor lucrări de referinţă care au fost consultate în vederea elaborării tezei de abilitare

OVERVIEW OF ACADEMIC, PROFESSIONAL, AND SCIENTIFIC ACHIEVEMENTS

Teaching is one of the most challengind ansd demanding profession because training the future doctors implies a huge responsibility, because it does not involve from the teachers only the transmission of some necessary knowledge in the future activity but also the formation of slightly strong characters. In this sense, there is a continuous concern for increasing the quality of the didactic process, paying special attention to the theoretical and practical activity, the active involvement of the students in the didactic act and in the research projects of the faculty.

In the 27 years of my university career, my professional training and improvement has been continuous, in order to optimize and permanently upgrade the teaching act.

At the same time, the sustained research activity that I carried out in these years allowed me to be permanently connected to the latest news in the field of dentistry. The results of the research within the discipline, but also within the interdisciplinary projects were useful in the educational process, the students being always up to date with the latest news regarding the materials and technologies used in dental technology.

As in other fields of medicine, huge advances have been made in dentistry, which have permanently changed the protocols and methods of treatment. In the discipline of dental prosthesis technology, we always connect the teaching activity with the research activity, in order to guide the students in the discerning choice of the optimal therapeutic solutions.

I have structured the presentation of my academic career according to the following plan: professional and academic activity, scientific research activity, achievements in the scientific publication area, clinical activity, recognition of the national and international level.

I.1. Professional and academic activity

My academic and scientific formation was carried out at Faculty of Dentistry, University of Medicine and Pharmacy „Grigore T Popa" Iasi, which I graduated in 1993, with doctor's degree, with the diploma series L nr.1184/27.IX.1993.

In 1994 I became Junior assistant at Technology of Dental Prostheses discipline, Dental Medicine Faculty (249/1.04.1994).

I continued my didactic activity as Assistant Professor untill 1998 and in 2002 I became Lecturer at the same Department (14.718/14.10.2002).

Since 2017 until present I am Associate Professor at the Technology of Dental Prosthesis Discipline, Implantology, Removable Prosthesis, Technology Department, Faculty of Dental Medicine, „Grigore T Popa" University of Medicine and Pharmacy, Iasi.

I performed my teaching activity with students from the Dental Technician Specialization, namely with the 1-st year (Morphology of teeth and dental arches), 2-nd year (Technology of metal-ceramic bridges), 3-rd year (Technology of full denture), Dental Medicine Specialization - Romanian Section, with the 1-st year (Morphology of teeth and dental arches) and 4-th year (Technology of full denture) and from 2010 with the students of Dental Medicine Specializatin - French Section with the 1-st year (Morphology of teeth and dental arches), 3-rd year (Technology of dental crowns), 4-th year (Technology of full dentures) and 5-th year (Technology of removable partial dentures).

Throughout this period, I focused my concerns on the permanent reorganization of the teaching process, by restructuring the content of the syllabus and curricula, following their connection to the norms imposed by the european community.

I have always followed that theoretical and practical training of graduates must be related to the needs and requirements of the national and international labor market

Dental technology is a field in a permanent dynamic, and the materials used in dental prosthetics have evolved enormously in recent years, practically revolutionizing dentistry. In this context, both the students from the Dental Technique specialization and the ones from Dental Medicine must be connected to the novelties in the field.

Therefore, during the scientific debate meetings that take place within the discipline of Dental Technology, new methods of prosthetic treatment were presented and discussed, stimulating training specialists to know new technologies and compare them with conventional methods. Also, involving the students in making these presentations of the clinical and technological steps of making different types of prostheses, we aimed to increase their appetite for research. By training them in this sense and teaching them to corroborate the activity of learning and accumulating new information with the research activity, we prepared them for the final stage, of accomplishing the bachelor's thesis.

In my teaching activity I guided, on average, a number of 15 bachelor's theses per year, in the specialization of Dental Technique and in the specialization of Dental Medicine, works that brought to attention new technologies and prosthetic therapeutic solutions for complex clinical cases.

The pandemic with SARS-CoV-2 was a new challenge in everyone's activity, which forced us to restructure the learning process, without the didactic act being affected from the qualitative point of view.

In this situation it was necessary to rethink the teaching methods, to design plans, reports and presentations, according to this new way of working.The students benefited from all the necessary materials, the practical works were filmed and distributed to them, so that, thanks to the electronic platforms, they continued their training process, without major difficulties.

Along with the mandatory disciplines, we followed the introduction in the educational process of some optional disciplines, which would allow the students to capitalize on other values, indispensable to the specialists in the field of medicine.

Thus, in the specialization Dentistry, for the first year, the French language series I introduced the optional course „Éléments de la morphologie fonctionnelle des dents et des arcades dentaires", which offers students the opportunity to deepen the notions of morphology and to correlate the elements of dental anatomy with the functions of the dento-maxillary system.

Besides the didactic activity with the students from the bachelor program, I am also involved in the preparation of the master students, supporting courses and practical activities with the students within the master program „Modern techniques in aesthetics and technological rehabilitation in particular edentulous situations".

Also within the project financed by Agence Universitaire de la Francophonie (AUF)- L'assurance de la qualité dans l'enseignement superieur par la formation de specialistes dans le domain de la Rehabilitation Orale Complexe and carried out in the period 22.06-20.12.2020, I held online courses for French-speaking teachers in the member countries of the CIDCDF association and 6th year students, French language series, Faculty of Dentistry.

Another activity in the didactic area is represented by the training of residents in the General Dentistry specialization. Within this program I support courses and practical works for second year residents.

I.2. Scientific research activity

I have been admitted to be PhD training at the 'Grigore T. Popa' University of Medicine and Pharmacy Iaşi, Faculty of Dental Medicine in 1999 and I publicly supported the work in 2004. I was awarded the title of Doctor in Dental Medicine in 2005, (Doctor's Degree Series D no. 0002875, Order of the Minister of Education and Research nr. 3956/ 25.IV.2005) – with the thesis „Consideration about privind indirect inlay restorations" (Scientific coordinator Prof.univ.dr. Ştefan Lăcătuşu).

My doctoral thesis was divided into two sections: stage of knowledge and personal contribution.

In the first part I focused my research on comparing the biomechanical properties of the materials used in inlay systems, classic and modern technologies used for inlay systems and on the possibilities of optimizing the biomecanical properties of the inlays.

In the second part, represented by personal research, I followed several particular aspects regarding the characteristics of these prosthetic restorations:

-Long therm survival estimates of cast gold and aesthetic inlays- a clinical comparison at five years,

-Technical posibilities for improving the structure of metalic inlays,

- Aspects of the biomecanical behavior in inlay restorations,

- Study regarding the influence of the tensions induced by the restorative material on the dental tissues.

The originality of my doctoral thesis consisted in this comparative analysis between the three major categories of materials used in making inlays, these prosthetic restorations so precise and difficult to achieve from a technological point of view. At the time the doctoral research was conducted, there were few comparative studies in this regard, and opinions on the characteristics, advantages and disadvantages of the materials were divided and contradictory.

The research Icarried out, using the Finite Element Method, then completed by mechanical tests, carried out in collaboration with the Faculty of Materials Science and Engineering- Technical University „Gheorghe Asachi" Iași, allowed us to concretize some pertinent conclusions, with important practical impac.; thus, we were able to systematize which are the optimal materials for making the inlays restorations, depending on the amplitude of the dental destruction and the position of the tooth on the dental arch.

After finishing my doctoral studies, I continued my research, in the direction of optimization the mechanical properties of inlay prosthetic constructions. The digital technologies that have appeared in the meantime require the use of new materials that need to be analyzed; also the marginal adaptation, at the level of the interface, is another important aspect that must be followed. In this sense, we wanted to comparatively analyze thismarginal area to inlays made by conventional methods and digital methods.

Subsequently, the area of interest in my research activity extended to other types of prosthetic constructions and thus defined the subsequent study directions, which I have focused on from 2005 until now.

In the field of fixed prostheses, the research activity focused on two main directions:

-optimizing the structure and quality of materials used in fixed prosthetic works
-clinical and experimental studies relating to the primary and secondary prevention in case of dental treatments using dental materials and alloys;

Another area of great interest for me is the analysis of the possibilities and limits of cross-infection control in the dental laboratory.

In this sense, my studies were aimed at detecting the main sources of contamination in the dental laboratory, establishing measures to reduce the risk of contamination and the implementation and systematization of these measures in a guide of prophylactic measures to protect patients and members of the dental team, to allow the reduction of the number of pathogenic germs in the workspace and to ensure the implementation of a high standard in the control of cross-infection.

Another important research direction on which I focused my attention was the possibility of optimizing the characteristics of acrylic mobile prostheses. In aceasta directie am analizat principalele tipuri de rasini acrilice utilizate in laboratul de tehnica dentara in vederea realizarii protezelor mobile, urmarindu-le parametrii mecanici, starea de suprafata si longevitatea in timp, cautand sa optimizez proprietatile acestora si sa crec performantele biologice si functionale.

A relevant study conducted during this period was to analyze the bio-mechanical performance of dental acrylic resins silver nanoparticles enriched.To provide antibacterial properties, in the last years more attention has directed toward the incorporation of silver nanoparticles into acrylic resins. Silver particles utilization aims to avoid or at least to decrease the microbial colonization over dental materials, increasing oral health status and improving life quality. A question still remains: how AgNps could influence the structure, mechanical and physical properties of the resins.

In our researches we investigate the stress distribution in a dental acrylic resins reinforced with silver nanoparticles with different diameters and in different concentrations. Our conclusions have great clinical importance and determine the optimal size and concentration so that the nanoparticles do not affect the mechanical characteristics of acrylic prostheses.

In addition to research directions in the field of technology and dental materials, I have conducted studies and research on the dental students attitude toward patients with chronic diseases, on the importance of knowing the ethical aspects in dental practice and on the economic aspects of oral health (the influence of economic crisis on the management of dental office and dental technique labs). During these researches we followed the knowledge of bioethics and deontology for students of Dental Medicine and Dental Technique Specialisation, and how these notions are applied, in relation to patients with a special pathology. The conclusions of these researches focused us on the directions that need to be improved and on the aspects that need to be emphasized in the training of future specialists in dentistry..

Also, as a result of the extension of digital technologies in the current laboratory practice, it6 was analyzed the point of view of the students from the Dental Technician Specialization, but the opinion of dental technicians practitioners was also followed, regarding the impact that these new methods will have on their future activity. In this sense, we made several sets of questionnaires, which we distributed to a large number of students and specialists in dentistry; Following the analysis of their answers, we were able to systematize a series of pertinent conclusions, which will guide us in the process of training future specialists.

The most recent field of interest in the research activity is represented by the impact of digital technologies on dental activity during the SARS Cov 19 pandemic. The present study aims to analyze the impact that these modern methods of treatment have on the current activity of dentists and how digital technologies have influenced the addressability of patients in dental offices during the pandemic. In this sense, we realized a questionnaire that was distributed to a number of 114 dentists with private practice in Iasi.

The answers clearly show that dentists want to implement digital systems in current dental practice, which would allow prosthetic work to be performed in a shorter time and with maximum accuracy, reducing working time and materials, reducing the risk of contamination, both for patients as well as for the dental team. Minimizing treatment time and the number of appointments is not only favorable for the patient, but also excludes complications and it is possible to obtain optimal treatment results by simplifying the entire procedure

My participation in several projects allowed me to materialize these different directions of research, both within the discipline and in collaboration with other disciplines and faculties. The most relevant participations in research projects were:

- Research grant director „Effect of silver nano-particles on the properties of acrylic dental resins" No. 31588 / 23.12.2015. 2015-2017

- Member of a complex project carried out in a CDI consortium: "Obtaining and expertise of new biocompatible materials for medical applications, no. 63 / 19.03.2018, (MedicalMetMat), type grant PN III – PCCDI, project director Forna Norina Consuela

-Member in the group of experts within the Project "Practical training courses for the rapid integration on the labor market of students specialized in dentistry", Contract number POSDRU / 90 / 2.1 / S / 63942, 2007-2013, Project Director Prof.univ .dr. Norina Forna

- Member in the project Prevention of school dropout and counseling in choosing the career path for first year students of Dentistry and Dental Technique (Be.MeDTech)

-Member of the target group Quality Assurance Commission within the project "Adapting the offer of higher dental medical education to the needs of the labor market and of the knowledge-based society" POSDRU / 86 / 1.2 / S / 63699, 1.07 2010-30.06.2013, Director poiect Prof .univ.dr. Norina Forna

- Member of the target group of the MEDICALIS project-Educational Management and Quality Education in the Information Society ", Contract number POSDRU 86 / 1.2 / S / 62594, 1.07.2010-30.06.2013, Project Director Prof.univ.dr. Norina Forna

-Member in the project "Insertion of medical graduates on the labor market, through the development of internships in practical training of practical skills-MEDPRO

- Member in the project financed by Agence Universitaire de la Francophonie (AUF)- L'assurance de la qualité dans l'enseignement superieur par la formation de specialistes dans le domain de la Rehabilitation Orale Complexe, 22.06-20.12.2020

The results of these studies have been translated into a number of articles published in extenso in Web of sciene Core Collection-indexed journal with impact factor, in ISI proceedings volumes, in International database listed papers in articles published in extenso in the volumes of international conferences and in oral presentation at national and international congresses.

I.3. Achievements in the scientific publication area

Books / Book chapters in the national publishing house

1. **Diana Antonela Diaconu**, Monica Silvia Tatarciuc, - Éleméments de morphologie de l'appareil dento-maxillaire, Editura Pim, Iași 2021, ISBN 978-606-13-56152-6
2.Monica Silvia Tatarciuc, **Diana Antonela Diaconu**, Diana Tatarciuc- Elemente de morfologie a sistemului stomatognat, Editura Pim, Iași 2020, ISBN 978-606-13-5468-9
3. **Diana a Diaconu-Popa**, Monica Silvia Tatarciuc, Anca Vițalariu-Technologie de la prothese totale, Ed. Performantica Iaşi 2019, ISBN 978-606-685-661-4
4.**Diana Antonela Diaconu,** Monica Silvia Tatarciuc, Technologies des protheses unidentaires- Ed Performantica Iasi, 2012, 180 pg., ISBN 978-973-730-948-8
5. **Diana Antonela Diaconu**, Monica Silvia Tatarciuc, Particularitati tehnologice in realizarea puntilor ceramice, Ed Performantica Iasi 2015, 313 pg, ISBN 978-606-685-241-8
6.**Diana Antonela Diaconu,** Monica Silvia Tatarciuc, Tehnologia Protezelor mixte metalo-ceramice, Ed.Junimea, Iași, 2006, ISBN(13) 978-973-37-1216-9
7.**Diana Diaconu,** Monica Tatarciuc, Anca Vitalariu, Prevenirea afecțiunilor stomatologice, Capitol IV- Prevenirea afectării stării de sănătate generală în medicina dentară-Posibilități şi mijloace de prevenire a infecţiei încrucișate în laboratorul de tehnică dentară- Ed. „Gr.T.Popa" UMF Iași, 2014, ISBN 978-606-544-229-0
8.Anca Vitalariu, **Diana Diaconu**, Irina Chonta, Monica Tatarciuc-, Gutierele pentru protecție în activitățile sportive, Cap.IV.7., p.259-273 , Vol. Managementul preventiv și interceptiv al afecțiunilor stomatologice la copii și adultul tânăr, ISBN 978-606-544-392-1, 2016
9.Anca Vitalariu, Cristina Masgras, Irina Chonta, **Diana Diaconu-Popa,** Monica Tatarciuc-Impactul local şi sistemic al refacerii morfologiei ocluzale şi a funcţiei masticatorii, Cap.II.15, p.163-173, Vol. Sănătatea orală în contextul sănătăţii generale, 2017
10. Monica Tatarciuc, **Diana Diaconu-Popa**, Anca Vitalariu-Prevenirea afecţiunilor orale determinate de coroziunea aliajelor dentare, Cap.III.11, p.266-273, Vol. Sănătatea orală în contextul sănătăţii generale, 2017

Articles published in extenso in ISI Web of Science Core Collection -indexed journals, with IF - 17

-First / last / correspondent author in ISI listed papers - 14;
-Coauthor in ISI listed papers - 3;
-First / last / correspondent author in international databases listed papers – 28;
-Co-author in international databases listed papers – 6;
-Oral presentations at international scientific meetings – 40;
- Oral presentations at international scientific meetings-
-Poster presentations at international scientific manifestations - 10;
-Citations in ISI Web of Knowledge- indexed journals - 95;
--Hirsch Index (Clarivate Analytics): 6

I.4. Clinical activity

My concern for my training as a dentist was continuous, the professional trajectory following the next steps:

- trainee doctor during January-March 1994, at the Dental Gnatoprosthetics Clinic of the University Clinic no.1 Iaşi,
-resident doctor confirmed with the order of M.S.nr.2017 / 1994, March 1994-November 1996 at the University Clinic no.1 Iaşi,
- specialist doctor 1996-2001 general dentistry, confirmed by order of M.S. nr.2707 / 18.XII.1996
2012 - present, specialist doctor in the second specialty- Dental Prosthetics, confirmed with the order of the Ministry of Health no. 786 / 03.08.2012
-in 2001 primary dentist, speciality of general dentistry, confirmed with the order of the Ministry of Health no..538/07.08.2001
- 2012, primary dentist in the second specialty - Dental Prosthetics, confirmed by order of M.S. nr.1077 / 2012

In all these years, I continued developing my professional education, by involving in post-graduate training courses, scientific and research-related projects. I have participated at various international and national courses with international participation, national courses and conferences.

The most relevant courses are:
- Courses of the Pedagogical Seminar, within the University „AL.I.CUZA" IAŞI, 1995-1996
- „Actualities in periodontology, endodontics and cariology", 1-31.03.1997, UMF Iaşi
- International Seminar on Dentistry „Rehabilitation Orale Complexe", 18-20 mai 1998
- Dental treatment for general health compromised patients" (Prof. Dr. Adi Garfunkel – Israel), 27-31 mai 1999, Iaşi
- „The surgical treatment in parodontopathies" (Prof. Dr. Wember Matthes – Germania), 14-17 iunie 1999 Iaşi
- International postgraduate course in Periodontology (Prof.Dr. W.Matthes – Germania), 29.11-4.12.1999, Iaşi
- International postgraduate course in hypnosis in dentistry (Prof. Dr. Vlad Solomon – Israel), 29.11-4.12.1999, Iaşi
- „Actualities in contemporary dentistry ", May 18 - June 16, 2001, Iaşi
- „Biointegration of oral implants "within the Congress" Drugs, biomaterials, equipment and techniques in dentistry", 27.02-1.03 2002, Iaşi,
- „Flexite elastic thermoplastic materials. R-3C injector "(Szalina Luis Albert - dental technician), organized by the Faculty of Dentistry UMF Iaşi and Nastimed-Cluj Napoca), December 2005, Iaşi
- "Periodontal incidents of fixed prosthetic treatments" (Prof. Dr. Teodor Traistaru Oct.2006, Bucharest
- „ Prophylactic and treatment applications from the perspective of specifying the diagnosis in gingivo-periodontal diseases" (Prof. Dr. Horia Dimitriu), oct. 2006, Bucharest
- „ Cast removable parial denture with clasps - logical concept, efficiently practicable everywhere" (Prof.Dr. Ion Coca/ Germania), oct. 2006, Bucharest
- Continuing medical education courses credited during the EURODENTIS 1 congress, on the occasion of the 10th anniversary of AMS Iaşi, March 2007
Postgraduate course "Smile Aesthetics" (Dr. Elliot Mechanic / Canada) - Marriot Grand Hotel, Bucharest, April 13, 2007
- „Attachement and telescope retainers in the therapy of partial edentulism"(Prof. Dr. Forna Norina Consuela), Iaşi, March 20-21, 2008

- Postgraduate course "Actualities on the risk of medical emergencies in the dental office" (Prof. Dr. Forna Norina Consuela), Iasi, June 2007
- Postgraduate course "Principles of scientific medical writing", 15.06.- 10.07.2009, UMF Iasi
- Postgraduate course „ Research ethics in Romania **”**, 9-11.11.2009, UMF Iasi
-„ Postgraduate course Current approaches in implant-prosthetic rehabilitation ”- Dental technician Richard Abulius (France) and Prof. Dr. Georges Khoury (France), 25-26 Oct.2010, Iasi, Romania (Lectures:“: „Alternatives a la chirurgie reconstructrice des pertes tissulaires par les gencives artificielles” –R.Abulius; „Evolution des augmentations osseuses: des prelevements auto;ogues aux osteotomies segmentaires”)
- Training courses for trainers in oral rehabilitation, 21.01-28.02.2013, UMF, Iaşi
- Postgraduate course Medical and dental emergencies, April 14, 2016, Bucharest
- Postgraduate course Medical and dental emergencies, Iasi, 2017

In the Dental Technology discipline' coordinate the activity of the dental laboratory, where the scale of prosthetic works for the disciplines of Fixed Prosthesis, Partial removable Prosthesis and Complete Removable Prosthesis is performed. Thus, my activity involves checking the quality of each prosthetic element within the technological algorithm, but also the standards of prostheses made in the laboratory. Also, our activity involves coordinating the activity of the laboratory and supervising the clinical and technological steps of performing fixed and mobile prosthetic restorations.

I.5. Recognition at the national and international level

I am currently member in 2 international scientific societies and 4 national societies:

- European Prosthetic Association of Dental Public Health (EPA)
- Balkan Stomatological Society (BASS)
- Romanian Dental Association for Education (ADRE)
- Romanian Association of Oral Rehabilitation (ASRRO)
- Society of Physicians and Naturalists (SSM) Iasi Branch
- The College of Stomatologists from Romania (CMSR)-

In 2015 I received the UEFISCDI award for the research paper published in ISI journals located in the top area, within the HUMAN-RESOURCES-Program — Research projects to stimulate the establishment of young research teams, December 2014 session:
Diana Diaconu, Anca Vitalariu, Monica Tatarciuc, Alice Murariu, The economic crisis effects on the cross contamination control in dental laboratories, Revista de cercetare şi intervenţie socială, 2014, vol. 47, 105-117, PN-II-RU-PRECISI-2015-9-8471, position 1073

My scientific publlications have counted over 95 citations in ISI Clarivate Analytic Indexed Journal, and participation in international and national scientific events, with conferences or as a member of scientific committees have contributed to increasing the prestige of the discipline and to increasing the visibility of the Faculty of Dentistry .

SECTION I

SCIENTIFIC ACHIEVEMENTS FROM THE POSTDOCTORAL PERIOD

CHAPTER 1

RESEARCH ON THE CHARACTERISTICS AND BIOMECHANICAL BEHAVIOR OF ACRYLIC RESINS FOR FULL DENTURES

1.1. EFFECT OF SILVER NANOPARTICLES INCORPORATION ON MECHANICAL PARAMETERS OF DENTAL ACRYLIC RESINS

II.1.1.1 State of the art

Acrylic dental resins are commonly used in dentistry for different purposes such as partial and complete denture, epithesis, orthodontic functional appliances, anti-snoring or bruxism mouth guard, due to their advantages: good physical properties, sufficient strength, low water sorption, low solubility (Raszewski Z et al., 2021; Hsu C-Y *et al.*, 2020). However, a series of disadvantages have also been reported: poor mechanical properties, high coefficient of thermal expansion, low modulus of elasticity and mucosal irritation, caused by the release of methyl metacrylate or by the bacterial colonization. One of the major disadvantages of removable prostheses, frequently reported by practitioners, is their insufficient mechanical strength, in certain clinical situation (Allahyari S *et al.*, 2018; Bettencourt AF *et al.*, 2010).

Over years, many attempts have been made to improve the mechanical properties of acrylic resins in three directions: the development of alternative materials. (Köroğlu A *et al*, 2016) the chemical modification by the addition of various polymers (Machado-Santos *et al*, 2020; Morais FAI *et al*, 2007) and the reinforcement of polymethyl methacrylate with other materials, such as carbon fibers, glass fibers, metal inserts (Elshereksi NW *et al*,2017)

Another disadvantage that specialists faced is the mucosal irritation caused by microbial adhesion to inner denture surface. Epidemiological studies report that approximately 70% of removable denture wearers suffer from denture stomatitis, Candida albicans being regarded as essential prerequisites for denture stomatitis. The elderly patients with removable acrylic prosthesis present difficulties on keeping the denture clean. Recently, to induce antibacterial properties, more attention has been paid to the incorporation of silver nanoparticles (AgNps) into acrylic resins. AgNPs incorporation aims to avoid or at least to decrease the microbial colonization over dental materials, increasing oral health levels and improving life quality (Alla RK *et al*, 2020; Swamy KNR *et al*, 2018).

Nanotechnology brings emerging changes in translational research in the last couple of decades. Nanomaterials have gained popularity for countless applications in various fields including clinical dentistry. In dentistry, nanotechnology has revolutionized the materials interaction and behaviour with oral structures such as antibacterial dental adhesive, nanoparticles based aesthetic restorative materials, surface decoration on dental implants, high strength denture bases (Zafar MS *et al*., 2017). Better understanding of materials and oral tissues interface at nanoscale has attracted many researches for therapeutic dental applications such as fluoride release, drug delivery. Silver (Ag) salts have been used for thousands of years, because of their antimicrobial efficiency against Gram-positive and Gram-negative bacteria, protozoa and fungi, as well as viruses. Nowadays, elemental Ag and associated compounds are used to reduce the risk of infection in the treatment of burns, prevent bacterial colonization on medical devices, in surgical textile fabrics, for water purification, bone cements, and dental materials. In dental applications, different forms of Ag such as Ag ions (Ag+), Ag nanoparticles (AgNPs), and Ag-polymeric complexes have been used to improve antibacterial efficiency. The instability of Ag+, however, restricts its practical implementation. The problem can be resolved by protecting the Ag+ with a polymeric matrix sheath. The major advantage of using AgNPs arises from their large ratio of surface area to volume. AgNPs exhibit more effective ion release and enhanced antimicrobial activity. AgNps have been satisfactorily incorporated into polymers used as tissue conditioners and as denture base.

The influence on the features of resins depends on the type of nanoparticles (size and shape), and concentration as well. AgNps have been added to resins due to their proved antimicrobial effects, but their influence on the mechanical properties is not completely elucidated. Even all researchers agree on the antibacterial effect of AgNps, the influence on the mechanical properties is still controversy. Some experts found that AgNPs incorporation within acrylic prosthesis material can improve its physical and mechanical properties, while there are also studies demonstrating negative effects on the resins features (Mathew M *et al.,* 2014; Soygun K *et al.*, 2013)

Their unique chemical and physical properties and pronounced antibacterial activity, provide one of the most cost effective antibacterial agents for applications in medicine for: diagnosis, treatment, dug delivery, bone cements, cardiovascular implants, medical device coating, wound dressings, medical textiles, contraceptive devices, etc. Induction of antimicrobial activity in dental materials has been widely a large concern in dentistry, their usefulness being proved in Orthodontic adhesives, Dental instruments, Endodontics filling materials and Prosthodontics. Despite the continuous progress in material science, Polymethyl Methacrylate (PMMA) is still the most used material for denture bases. A common problem faced by the acrylic denture wearers is the denture stomatitis, which is related to the specific conditions of the oral cavity, the state of the patient's immune system, but also to the PMMA surface characteristics, that facilitates the bacterial-fungal biofilm formation (Khanna G *et al.*, 2013; Zebarjad SM *et al.,* 2011)

The classic treatment for denture stomatitis is based on topical or systemic antifungal drugs, but this infection is often persistent, since antifungal resistance has been reported in *Candida Albicans* biofilm. So, the prophylaxis of dental stomatitis by AgNPs incorporation represent a challenge.

The antimicrobial effect of AgNPs was demonstrated to be directly proportional to the concentration and inversely proportional to their diameter. Normally, a high concentration leads to more effective antimicrobial activity, while particles of small size can kill bacteria at a lower concentration. Particles larger than 100 nm showed only a bacteriostatic activity, while smaller particles have bactericidal effect. The smaller the particles (l< 10nm), the greater the antimicrobial effect (because they can penetrate into the bacteria, not only on it's surface).

The antimicrobial characteristic of AgNPs in acrylic resins has been demonstrated in a lot of studies (Oyar P *et al*, 2018; Dakal TC *et al*, 2018; Qayyum *S et al*, 2016) but there are few studies which analyzes the influence of NPs on the mechanical properties of denture base resins (de Souza Neto FN *et al*, 2019; Köroğlu A *et al,* 2016; Monteiro DR *et al*, 2015; Zomorodian K *et al*, 2011)

So, in addition to the undeniable advantage of antimicrobial action the addition of AgNPs effect on the mechanical properties of the resin should be examined with more attention.

The study of Sodagar (Sodagar JA *et al*, 2012) demonstrated that the addition of 0.05% AgNPs caused a decrease in the flexural strength of one brand of self-curing resin but led to an increase in the other brand's strength.

The type of acrylic resin and the amount of NPs incorporated are important factors which can affect the biomecnanical characteristics of PMMA. There are also studies that conclude that the incorporation of AgNPs optimizes the mechanical parameters of acrylic resins, especially flexural strength (Kassaee *et al.,* 2008) indicated that adding.

So, regarding the influence of silver nanoparticles on the structure and properties of acrylic resins, the conclusions of the studies are controversial. Most of researchers agree that, in low concentrations AgNPs have no negative effects on the mechanical properties of acrylic resins.

Another important factor that influences the mechanical properties and clinical behavior of complete dentures is the porosity. Resins porosity is a complex, plurifactorial phenomenon and numerous studies have aimed to evaluate (qualitative and/or quantitative) the porosity of acrylic resins, a universally accepted standardization for pores size has not been imposed yet.

According to the ADA "there must be no bubbles or voids when viewed without magnification", pointing out that clinical highlighting is difficult. In the specialty literature the acrylic resins porosity is incriminated as factor favoring the denture stomatitis and fractures of dentures bases, due to their presence on the fracture line and on the interface artificial tooth / denture base.

The porosity is a non-desirable characteristic to the acrylic resin denture base (Figuerôa RMS *et al.* 2018) that can weaken the prosthesis and result in high internal stress, leading to greater vulnerability to distortion and warpage (Kasina SP et al, 2014) . A porous surface promotes colonization of the material by oral microorganisms such as Candida albicans (de Oliveira CE *et al,* 2010) and facilitates the retention of substances and deposition of calculus, resulting in staining and impaired aesthetic (Al-Fouzan AF *et al,* 2017; von Fraunhofer JA *et al,* 2009)

Regarding the porosity of acrylic resins, experimental studies results have been extremely variable, sizes falling between 10 and 300 μm, however, much higher values (500μm) being reported. Currently accepted and used classification distinguishes small pores (approx. 10 micrometers diameter), medium pores (10-30 μm diameter) and large pores (over 30 μm diameter).

Denture plaque formation occurs as a result of adhesion of various microorganisms to the acrylic surface of dentures. According to some in vivo studies clinically acceptable roughness (Ra) of hard surfaces in the oral environment after polishing should not exceed 0.2 μm.

Results of several studies have indicated that surface roughness of acrylic resin polished with prophylactic pastes, various rubber polishers, abrasive stones, and pumices still exceeds the threshold at Ra of 0.2 μm (Durán G *et al.,* 2020;. The value reported as characteristic of smooth acrylic resin is 0.12μm. However, surface roughness of polished acrylic resin may vary between 0.03 and 0.75μm.

Dental technicians use effective techniques for polishing denture base acrylic resin, because the surface characteristics of acrylic resins vary according to the type of finishing and polishing systems. Some glazes have been used for sealing acrylic dentures. According to the manufacturers, a glaze would make the acrylic resin surface smoother, decreasing accumulation of residual food and plaque adhesion, and providing improved oral hygiene conditions.

Another important physical property of these dental materials is the wettability, affecting both bacterial colonization and denture retention in the oral cavity, therefore it is recommended to use materials with increased wettability for dentures base (Rao DC et al., 2015; Al-Kheraif AA *et al.*, 2014).

Water absorbed by acrylic resins during the use of prosthesis acts as a plasticizer and can result in volume changes, so the water sorption evaluation also has clinical relevance. Furthermore, residual monomer and other water soluble byproducts are released into the oral cavity and may cause tissue irritation; therefore, it is desired that these materials have low solubility (Kasina SP *et al*, 2014; 94. Jin N-Y *et al*, 2009)

My contributions to this research direction can be found in the following articles:

1. **Diaconu-Popa D**, Viţalariu A, Tatarciuc M, Munteanu F. Effect of silver nanoparticles incorporation in dental resins on stress distribution- Finite Element Analysis. *Rev.chim. (Bucharest*) 2016; 67(8):1571-1574. IF=1.232.
2. **Diaconu-Popa D**, Comaneci R, Tatarciuc M, Murariu A, Viţalariu AM. Influence of silver nanoparticles on mechanical properties of dental acrylic resins *Rev.chim. (Bucharest*) 2016; 67(1): 2016:2311-2313. IF=1.232.
3. Viţalariu A, Tatarciuc M, Luca O, C Holban Cioloca C, Bulancea B, Aungurencei A, Aungurencei O, Raftu G, **Diaconu Popa D**. Structural and Thermal Changes in Dental Resins Enriched with Silver Nanoparticles. *Rev.chim. (Bucharest)* 2019; 70(2):591-595. IF=1.755.
4. Viţalariu AM, Lazăr L, Buruiană T, **Diaconu D,** Tatarciuc MS. Studiu privind starea de suprafaţă a răşinilor acrilice in raport cu metodele de prelucrare mecanică. *Rev Med Chir Soc Med Nat Iasi* 2011; 115(2):542-547.
5. Viţalariu AM, **Diaconu D**, Tatarciuc D, Tatarciuc MS. Factori implicaţi în colonizarea microbiană a răşinilor acrilice. *Rev Med Chir Soc Med Nat Iasi* 2012; 116(2):600-604.

Introductions

To provide antibacterial properties, in the last years more attention has directed toward the incorporation of AgNps into polymers used as tissue conditioners and as denture base.

The prophylaxis of dental stomatitis still represents a challenge for dentists and more studies are necessary in order to find the optimal prevention method. Silver particles utilization aims to avoid or at least to decrease the microbial colonization over dental materials, increasing oral health status and improving life quality. The question is if AgNps could influence the structure, mechanical and physical properties of the acrylic resins.

In our researches we investigate the stress distribution in a dental acrylic resins reinforced with with different diameters and different concentrations

In order to predict the optimum size and distribution of AgNps as average distance between particles, a finite element analysis (FEA) was performed, revealing the stress field at the particle/matrix interface.

In dentistry, Finite Element Analysis has been used to simulate different dental structures and internal stresses in teeth and dental materials. Because of the large inherent variations in biological material properties and anatomy, mechanical testing involving biomaterials usually require a large number of samples.

FEA-based studies are indicative only, so our research has also focused on the effects of AgNPs on the mechanical properties dental acrylic resins; we also followed up on any structural and thermal behavior changes of the composite material AgNPs modified.

Materials and methods

In order to track the influence of silver nanoparticles on the specific properties of acrylic resin it was first made a virtual model to perform a finite element analysis; then it was realized samples of acrylic resins, which have been subjected to mechanical testing.

In dentistry, Finite Element Analysis has been used to simulate different dental structures and internal stresses in teeth and dental materials. Because of the large inherent variations in biological material properties and anatomy, mechanical testing involving biomaterials usually require a large number of samples this method is extremely useful to create a guideline for future in vitro tests.

To determine the tensions within a composite material consisting of silver nanoparticles and acrylic resin a FEM analyze was performed, using Autodesk soft (Autodesk AutoCAD 2014 and Autodesk Simulation Mechanical 2014).

Designing the geometry of the resin is a complex procedure that requires a higher accuracy. In order to create the mathematical model it should be understood the physical behaviors of the composite material, predicted the performance and the behaviour of the design and identified the optimal concentration.

The Finite Element Method is a computational technique which is dividing a model body into an equivalent system of many smaller units (finite elements) interconnected at nodal points.

For the analysis we considered two hypotheses: assumptions related to the mechanical solicitation of the material and assumptions concerning the type of the tested material. For this study, silver nanoparticles with dimensions of 20 nm, 40 nm and 60 nm are used, and for each dimension, three different concentrations of 5%, 10%, and 20% are taken into account.

The construction of the geometric model consisted in making a cube of acrylic resin inside which the nanoparticles will be located.

These constructive units were arranged as follows: four in length, three in width and four in height, so that in the final volume there will be 48 nanoparticles for each geometric pattern. The side of the cube was calculated according to the size of the nanoparticles, and the distance between the nanoparticles is determined according to the characteristics of the materials (density of silver, with a value of 10.49kg / dm^3 and that of acrylic resin, with a value of 1.51kg / dm^3) and the concentration of nanoparticles.

From geometric point of view, each nanoparticle is situated at an equal distance of one to the other, in three directions: two horizontal and one vertical.The solid model is transferred into a finite element analysis program, where a 3D mesh is being created, and subsequently the stress distribution analysis performed.

The finite element analysis consists in two steps: modeling the structure /system and simulating factors acting on the system.

For the analyze it is necessary to define: the geometric field of the problem, the elements to be used, element's geometric properties, the element's connectivity and the physical constraints.

A mathematical model is developed based on analysis o fthe data in relation to the phenomenon of interest and define the problem to be solved. Data for the theoretical modeling are established at this stage seeking answers to a minimum series of questions concerning synthesis of the geometric structure, synthesis of the material properties, synthesis of the support and of the loads acting on the system and the result to the FEM analysis.

The geometric model is based on a cube, with the side corresponding to the diameter of the nanoparticle (table I) which will be located in the center of the cube.

Table no I The cube size according to silver nanoparticle dimensions

AgNps diameter [nm]	AgNps volume [nm³]	AgNps weight [g]	Concentration [%]	Resin weight [g]	Resin volume [nm³]	Total volume [nm³]	Side of the cube [nm]
20	268082.5	$2.812x10^{-15}$	5	$53.43x10^{-15}$	35621025	35889107	329.85
40			10	$25.31x10^{-15}$	16873117	17141199	257.84
60			20	$11.25x10^{-15}$	7499163	7767245	198.04

These structural units were arranged as it follows: four on the length, three for the width and four for the height, resulting in a final volume of 48 nanoparticles (fig.1).

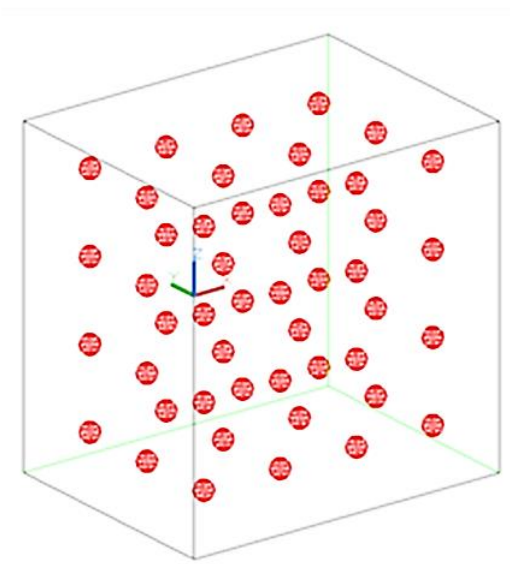


Fig. 1 Distribution of the AgNps into the acrylic resin

This arrangement was elected due to limitations on items number that can be used in finite element analysis, but also for the accuracy of the results.

For the final results interpretation only the items located in the center of the structure will be taken into consideration.

FEM analysis consist in a mesh realization by splitting a solid volume into finite elements, of parallelopipedic or tetrahedral shape; each element behaves individually, with the same characteristics as the base material.

Depending on the action applied on every element, a specific load or temperature will be supported, and will be transmited to the adjacent elements through nodes.

For a better accuracy of the results a condition was imposed for the mesh realisation: the lenght between two nodes must be allways the same, according to the diameter of the silver nanoparticles; so, for a 60 nm diameter the chosen length was 2 nm (fig. 2).

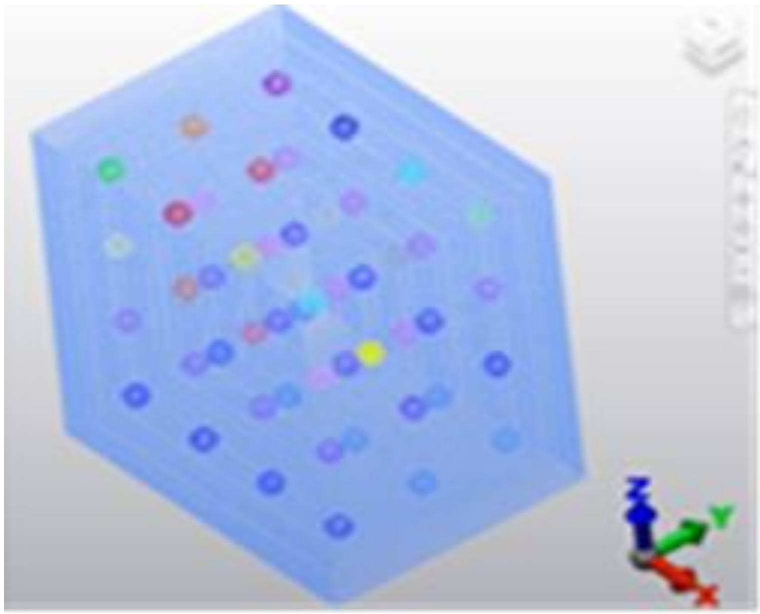


Fig. 2 Results of the meshing procedure

The material used in the finite element analysis was a composite consisting in AgNps incorporated in the acrylic resin matrix.

The material's properties used in the analysis were: the modulus of elasticity, Poisson's ratio, and density (table II).

Table II Material charactheristics for each component of the Finite Element Analysis

Element	**Modulus of elasticity [MPa]**	**Poisson's ratio**	**Density [kg/m^3]**
Acrylic resin	**2000**	**0,39**	**1,5**
Silver	**76000**	**0.37**	**10,491**

The load acting on a volume element of the composite material (the cube with 48 AgNps) is based on several biomechanical aspects of the mandibular movements.

The most important masticatory muscles are the masseter (on the external side of the lower jaw) and pterygoid muscles on the (internal surface of the mandible). For the load application we considered the moment of the maximum force developed by the masseter and pterygoid muscles during mastication (total value 16000 N.mm).

On the volume element of the composite material a pressure of 8 MPa was applied to the upper surface (yellow) and constraints were applied on the lower surface (green) (fig. 3).

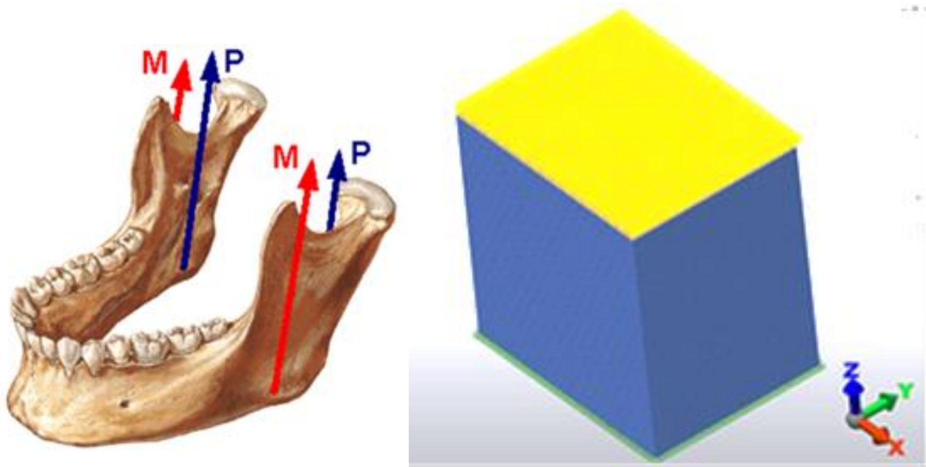


Fig.3 The action of pterygoid and masseter muscles on the mandible

The distance between two nodes must be always the same, according to the diameter of the silver nanoparticles. To calculate the average value of the forces, the force diagrams were registered for the two main categories of muscles, during a masticatory cycle (fig.4, fig.5).

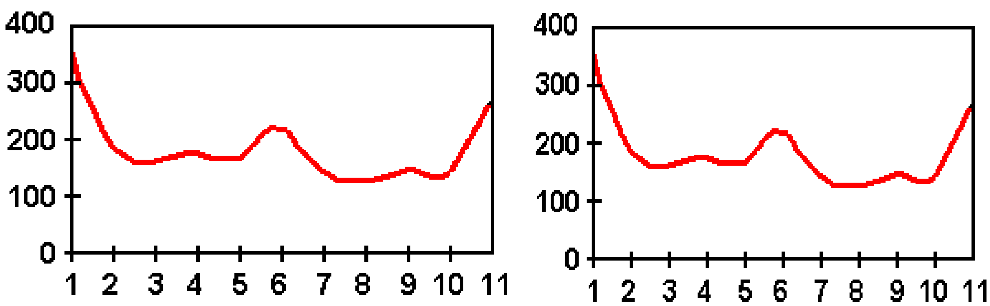


Fig. 4. Duration of the masticatory process for masseter muscles

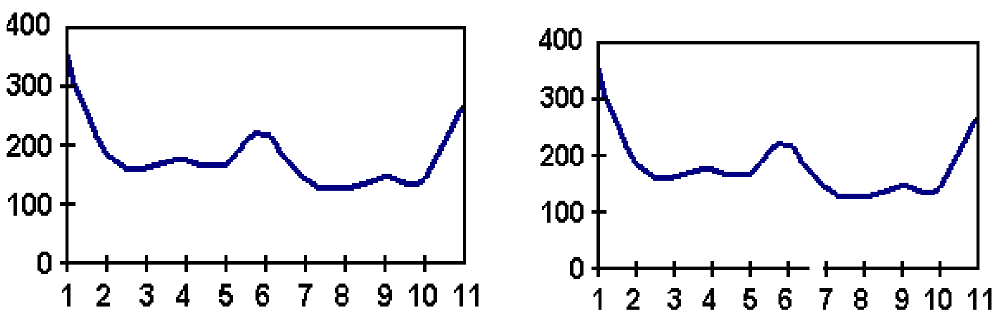


Fig.5 Duration of the masticatory process for pterygoid muscles

For testing the mechanical parameters, in the next step, we made two types of acrylic resins samples, commonly used in dental practice: a heat curing resin (Futura Basic Heat/Schutz Dental/Germany), indicated for full and partial removable dentures, and a self-curing resin (Futura Basic Cold/Schutz Dental/Germany), used for relining and rebasing removable dentures, and for making the acrylic elements of cast removable partial dentures.

The silver nanoparticles were 20, 40, 60 nm size, 0.02 mg/mL, in aqueous buffer, containing sodium citrate as stabilizer (Lot#MKBV9651V/Sigma Aldrich/USA) (fig.6)

Fig.6 Acrylic resins and AgNPs solution

A total of 80 rectangular cross-section specimens, 40 for each type of resin were made and divided into four groups, depending on the concentration of AgNps, as follows:
Group 1: **Control group**- HCR without nanoparticles
Group 2: HCR with 5% AgNps
Group 3: HCR with 10% AgNps
Group 4: HCR with 20% Ag Nps

Group 1': **Control group**- SCR without nanoparticles
Group 2': SCR with 5% AgNps
Group 3': SCR with 10% AgNps
Group 4': SCR with 20% AgNps

For specimens preparation the wax patterns were made of pink wax, 2 mm thickness, having the following dimensions: 75 mm length, 12.5 mm width (the extremities) and 4 mm in thickness (the central area) (fig.7).

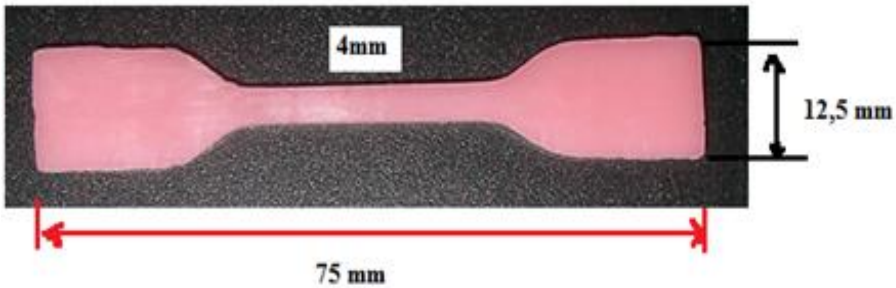


Fig.7 The specimen wax-up

The wax patterns were transformed in acrylic specimens according to the same technology used for acrylic dentures. They were first invested in dental stone (Elite Rock class IV/Zhermack) in order to obtain a mold (fig.8 a, b). After the mold isolation with a separating agent (Isodent/Spofa Dental), the acrylic resin pastes wereprepared, following the producer indications for each type.

For Futura Basic Hot the polymer/monomer mixing ratio was 2.5:1, and for Futura Basic Cold 10:7. The AgNps in colloidal solution was added to the monomer of acrylic resin by volume proportion in 5, 10 and 20% concentration, excepting the control group specimens.

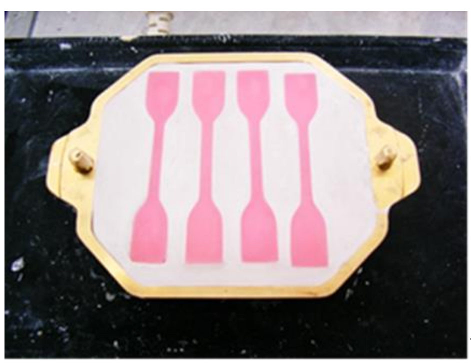
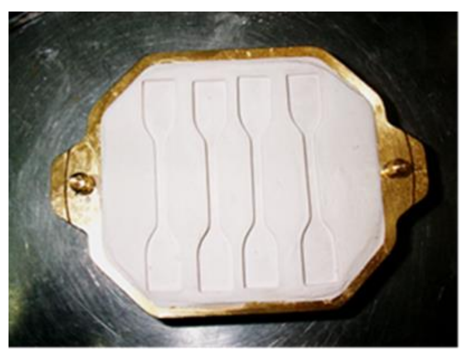
a.  b. 

Fig.8 a. Wax-up investing Fig.8b. Mold realization

The powder and liquid with nanoparticles solution were mixed into a porcelain jar (fig. 8 c), then the acrylic resin paste was packed into the mold at the dough stage, the flask was closed and pressed.

The polymerization technique was different, according to the manufacture recommendation: for the HCR the flask was immersed into a water bath and the temperature was rise up to 100°C, at 2-4 bar, during 20 minutes and for SCR reaction conditions have been 45°C, 2-4 bar, during 5 minutes.After polymerization the flask was opened and the specimens were removed from the investing material (fig. 8 d).

The specimens were washed with a stiff brush under running water to remove all gypsum traces, finished with fine carbide burs, polished to a smooth and glossy surface, and finally immersed in distilled water and stored at 37°C, for one week, before testing (fig.9).

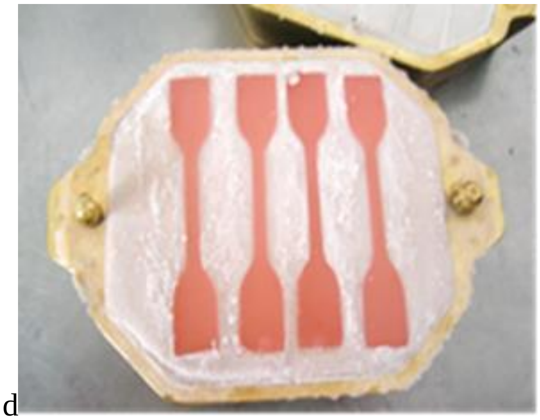
c.  d 

Fig.8c The acrylate preparation Fig.8d. Introduction of the resin in the mold

Fig.9 Acrylic samples after finishing and polishing

Tensile tests were carried out at room temperature according to the ISO 527-1: 2000 standard, using a computer-controlled testing machine (Instron 3382) equipped with a dynamic clip-on strain gauge extensometer (Instron 2620-601) for direct strain measurement. The rectangular specimens were placed and fixed between the grips of the testing machine (fig.10).

The tensile load was applied at a crosshead speed of 1 mm/min. Young's modulus (the slope of a secant line between 0.05% and 0.25% strain on a stress-strain plot), tensile yield (tensile stress at yield) and tensile strength(maximum tensile stress during the test) were determined.

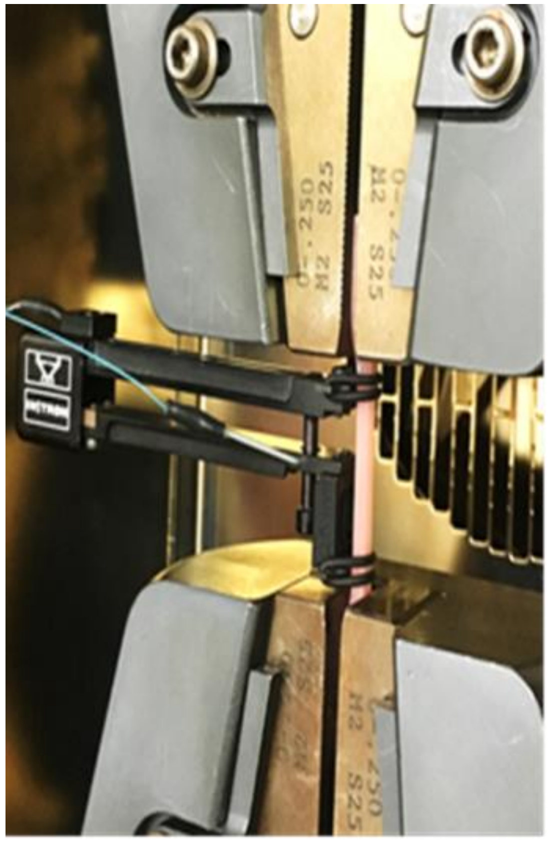


Fig.10 The specimen in the testing machine

Results and discussions

In the finite element analysis we determined two main features: Von Mises stresses and volume element deformations. Von Mises stress is a value used to determine if a given material will yield or fracture.The von Mises yield criterion states that if the von Mises stress of a material under load is equal or greater than the yield limit of the same material under simple tension then the material will yield. In order to visualise the stresses inside the volume element we used the option slice planes, which makes a section on a plane in the center of the volume element. Thus, it was established the section plane XZ (fig. 11, fig.12).

In order not to affect the analysis results, this plan can be setted to zero visibility. Basically, it is interesting to analyse the stress that occurs in the acrylic resin. The maximum load into the acrylic resin is 14 Mpa, lower than the maximum load supported by the acrylic resin, which is 30 N / mm².

Therefore, for all considered cases, the maximum load of 14MP will be imposed (in legend properties - as a maximum value visualized). So, it is possible to compare the difference between different values of loads, for each concentration.

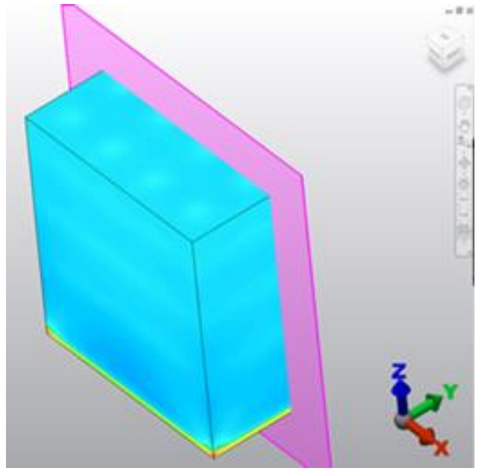


Fig.11 The section plane XZ in the center of the volume element

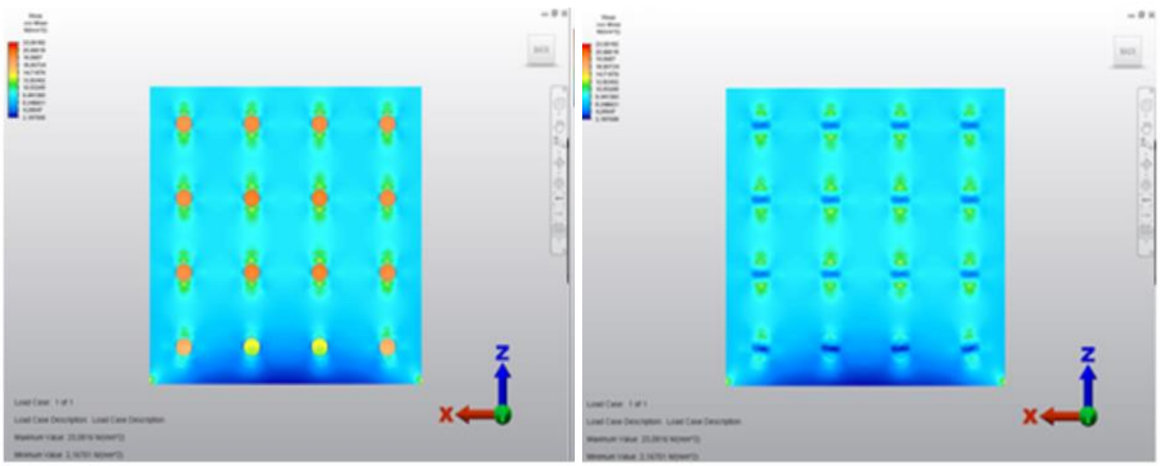
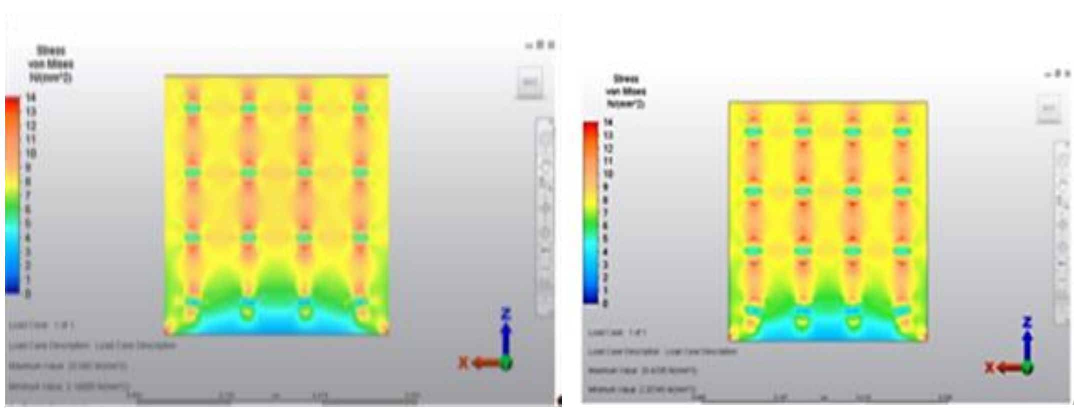


Fig.12 Tension value in section XZ

The images illustrate the stress distribution inside the acrylic resin, when the composite material contains AgNps, of 5, 10, 15 and 20% weight concentration (fig. 13 a, b, c).



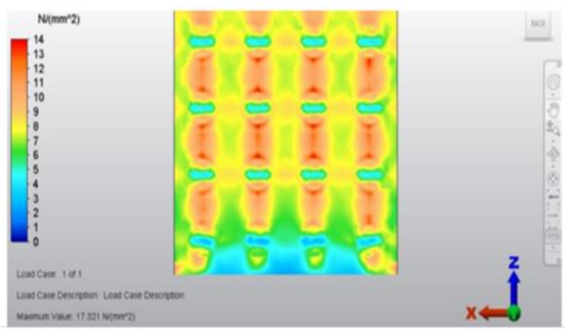


Fig.13.a. Von Missis stress values and deformation for resins with silver nanoparticles with a diameter of 20 nm, at concentrations of 5, 10 and 20%

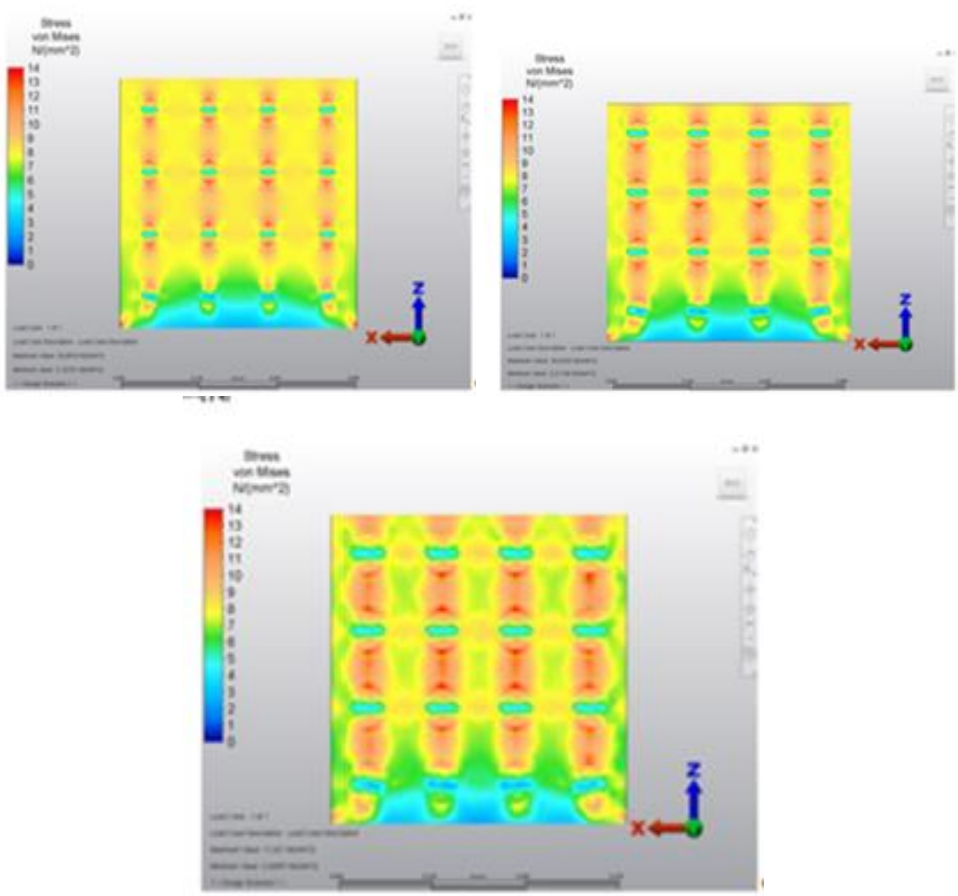


Fig.13.b. Von Missis stress values and deformation for resins with silver nanoparticles with a diameter of 40 nm, at concentrations of 5, 10 and 20

Comparing the results of this analysis, it can be noticed that, although the maximum amount of tension around AgNps has the same value, in the central area, which is relevant for the analysis (on columns 2 and 3 between rows 2 and 3) the lowest stress was found at 5% concentration, while the highest value of the stress corresponds to 20% concentration.

A lower loading is generating a lower stress into the acrylic resin, especially for the fatigue strength of the material under dynamic conditions. Another important aspect is concerning the nanoparticle density per volume unit

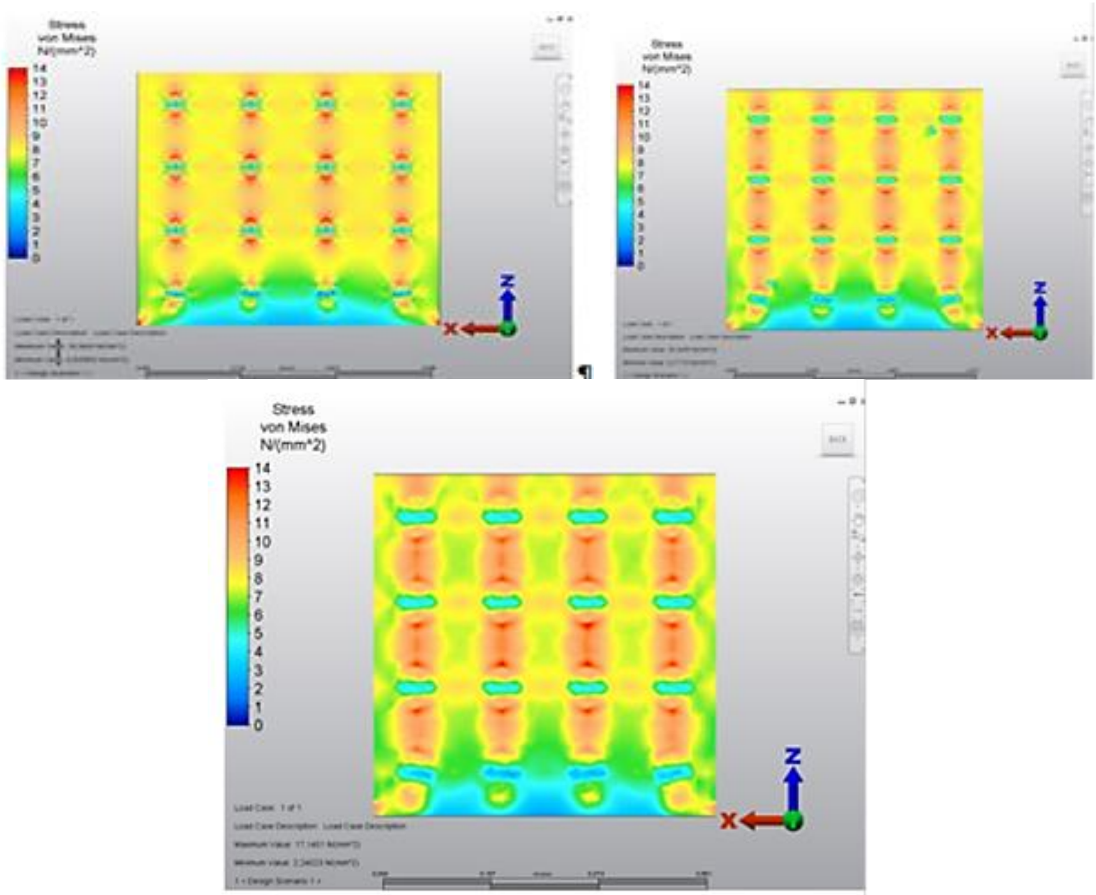


Fig.13.c. Von Missis stress values and deformation for resins with silver nanoparticles with a diameter of 60 nm, at concentrations of 5, 10 and 20%.

Taking into consideration the results it is obvious that the optimal AgNps concentration is 5%, from both biological and mechanical point of view.

Based on the results obtained within the FEA, we also performed the effective mechanical testing of the samples made from the two types of acrylic resins (table III).

Table III the value of mechanical parameters depending on the concentration and size of AgNPs

Sample	**Young modulus**
HCR without AgNPs	**2723**
HCR 5%	**2706**
HCR 10%	**2497**
HCR 20%	**2264**

Sample	Young modulus
SCR without AgNPs	2795
SCR 5%	2122
SCR 10%	2341
SCR 20%	2161

Tensile stress vs. tensile strain graphs for SCR and HCR samples are shown in figure no 14.

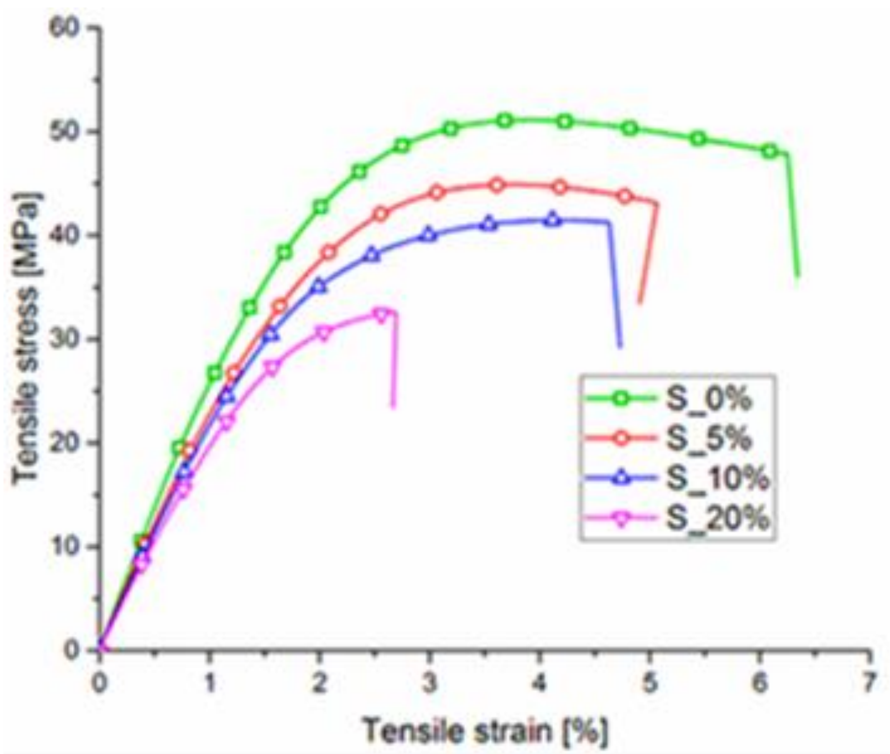
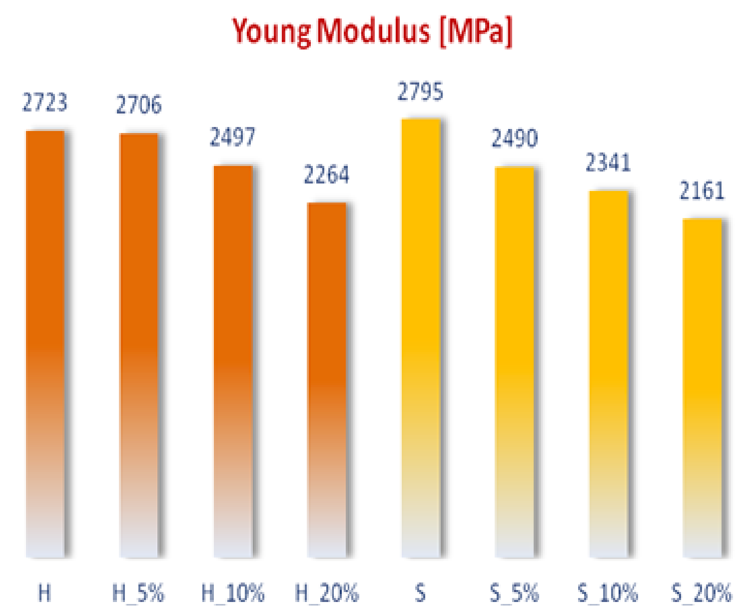


Fig.14 Tensile strength vs Fracture strength for the two types of resins

Under pressure, the resin samples first deform elastically, undergoing a reversible elongation; if the action of the force continues, the parts will deform plastically, irreversibly, after which they fracture; the value of the pressure at which the fracture phenomenon occurs depends on the mechanical characteristics of the material

Young's modulus (E), was calculated according to the Hook's law E = Ϭ / ε, as the ratio between stress (Ϭ) and deformation (ε) and describes tensile elasticity, or the tendency of an object to deform along an axis when opposing forces are applied along that axis; it is defined as the ratio of tensile stress to tensile strain. A solid material will undergo elastic deformation when a small load is applied to it in compression or extension. Elastic deformation is reversible (the material returns to its original shape after the load is removed). At near-zero stress and strain, the stress–strain curve is linear, and the relationship between stress and strain is proportional to strain. As can be seen the behavior of the two groups are quite similar, and all specimens exhibit brittle fractures (typical flat crack at break). A progressive decreasing in mechanical properties when the amount of AgNPs increases is obvious (fig.15) but the evolution is different.

At a constant pressure, the decreasing of Young's modulus demonstrates a more important deformation; the lower the Young's modulus, the greater the flexibility of the material, for total prostheses being not considered an advantage. The results were statistically processed by the method of two-way ANOVA dispersive analysis and statistical significance was set at $p < 0.05$ (fig.15).



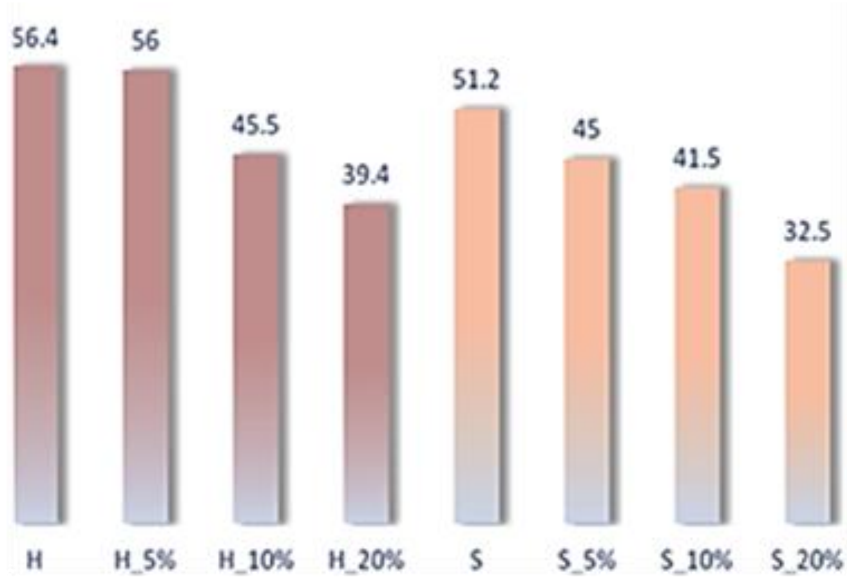
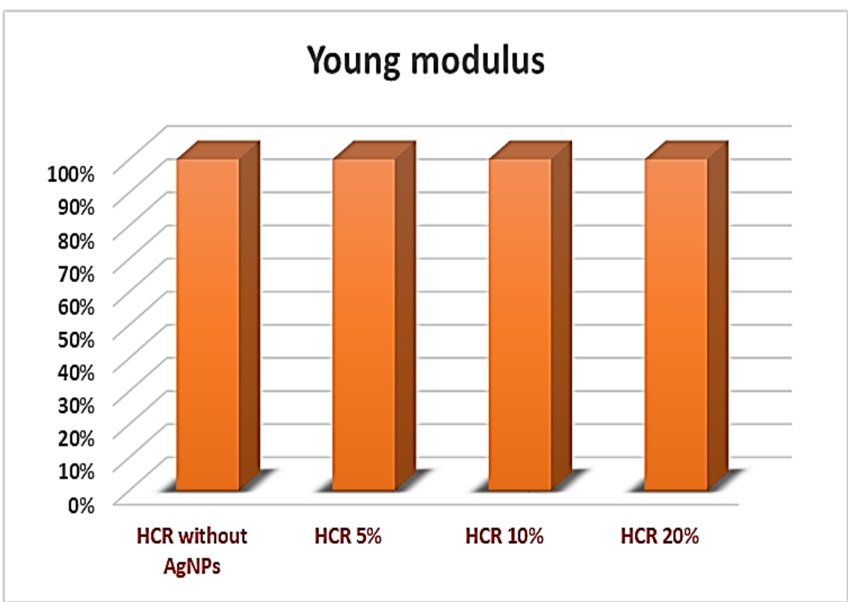


Fig.15 Values of Young's modulus

The results show in this case that for heat-curing acrylic resins there are statistically insignificant differences compared to the control samples at a concentration of 5% and significant differences at concentrations of 10 and 20%.

For the heat-curing acrylic resins, it is found that the samples with a concentration of nanoparticles of 5% have very similar characteristics to the control samples, the differences not being statistically significantly different ($p > 0.05$).

For the concentrations of 10 and 20%, differences of values are observed, both at traction and at fracture, statistically significant, in relation to the control samples ($p < 0.05$). For HCR samples we noticed that increasing the AgNPs concentration leads to a constant decrease of all mechanical features (fig.16).



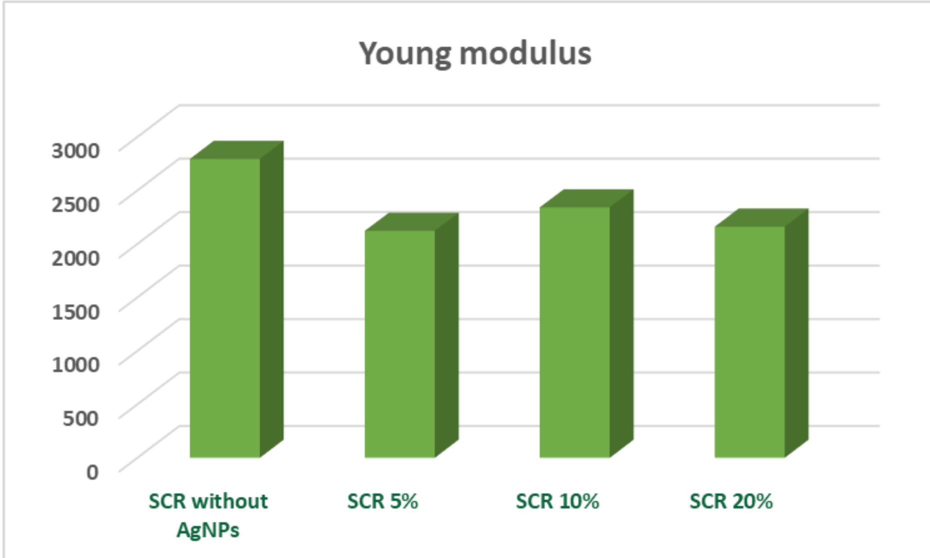


Fig.16 The mechanical behavior of the two types of resins

The specimens with 5% AgNPs showed very similar mechanical properties with the control group.

Self-curing acrylic resins have a significantly lower Young's modulus value compared to control samples at all three concentrations. For SCR samples we found a more pronounced decreasing of all mechanical features comparing to control group. It seems the lack of chemical bond between the inorganic material (AgNps) and polymer itself is the main cause of decreasing in mechanical properties which affects especially the SCR specimens.

The results of this study are similar with these of our previous research conducted through FEM analysis on the effect of AgNPs incorporation into the dental resin

Conclusions

AgNps incorporation aims to avoid or at least to decrease the microbial colonization of the acrylic dental resins In order to predict the optimal distribution and concentration of AgNps, we used a finite element analysis, revealing the stress field at the particle/matrix interface.

Our FEM study demonstrates that the best concentration that does not affect the mechanical characteristics of the acrylic resin is 5%.

According to the biological criterion a 10% concentration can be also used, because the stress inside the material being not significantly different in comparison to the situation registered for 5% concentration.

The FEM analisys should be accomplished by mechanical tests and in vivo experiments in order to sustain the final conclusions and to indicate a better antimicrobial material for the prosthodontic treatment.

Our study illustrates that incorporating AgNps in acrylic resins decrease the rigidity of the materials. According to this research, for optimal mechanic properties, it is indicated a lower concentration of AgNPs.

Within the limitations of this study, the mechanical properties of acrylic resins were influenced by the concentration in AgNPs.

The HCR specimens with 5% AgNps illustrated similar mechanical characteristics with the control group, so, this concentration can be successfully utilized with an optimal antimicrobial effect, without negatively influencing the behaviour of the resins.

1.2 EFFECT OF SILVER NANOPARTICLES INCORPORATION ON STRUCTURE AND SURFACE OF THE ACRYLIC DENTAL RESINS

Introduction

The exceptional broad antimicrobial spectrum of Silver has been known and used for hundreds of years. Silver Nanoparticles are clusters of silver atoms that range in diameter from 1 to 100 nm. Due to their antibacterial, antifungal, antiviral, and anti-inflammatory activity, AgNPs provide one of the most cost effective antibacterial agents for various applications: textiles, renewable energy, environment, electronics, food/ agriculture, health care and biomedical. Their unique chemical and physical properties and pronounced antibacterial activity, provide one of the most cost effective antibacterial agents for applications in medicine for: diagnosis, treatment, dug delivery, bone cements, cardiovascular implants, medical device coating, wound dressings, medical textiles, contraceptive devices, etc (Zhang X-F *et al*, 2016; Albanese A *et al.*, 2012).

Induction of antimicrobial activity in dental materials has been widely a large concern in dentistry, their usefulness being proved in orthodontic adhesives, dental instruments, endodontics filling materials and prosthodontics.

In prosthodontics, despite the continuous progress in material science, Polymethyl Methacrylate is still the most used material for denture bases. A common problem faced by the acrylic denture wearers is the denture stomatitis, which is related to the specific conditions of the oral cavity, the state of the patient's immune system, but also to the PMMA surface characteristics, that facilitates the bacterial-fungal biofilm formation.

The classic treatment for denture stomatitis is based on topical or systemic antifungal drugs, but this infection is often persistent, since antifungal resistance has been reported in Candida Albicans biofilm. So, the prophylaxis of dental stomatitis by AgNPs incorporation represent a challenge (Panáček Aet al, 2009; Wong K.K *et al.*, 2009). The antimicrobial effect of AgNPs was demonstrated to be directly proportional to the concentration and inversely proportional to their diameter. Normally, a high concentration leads to more effective antimicrobial activity, while particles of small size can kill bacteria at a lower concentration. Particles larger than 100 nm showed only a bacteriostatic activity, while smaller particles have bactericidal effect. The smaller the particles (l< 10nm), the greater the antimicrobial effect (because they can penetrate into the bacteria, not only on it's surface).

Silver particles have been used as an addition to acrylic resin in order to improve its mechanical properties. Although adding 25% silver powder to denture base increases its thermal conductivity more than four times, it results in a significant decrease in the mechanical properties of acrylic resin, making denture more susceptible to breaking by an impact.
In the past, micrometer-sized particles were used to improve the resin characteristics; however, these particles presented several drawbacks.

Regarding advances in nanotechnology sciences and benefits of adding silver nanoparticles to the acrylic base, which leads to better processing and smoother surface compared to micrometer-sized silver powder, the use of silver nanoparticles is preferred. Among various nanofillers available the silver nanoparticles are the most widely used nanoparticles because of their ductility, electrical and thermal conductivity and antimicrobial activity. On the other hand, resin discoloration and high cost can limit its use (Dawadi S. *et al.*, 2021)

The present study was conducted to evaluate the effect of the addition of silver nanoparticles at 2 and 0.2 wt% concentrations on compressive and tensile strengths of acrylic base. Our aim was to evaluate the structural changes and the thermal behavior of the composite material resulted after AgNPs incorporation into acrylic dental resins

Materials and methods

In order to test the quality of the surfaces of resins enriched with AgNPs, we performed samples from the two categories of HCR and SCR materials. The technological algorithm followed exactly the same steps as in the case of making full dentures: They were first invested in dental stone (Elite Rock class IV/Zhermack) in order to obtain a mold. After the mold isolation with a separating agent (Isodent/Spofa Dental), the acrylic resin pastes were prepared, following the producers indications for each type.

The polimerization process was done under the same conditions: for the HCR the flask was immersed into a water bath and the temperature was rise up to 100°C, at 2-4 bar, during 20 min and for SCR reaction conditions have been 45°C, 2-4 bar, during 5 min. The samples were processed and finished in the same way as the processing of commplete acrylic prostheses.

For the analysis of the surface condition, the roughness and hardness were analyzed, and for the structural analysis we performed an analysis with the help of SEM and AFM. We also compared the changes in the characteristics of these two categories of resins enriched with AgNPs, during temperature variations.

On the very first step we tested **the hardness** of the samples obtained by the classical technology. Hardness is an extremely important parameter used in to the comparison of the restoration materials. It can be defined as the resistance to the superficial printing or to penetration; the hardness is, therefore, a resistance measure to plastic deformation and it will be expressed as the force related to the area unit of the print.

Hardness indicates the resistance of a material to cracking and to abrasion during mechanical stresses. There are many methods used to determine the hardness, but we chosed the Vickers method. This is a static technique of determining the pressure resistance exerted by a diamond pyramid, with the peak angle of 136º.

The Vickers hardness was calculated according to the formula:

$$\mathbf{HV = F/\,S \times \frac{2F \times \frac{\sin 136^{\circ}}{2}}{d^2}}$$

where F is the stressing force, S is the area of the surface left by the penetrator on the specimen and d is the diagonal of the pyramid base. In order to test the Vickers hardness we used the standard Vickers microhardness device CV Instruments 400 DM (Tecnimetal)

Vickers hardness test was performed with a Micro Hardness Tester device, under a 25-g load and 30 s penetration. A total of three indentations were made at different points for each specimen, and the means of individual specimens were averaged. It was registrated the lengths of the diagonal immediately after each indentation, allowing a minimal time interval to elapse between making and reading the indentations, the elastic recovery of the diagonals after indentation was minimal1. The measurements in millimetres were transformed into Vickers hardness values using a conversion chart.

Roughness is an important characteristic of surface quality and can be assessed by determining the micrometric profile of the finished and polished samples.

Surface roughness is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough and if they are small, the surface is smooth. In surface metrology, roughness is typically considered to be the high-frequency, short-wavelength component of a measured surface. However, in practice it is often necessary to know both the amplitude and frequency to ensure that a surface is fit for a purpose.

The shape and dimensions of the micrometric profile have an influence on the adherence and development of the bacterial biofilm at the internal surfaces of the acrylic prostheses. Diagramele au fost înregistrate cu rugozimetrul Mahr Perthometer M1 (fig.17).

The investigations carried out on the surface quality aimed at highlighting the variations of roughness corresponding to the samples.

Fig.17 Mahr Perthometer M rugosimeter

For each sample we calculated Ra, which represents the arithmetical mean of the absolute values of the profile deviations from the mean line of the roughness, and Rz the average of all values represented by the maximum height between the maximum and the minimum profile within the assessment length, for each sample (fig.18).

For the structural analysis in a first stage we would uset scanning electron microscopy (SEM). To highlight possible changes in surface three dimensional morphology caused by AgNps addition, high resolution scanning electron microscopy (SEM) were performed. SEM analysis is the appropriate method to investigate microstructural changes occurring in resins after AgNPs incorporation

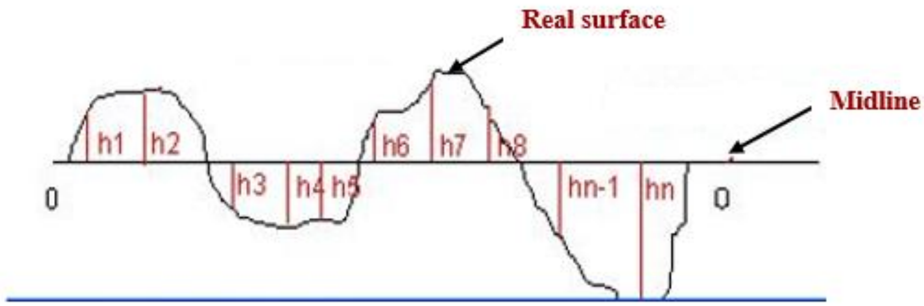


Fig.18 Maximum and the minimum profile within the assessment length, for each sample.

For the structural analysis in a first stage we would uset scanning electron microscopy (SEM). To highlight possible changes in surface three dimensional morphology caused by AgNps addition, high resolution scanning electron microscopy (SEM) were performed. SEM analysis is the appropriate method to investigate microstructural changes occurring in resins after AgNPs incorporation.

SEM produces images of a sample by scanning the surface with a focused beam of electrons that interact with atoms in the sample, producing various signals that contain information about the sample's surface topography and composition. Due to the very narrow electron beam, SEM micrographs have a large depth of field yielding a characteristic three-dimensional appearance useful for understanding the surface structure of the sample (fig.19).

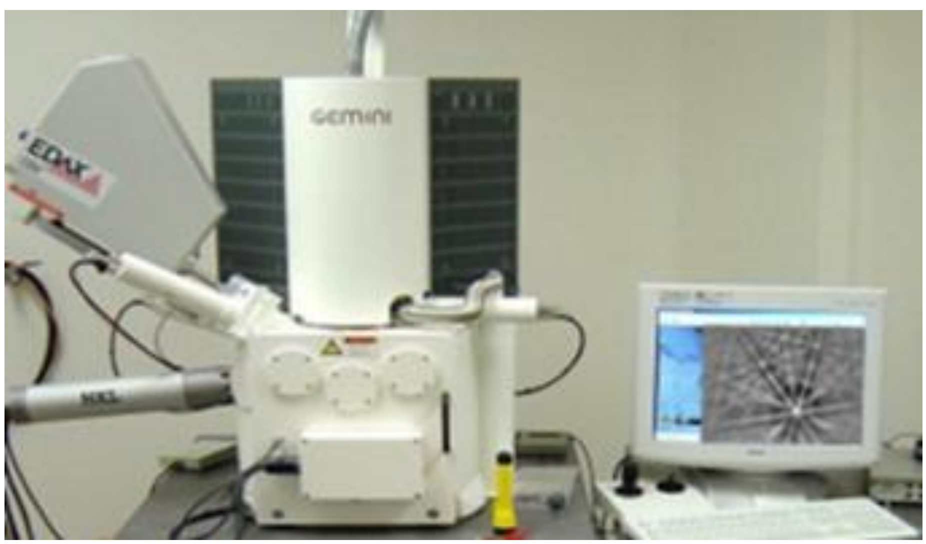


Fig. 19 Scanning electron microscope

In the second step an **AFM** depicts the topography of a sample surface by scanning a cantilever with a sharp tip over a region of interest. The force of attraction between the surface and the tip causes the cantilever to deflect towards the surface.

A laser beam is used to detect cantilever deflections towards or away from the surface. The structural analysis by using AFM wants to reveal – on submicronic and even nanometric scale -the AgNps integration into resin matrix by surface topography.

To achieve the goal, prepared samples were examined using a NanosurfeasyScan 2 FlexAFM having a scan head capable of a maximum scanning range of 1 mm.

3D topography and 2D deflection over the scanning range and along a control line were obtained. To get an overall depiction of the nominated dental acrylic resins enriched with AgNps, a HCR’s micron size analysis surface having 8mm scanning range was initially chosen for structural analysis.

Thermal characterization of the modified resins was performed by Differential Scanning Calorimetry (DSC) giving valuable information on possible induced transformations up to 65°C.

DCS is the most frequently used method in the field of Thermal Analysis, being used to determine transition temperatures and enthalpy changes in solids and liquids. Thermodynamically, the driving force responsible for conducting a phase transition is the chemical potential, which is affected by temperature and pressure. When there is a gradient in the chemical potential between two phases, a spontaneous phase transition is produced from the higher chemical potential phase to the lower chemical potential phase.

Our purpose was to determine possible glass transition, decomposition and solid-solid transition. Thermograms over 20-60°C with typical temperature rate of 10K/min were achieved by using the Netzsch DSC 200 F3 Maia (fig.20).

This device has two pans: the sample pan with the polymer sample, and the reference pan (empty). Each pan sits on top of a heater. The computer turns on the heaters, and heat the two pans at a specific rate, usually something like 10°C per minute. The heater underneath the sample pan has to work harder than the heater underneath the reference pan.

By measuring just how much more heat it has to put out is what we measure in a DSC experiment.

Fig.20 Thermograph

Results and discussions

Acrylic hardness measurements will indicate the possibility of polymeric matrix degradation, which will result in decreased acrylic hardness, and increase the possibility of fracture, diminishing the longevity of denture bases.

Hardness is an important physical property of acrylic resins, enabling these materials to be used for manufactturing denture bases that resist forces, such as those arising from occlusion and mechanical denture cleansing, increasing the longevity of elderly peoples' dental prostheses Acrylic resins present a group of characteristics that make them acceptable and advantageous for pros-theses manufacturing, such as biocompatibility; possibility of being relined; low specific weight, solubility, cost and manufacturing complexity.

Nevertheless, these materials also present some less favorable properties, such as low thermal con-ductility, presence of micro-porosities, low resistance to fracture and susceptibility to abrasion. Assuming that the hardness property indicates the ease with which the material is scratched or abraded, dental prostheses made of acrylic resins with low surface hardness will probably be damaged by mechanical brushing, compromising their surface roughness and allowing plaque retention and pigmentation, eventually compromising the aesthetic appearance and longevity of the dental prosthesis.

Hardness evaluation has frequently been used to predict dental material wear. Thus, the Vicker micro-hardness test is considered to be a valid method to evaluate rigid polymers by means of the ability of the material to resist the penetration of a specific load. This is a simple and effective way to evaluate the degree of conversion during the polymerization reaction after mixing the powder (spheres of poly methyl meth-acrylate and a small amount of benzoyl peroxide) with the liquid (methyl methacrylate with hydroquinone).

Although the Vickers micro-hardness testis considered a valid method to evaluate rigid polymers, a specific limitation of some Vickers hardness tests is the microscopic measurement of the hardness indentations after the indenter is removed. Firstly, these measurements can be affected by the limitations in the resolution of the optical system; secondly by the operator's per-ception and finally by elastic recovery of the material. Based on the results of this study, for both types of resins there is a statistically insignificant change in Vickers hardness values, regardless of particle size or concentration. Regarding the surface roughness, the values of the recorded diagrams (fig.21) were centralized and comparatively analyzed (tables III and IV)

Table III Centralization of surface roughness for heat curing resins

Heat- curing resin								
	0 nm		**20 nm**		**40 nm**		**60 nm**	
	Ra	**Rz**	**Ra**	**Rz**	**Ra**	**Rz**	**Ra**	**Rz**
-	**1.983**	**11.5**						
5%			**0.248**	**2.51**	**0.225**	**1.74**	**0.202**	**1.33**
10%			**0.25**	**2.1**	**0.209**	**1.69**	**0.228**	**2.06**
20%			**0.451**	**3.46**	**0.215**	**1.72**	**0.425**	**5.15**

Table IV Centralization of surface roughness for self-curing resins

Self curing resin								
	0 nm		20 nm		40 nm		60 nm	
	Ra	Rz	Ra	Rz	Ra	Rz	Ra	Rz
-	3.374	16.3						
5%			0.302	2.07	0.264	1.99	0.375	2.54
10%			0.389	4.02	0.372	4.03	0.57	3.47
20%			0.281	2.51	0.473	3.74	0.826	5.05

The results showed no changes in the roughness of the heat curing and self-curing acrylic resin surfaces AgNps, compared to control samples (fig.22)

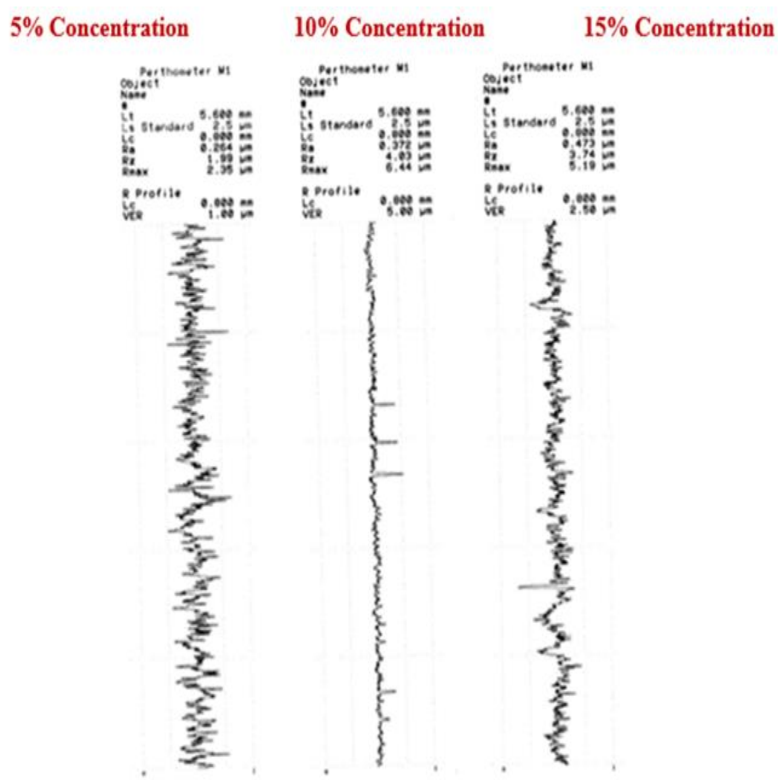
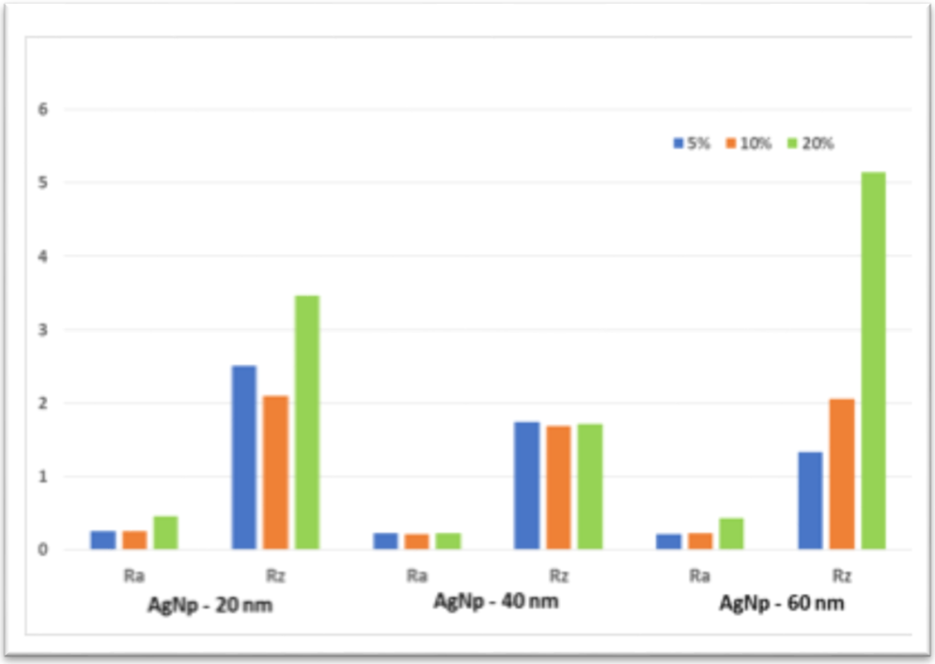


Fig. 21 Roughness diagrams

It is observed that the introduction of silver nanoparticles in the composition of acrylic resins does not influence the surface condition and implicitly does not affect the roughness of the materials.

It is very important to know this fact, because the quality of the complete dentures surface is a factor that influences their stability and longevity over time

HCR



SCR

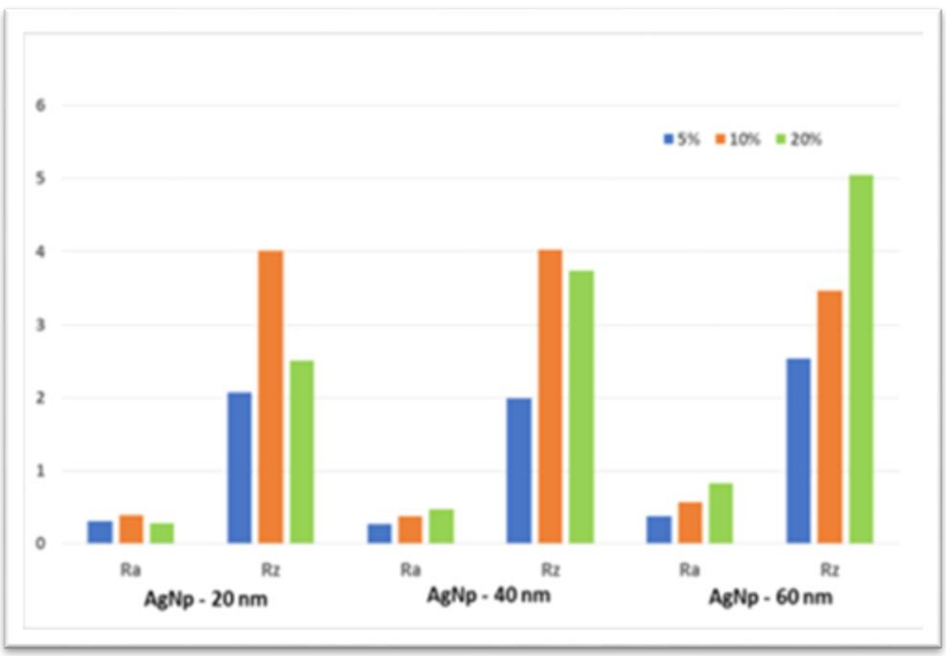


Fig.22 Comparative analyse of roughness values

The SEM images showed a homogenous dispersion of AgNPs into the organic matrix, without any dehiscence at the resin-nanoparticle interface (fig.23).

This demonstrates that the internal architecture of the resins is not modified following the introduction of AgNPs.

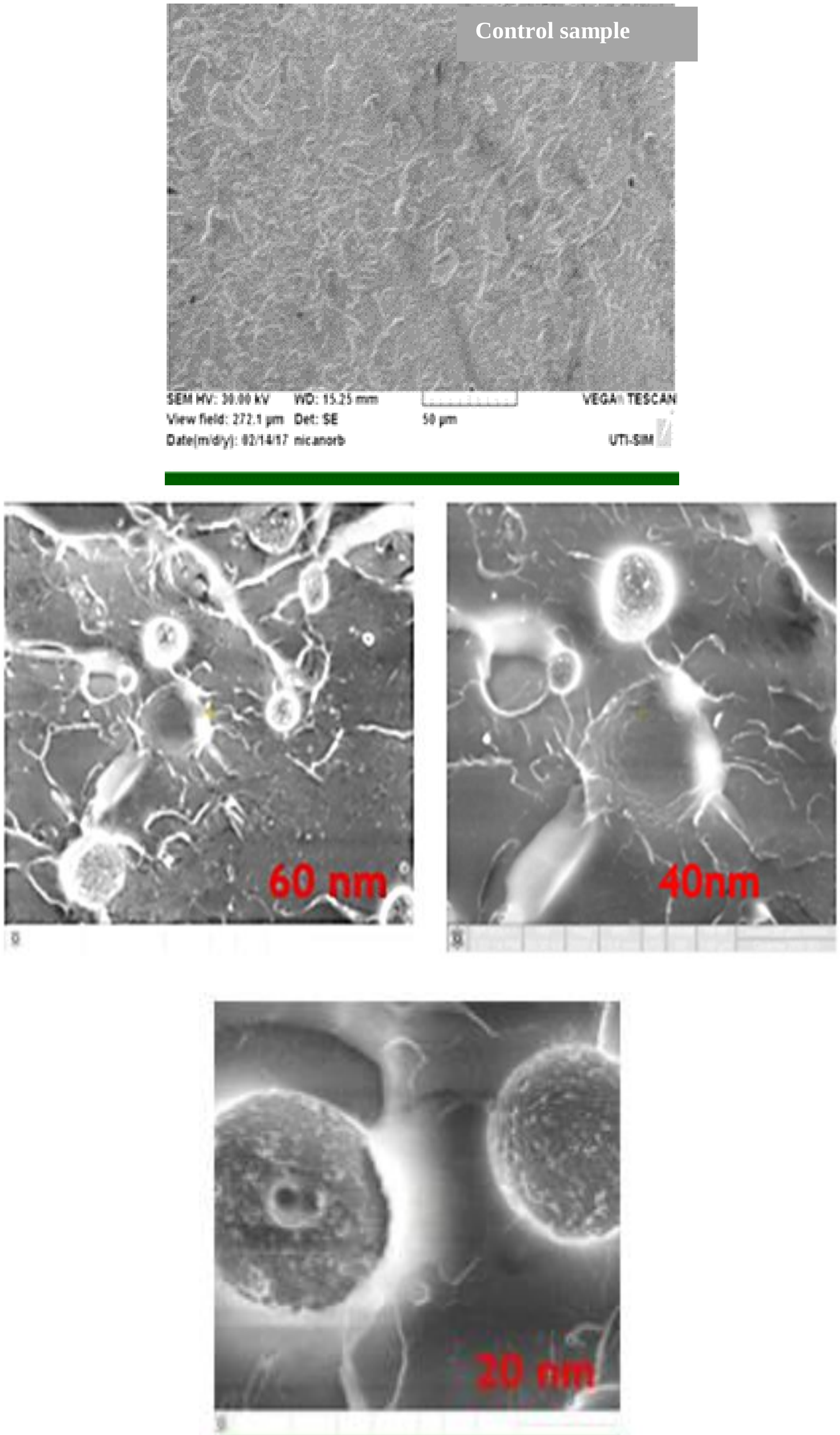


Fig.23 SEM images of the sample structure

To get an overall depiction of the nominated dental acrylic resins enriched with AgNPs, a HCR's micron size analysis surface having 8 μm scanning range was initially chosen for structural analysis through AFM

For 8 μm size analysis surface of HCR there are no steps or cleavage on the relief of the sample, revealing an homogenous surface.

The 2D deflection along the selection line shows a dimensional homogeneity. The vertical deviation of the roughness profile from the mean line is in range of +33.3 nm….-20.5 nm (the profile has 8.5 μm) (fig.24).

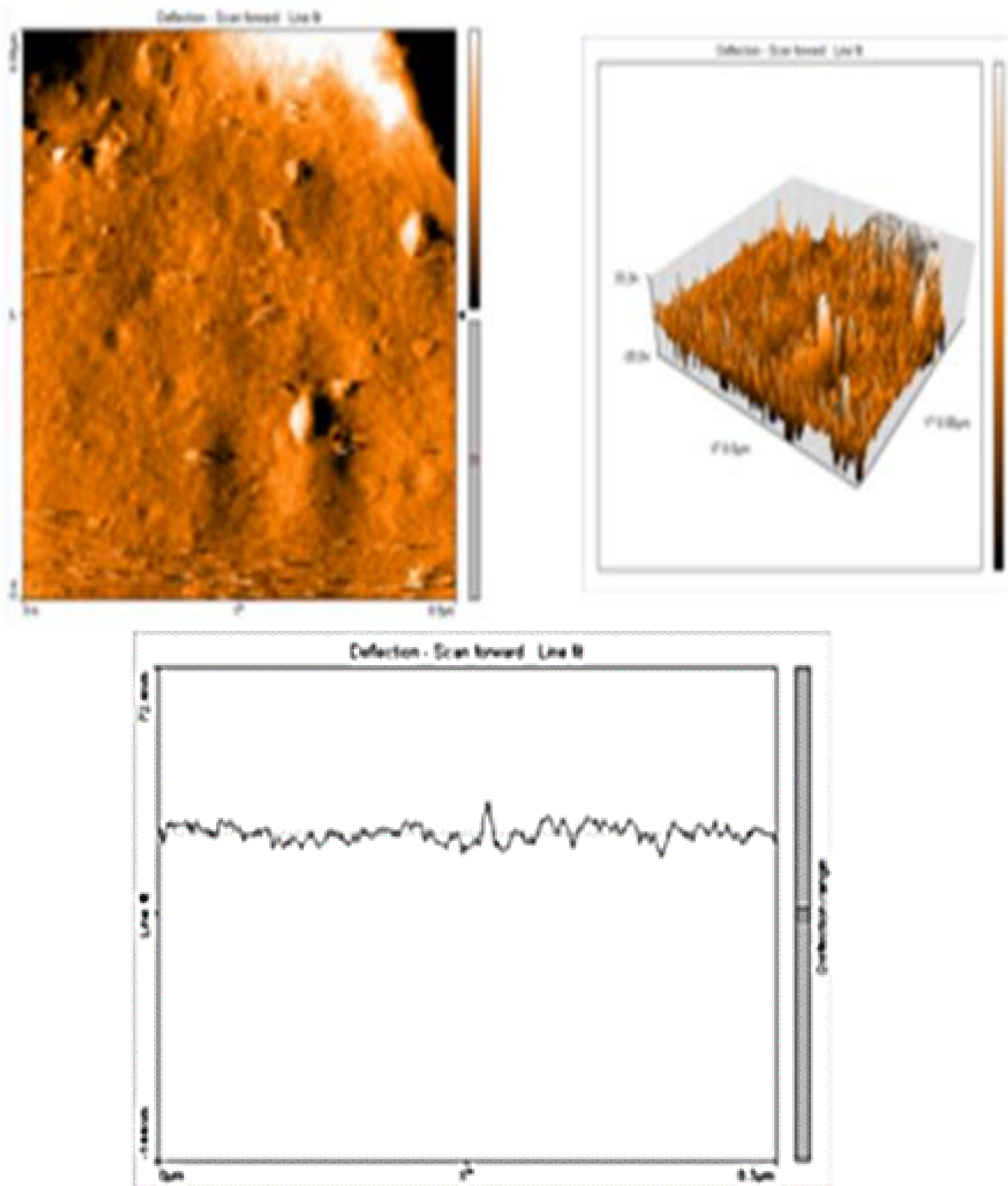


Fig.24 HCR sample

Similarly, for a detailed analysis, a SCR's micron size analysis surface having only 1µm scanning range was nominated for submicronic analysis. Even for the smallest area of analysis that device can scan, a homogenous surface profile is registered. Again, the 2D deflection along the selection line shows a surprising dimensional homogeneity. The vertical deviations of the roughness profile from the mean line is in range of +8.56 nm…-8.14 nm (fig. 25).

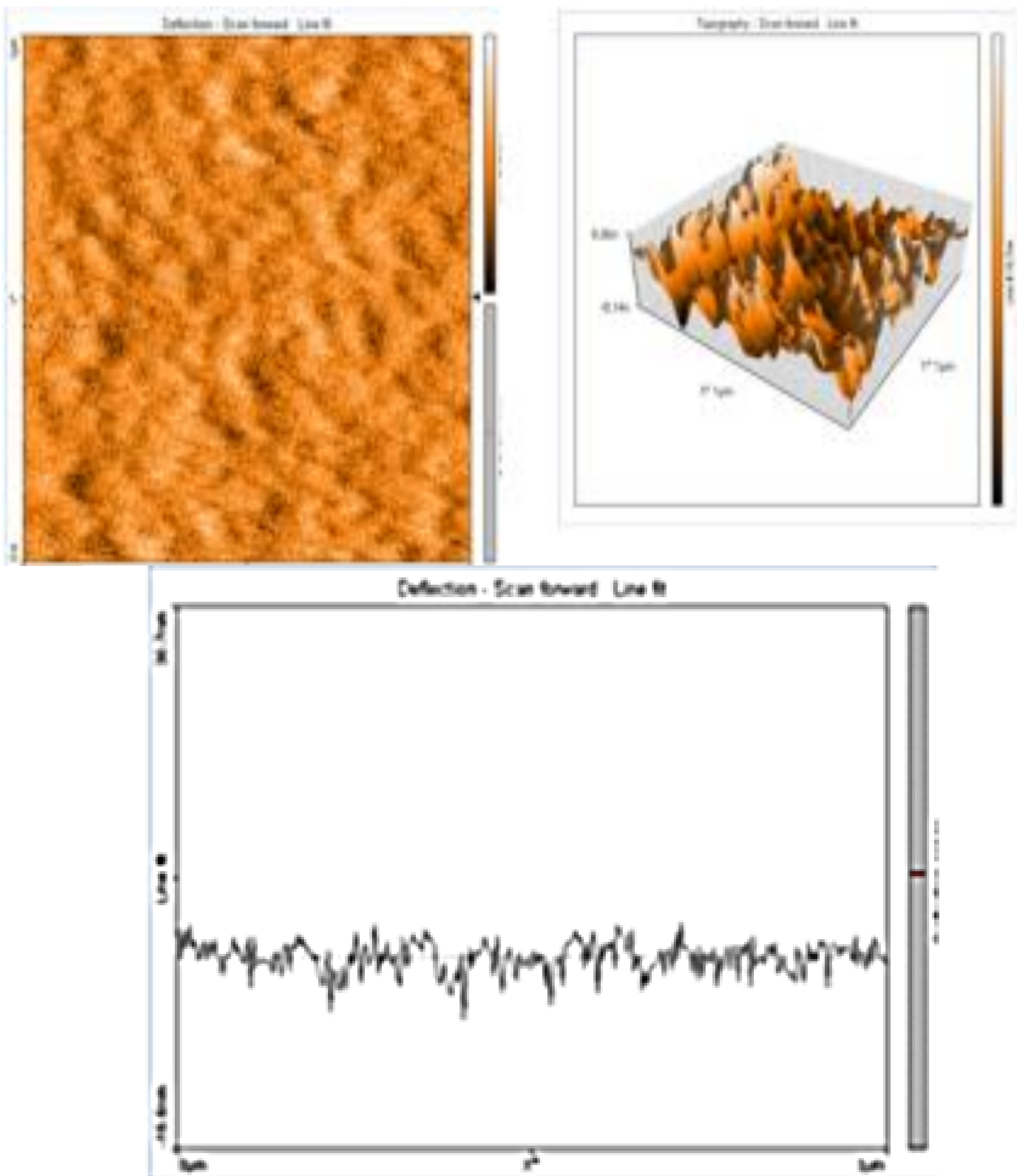


Fig.25 SCR samples

Differential Scanning Calorimetry (DSC) determines transition temperatures and enthalpy changes in solids and liquids being the most frequently used method in the field of Thermal Analysis.

Thermograms achieved over 20-60oC with typical temperature rate of 10K/min reveal no glass transition, decomposition or solid-solid transition by adding AgNPS both in SCR and HCR samples.

No significant phase transformation in dental acrylic resins or AgNPs de-bonding were reported, in other words, adding of AgNPs doesn't affect the cross-linking system of resins (fig.26).

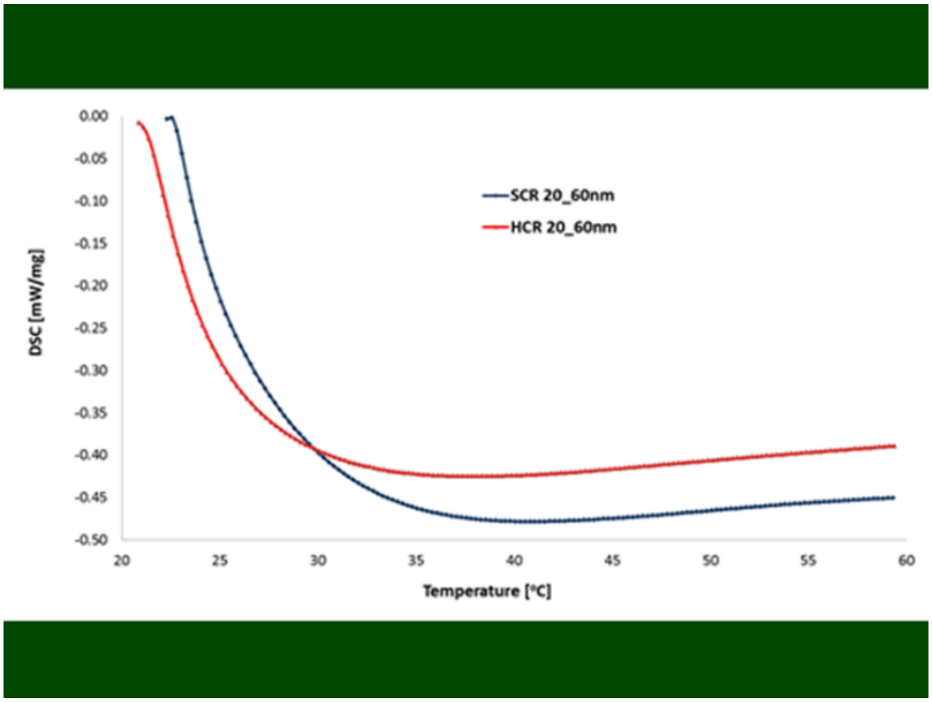


Fig.26 Thermograms

Conclusions

Recent studies though have demonstrated excellent antimi-crobial activity of AgNPs in materials such as nanocomposites, acrylic resins, resin co-monomers, adhesives, and implantcoatings. Few clinical studies have investigated the therapeu-tic efficacy of AgNPs; among them are those that evaluated the anti-cariogenic potential of these particles.There are certainly potential benefits to patient outcomefrom the use of AgNPs in dentistry. Even though the antibacterial activity of AgNPs is mainly associated to the release of Ag+ (which occurs by dissolution process influenced by conditions such as medium, ionic strength, pH, concentration of the dissolved O2, temperature, presence of complexing ligands, AgNP surface coating, shapeand size), it is worth mentioning that in some bacteria species its antimicrobial activity is also attributed to the nanoparticle itself, which enters the bacteria more effectively than Ag+. Therefore, clinical studies are necessary to confirm their antibacterial activity in the oral cavity conditions

Overall, the incorporation of AgNPs into dental materials does not appear to alter the mechanical properties of these materials, and confers additional antimicrobial activity. However, there is some concern about the risk of an incomplete polymerization in resins and adhesives combined with AgNPs, as these nanoparticles may alter physical and/or chemical processes, which would impact negatively on clinical results and toxicity of these materials.

In addition, there is very few information about the influence of the Ag release and dissolution from the composite matrix on the physical, mechanical, and chemical properties of the composite over the time. Silver nanoparticles are uniformly dispersed in the organic matrix, without producing structural or surface changes.

The size of the nanoparticles does not influence the mechanical properties of acrylic resins, only their concentration

In the case of heat-curing resins, the concentration of 5% of silver nanoparticles does not significantly influence the biomechanical characteristics of acrylic resins, while at concentrations of 10 and 20%, significant changes in the tensile and compressive behavior are observed.

In the case of self-curing resins, the introduction of silver nanoparticles affects the mechanical parameters of these materials, the changes being all the more important the higher the concentration of nanoparticles.

1.3 RESEARCHES ON SURFACE CHARACTERISTIC OF CONVENTIONAL DENTAL ACRYLIC RESINS

Introduction

In prosthodontics, acrylic resin are used for denture bases, denture teeth, reline and repair of prostheses, provisional acrylic partial dentures, tissue conditioners and custom impression trays (Sabri BA *et al.*, 2021)

The most used resins in dental laboratories, for removable dentures, are based on polymethyl methacrylateand are composed of numerous methyl methacrylate monomer units linked together to form a long-chain polymer.

As a result of the polymerization reaction, the resins undergo a series of dimensional change. Heat-cured acrylic resins shrink about 6% by volume and about 0.2% to 0.5% linearly (from one point on the denture to another).

According to the ADP, for a denture to be hygienically acceptable it should be nonporous because porosity will detrimentally affect the resistance of the material to staining, calculus deposition, and adherent substances. Porosity in PMMA also results in high internal stress and vulnerability to distortion and warpage.To evaluate porosity, microscopic observation, water absorption, photography, mercury porosimetry, have been used.

Since porosity reflects the quality of polymerization, studies for better polymerization techniques should be conducted.

The classic technology for full denture heat-curing acrylic resins realization involves a succession of clinical and laboratory steps, which must be well known and carefully observed.

The conventional technology of full dentures realization involves a multitude of laboratory stages, during which errors can occur; a mistake during a technological step is transmitted and amplified in the next step, and can eventually lead to an incorrect adaptation of the denture on the prosthetic area, incorrect occlusal repports or reduced mechanical strength. Researches has also shown that conventional acrylic resins, based on methyl polymethacrylate, in addition to the many advantages, also have a number of disadvantages (May LW *et al.,* 2018; Pfeiffer P *et al.,* 2004)

Therefore, as new materials emerged and technologies evolved and diversified. Systems for injecting the resin into the mold have become increasingly popular in practice, a method that has several advantages over the manual introduction of acrylate (Machado C *et al*., 2007; Diaz-Arnold AM *et al.,* 2008)

The injection machines are equipped with a piston, which is operated manually or pneumatically and which allows the introduction of acrylate under pressure and its penetration into all the details of the mold. The process allows to obtain very precise, resistant and dimensionally stable prosthetic constructions, so with high longevity.

Manual injection systems are the simplest d3evicec for injection, which works on the principle of transforming the rotational movement into a slow translational movement (the piston is moved by rotating a lever).

In this technology, the acrylate, in the plastic phase (Acrypress) or liquid (Unipress), is introduced into a metal cylinder, which is then fixed in the injection device; by turning the lever, the piston is moved downwards and pushes the resin from the metal cylinder towards the mold. The resin cartridges are of variable sizes, depending on the amplitude of the prosthetic work.

Currently, full dentures can also be made from new generation self-curing resins, with cold polymerization, under 60 °C (Palapress, PalaXpress, Palapress Vario / Kulzer) that have comparable or even superior properties to thermopolymerizable ones: chromatic stability over time, resistance to bending, shock and elasticity. They can be molded by both pressing and injection.

Light-cured resins have revolutionized the technology of making removable dentures.

The Eclipse system is one of the most well-known and used technologies that use light-cured materials, with indications for making partial or complete removable dentures, temporary bridges and splints. This type of prostheses do not contain monomer, traces of metal, ethyl, propyl or butyl methacrylate (Mumcu E *et al.,* 2011)

This new system shortens a lot the working flow: the three types of resin used - for the base, for the teeth and for the finishing, are without monomer, are handled like wax and are available in four shades of color.

The system has many advantages: elimination of laboratory steps - investing, mold realization, preparing and introduction of acrylate into the mold, devesting; it also requires less material (the same resin is used for the occlusion rims and for the denture bas) and have a very good biocompatibility, compared to methyl polymethacrylate resins.

The base has a superior adaptation on the prosthetic field because the contraction at light curing is 3%, and at heat curing it is 7%, so the doctor's intervention on the final prosthesis is minimal or absent.

The color stability is high, the mechanical strength is maintained for a long time, and the However, the Eclipse system also has a number of disadvantages, which are good to know before choosing this material: the high price of the complete kit, the low viscosity of the resin for fixing artificial teeth, which makes handling difficult, incorporation of air bubbles during resin preparation operations, the need to duplicate the functional model, difficult processing of the prosthesis.

The aim of our research is to determine the main surface characteristics of acrylic resins (roughness, porosity and wettability) after the finishing and polishing procedures, and their influence on microbial colonization. The research consisted in analyzing by optical microscopy the morphology of the surfaces (the presence of mechanical impressions resulting from grinding), porosity and inclusions, following their size and distribution, as well as the surface condition after the glazing process, for six acrylic resins with different curing regime (self-curing and heat -curing) which were mechanically processed differently.

Also, using optical microscopy, the degree of bacterial colonization of five acrylic resins, frequently used in dental laboratories, with different polymerization regime (self-curing, self-curing under pressure and heat curing) were analyzed.

Our studies aimed at comparative analysis of the surface condition of different acrylic resins obtained by different polymerization methods, while corroborating the surface quality with the degree of microbial colonization.

Materials and methods

The resins selected for the study are frequently used in dental laboratories for the dental prostheses realization: Castapress / Vertex, Prothyl Hot / Zermack, Rapid Simplified / Vertex, Duracryl Plus / Spofa Dental, Vertex - Soft / Vertex, Superacryl Plus /Spofa Dental. Thirty samples were made, divided into six groups (A-F) consisting of five plates for each type of resin.

The samples were made in the form of parallelepiped plates with a length of 50 mm, a width of 25 mm and a thickness of 2 mm. The wax patterns of the plates were transformed into final acrylic samples following the technological steps specific to each class of acrylic resin: heat-curing (B, C, D, F) and self curing under pressure (A, E).The finishing and polishing of the samples was done differently on each surface of the plates, but the speed and the time were the same (30 seconds, 1500 rpm). The surfaces were marked with the letters A-F and A'-F ', respectively. The mechanical processing was done with an extra-hard tungsten carbide burr, with fine granulation (yellow) for the surfaces: A, B, C, D, E, F and for the surfaces A ', B', C ', D', E ', the processing was done both with an extra-hard burr with extra-fine granulation of 53-63 μ , conical shape and with a diamond burr, with fine-grained (red) cylindrical shape. The final polishing aimed at obtaining a "mirror gloss" and was done with brushes and abrasive polishing powder (Poli-shing powder / Astar Fedent) and abrasive paste (High luster polishing paste).The F 'sample, being made of a resilient material, which is used only on the mucosal surface of the prosthesis, benefited from an easy processing with Vertex ™ Soft powder. The polishing was done with abrasive powder (Astar-Fedent) and abrasive paste (table no V).

Table V. Centralization of samples and technologies used

Sample	Product/Brand	Curing regime
A, A’	**Castapress/Vertex**	**30 minutes at 55º C and 2.5 bar**
B, B’ C (glazed) C’(glazed)	**Prothyl hot/Zermack**	**5 minutes from 80° to 100°C + 20 minutes lat100°C**
D D’(glazed)	**Rapid Simplified/Vertex**	**20 minutes at 100°C**
E (glazed) E’	**Duracryl Plus/Spofa Dental**	**30 - 40°C / 0.2 – 0.3 MPa.**
F’	**Vertex- Soft/ Vertex**	**3 hours at 70º C, then 30 minutes lat100º C**
F	**Superacryl Plus/Spofa Dental**	**The temperature rises in 30 minutes to 70ºC, 30 minutes remains at 70ºC, rises in 30 minutes to 100ºC, 30 minutes remains at 100ºC.**

Glazing was performed for the samples C, C', D' and E, with Bell Coat / K B Mutsumi glazing agent (light-curing glaze for acrylic resins and composite materials). A thin layer was applied with a brush, after the surface was previously dried very well, and then light-cured for four minutes.

Surfaces porosity measurement

The study consisted of optical microscopy analysis of surface morphology (presence of impressions after mechanical finishing), the porosity and inclusions, for determination of their size and distribution, as well as the surface status after glazing of acrylic resins studied.

We used optical microscope Leica SM 2500 M, at x20 and x50 magnification. Storage and processing of data was made using Leica application.

Initially, an inspection of the entire samples surface was conducted, to assess the surface homogeneity condition. Since on x20 magnification the surface condition of the entire area was homogeneous over, detailed analysis was performed at a x50 magnification, on three randomly fields.

Surface roughness (Ra) of the acrylic resin specimens was measured by atomic force microscopy (AFM). For hard materials roughness measurements with traditional diamond stylus profilers are adequate. The smooth surfaces consist often of soft materials such as pure metals (aluminium, gold, copper, etc.) or polymers and lacquers.

For roughness measurements on such surfaces diamond stylus profilers can not be used because they will scratch the surface and the measured value will be meaningless.

With AFMs the interaction force between the probing tip and the sample is very small and the spatial resolution is high. Additionally, for bacterial colonization roughness at nanometric scales becomes important. For this reason, roughness measurement by AFM is justified.

To determine the **wettability** of materials studied the contact angle measurements were performed. This angle is given by the surface tension of the liquid and the surface energy of the solid. A low contact angle indicates a good wettability. As the contact angle increases, wettability decreases.

To eliminate variability of surface porosity, each sample was finished and polished to obtain flat and very well polished surfaces.

We aimed to compare wettability results, which was determined by calculating the contact angle (o), depending on the types of acrylic resins studied.

We also aimed to determine the **microbial load** of collected saliva and the microbial load of salivary pellicle on samples surfaces. Saliva was obtained from one patient aged 43 years, clinically healthy, which did not follow any drug therapy in the last three months and did not use oral rinses that could alter saliva's secretion or composition.

The working method consisted of:

- Disinfection samples for one hour immersion in Zeta 1 Ultra solution
- Maintaining the samples in saliva for 24 hours
- The contamination degree assessment was achieved by the method of growing microorganisms on Petri dishes, using nutritive agar (Merck, Germany).
-The inoculum was obtained by repeatedly washing the prosthesis with 5 ml of sterile distilled water
-For inoculum we used a volume of 100 ml inoculum / Petri dish, and in the brushes case we conducted the insemination both by washing it and by imprinting it in the agar.
- Incubation (24 hours at 37°C) was followed by a quantitative assessment of the microbial load.
- May Grunwald Giemsa panoptic coloring (MGG) of samples for determination of bacterial adhesion through optical microscopy (OM).

Result and discussions

In the case of Castapress / Vertex resin, surfaces A showed numerous pores up to 2 µm in size, evenly distributed in the material structure and large inclusions (up to 24.5 µm) with uneven distribution in the analyzed fields (fig.27).

It was found that large inclusions have an irregular shape as opposed to the porosities characterized by the spherical shape. A 'surfaces were generally characterized by the absence of large inclusions and a low presence of pores, while maintaining the finishing lines.

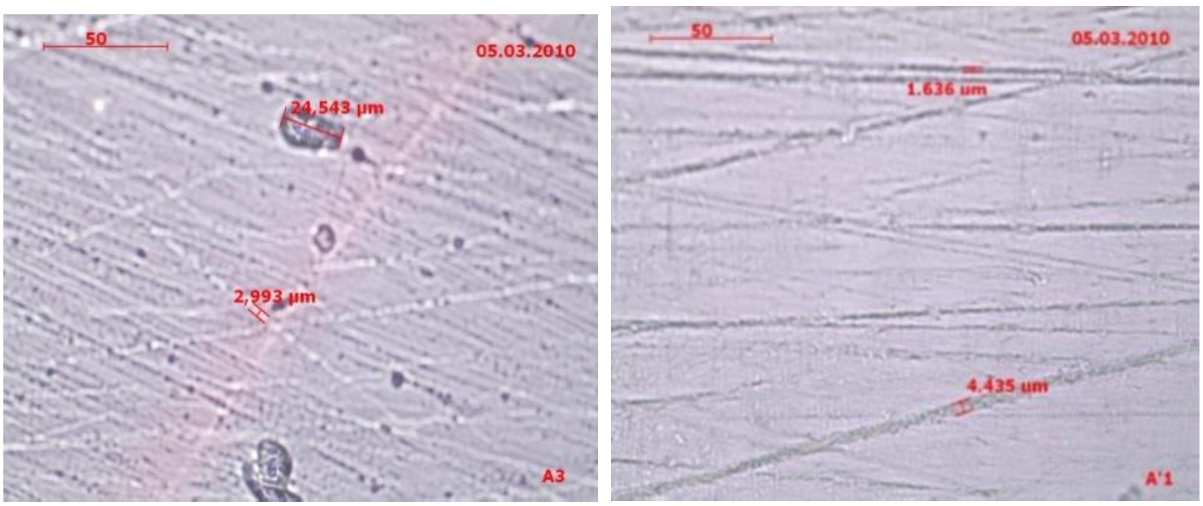


Fig. 27. Microscopic aspects of Castapress / Vertex resin X50

In the case of Prothyl Hot / Zermack resin, the surfaces B and B 'resulting from the two types of processing, were characterized by a reduced presence of pores on the surface. In the case of surfaces B, several mechanical impressions were highlighted (fig. 28).

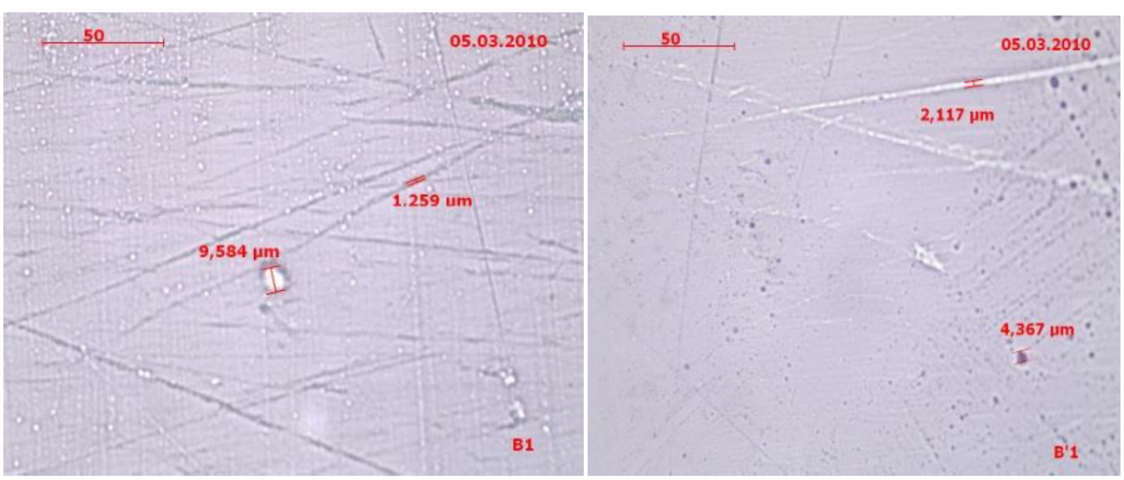


Fig. 28 Microscopic aspects of resin Prothyl Hot/Zermack X50

In the case of samples from Prothyl Hot / Zermack resin, in which both surfaces were glazed with Bell Coat, it was observed that after finishing with tungsten carbide burrs the glaze film covers the mechanical impressions produced by the abrasive tool, while presenting it the pores themselves are very small, approximately 2 μm (Fig. 29).

The surface C ', processed with extra-fine and diamond cburrs showed only small pores (about 3 μm) of the glaze film.

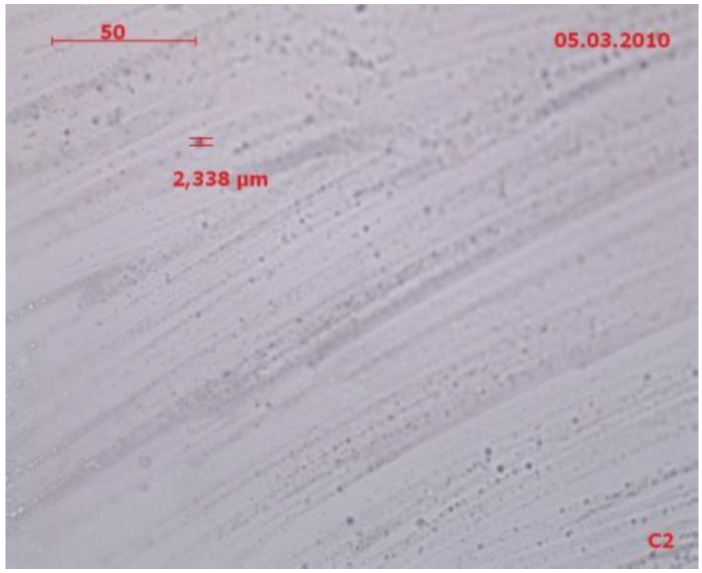


Fig. 29. Microscopic aspects of the C surfaces of Prothyl Hot / Zermack resin (glazed) X50

The same aspects were found in the case of samples made of Rapid Simplified / Vertex resin (fig.30).

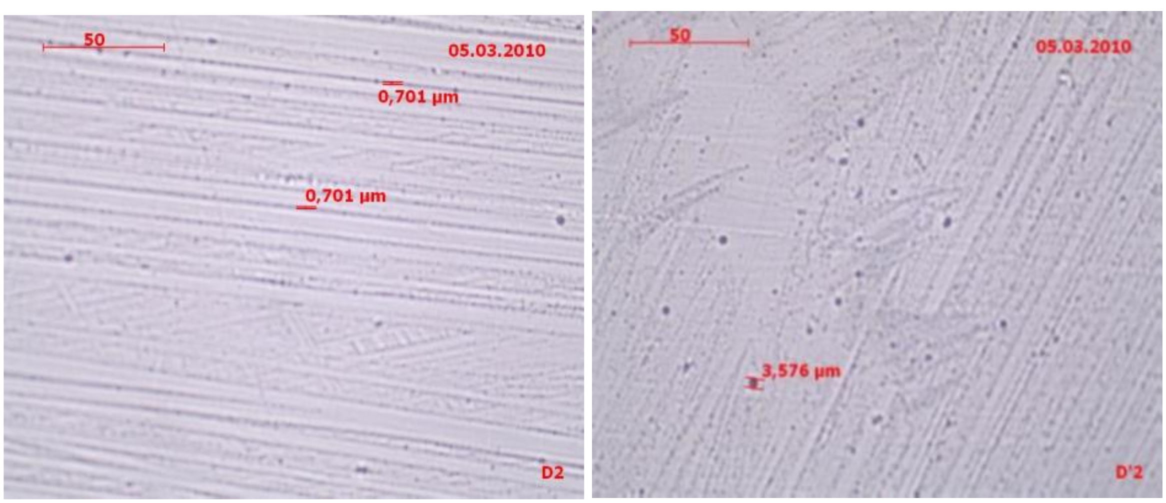


Fig. 30. Microscopic aspects of Rapid Simplified / Vertex X 50 resin surfaces (D-glazed, D-glazed)

In the case of Duracryl / Spofa Dental resin, the microscopic analysis of the glazed surfaces with Bell Coat showed that the large inclusions could not be covered by the glazing agent. In the case of images of E' surfaces (non-glazed rates), the presence of pores with dimensions of approximately 6.5 µm and the presence of sanding impressions were found (fig.31).

The images in the case of Superacryl Plus / Spofa Dental resin showed regular surfaces, with few pores, of small dimensions and the absence of impressions consequent to the mechanical processing.

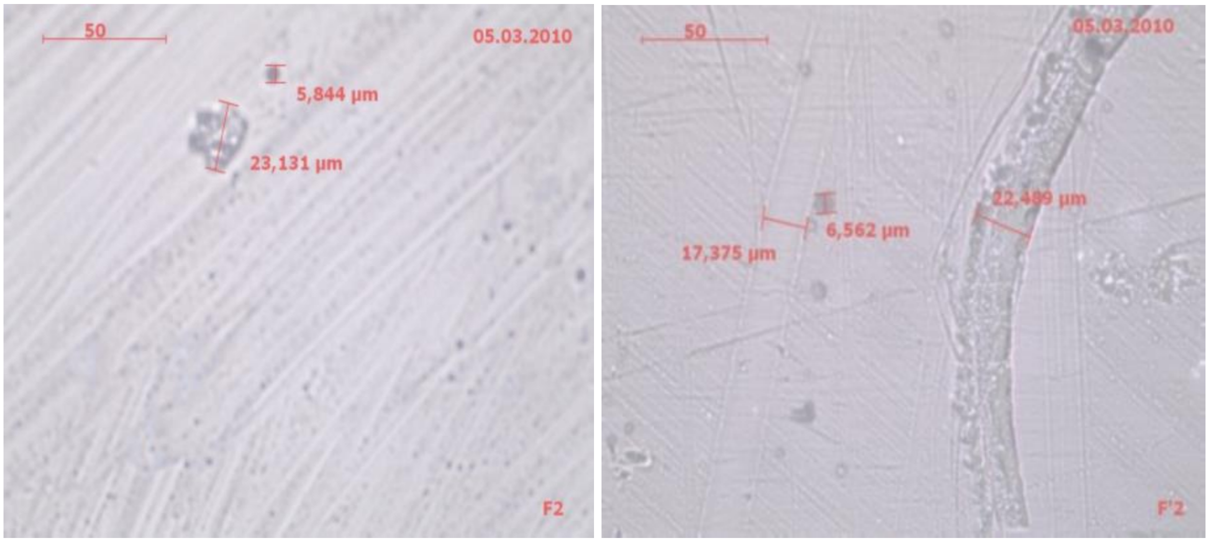


Fig. 31 Microscopic aspects of Duracryl Plus / Dental Sponge resin surfaces - E glazed, E unglazed X50

The F 'surfaces lined with Vertex Soft resilient material have a spongy texture due to the incorporation of air inclusions in the material (fig.32).

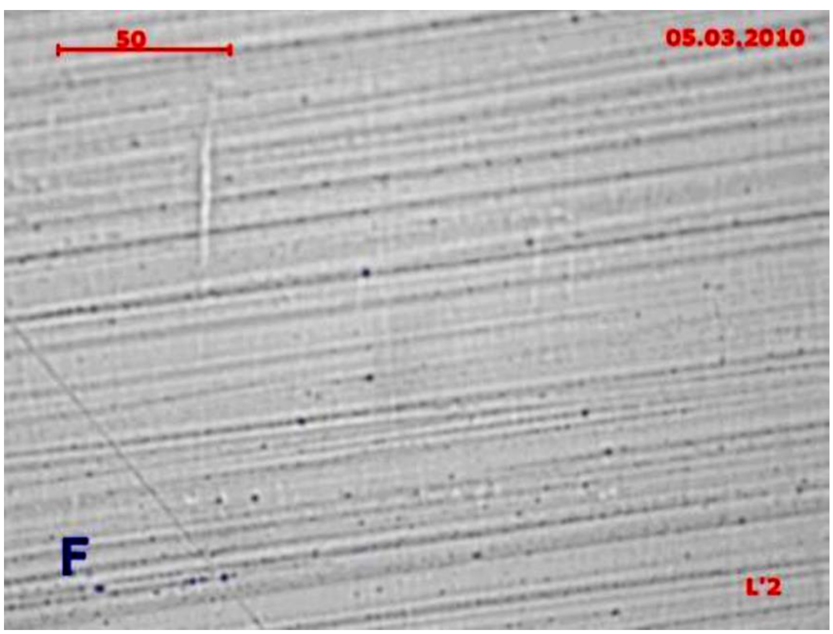


Fig. 32. Microscopic aspects of Superacryl Plus resin surfaces (F)

In the study of porosity, inclusions distribution was not uniform for all types of resins studied, the self-curing resins showing such inclusions and higher porosity, our results being similar to those of other studies.

The inclusions can be different in shape and size, distributed throughout the resin thickness, and have as main causes: improper monomer distribution, too large variation of the polymer molecular weight or lack of resin paste homogenization.

Regardless the porosity of the material, it was observed that the finishing and polishing to “mirror gloss” causes a reduction in the size and number of superficial pores, the obtained values being up to 10 micrometers in diameter.

Based on images obtained by optical microscopy we can say that the state of the surface after glazing presents superior qualities in terms of porosity and mechanical impressions. Samples of resilient material Vertex Soft, showed a spongy texture due to the air inclusions in the material (fig.33).

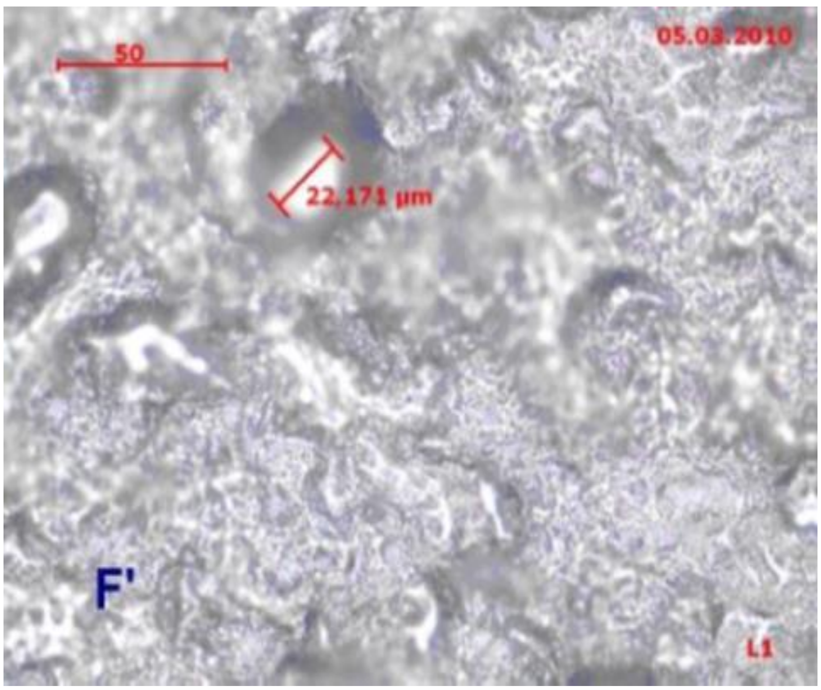


Fig.33 Microscopic image Vertex Soft surfaces at X 50 magnification

Regardless of the porosity of the material, it has been observed that processing and polishing to "mirror gloss" causes a reduction in the size and number of surface pores, the values obtained being up to 10 μm in diameter. On examination by light microscopy it was observed that by finishing with both types of burrs - extra hard and diamond - the porosity was lower than in the case of finishing only with extra hard burrs. At the same time, finishing only with the extra-hard burrs induces the existence of much more obvious mechanical impressions.

Analyzing these two qualitative aspects of the surface condition, we appreciate that the processing with extra-hard and diamond burrs induces a surface with much better qualities compared to the processing only with extra-hard burrs.

Regarding glazing, based on the images obtained by optical microscopy we can say that the surface condition after the application of the varnish layer has superior qualities to unvarnished surfaces in terms of porosity and mechanical impressions post-processing.

AFM analysis showed that the surface roughness was influenced to the greatest extent by the finishing and polishing procedures and to a lesser extent by the acrylic resin material (table VI)

Table VI. Ra values for acrylic samples

Material	Type of resin	Polishing method	Ra(nm)
Prothyl Hot	**Heat- curing resin**	**Conventional laboratopry polishing method**	**12.26**
Prothyl Hot	**Heat- curing resin**	**Conventional laboratopry polishing method- Glaze**	**5.33**
Duracryl Plus	**Self- curing resin**	**Conventional laboratopry polishing method**	**13.95**
Duracryl Plus	**Self- curing resin**	**Conventional laboratopry polishing method- Glaze**	**13.11**
Vertex Soft	**Resilient heat curing resin**	**Vertex TM soft Powder**	**121.63**

The highest smoothness, a mean surface roughness significantly below the threshold Ra=0.2 µm level, was produced by conventional laboratory polishing techniques combined with glazing of the heat curing samples.

There was no significant difference in mean average surface roughness (Ra) between glazed and non/glazed self curing resin specimens, yet a significant difference in surface roughness was found between self curing and heatcuring resins.

The mean value of Ra for resilient resin (Vertex Soft) was the highest from all samples in this experiment. Nevertheless, the values recorded were lower than the threshold Ra (0.2 µm) found in the literature.

The 3D topography could reveal the lack of homogeneity of the sample surface which is closely related to previous processing technique.

Wettability

Wettability is the tendency of one fluid to spread on or adhere to a solid surface in the presence of other immiscible fluids. To calculate this parameter we analyzed the contact angle values on the surface of each resin sample; the data were centralized in table VII.

We noticed that glazed samples have lower contact angle values, compared to unglazed resins, which demonstrates superior wettability.

Table VII Contact angle values correlated with polymerization regime

Sample	Polymerization/Finishing condition	Contact angle(°)
P	**Heat-curing/glazed**	**58.33**
P'	**Heat-curing**	**86.68**
D	**Self-curing/glazed**	**56.66**
D'	**Self-curing**	**53.57**
V	**Heat-curing**	**64.37**

Analyzing the contact angle values versus resins porosity, we noticed that the samples characterized by a high contact angle had increased porosity, except Vertex Soft samples, which, although it has a spongy texture, the contact angle value is below average (64.40).

The contact angle and sliding angle of the liquid on the solid surface are commonly used to characterize and measure the wettability of a particular surface. They have a wide range of values, which results in different wettability.

Although previous studies have shown that porous materials have increased wettability, the contact angle value (hence the wettability) is not necessarily conditioned by the porosity itself, but also by the hydrophilic or hydrophobic nature of the material.

Wettability is an important physical property of materials, being the result of bilateral influence between the surface characteristics of the material (dependent on the processing method) and its general characteristics (independent on the processing method).

Since wettability influences both bacterial colonization and denture retention, it is recommended to use materials with increased wettability for making dentures base.

Microbial colonization

The total germs number TGN /mL from saliva was 46 x 1010 and TGN values related to the acrylic samples were between 0.16 x 108 cfu/cm2 - 12.1 x 108 cfu/cm². (fig.34).

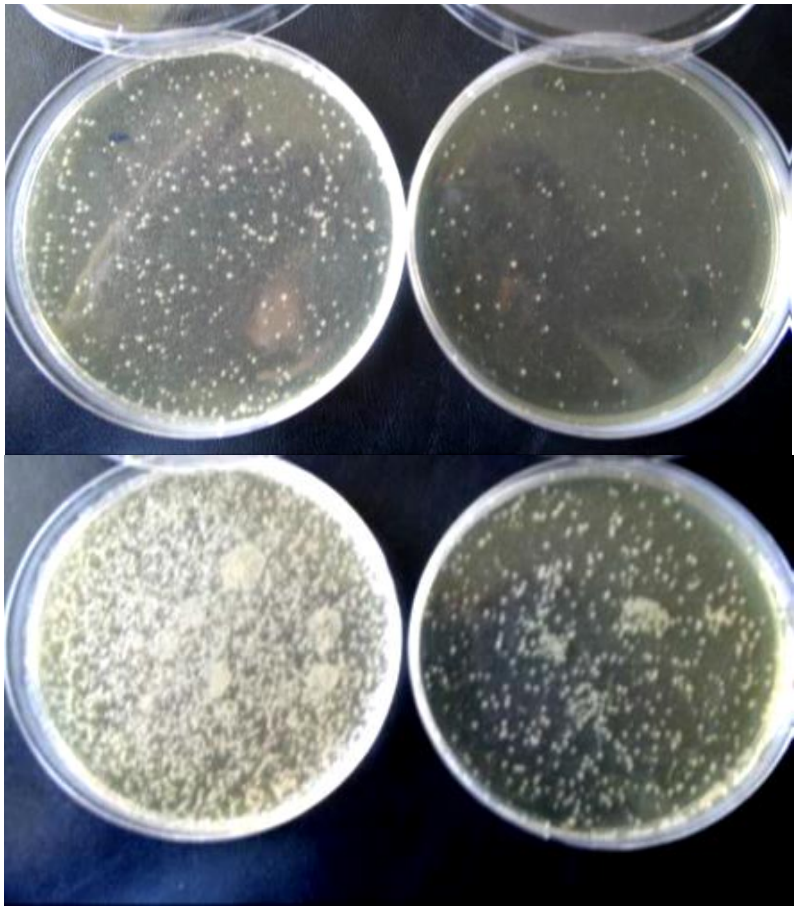


Fig. 34. TGN determination

The lowest value (0.16 x 108) was found in sample C (glazed), which demonstrates that although glazing cannot prevent bacterial colonization, it significantly changes the amount of microorganisms that adhere to the surface (Fig. 35a, b)

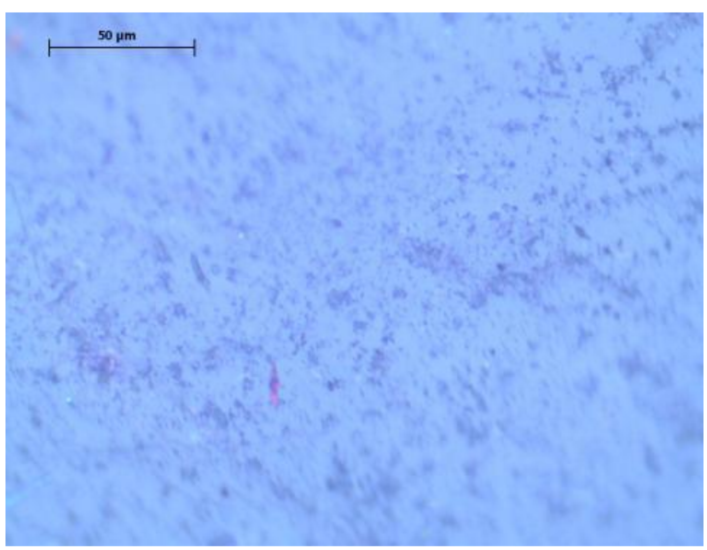


Fig.35.a.Sample C=0,16x108 UFC/cm² (magnification X 50)

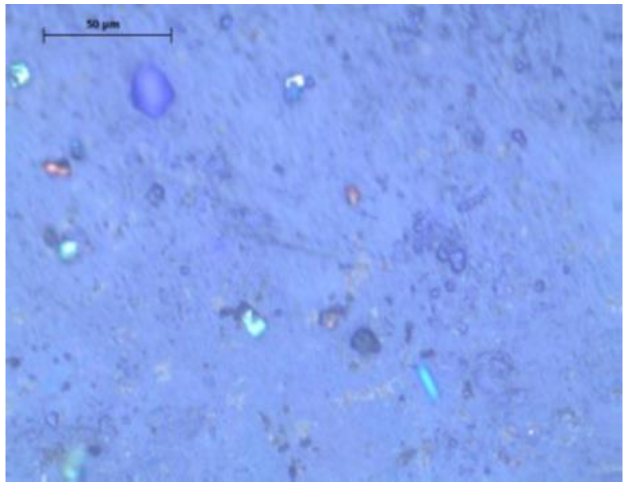


Fig.35.b.Sample C’=1,65x 108 UFC/cm² (magnification X 50

Correlating the results of bacterial colonization with the resin type and the finishing method used, differences are observed between the glazed and unglazed samples, in both Duracryl and Prothyl Hot resins. The highest microbial load value (12.1 x 108 cfu/cm2) was registered in resilient resin sample because of its spongy structure (table VIII).

Table VIII. The correlation between bacterial colonization, resin type and finishing method

Sample	**Resin finishing/polishing method**	**Bacterial colonization CFU /cm2**
A	**Vertex self- curing**	**1.76 x 108**
A’	**Vertex self-curing -glaze**	**1.68 x 108**
B	**Prothyl Hot heat-curing**	**1.46 x 10$_8$**
B’	**Prothyl Hot heat-curing-glaze**	**1.11 x 10 8**
C	**Duracryl self-curing-**	**1.65 x 10 8**
C’	**Duracryl self-curing-glaze**	**0.16 x 10 8**
D	**Vertex soft termopolimerizare, rezilienţă**	**12.1 x 108**
D’	**Vertex Soft resilient heat-curing resin**	**12.1 x 108**
E	**Superaryl Plus**	**1.01 x 108**
E’	**Superaryl Plus-glaze**	**0.83 x 108**

The highest *colonization* value recorded in Vertex Soft samples (12.1 x 108 cfu/cm2) is congruent with literature data that states that resilient resins due to their spongy texture, have a higher porosity and therefore a higher bacterial colonization, limiting clinical longevity of the material.

Studying the correlation between polymerization type and microbial colonization, we noticed that self-curing acrylic resins have higher microbial load values, due to their elevated roughness and porosity.

Regarding the bacterial colonization of glazed acrylic resins, the results were higher comparing with the unglazed samples. Several studies has demonstrated in a clinical trial that a month after glazing the dentures showed a thinner film of plaque compared with unglazed resins. After 3 months reassessment showed a cracked glaze, creating microretentive areas that led to the accumulation of plaque. These findings made him to conclude that glazing efficiency is conditional on preserving the integrity of the deposited layer.

In the literature, opinions on the type of relationship between surface roughness and bacterial colonization (direct or indirect dependency) are divided and some notice that “it is possible” that the surface roughness to provide an environment that promotes the initial attraction of early colonization. However, biofilm formation is dependent on many factors, including the bacterial species, the nature of the substrate and the ambient environmental factors.

Conclusions

Protocols for polishing dentures surface have been established, but the effect of polishing on surface roughness has not been studied systematically.

Smooth and highly polished denture surface are of utmost importance for patient comfort and denture longevity, and it is desired for reducing microorganism’s retention. It can improve good aesthetical results, oral hygiene and low plaque retention, preventing oral diseases.

The aim of the polishing procedure of the denture is to make the denture glassy without changing its contour. For obtaining this aim, all scratches and rough areas must be removed. A series of progressive finer abrasive is used to produce a shiny surface on the denture.

The mechanical polishing procedure uses abrasives which produces wear of the surface in a selective controlled manner and this reduces the surface roughness of the material. Mechanical polishing is preceded by finishing using stone bur and sand paper in order to make the acrylic denture reach to the final form before polishing.

It has been observed that regardless of the porosity of the material, processing and polishing results in a reduction in the size and number of surface pores.

One factor that could potentially affect adhesion is surface roughness of a denture liner. Surface roughness has been shown to affect bacterial and yeast colonization of denture acrylic resin.

In our study, the distribution of inclusions was different for the studied resins the self-curing ones having more inclusions and porosities. The presence of inclusions can negatively influence the result of the mechanical processing of the surface; these defects occurobvious during the contact between the finishing burrs and the resin, determining the increase of the roughness of the material.

The use of the glazing procedure allows the optimization of the surface parameters, and the processing performed with extra-hard and t diamond burrs leads to the reduction of the number of mechanical impressions.

Following this study we can conclude that unglazed acrylic resins have higher values of porosity and roughness, and lower wettability values, favoring greater extent microbial colonization. Use of the glazing procedure allows the optimization of surfacecharacteristics.

Also, finished and polished specimens of self curing resin had a higher mean average of surface roughness and bacterial colonization than heat curing resins after the same surface treatment.

Chapter 2

POSSIBILITIES AND LIMITS OF CROSS-INFECTION CONTROL IN THE DENTAL LABORATORY

State of art

Dental technicians, during their activities, are exposed to a series of noxious factors, which might affect their health. The Occupational Information Network, a US Department of Labor database, conducted a study to rank the „Most Unhealthy Jobs" in America. They analyzed the health risks in each of the 974 occupations in the database using criteria such as exposure to radiation, contaminants, infections, and time spent sitting, with scores of these factors on a scale from 0-100, with a higher score indicating an increased health risk. Dental profession ranked number 1 as the unhealthiest job of all 974 occupations in this study (American Dental Association Council on Scientific Affairs and ADA Council on Dental Practice. Infection control recommendations for the dental office and the dental laboratory; Vázquez-Rodríguez I *et al.*, 2018)

Dental laboratory technicians are exposed to numerous pollutants that could cause occupational diseases in the medium or long term, such as bronchitis, asthma, silicosis and other respiratory complaints (Gupta S *et al.*, 2017; Ozdemir DD *et al*., 2010; Rasam S *et al*.,, 2015)

Exposure occurs during handling the refractory investments, sandblasting of metallic parts and finishing operations.

Dusts of non-precious alloys (very often used dental technology) are extremely toxic and can cause allergic symptoms, respiratory complaints, dermatological problems and neurotoxicity among dental technicians (Sedky NA *et al.*, 2019)

Each stage of the technological algorithm can involve the inhalation of a number of harmful substances (Diaconu D *et al.*, 2012). Several cases of respiratory problems have been reported among dental laboratory stuff and epidemiological studies have shown a high prevalence of pneumoconiosis related to combined exposure to several contaminants and their period of action.

Metals, waxes, resins and silica can cause irritation or allergic reactions, affecting the skin and the respiratory system, as well. The risks of benign pneumoconiosis induced by hard metals are well documented, a prevalence of 15.4% after 20 or more years of exposure being reported, whereas the prevalence in the general population is less than 1% (Diaconu-Popa *et al.*, 2018; Belkıs Y *et al.*, 2015; Lang A *et al.*, 2018). Malignant pneumoconiosis is caused by dust from crystalline silica, asbestos or beryllium. Silicosis is the most common occupational disease among dental technicians, and isolated cases of systemic autoimmune diseases have been observed (Verran J *et al.*, 2004; Vafaee HF et al., 2013).

Contaminated invisible aerosol particles remain in the air for a long time after using lathes for the polishing of prostheses. The rotation speeds of engines are usually high, thus generating very fine powders, whose pathogenicity depends on the particles size, concentration, composition, and duration of exposure (Thomas RJ *et al.*, 2013)

The smoke released during the wax burnout stage, contains mainly colophonyknown as an allergic substance that may cause asthma. In most cases, the processed pieces are also microbial contaminated, so that their pathogenic potential is even higher. Therefore all these chemical agents (gases, vapors, powders), have an irritating or carcinogenic action. Because it not possible to eliminate all sources of contamination in the laboratory, a series of prevention measures should be taken in order to avoid the professional diseases.

Dust from processing prosthesis parts is often microbial contaminated. Motor rotation speeds are typically high, thus generating very fine powder, usually less than 5 microns, which penetrate pulmonary alveoli (Firoozeh F *et al*., 2013; Williams DW *et al.*, 2011)

Harmfully potential is conditioned by particle size, concentration, composition, time exposure (often more than ten years). There are numerous studies that analyse the microbial air in dental offices and the contamination risk due to trespassing strictly prophylactic rule (Hallier C *et al.,* 2010; Chatterjee S *et al.,* 2021)

Protocols for dental offices activity provide air decontamination using germicidal generating ultraviolet radiation lamps. Approximately 95% of the radiation have germicidal wavelength of 253, 7 nm. The remaining 5% is the radiation wavelength of 184.9 nm, producing ozone effect also germicide. Time for action indicated is 20 minutes. The contamination risk throughout the activities conducted in the dental laboratories raised specialist's interest, especially in the last years, because in this segment of the dental algorithm the cross-infection risk is still high (Balcos C *et al.,* 2018; Kilimo CS *et al.,* 2016). If in the dental praxis the asepsis and antisepsis rules are very strict, and the instrument circuit is well documented (The Ministry of Health Order no.349 from 11 April 2005.), for the dental laboratories strict regulations are still absent.

Both practitioners and researchers have been constantly concerned with detecting sources of contamination in the dental office and dental laboratory, wanting to establish a set of prophylactic measures to prevent cross-infection (Kohn WG et al., 2016, Debattista N *et al.,* 2007). There are studies that show that over 60% of the impressions arrived from dental offices in the dental laboratories are contaminated with *Enterobacter cloacae, Escherichia coli, Klebsiela oxytoca* (Barenghi L *et al.,* 2019; Pankhurst CL *et al.,* 2017; Barenghi L *et al.,* 2018)

Although microorganisms transition can be carried out by the impressions received from the dentist, there are a few studies that also incriminate the processing of the denture or the intermediate prosthetic parts that were verified or adapted in the oral cavity of the patient (Schierz O *et al.,* 2021; Bensel T *et al.,* 2013; Agostinho AM *et al.,* 2004; Nair VV et al., 2016)

Research shows that the tools used in processing and pastes for polishing prostheses are important sources of contamination.

All these studies confirm the need to establish strict rules regarding the circuit of fingerprints and prosthetic parts, in order to minimize the risk of contamination of staff and patients during the clinical-technological algorithm.

In this sense, several steps must be followed:

I. Detection the contamination sources

-impressions and prosthetic elements

- laboratory instruments

- microorganisms contaminated powders

II. Reducing the risk of contamination

-contamination control in the dental office

-hygiene measures of laboratory staff

-effective communication between the dental office and the laboratory

III. Development of a guide with prophylactic measures, for:

-protection of patients and members of the dental team

-reducing the number of pathogens in the workspace

-implementation of a high standard in the control of cross-infection, which allows the protection of each patient.

In the absence of a rigorous control of the work circuit there will be a potential risk for the dentist, following the handling of contaminated parts from the laboratory and a risk for laboratory staff, which can be contaminated by direct contact with the prostheses checked in the oral cavity or by inhalation or ingestion of contaminated powders resulting from the finishing and polishing of the prosthetic elements (.Sacoor S *et al.,* 2020; Ataei B *et al.,* 2019).

The risk of contamination during the work in the dental laboratories has attracted the attention of specialists, especially in recent years. If in dental offices the rules of asepsis and antisepsis are certainly established and the instrument circuit is rigorously controlled, in dental laboratories the risk of cross-infection still exists (Yadav BK *et al.,* 2017; Ch AN *et al.,* 2018; Lamb A *et al.,* 2019)

Infection control is an area of dentistry, which is associated with an increased risk of transmitting the infection through direct or indirect contact with contaminated elements (Banglani MA *et al.,* 2016)

Dental laboratory personnel are at risk for infection transmission by the same mechanisms as other dental healthcare professionals (Patel M, 2020)

A primary goal of infection control is to minimize the spread of infection by breaking as many links in the chain as possible. In the dental laboratory, this would incorporate adherence to principles of aseptic technique, appropriate immunizations for laboratory staff, the use of barrier techniques, and implementation of standard precautions. Standard precautions dictate that all laboratory cases are handled the same way and are treated as if contaminated and infectious. Knowing the sources of contamination in dental laboratories allows a correct assessment of the risk of cross-infection and the consequences on patients, dentists and dental technicians. The protection of the dental team in the dental laboratory considers the protection of the visual analyzer, protection of the auditory analyzer, protection against vibration, protection against dust, gases, acids, antimicrobial and antiviral protection, protection against hypokinesia, protection against ionizing radiation, protection from electrical installations, or natural gas (Inayati E et al., 2021; Rodrigues AC et al., 2013)

Antimicrobial and antiviral protection is the fundamental objective of dental activity on which the safety of staff (doctor, dental technician, patient) depends.

Laboratory personnel must wear a bathrobe, mask, gloves, goggles; also, it must be rigorously disinfected the furniture, equipment, surfaces and instruments in the laboratory with adequate solutions (glutar-aldehyde, formaldehyde, ethylene-hexanol alcohol). Decontamination of fingerprints, models, diagnostic models, color keys, temporary prostheses, decontamination of articulators and facial arches should not be neglected (Samejo I *et al.,* 2018)

Disinfection is usually done by the immersion method, which has the advantage of allowing full coverage of surfaces, so it achieves effective decontamination, but there is a risk of changing the size of certain prosthetic parts (Pradhan D *et al.,* 2019;. Sedky NA *et al.,* 2014; Al-Mortadi N *et al.,* 2019).

For disinfection by spraying method there is a range of products is narrower and there is a risk of incomplete coating of surfaces and removal of disinfectant particles in the air.It is extremely important that the substances used for decontamination have an effective antibacterial effect and do not affect in any way the accuracy of the prosthetic part.

Although there have been concerns in this field for many years, the lack of concretization of the results as a direction of practical application is lacking, so that the realization of a guide of unitary measures to be observed in all dental work units is an extremely useful measure.

Evaluation of the development conditions of activity in dental laboratories regarding the application of dental protocols infection control demonstrates the need to implement measures to increases the level of knowledge of the staff.

The evaluation of the conditions for carrying out the activity in the dental technique laboratories regarding the application of the infection control protocols demonstrates the need to implement energetic measures to increase the level of knowledge in this field. The organization of medical education actions and the initiation of specific programs must aim at increasing the compliance of dental technicians with the control measures of cross-infection.

My contributions to this research direction can be found in the following articles:

1**. Diaconu D,** Vitalariu A, Tatarciuc M, Murariu A. The economic crisis effects on the cross contamination control in dental laboratories. *Revista de cercetare și interventie socială* 2014; 47:105-116. IF=0,798.

2. **Diaconu-Popa D,** Tatarciuc M, Viţalariu A. Evaluation of the air quality in dental laboratory. *Romanian Journal of Oral Rehabilitation* 2018; 10(3):142-146.

3.**Diaconu D,** Tatarciuc M, Viţalariu A. Quantitative analysis of bacterial contamination in dental laboratory air, *Romanian Journal of Oral Rehabilitation* 2012; 4(4): 27-29.

4. **Diaconu D,** Tatarciuc M, Viţalariu A. Determination of the concentration of respiratory powders in dental technique laboratories. *International Journal of Medical Dentistry* 2011, 15(4):382-385.

5. Tatarciuc M, Zamfirache I, Marius S, Vitalariu AM**, Diaconu D.** Microbiologic study regarding the risk of cross infection in the technical laboratory. *Analele ştiinţifice ale Universităţii Al.I.Cuza, Secţiunea Genetică şi Biologie moleculară* 2010; XI(4): 53-58.

2.1 Research on the knowledge and implementation of measures to control cross-infection in the dental laboratory

Introduction

Numerous studies have shown that in the dental laboratories the transmission of microorganisms takes place by means of impressions received from the dentist, and by processing of acrylic dentures and prosthetic devices which come back to the lab, after they have been checked or adapted in the patient mouth.

In the literature, researchers show that 9 out of 10 prosthetic devices sent completely sterile from the dentist were contaminated after their processing in the lab with microbial germs that do not belong to the oral saprophyte flora and which may cause serious diseases for patients (American Association of Public Health Dentistry, 1986). For these reasons, it is mandatory to decontaminate all prosthetic devices coming in the lab from the dental office and any prosthetic device leaving the laboratory must also be disinfected.

Another important source of contamination in the dental laboratory, overlooked by dental technicians, is represented by the wheels and pumices used in the finishing and polishing process (Naz A *et al.*, 2020; Hakam FA *et al.*, 2018; Gray J, 2105).

The aim of this study is to highlight the degree of knowledge of prophylactic measures in the dental laboratory and to analyze how these standards are implemented in current practice.

We also centralized the attitude of dental technicians towards the application of prophylaxis measures and their opinion on the impact on the additional costs imposed by these measures.

Matherial and methods

First step was to quantify the knowledge and practices in infection control among dental technicians working in commercial dental laboratories in Iasi and also to analyse if they consider that the prophylactic measures would involve some unjustified additional costs in their activity.

To perform this research, we used a questionnaire containing 13 questions conceived by the authors. The questionnaire was divided into two sections: the first section containing 9 questions focuses on the testing of knowledge of dental technicians regarding the control measures of crossed infection; the second section containing 4 questions evaluates whether the observance of prophylactic measures has imposed additional expenses in the context of the economic crisis.

The questionnaire was pilot-tested by distributing it to twenty dental technicians who work in or collaborate with our university dental clinic.

The answers to the pilot test were analyzed to assess the clarity and relevance of the questions, and modifications were made. After receiving feedback from pilot test participants, it was sent to 26 laboratories of Iasi. The study was conducted between August-October 2013.

Data were analyzed with the SPSS 17.0 system for Windows (SPSS Inc. Chicago, IL, SUA). Variations in distributions of the answers were analyzed by cross tabulations. Statistical significance of the bivariate analysis was assessed by the Pearson chi-square, at the 0.05 level. Correlations between different questions were determined by Pearson correlation coefficients.

If in the dental offices, asepsis and antisepsis rules are clearly established andthe circuit of instruments is strictly controlled, the risk of cross-infection is still present in the dental laboratories.

Results and discussion

Following the distribution of questionnaires regarding the analysis of the level of prophylaxis knowledge and implementation of these measures in current practicewe received 108 answers out of 113 representing an answer rate of 95.57%.

Dental technicians who participated in the study were divided into three lots depending on their length of service in the dental lab: 38 of them had less than one year length of service (35.2%), 33 respondents had the length of service between 1 and 5 years (30.6%), and 37 technicians had a length of service over 5 years (34.3%).

The returned questionnaires were reviewed for completeness and statistically analyzed.

In the first stage of statistical processing, the univariated descriptive analysis has been used in order to calculate the percentage of responses to the survey questions (Table IX), and the bivariate analysis to explore existing relationships between two variables, namely the survey questions that make reference to the economic crisis in relation to length of service (Table X).

Table IX. Survey questions

Question	Answer	Number	%
1.It is possible to contaminate surfaces and instruments in dental laboratory	a. YES b. NO c. I dont't know	103 5 0	95.4 4.6 0
2. There is a risk of contamination for prosthesis/prosthetic parts sent from lab to dental office?	a. YES b. NO c. I dont't know	103 5 0	95.4 4.6 0
3. There is a risk of contamination for dental aboratory workers?	a. YES b. NO c. I dont't know	100 6 2	92.6 5.6 1.9
4. What do you think are the sources of contamination? Specify some of them.	a.impressions b. prosthesis c. everything d. I don't know	51 2 48 7	47.2 1.9 44.1 6.5
5. What pieces received from the dental office should be disinfected in the lab?	a.impressions b. prosthesis c. all d. I don't know	35 1 68 4	32.4 0.9 63 3.7
6. What pieces sent to the dental office should be disinfected in the lab?	a.impressions b. prosthesis c. all d. I don't know	2 30 70 6	1.9 27.8 64.8 5.6
7. Do you consider necessary the disinfection of the laboratory working tools	a. YES b. NO c. I dont't know	98 9 1	90.7 8.3 0.9
8. Do you perform surfaces and air decontamination every day?	a. YES b. NO c. I dont't know	41 55 12	38 50.9 11.1
9. Do you wear protective equipment (gloves, goggles) during maneuvers	a. YES b. NO c. Sometimes	60 8 40	55.6 7.4 37

Table no X. Questions about additional costs

Question	Answer	Number	%
10. Do you try to reduce the costs by changing polishing pastes and brushes at larger intervals of time?	a.I change them daily b. I change them weekly c.I change them after each use d. I don't know	6 81 10 11	5.6 75 9.3 10.2
11. Do you consider an additional financial effort using the cross-infection preventing methods?	a.YES b. NO c. I dont't know	34 61 13	
12. You consider that the economic context of recent years imposed spending reduction regarding preventing methods?	a.YES b. NO c. I dont't know	26 56 24	24.1 53.7 22.2
13. Which contamination prevention methods you could give in order to reduce the laboratory costs?	a. mask, gloves, glasses b. surfaces decontamination c. air decontamination d. none	10 1 81 16	9.3 10.8 75 14.8

From the dental technicians' answers we noticed that 95.4% are aware of the real risk of contamination correlated to the surfaces and instruments in the lab.

The same high percentage of 95.4% represents those who are aware of the high risk of crossed infection having as a vector all the prosthetic devices coming from the dental office or leaving the laboratory.

Answers to question no. 3 about the rendering sick of the lab personnel through the handling of contaminated prosthetic devices were affirmative for 92.6% of respondents.

A reduced percentage of 47.2% consider only impressions as the most important source of contamination, whereas 63% think that all devices coming from the dental office must be disinfected by the technician (question 5). A similar percentage was obtained for question no. 6 where 64.8% declared that the same devices must be disinfected as well when they are sent back to the dentist.

A well known aspect regarding decontamination methods is the disinfection of lab surfaces sustained by the percentage of 90.7% of those who answered question no. 7. At the opposite end there is the reduced knowledge of technicians about the air decontamination methods, and this is supported by the fact that only 38% of them do this every day (question no. 8), and in the context of reduction of lab budget 75% would give up this procedure (question no. 13). Wearing protective equipment (gloves, glasses) is a daily routine for 55.6% of respondents whereas 37% sporadically use these prevention measures (question 9).

The last four questions focus on the economic side of the activity in the dental laboratory due to the reduction of expenses in the context of decrease of clinical handworks.

Most respondents (75%) answered question 10 regarding the interval for changing the denture pumice saying that they do this every week, 5.6% daily and 9.3% after each use. 31.5% of technicians consider the application of all prevention methods as a supplementary financial effort, whereas a higher percentage 56.5% affirms that this does not represent a financial burden (question 11).

In connection with the context of economic crisis, 53.7% answered negatively the question about the need to reduce the expenses allocated to the prevention methods (question 12). If the lab expenses were to be reduced, 14.8% declared that they would not give up these procedures.

Answers to question no. 11 demonstrate that most technicians do not consider these prevention methods as an additional financial effort (50% of those having a length of service within one year, 57.6% having the length of service between 1 and 5 years and 62.2% having a length of service over 5 years), and the differences identified do not have a statistic significance p=0.531. As for the reduction of lab budget, only 34.2% of those having a length of service within one year and 28.9% of those having a length of service over 5 years declared that they also reduced the expenses related to these decontamination methods (question no. 12).

Most answers belonged to those who declared that they have reduced the lab expenses, the highest percentage belonging to those having the length of service between 1 and 5 years (63.6%) followed by the young ones 36.8%, and finally 24.2% of the old ones.

The differences identified for the 3 age groups have statistic significance (p=0.005). The methods for infection prevention (question no. 13) which they would give up are, for most categories of length of service, the ones used for air decontamination: 57.9% for the group having a length of service within one year, 90.9% for the group having the length of service between 1 and 5 years and 78.4% for those having a length of service over 5 years. Only 3% of those having the length of service between 1 and 5 years would give up the methods for surface decontamination. The differences identified have statistic significance, p=0.023

Besides the descriptive statistics analysis, by means of cross tabulations and Chi-square test we made a differentiation of answers to questions referring to the effect of economic crisis depending on the length of service.

As for the sparing of pumice and wheels (question 10), most dental technicians, regardless of their age, declared that they do this once a week. We have noticed statistically significant differences p=0.005 in terms of the daily change of pumice and wheels within the meaning that the highest percentage (21.1%) belongs to those having the length of service within one year as compared to the elderly ones who perform this activity every day in a percentage of only 5.4%. At the opposite end, there were the ones having the length of service between 1 and 5 years since no technician of this group declared anything about this aspect. (Table XI).

Table XI. Pearson correlation significance

Questions	**Answers**	< 1 year (%)	1-5 years (%)	> 5 years (%)	p value; Pearson chi-square value (χ^2)
10. Do you try to reduce the costs by changing polishing pastes and brushes at larger intervals of time?	a.I change them daily b. I change them weekly c.I change them after each use d. I don't know	2.6 65.8 21.1 10.5	9.1 90.9 0 0	5.4 70.3 5.4 18.9	p=0.005 χ^2=18.47
11. Do you consider an additional financial effort using the cross-infection preventing methods?	a.YES b. NO c. I dont't know	31.6 50 18.4	30.3 57.6 12.1	32.4 62.2 54	p=0.531 χ^2=3.165
12. You consider that the economic context of recent years imposedspending reduction regarding preventing methods?	a.YES b. NO c. I dont't know	34.2 36.8 28.9	12.1 63.6 24.2	28.9 24.2 13.5	p=0.005 χ^2=9.372
13.Which contamination prevention methods you could give in order to reduce the laboratory costs?	a. mask, gloves, glasses b. surfaces decontamination d. none c. air decontamination d. none	15.8 0 57.9 26.3	3 3 90.9 3.1	8.1 0 78.4 13.5	p=0.023 χ^2=15.854

From Pearson correlation analysis, we may notice a strong association between the answers obtained for questions 11 and 12, r=0.459, p=0.01. This aspect demonstrates that the methods dedicated to contamination prevention (question no. 12) represent, in the current context of economic crisis, an additional financial effort for the dental laboratory (question no. 11). The same positive correlation with statistic significance has been noticed between the answers given for questions 11 and 13, but with a lower intensity, r=0.350, p=0.01.

The results of Pearson analysis show that out of the same financial motivation some technicians are ready to give up certain methods for crossed infection prevention (question no. 13), one of these being the daily decontamination of surfaces (question no. 8).

The association identified has a statistic significance and a lower correlation coefficient, r=0.303, p=0.05 (table XII).If in the dental offices, asepsis and antisepsis rules are clearly established and the circuit of instruments is strictly controlled, the risk of cross-infection is still present in the dental laboratories. Our researche demonstrated that only 63% of technicians decontaminate all the prosthetic devices coming from the dentist, impressions occupying the first place as contamination vectors in a percentage of 47.2%.

The results obtained are similar to the percentage obtained other studies carried out in 2011 in Iasi (Barlean *et al.*, 2011).

Table XII Pearson correlation analysis.

	Changing pumices/brushes at larger interval; of time(10 hours)	**Additional efforts (11)**	**Reducing costs (12)**	**Quit preventive measures (13)**	**Wear protective equipment (9)**	**Daily decontamination (8)**
Changing pumices/brushes at larger interval; of time(10 hours)	**1.000**					
Additional efforts (11)	**.064**	**.1000**	**.**			
Reducing costs (12)	**.125**	**.459****	**..1000**			
Quit preventive measures (13)	**.105**	**.350****	**.073**	**.1000**		
Wear protective equipment (9)	**.072**	**.080**	**.038**	**-.134**	**1.000**	
Daily decontamination (8)	**.101**	**.281***	**.094**	**.303***	**.085**	**1.000**

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

In the dental laboratories, the procedures for cross-infection prevention focus on the following aspects: protection barriers against the microbial germs (gloves, mask, and glasses), decontamination measures for impressions, instruments and lab air and the immunization of the lab personnel against hepatitis B virus. In this study, we have noticed that only 55.6 % of technicians regularly use gloves, protection glasses and mask.Other researches in the field show that in the labs from the Great Britain, 44% of technicians wear gloves and 74% wear glasses, unlike the technicians from Jordan where only 24% of technicians wear gloves and 35% wear a mask.

In Romania, the results of the study published by Barlean et al, in 2011, demonstrated that only 49.1% of technicians use protective equipment. From the correlation analysis carried out, we have noticed that there is a positive association and with strong intensity ($r=0.459$, $p=0.01$) between the answers for questions focusing on the possibility to give up the decontamination methods considered as an additional financial effort (questions 11 and 12).

Although they are not in a high percentage, still the fact that 34.2% of those having a length of service within one year declared that they may give up decontamination represents an alarm signal in order to introduce these very important aspects for the public health in the conduct of young technicians as early as their academic studies. A third of them also declared that they would easily give up these procedures because they require supplementary funds. Also serious is the fact that a high percentage of 75% would give up the methods for lab air decontamination requiring the purchase of special equipment. Depending on their length of service, we have noticed statistically significant differences within the meaning that 90.9% of those having the length of service between 1 and 5 years declared that they give up this procedure unlike those having a length of service within one year whose percentage is lower, 57.9%. Otherwise, for this age category, we noticed that a very low percentage of only 3.1% would not give up any method for crossed infection prevention.

These answers suggest an insufficient knowledge of the issues and require the increase of the knowledge level by post-academic courses and continuous profes sional training

Conlusions

Our studie's results along all the others confirm the necessity of a set of strict regulations, regarding the impressions and prosthetic devices circuit, in order to reduce the contamination risk of both medical personnel and patients, throughout the clinical-technologic algorithm.

Although we found that most technicians (95.4% of respondents) are aware of the existence of a real contamination risk both of the lab surface and the personnel, however we have noticed a decreased vigilance when they are forced to reduce the lab budget. On the other hand, we have noticed a reserved attitude towards certain decontamination methods considered unnecessary, such as those addressing the air decontamination, 75% of respondents declaring this aspect.

The measures of personal protection do not represent a permanent need for 37% of respondent technicians which means that, although theoretical notions are known, they are not always put into practice.

In the same line are the answers given for the question regarding the daily decontamination where only 38% of technicians answered affirmatively.

That is why we consider important the organization of practical courses for the reevaluation of knowledge and behaviour towards the standard procedures for infection control in the dental laboratory.

Depending on their length of service corroborated with the effects of budget reduction, the analysis carried out demonstrates the existence of some statistically significant differences between the three age groups. Thus, we have noticed that the reduction of expenses determined by the economic crises is higher for those having a medium length of service as compared to the younger or older ones, and they also represent the lowest proportion of technicians who would not give up the methods for crossed infection prevention, regardless of the existing financial effort.

As a conclusion, in the current conditions of reduction of the lab expenses caused by the lack of addressability to dental services, we notice an alarming aspect, namely the giving up on some decontamination methods (air, surfaces, and devices) in the dental laboratory. This is not necessarily due to the lack of theoretical knowledge, but especially to the lack of concern for the implementation of these measures. Dentures processing using instruments and polishing paste that were used before in other operations, as well as handling them, accounts as the main microbiological contamination sources along the work algorithm conducted in the dental laboratory. Also the old polishing paste can be considered an important vector in the contamination of the denture.

The future elaboration of a good practical guide, which will be implemented in all dental work units, is well supported by the conducted microbiological analysis, being a necessary and welcome measure.

These conclusions will contribute in the future to developppe a practical guide for preventive measures and to establish strict rules of asepsis and antisepsis along the clinical algorithm.

2.2. Research on powder loading and their microbial contamination in the dental laboratory

Introduction

Technological algorithm in prosthesis construction achievement involves a variety of stages, after which appears both: pollution and contamination in atmospheric air, which can cause serious health damage in all dental team members. Dental technicians, during their professional activity, contact several harmful factors and their harmful effects depending on toxic concentration in air and exposure in time. Studies to date indicate that the most common diseases in dental technicians are located in respiratory system and consist of silicosis, berylliosis, interstitial pneumonia, pulmonary fibrosis, asthma, chronic obstructive bronchopneumopathy, allergic respiratory reactions, reduced respiratory capacity, and emphysema. Dust generated by processing prosthesis parts is often microbial contaminated. Motor rotation speeds are typically high, thus generating very fine powder, usually less than 5 microns, which penetrate pulmonary alveoli. Harmfully potential is conditioned by particle size, concentration, composition, time exposure (often more than ten years) (Sykes LM *et al.*, 2019;
156. Vafaee F *et al.*, 2013). There are numerous studies that analyse the microbial air in dental offices and the contamination risk due to trespassing strictly prophylactic rules. Risk of infection

depends on the minimum infective dose of any given organism, as well as the virulence (Williams DW *et al.,* 2011).

In a study evaluating microbial counts of polishing pumice in a dental production laboratory there were reported abnormally high counts of pathogenic organisms. These bacteria were identified on patient dentures, pumice samples and scrub jackets. However, knowing that cross-contamination inevitably occurs in many dental laboratories, it is critical for the clinician to be aware of and follow proper protocols for maintaining an aseptic and/or sterile surgical field to ensure minimal post-operative complications (Ganesh S *et al.,* 2013; Raiyani CM et al., 2015; Boyce R *et al.,* 2008; Salvia AC *et al.,* 2013)

The aim of the study was to evaluate the amount of powders produced into dental laboratories, to corroborate the obtained results with the conclusions of other investigations developed by the same team, for the elaboration of a practical guide of the main prophylactic measures to be taken. The study develops a quantitative analysis of the respiratory powders present in the laboratory of dental technique, without determining the nature or prevalence of each pathogenic agent and to determine thei microbial load.

Materials and methods

For the determination of the amount of powders, produced in the laboratory of dental laboratories, air samples have been taken over, for 8 hours, along 10 days, from three spaces of the laboratory of dental technique, namely: the room of fixed prostheses, the room of ceramics and the processing room.

Respiratory powders have sizes below 10 microns, while the maximum values accepted in the atmosphere are of 10 mg/mc.

Determination of powders' concentration in air was made HPC601 laser particle pumps, placed in each room, in the vicinity of the working space. On each pump, a (previously weighed) paper filter was mounted, the pumps being set at a 5 l/min flow, at constant temperature of 24°C.

The obtained values were statistically analyzed in the Department of Informatics of the Faculty of Medical Dentistry, by means of the IBM SPSS Statistics 25 program, in cooperation with the Department of Medical Informatics and Biostatistics of the U.M.Ph.Iasi

For the microbial evaluation we used the Koch method. Their inoculation was done on preformed solid culture medium, based on agar-agar, in opened and exposed Petri dishes with a diameter of 90 mm.

Five samples were placed in various working areas of dental laboratory; first samples were left uncovered for 15 minutes at the first hour in the morning. Next group, also consisted in five samples, was obtained during specific working steps. The last five samples were recorded at the end of working day.

After exposure, the Petri dishes were sealed and sent to the microbiology laboratory. Samples were incubated for 24 hours at 37ºC, and then were allowed for additional 24 hours at room temperature and light exposure. Colonies were counted starting from the premise that each colony has grown from a microorganism, and by counting all colonies, we obtained the total number of bacteria. The method used is simple and allows simultaneous multiple determinations, thus achieving very accurate characterization of air contamination.

To express the microbial load per unit air volume, Omeliansky formula was used, which calculate the germs from 10 litters of air deposed on a surface of 100 cm^2 in 5 minutes:

Number germs/ air $m^3 n$ X 10000: S T/ 5, n being the number of colonies developed on culture medium surface, S the Petri dish surface in cm^2, and T being the time of exposure, in minutes.

Results and discussions

For the second stage of the study, the analysis of the powder charge of the air from the dental technique laboratory, we centralized the information obtained after collecting the samples.

The data registered for the first working room – the laboratory of fixed prostheses – were systematized in view of a subsequent comparative analysis (table XIII):

Table XIII. Data registered for the first working room

Room	Laboratory of fixed prostheses									
Day	1	2	3	4	5	6	7	8	9	10
µg/m³,	0.7	1.2	1.3	1.1	2.3	1.3	0.9	0.9	1.41	1.7

The listed values show that the highest amount was of 2.3 µg/m³, the lowest one being of 0.7 µg/m3 (fig.36).

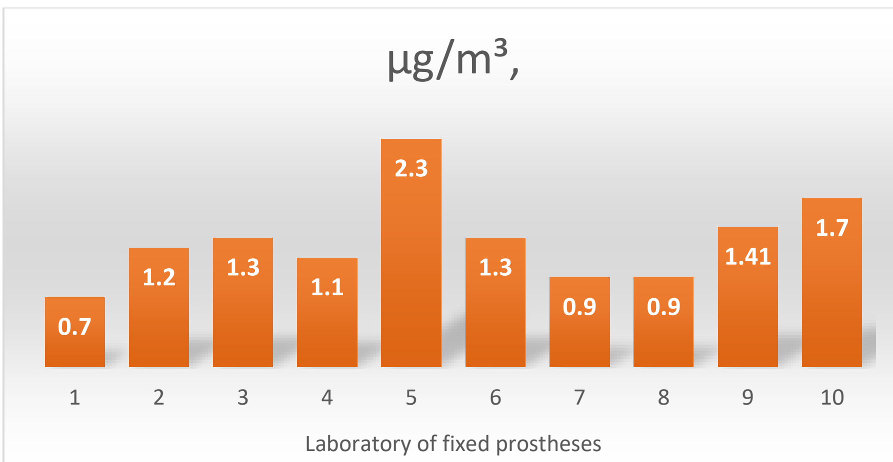


Fig. 36 Values obtained for respiratory powders in the first working room

For the ceramic room, the maximum values obtained were of 1.7 µg/m³, while the minimum ones were of 0.2 µg/m³ (Table XIV).

TableXIV The data registered for ceramic room

Room	Ceramics laboratory									
Day	1	2	3	4	5	6	7	8	9	10
µg/m³,	0.7	0.2	0.3	0.2	1.7	0.3	0.2	0.2	0.6	0.4

The maximum registered amount is lower than in the first working room (fig. 37).

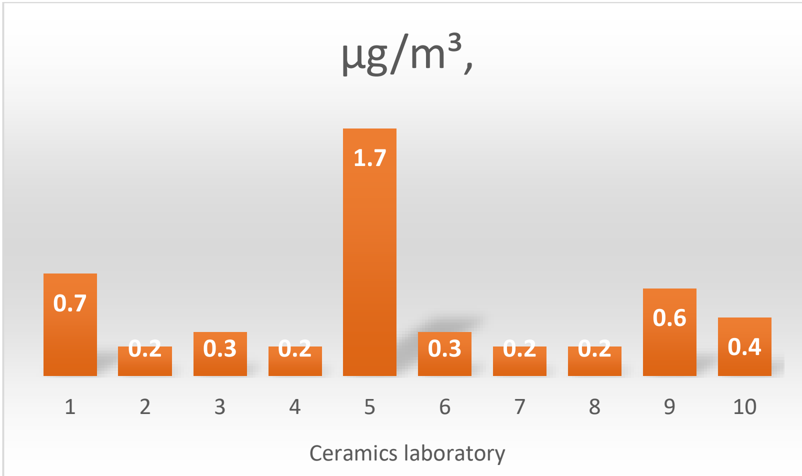


Fig. 37 Values obtained for respiratory powders in the second working room

In the finishing and polishing room, the highest value was of 3.7 µg/m³, and the lowest one – of 0.9 µg/m³ (table XV).

Table XV. The data registered for the polishing room

Room	**Finishing and polishing laboratory**									
Day	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
µg/m³,	**0.9**	**1.8**	**2.3**	**1.5**	**3.7**	**3.2**	**2.9**	**1.8**	**2.1**	**2.6**

The above data show that, in this room, the maximum value is higher than in the others, which is also the case of the minimum value (fig.38).

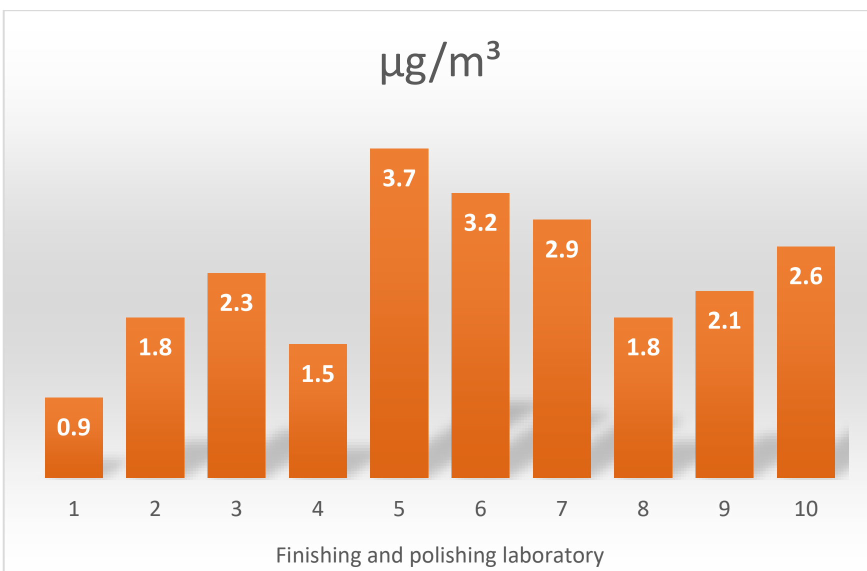


Fig.38 Values obtained for respiratory powders in the third working room

For a subsequent comparative analysis, the values obtained in the three working spaces were systematized in table XVI.

Table XVI. Data centralized for the three working rooms

o	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Finishing and polishing laboratory	**0.9**	**1.8**	**2.3**	**1.5**	**3.7**	**3.2**	**2.9**	**1.8**	**2.1**	**2.6**
Ceramics laboratory	**0.7**	**0.2**	**0.3**	**0.2**	**1.7**	**0.3**	**0.2**	**0.2**	**0.6**	**0.4**
Laboratory of fixed prostheses	**0.7**	**1.2**	**1.3**	**1.1**	**2.3**	**1.3**	**0.9**	**0.9**	**1.41**	**1.7**

One may therefore observe that the highest amount of powders is concentrated in the processing laboratory, where deflasking and sandblasting operations are also performed; the lowest value of respiratory powders is registered in the ceramics laboratory, where only veneering of the metallic frameworks with ceramic masses and adaptation of the ceramic bridges after firing are performed.

The data provided in the present investigation are much under the maximum accepted values for respiratory powders in atmospheric air, however their high toxicity level and a constant exposure, over very long time intervals, should be necessarily had in view.

Such conclusions should make the dental technicians more aware of the risks and contamination sources to which they are exposed; also, establishment of some efficient prophylactic norms in the laboratories of dental technique is a compulsory task (fig 39).

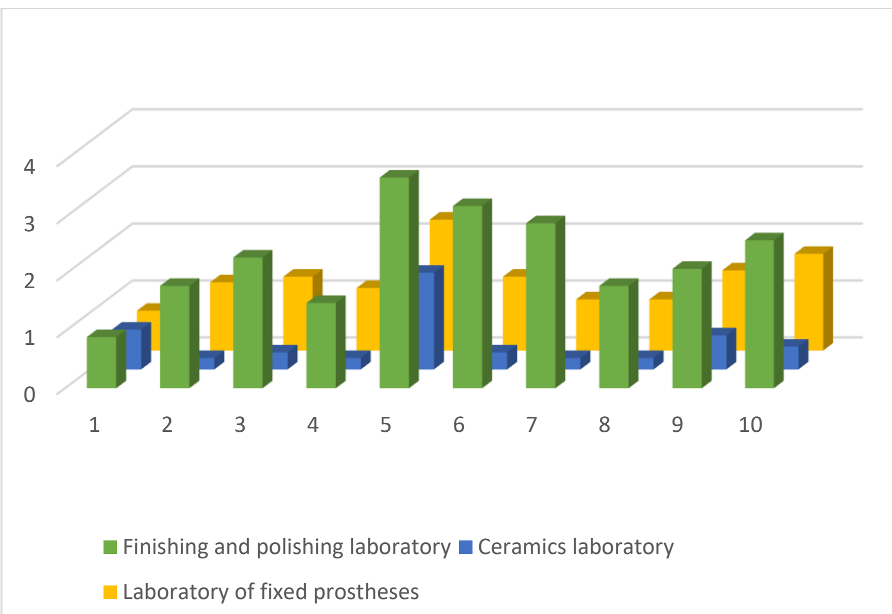


Fig. 39. Values obtained for respiratory powders in the finishing and polishing room

The average value of the dust concentration recorded in the dental lab was 2,51μg/m³, while the maximum admissible limit is 10 μg/m³.

Although all recorded values are below the maximum allowed, the high degree of toxicity and long exposure to these pollutants may cause a change in the health of practitioners.

Fine and ultra-fine particulate matter, which includes harmful bio-aerosol particles, are capable of reaching the deepest part of our lungs, being absorbed into the blood stream and having systemic effects to our health.

Determination of units number forming colony per cubic meter in air, allowed to assess the microbial load in the dental laboratory at different moments of the working day (fig.40)

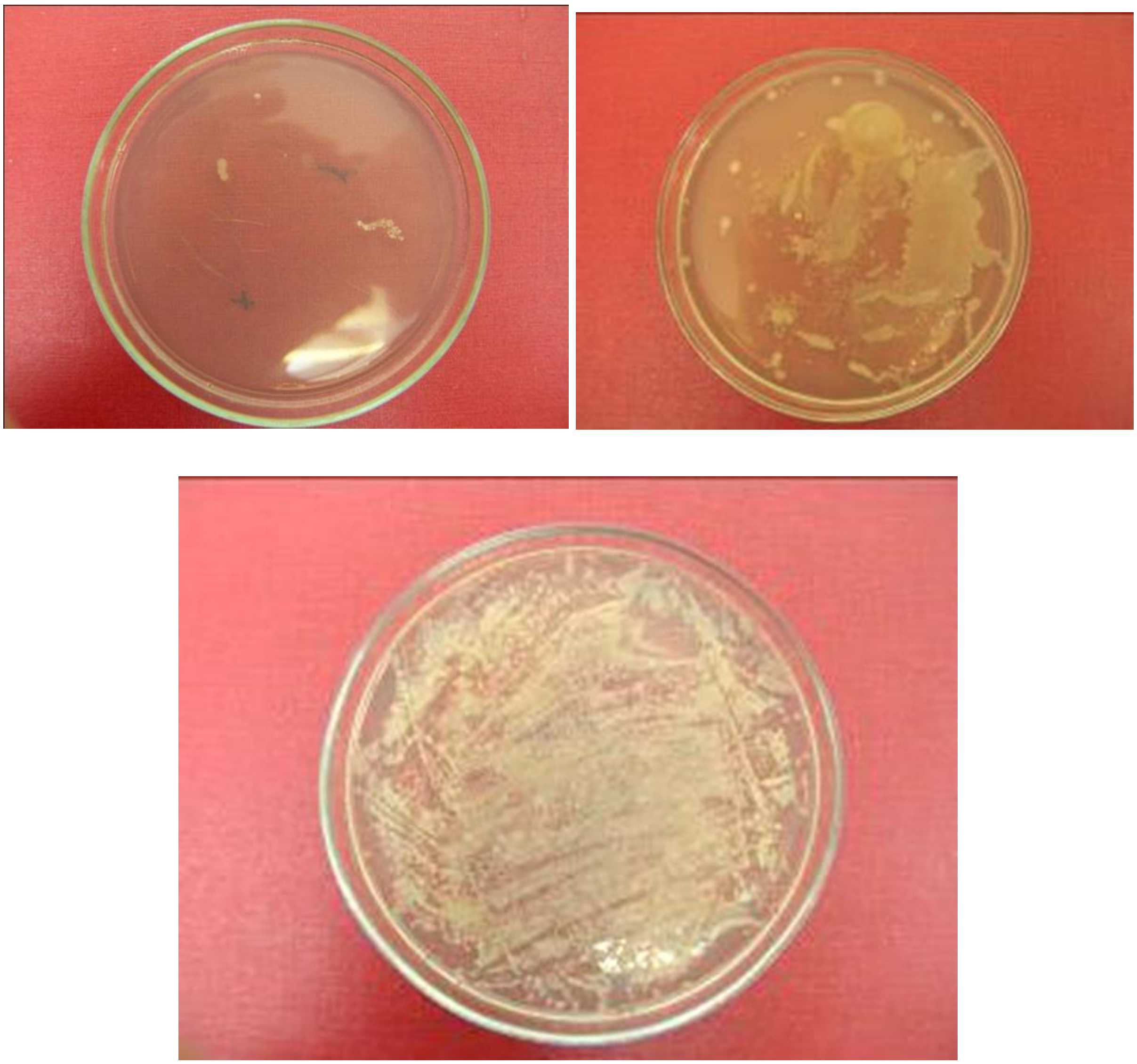


Fig.40 The Petri dishes with microbial colonies

Data obtained were statistically processed and results are expressed as mean values recorded (Table XVII).

Table XVII. CFU m³ of air in different stages of activity

CFU at the beginning of the working day ($m^3$of air)	CFU during specific activities ($m^3$of air)	CFU at the end of the working day ($m^3$of air)
40	**873**	**86**

The highest values corresponded to intense working moments when specific technological steps are performed. Values recorded at the end of the working day, after decontamination, were lower than those obtained during the work stages, but higher than those recorded at the beginning of the day (fig.41).

This underlines the need for daily air decontamination in workspaces and use of specific measures in order to protect the medical stuff.

The resulting powders are contaminated with bacteria as a result of an inappropriate decontamination of used prostheses or instrumentation. Microbial aerosols are generated during dental treatments and may represent an important source of infection.

The level of air born bacterial pollution generated during routine activity showed that a very high level was recorded during prostheses divesting and finishing stages. Aerosols resulted from polishing procedures may cause different infection and can damage the general health status.

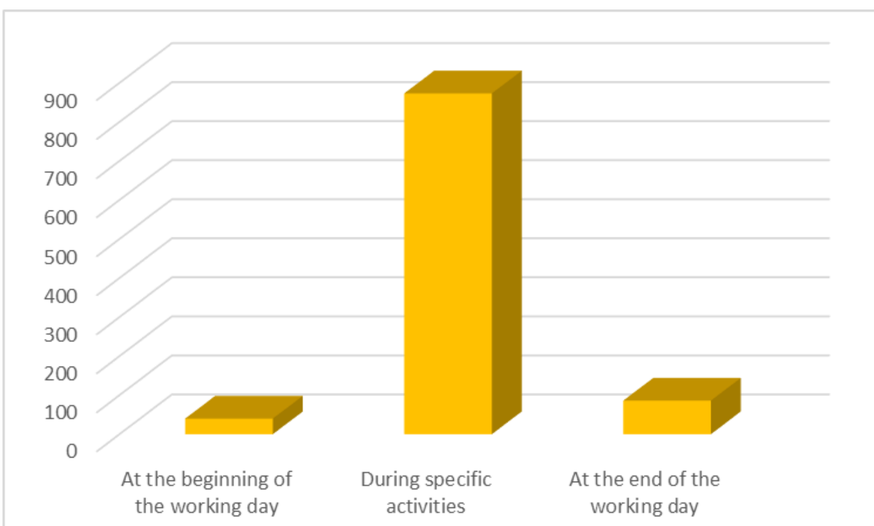


Fig. 41 Microbial load in the dental laboratory

For air bacterial content so far there are no standards or rules indicating by which degree of air contamination could be assessed. In room is accepted as the maximum limit of mesophilic – 2500 within the limits in the specialty literature. The highest values were obtained corresponding to periods of intense work while performing specific manoeuvres. Values recorded at the end of the working day, after decontamination, were lower than those obtained during the work stages. This underlines the need for daily air decontamination in workspaces and use specific measures to protect personnel. It is recommended to capture dust at point where emission exhausting and discharge it externally (i.e. by using sandblasting with externally exhausting) and adequate air refreshment (40 m3/hour/persona). It is also necessary to use specific protective equipment: goggles, gloves, and masks dust protection.

The existing studies results, along the current dentist activity show the necessity to introduce of a more efficient control for the medical act. In the dental praxis the rules are clear but sadly in the dental laboratory this methodology is still not enough documented. This is why the introduction of a good practical guide is vital.

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Conclusions

Devices realized the dental laboratory are essentially inert materials which have been in contact with the patient's mouth, saliva, and possibly blood. Appliances leaving the laboratory are then returned to the clinician to be tried or adapted into the oral cavity. Relatively little attention has been paid to infection control policy within dental laboratories, due to lack of appropriate training, and lack of relevant research.

Durind the technological steps, the dental technicians are not just exposed to chemical hazards, but also to dust particles of various compositions and sizes. Research has shown that the dust from the types of materials that are used in dental technology are harmful to the laboratory team, not because of the high concentration, but due to the long exposure time and microbial contamination of these powders.

All these studies are desirable, in order to identify any potentially hazardous procedures, and to make an assessment of risk for these procedures.

2.3. Research on microbial contamination of prostheses after finishing and polishing

Introduction

Another important source of contamination in the dental laboratory, overlooked by dental technicians, is represented by the wheels and pumices used in the processing of the prosthetic devices.

The risk of contamination of prostheses in the dental laboratory is an aspect that must be further analyzed and regulated in order to ensure and maintain a healthy oral function and environment.. The dentures of even healthy individuals must be considered as possible sources of pathogenic microorganisms. Regular denture maintenance and decontamination should be done to prevent and control microbial contamination of removable dental prosthesis. (Nair VV *et al.*, 2016)

From our present research results that 75% of technicians change this type of instruments once a week, possibly due to the need to spare as many materials as possible, though the standard procedures for infection control in the labs provide a daily change. This is performed by only 9.3% of all technicians and, depending on the length of service, we obtained statistically significant differences (p=0.005), only 21.1% of those having a length of service within one year declare this aspect and, unfortunately, no technician having the length of service between 1 and 5 years declares this (Kartika UK *et al.*, 2015; Lima JF *et al.*, 2016) In a similar survey carried out in Jordan, it has been noticed that 85% of technicians very rarely change the dental burs

Materials and method

To trace the contamination sources from the technical laboratory, we assessed the microbial load of intermediate prosthetic devices prior to checking and adapting them in the oral cavity. We used non-sterile prosthesis, and sterilized ones using current disinfectants.

The prosthetic parts used in this study were especially made for this study according to the classic production algorithm, Donciu V. David D. Patrascu I Serb H. (1994), using thermopolymerized acryl Prothyl Hot (Zhermack SpA). The processing procedure was carried out using classic acryl burs mounted on a 30.000 rpm Marathon N3 hand grinder and brushes, pumices and slurries used for polising, mounted on a horizontal motor (40.000 rpm). We used Abraso- Starglanz (Bredent) polishing paste.

We analyzed four maxillary complete dentures and a polishing brush in order to asses the microbiologic contamination degree.

The samples were coded and analyzed as follows:

- P1 – non-sterile dentures polished using brushes and polishing paste that had been usedin prior processing
- P2 – non-sterile dentures polished using brushes and polishing paste that had not been in prior processing
- P3 – sterile dentures (sterilized using a Pursept 0.15 g/l solution) polished using brushes and polishing paste that had been in prior processing
- P4 – sterile dentures (sterilized using a Pursept 0.15 g/l solution) polished using brushes and polishing paste that had not been used in prior processing
- P5 – polishing brush that had been used for prior processing

-The control was represented by sterile and non-sterile dentures analyzed before they were processed in the dental laboratory.

The contamination degree assessment was achieved by the method of growing microorganisms on Petri dishes, Simona Dunca, Octavita Ailiesei, Erica Nimitan, Stefan Marius, (2004), using nutritive agar (Merck, Germany). The inoculum was obtained by repeatedly washing the prosthesis with 5 ml of sterile distilled water. For the samples processed with brushes and polishing paste used prior in other processing activities we made decimal dilutions (10-1 - 10-3), that were later used for insemination. For inoculum we used a volume of 100 µl inoculum / Petri dish, and in the brushes case we conducted the insemination both by washing it and by imprinting it in the agar.

The incubation (24 hours at 37° C) was followed by a quantities assessment of the microbial load and all determinations were carried out in triplicate.

Results and discussions

The experimental model that was used clearly demonstrates these premises. We underwent microbiological investigations both non-sterile and sterilized (using current disinfectants) dentures. In order to asses the microbiological contamination degree inside the dental laboratory, the dentures were processed using both new and used brushes and polishing paste.

The microbiological analysis of the non-sterile prosthesis (fig.42) showed that the processing conducted with instruments and paste that were used before in other dentures induces a considerable increase of the microbiological load (fig.43).

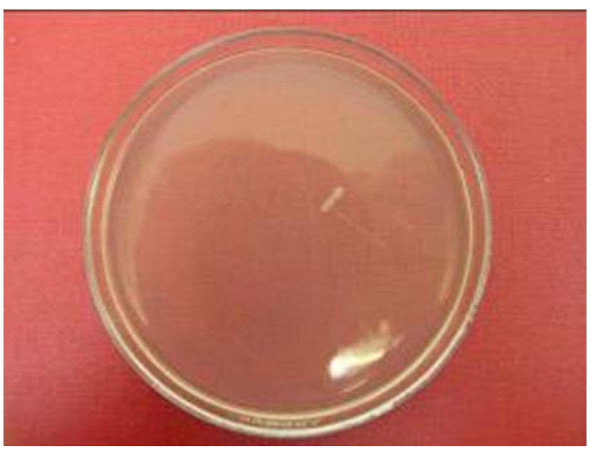
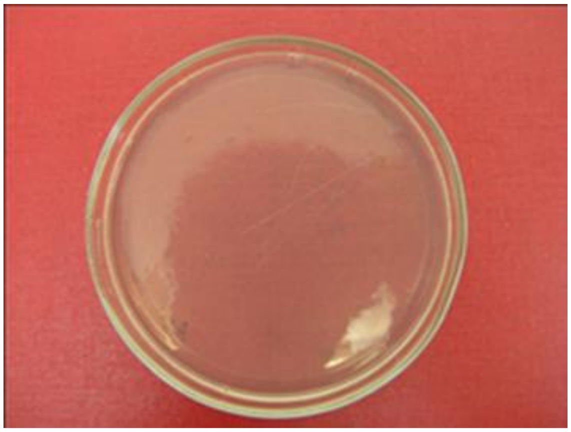


Fig.42 – Microbial load of sample P1 before processing with brushes and polishing paste that had not been used before (dilution 10^{-3})

Fig.43 - Microbial load of sample P1 after processing with brushes and polishing paste that had been used before (dilution 10^{-3}

A lower contamination level was established for the non-sterile dentures (fig.44) that were processed with brushes and polishing paste that were not used prior for other dentures (fig.45).



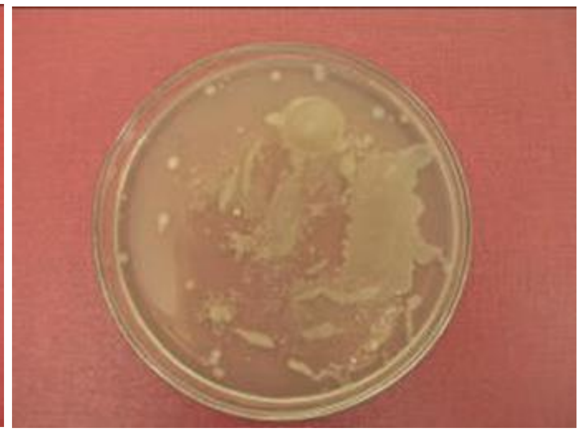


Fig. 44 - Microbial load of sample P2 before processing with brushes and polishing paste that had not been used before (dilution 10^{-3})

Fig.45 - Microbial load of sample P2 after processing with brushes and polishing paste that had been used before (dilution 10^{-3})

In this case the high number of contaminant microorganisms cannot be attributed to the used brushes and paste (fig.46, fig.47), but more likely to the manipulation of the prosthetic parts inside the dental laboratory.

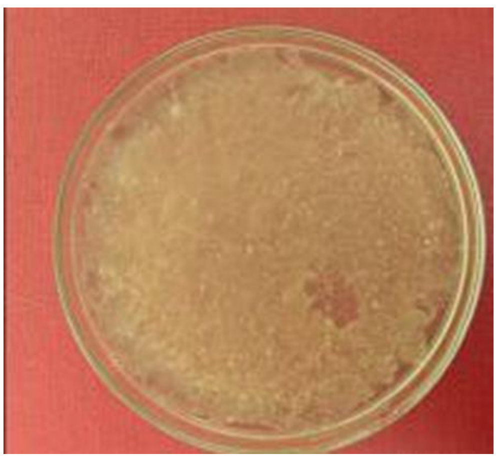


Fig. 46 - Microbial load of sample P5

Fig. 47 - Microbial load of sample P5 (imprint)

(dilution 10^{-3})

The existence of two contamination sources for the dentures through the processing algorithm is also supported by the result of the analyses made on dentures sterilized with Pursept 0.15 g/l. The sterilization was carried out to remove the initial microbial load of the dentures in order to better highlight the potential contamination sources from the dental laboratory Our results confirm initial observations according to witch processing dentures with wised brushes and paste (fig.48), induce a massive contamination (fig.49).

The results obtained in the present study come to complete existing studies (Vázquez-Rodríguez A et al., 2018; Moodley KL et al., 2020; Latib YO *et al.,* 2018) which have shown that in dental laboratories the transition of contaminant microorganisms is carried out by the prosthetic devices received from dental offices, but more importantly by processing these dentures that were checked and adapted in the oral cavities of patients .

Studies in the field have shown the instruments and pastes used for polishing dentures are the most important source of contamination toward the dental office but also toward the dental laboratory (Ajithan SL et al., 2021; Harel SK *et al.*, 2004; Tellier R *et al.*, 2019).

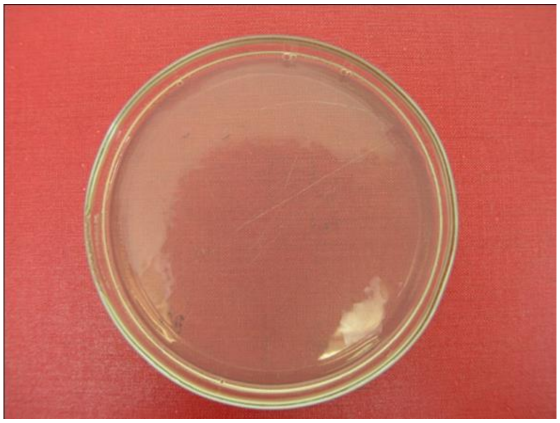


Fig.48 Microbial load of sample P3 before processing with brushes and polishing paste that had not been used before (dilution 10^{-3})

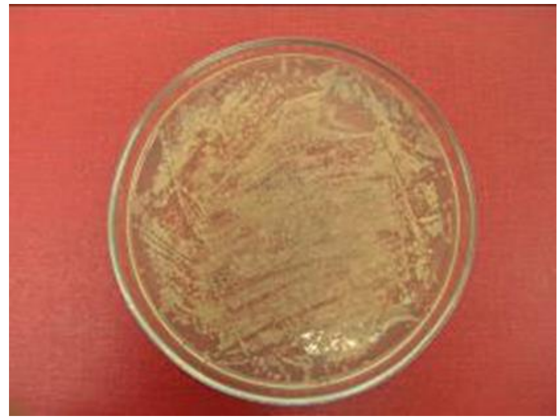


Fig.49 - Microbial load of sample P3 after processing with brushes and polishing paste that had been used before (dilution 10-3)

Also the test carried out in the Microbiologic Laboratory confirmed the fact that sterile dentures (fig.50) can be contaminated not only by processing them but also by simply handling them during processing (fig.51).

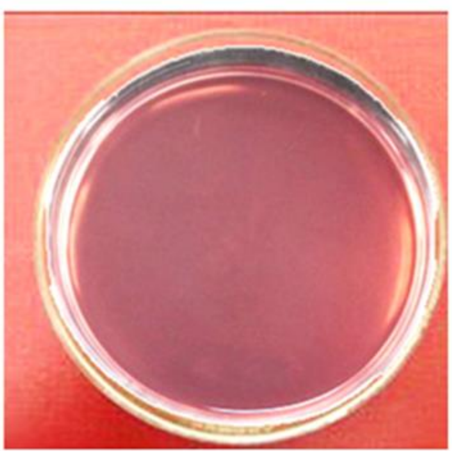


Fig.50 Microbial load of sample P4 before processing with brushes and polishing paste that had not been used before (dilution 10^{-3})

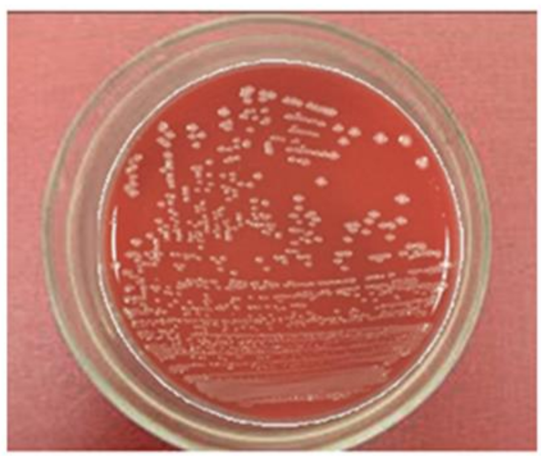


Fig.51 Microbial load of sample P4 before processing with brushes and polishing paste that had been used before (dilution 10^{-3})

Conclusions

Knowing the sources of contamination in dental laboratories allows a correct assessment of the risk of cross-infection and of the consequences on patients, dentists and dental technicians.

The technological steps for complete dentures realization, using conventional methods, involve a large number of technological stages and, implicitly, numerous intermediate prosthetic devices.

Not only dental impressions are a source of contamination but also working models, temporary prostheses, diagnostic wax-up, shade guides, wax rims, wax patterns, face bows, custom trays, as well as finishing and polishing tools.

Improperly disinfected prosthetic elements release contaminated dust into the work environment, which increases the risk of cross-infection.

Polishing of dental prostheses can cause a dangerous cycle of cross-contamination involving dentists, laboratory technicians, patients and auxiliary personnel.

In prosthetic laboratories, lathes and pumice, usually used for polishing procedures and finishing of prostheses have been described as thegreatest sources of contamination .

Although there have been concerns in this field for many years, there is a lack of concretization of results as a direction of practical application, so that the achievement of a guide of unitary measures to be observed in all dental work units is an extremely necessary and unique measure.

Anyhow, cross-contamination probability between the clinical setting and the dental technician seems to be greater than contamination risks between dentist and patients or from one patient to another. In fact, and despite the lack of contact with patients, dental technicians have been reported to experience significantly higher exposure to hepatitis B virus than a comparable population (2.7% vs. 0.76).

The conclusions drawn from this study are useful for the elaboration of a practical guide of effective prophylactic measures in order to establish strict rules of asepsis and antisepsis within the clinical-technological algorithm for making dentures.

CHAPTER 3

TECHNOLOGICAL POSSIBILITIES FOR FULL DENTURES REALIZATION

II.3.1. State of art

Full denture is a treatment solution frequently used in complete edentulism because technological process is accessible and the materials used are generally low cost.

The complex pathology of the stomatognathic system induced by the total edentation offered the researchers a vast field of analysis, demonstrated in the literature by the multitude of information, systematized in numerous articles (Sharma P *et al.,* 2020; Sheth N *et al.,* 2018)

Most often, the dento-maxillary dysfunctions are generated by the loss of teeth, by odontal or periodontal damage. The higher the number of missing teeth, the more important the imbalances will be and will lead to other disorders, at the level of the temporomandibular joint or at the muscular level, with consequences on the position of the remaining teeth, on the occlusion, on the aesthetic aspect, on the patient's psyche and his social integratione (Radke UM *et al.,* 2012)

Complete dentures are

in contact with a large area in the oral cavity and the insertion of a prosthetic construction of such amplitude does not only suppose the restoration of the altered or lost functions but also the creation of a new balance between all elements of the stomatognathic system. The treatment planning, having previously the informed consent of the patient, is a fundamental point for the success of a dental treatment (Albaker AM *et al.,* 2013; Marlière DAA *et al.,* 2018)

The choice of the optimal therapeutic solution must be based on a correct and complete clinical examination, on the results of the general, regional and local complementary examinations, on an objective evaluation of the patient's wishes and expectations. The difficulties of choosing a therapeutic strategy consist in achieving a balance between meeting the patient's requirements and the possibilities offered by the clinical situation (Foong KW *et al., 2*019).

Although, from a technological point of view, full denture is easy to make (the technique being simple and the laboratory does not require high-performance equipment) a number of problems arise when adapting it, due to important changes in the elements of the stomatognathic system and the installation of major imbalances (Suja J *et al.,* 2015).

Analyzing all the elements in the prosthetic area and establishing positive and negative clinical and biological indicators, the dental team will know what the therapeutic strategy is, during the stages of making the full denture and will be able to establish exactly the indications and contraindications for this type of prosthesis (Nitschke I *et al.,* 2021)

The material choosen for complete denture realization is very important, in order to have an optimal adaptation; therefore, implicitly, the appropriate technology must be known in detail, in order to avoid errors during the clinical and technological steps. The continuous evolution in the field of dental materials has led to the production of non-acrylic resins, clearly superior to classical materials (Mistry R *et al..* 2018; Schwindling FS *et al.*, 2016; Aslanimehr M *et al.*, 2017))

In certain clinical situations, the acrylic denture, in its conventional version, does not meet all the requirements or fails to properly restore the functions, due to certain features of the prosthetic field. Therefore, it is necessary to know all the possibilities of treating complete edentulism, in order to be able to choose the optimal therapeutic option (Ravalec G *et al.,* 2020.

There are situations when, in order to increase the resistance of the prosthesis, it is necessary to reinforce the base with metal nets or with fibers or resin nets, that considerably improves the mechanical characteristics of the denture. Or, in some cases, we can restore the dental arches choosing as a treatment option tooth supported or implant supported overdenture. In order to determine the most correct therapeutic solution it is necessary to evaluate the characteristics, advantages and disadvantages of each prosthetic restoration (Idzior-Haufa M *et al.,* 2021; Keshk AM *et al*., 2107)

The major concern in complete edentulous therapy is the restoration of facial aesthetics according to biological and biomechanical behavior of the individual and to the patient's needs and desires. Therefore, it requires the development of an artificial substitutes which gives wearer the feeling of existence of his natural teeth, in the context of psycho-affective personality, preserving the patient's aesthetic characteristics (McCunniff *et al.,* 2017; Santos BF *et al.,* 2015; Roumanas ED, 2009)

The full denture represents the therapeutic solution used in the treatment of complete edentulous, due to the numerous advantages: easy-to-achieve technology, rapid and optimal resumption of stomatognathic system functions, very good biocompatibility, the possibility of optimization or repair. At the same time, the disadvantages of these prosthesis (the atrophy of the alveolar ridges, difficulties in ensuring the retention and stability, diminishing the taste sensitivity, discomfort due to the large volume), cannot be ignored (Patel J *et al.,*2018; Jablonski RY *et al.*, 2015; Carlson GE *et al.*, 2010)

Hard and soft tissues can be replaced with modern materials and the wide variety of artificial teeth, with varied shapes and shades, meet the aesthetic requirements of patients. But all their advantages and disadvantages must be carefully analyzed before designing the treatment strategy for complete edentulous.

The insertion into the oral cavity of a prosthetic construction of such amplitude it doesn't mean only the restoration of altered or lost functions, but it also means to achieve a new balance between all the elements of the stomatognathic system. Planning the therapeutic steps having previously informed patient consent, is fundamental for the dental treatment success (Xie Q *et al.,* 2015; Sivakumar A *et al.,* 2012)

A correct prosthodontic treatment does not only means to restore the continuity of the dental arches, but it also means a holistic approach of the situation, in order to seamlessly integrate the construction into the prosthetic area. It should be taken into account that the complete edentation does not only mean the absence of teeth but also the occurrence of loco-regional imbalances, affecting all the elements of the stomatognathic system and even the appearance of general dysfunctions (Bhattacharjee B *et al.*, 2021; Mary KM *et al.,* 2020)

The prosthesis aims not only to replace the missing natural dental arches but also to restore the altered functions and to limit the installed imbalances to the maximum. The application of an artificial substitute involves a relationship between two elements: the prosthesis and the biological support on which it is inserted; changes between those elements occur over time, which may impede normal functionality (Sivakumar I *et al.,* 2105) Therefore, the prosthetic treatment should not be considered completed after the application of the prostheses in to the oral cavity, but must be continued after this step, following the patient, through periodic checks, to detect and correct any changes that have occurred, both on of the biological support and on the level prosthetic construction (Kimoto S *et al.,* 2018;. Müller F, 2014)

Aesthetics in full denture is achieved by restoring the correct vertical occlusion dimension, the facial contours, choosing the appropriate shape, size, color of artificial teeth and artificial gingiva. In the realization of a full individualized denture, a particularly importance is played by the vestibular slope of the saddles, which must reproduce all the morphological details and to restore the physiognomic aspect by volume, relief, color (Marachlioglou CR *et al*, 2010; Bin Abdul Salim N *et al.,* 2017))

The volume of the artificial gum contributes to the rehabilitation of the appearance of the harmonious contour of the lips, to the blurring of the perioral grooves, in accordance with patient's age; it also offers the orbicularis and buccinator muscles a proper support and optimal conditions for action, in order to ensure the retention and stability of the prosthesis.

Replicating the root eminences is also important for the aesthetic aspect. These morphological elements correspond to the roots of the teeth, the most marked being the canine eminence. The prominences become progressively less marked in the premolar and molar region. Special attention must also be paid to the modeling of interdental papilla and to the free gingival margin. The color of the artificial gum must be correlated with that of the oral mucosa, but also with the skin of the patient's face. There are different color keys capable of accurately reproducing the color variations of the natural gums, in order to create the illusion of natural.

In this article we present a clinical case that illustrates a technique for restoring the physiognomic function through an individualized aspect of the artificial gingiva of the full denture. The polychromy method consists of the superimposition of some layers of resin, in different shades of colors in order to restore the most natural appearance of artificial gum. This technology allows to obtain physiognomically optimized full dentures, compared to the prostheses obtained through the classical technology. An aesthetic aspect as close to natural as possible will make patients to accept faster the prosthesis (Alheeti OAR et *al.,* 2020; Soares GP *et al.,* 2016; Tarvade SM *et al.,* 2015)

Complete dentures are relatively economical, easy to fabricate and repair, and provide a level of esthetics and function acceptable to many patients.

Acrylic resins remain the materials of choice for removable complete dentures, due to their indisputable qualities: easy to make and repair, good physical properties, acceptable aesthetics, good thermal conductivity, low permeability to oral fluids, color stability, low water sorption, low solubility, very accurate in reproducing surface detail, low weigh and a low cost

But these materials also have a number of disadvantages, such as: poor mechanical properties, high coefficient of thermal expansion, low modulus of elasticity, increased risk of fracture, mucosal irritation caused by the release of methyl methacrylate or bacterial colonization, due to their porosity (Alla R *et al.,* 2015; Gad MM *et al.,* 2017) .

Denture porosity could potentially result in increased oral biofilm accumulation and microorganisms that cause denture stomatitis. Extensive researches have been done to eliminate these disadvantages and to improve the properties of acrylic resins; these studies aimed to develop alternative materials, to modify and to optimize the structure of polymers or to increase the mechanical strength of methyl poly-methacrylate.

Frequent complaints of full denture wearers include lack of denture retention and loss of the masticatory ability. The edentulous ridge undergoes continuous resorption over the years, ultimately compromising the fit and stability of dentures. Only 13% of denture wearers seek annual dental care; dental implant supported dentures may provide more functional capacity than less costly conventional dentures, but not every patient is an implant candidate (Parvez K *et al.*, 2020, Bosînceanu DG *et al.*, 2017).

Also, an important issue that specialists faced was the mucosal irritation caused by microbial adhesion to inner denture surface. Epidemiological studies report that approximately 70% of removable denture wearers suffer from denture stomatitis. Candida albicans adhesion and biofilm formation are regarded as essential prerequisites for denture stomatitis (Gendreau L. *et al.*, 2011)

Another problem related to denture stomatitis is that some elderly patients present difficulties on keeping the denture clean, due to their reduced motor dexterity, memory loss, and cognitive impairment. The classic treatment of denture stomatitis is based on topical or systemic antifungal drug,, but this infection is often persistent, since antifungal resistance has been reported in Candida albicans biofilms. The prophylaxis of dental stomatitis still represent a challenge for dentistry and more studies are needed to find the optimal prevention method (Zarco MF *et al.*, 2012; Carrasco-Labra A *et al.*, 2015). To provide antibacterial properties, in the last years more attention has directed toward the incorporation of AgNps into acrylic resins. AgNPs incorporation aims to avoid or at least to decrease the microbial colonization over dental materials, increasing oral health parameters and improving life quality.

Full dentures are not technologically difficult to make, but involve a large number of clinical and technological steps, so there is an increased risk of errors. With the development of digital technologies, subtractive and later additive methods, the working flow was considerably reduced and the precision of the prosthetic devices was greatly increased (Kattadiyil MT *et al.*, 2017; Schweiger J *et al.*, 2017) . These technologies use industrially produced materials, with physical, chemical and mechanical properties superior to the conventional materials. The main motivations for accepting or rejecting a new technology include the relative advantages they offer compared to the classical method, and these can be represented by time saving, financial advantages, and clinical benefits (Felton DA *et al.*, 2016; Bonnet G et al, 2017; Lo Russo L *et al.*, 2018)

The present study highlights the importance of the technologies on the characteristics of complete dentures and analyzes how modern technologies, especially digital technologies are implemented in current laboratory practice.

My contributions to this research direction can be found in the following articles:

1 **Diaconu-Popa D,** Vițalariu A, Tatarciuc M, Fratila D. Studies on the mechanical parameters of denture base acrylic resins. *Mater. Plast.* 2020; 57(4):360-365. IF=0.593.

2. Vitalariu AM, **Diaconu D**, Tatarciuc D, Aungurence O, Moisei M, Barlean- L. Effects of Surface Characteristics of the Acrylic Resins on the Bacterial Colonization. *Rev. chim. (Bucharest)* 2015; 66(10): 1720-1724. IF =0.956.

4. **Diaconu-Popa D**, Vițalariu A, Tatarciuc M. Digital technologies for complete dentures realization. *Romanian Journal of Medical and Dental Education* 2020; 9(3):43-49.

5. **Diaconu-Popa D,** Tatarciuc M, Vitalariu A. Study on the students attitude toward digital technology in dentistry. *Romanian Journal of Medical and Dental Education* 2019; 8(11): 47-55.

Tatarciuc M, Luchian I, Vițalariu A, Mârțu I, **Diaconu-Popa D**. Study regarding the technologies for complete dentures realization. *Romanian Journal of Oral Rehabilitation* 2021*; 3(13):200-211*.

3.1 Analysis on the main technologies for complete dentures realization

Intoduction

Complete edentulous therapy continues to concern specialists everywhere, being considered as a domain of particular difficulty, because it is not limited to the design and fabrication of a full denture, because it addresses to one of the most complex pathology, generating imbalances of all the elements of the dento-maxillary system. The installation of a full edentation should be seen as the beginning of an involution process of disturbing the physiological balance, generated by the constant depreciation of the anatomical structures of the whole body, with implications on the stomatognathic system, which can trigger permanent stresses, that places the elderly, in a state of psycho-somatic lability.

An important role in the satisfaction of the patients wearing a removable denture has the realization of a prosthetic construction that adapts perfectly to the oral cavity and completely restores the altered functions; also, a balance must always be maintained between the patient's wishes and the objective possibilities of the clinical situation (Lee J *et al.,* 2019;. Hsu Y-J *et al.*, 2020)

In order to obtain removable prosthesis that satisfies all these requirements, the material has to be very carefully chosen; the resin must sum up a series of characteristics: to have a color close to the oral tissues and a translucency that allows the optimal reproduction of the physiognomic function, not to change color over time, to present volumetric stability, not to alter its shape during mechanical processing or in the oral environment, to have an elasticity and abrasion resistance adequate to any demands in the oral cavity, to be waterproof for fluids in the oral cavity, to have a smooth and glossy surface, which does not allow the adhesion of food fragments or bacterial plaque and it should be easy to clean; also the material must have a low density, a low thermal conductivity, and it must not undergo volumetric variations during temperature variations (Urban VM *et al.,* 2007).

The materials frequently used for partial and full dentures are acrylic resins, offering these prosthetic constructions sufficient strength and a proper aesthetic appearance (Sakaguchi RL, 2012)

The question that arises is whether conventional technologies remain the method of choice for making full dentures and whether digital technologies can be implemented in the case of making these prosthetic constructions.

Making a complete denture involves a large number of clinical and technological steps, and digital methods have the advantage of greatly reducing the workflow. On the other hand, the costs of such a technological line are still very high and many technicians do not consider it an investment profitable purchase of equipment for making removable prostheses, by additive or subtractive methods.

In recent years, CAD / CAM technologies for the complete dentures realization became better known and more available, and methods and materials are becoming more efficient, allowing to obtain prosthetic constructions that satisfy the highest functional requirements. These procedures offer significant benefits to the dentist, dental technician and also to the patients (Saponaro PC *et al.,* 2016; McLaughlin JB *et al.,* 2019; Wulfman C *et al.,* 2020; Pacquet W *et al.,* 2019).

The present study analyzes the opinion of dental technicians regarding these modern methods of getting removable prostheses and follows the proportion in which laboratories use digital technologies.

In case of conventional technologies, for the two types of resins, heat-curing and self-curing materials, there are advantages and disadvantages. Therefore, it is very important for the dental technician to know the particularities, advantages and disadvantages of the materials and technologies on the market, in order to choose the optimal therapeutic solution for each clinical situation.

Materials and methods

In order to analyze the methods used in the laboratory for making full dentures, an original questionnaire was used, with 10 questions, which was distributed to 92 technicians, aged between 24 and 49, working in private dental laboratories (table XVIII).

Table XVIII. The questionare for the dental technicians

	Question		
1.	**For the realization of full dentures, do you use in the laboratory exclusively conventional technologies?**		
	Yes	**No**	**I don't know**
2.	**For making full dentures, do you use mainly digital technologies**		
	Yes	**No**	**I don't know**
3.	**If you use conventional methods do you prefer HCR?**		
	Yes	**No**	**I don't know**
4.	**If you use conventional methods do you prefer SCR?**		
	Yes	**No**	**I don't know**
5.	**Do you think that the technology that uses SCR is superior to the one that uses HCR?**		
	Yes	**No**	**I don't know**
6.	**Do you appreciate that complete dentures made of SCR have better longevity over time?**		
	Yes	**No**	**I don't know**
7	**Do you think that SCR should only be used for temporary prostheses?**		
	Yes	**No**	**I don't know**
8.	**Do you think that prostheses made by conventional methods have a better adaptation compared to total prostheses made by digital methods?**		
	Yes	**No**	**I don't know**
9.	**Do you consider that, for complete dentures, additive digital technologies are superior to subtractive technologies?**		
	Yes	**No**	**I don't know**
10.	**Do you think that laboratories should purchase software for making full dentures using digital methods?**		
	Yes	**No**	**I don't know**

74 respondents (80.43%) completed the questionnaire and expressed their opinions on the materials used in the laboratory for making complete dentures, as well as their opinions on the effectiveness of conventional and modern methods of making these mobile prostheses.

Result and discussions

Following the answers to the first and second questions, it is a clear the preference of dental technicians for the use of conventional methods (90.54%) of performing full dentures (fig.52).

Even though digital technologies reduce a lot the workflow, the relatively high costs of equipment and the need for additional training of technicians, make these modern methods not preferred in current practice.

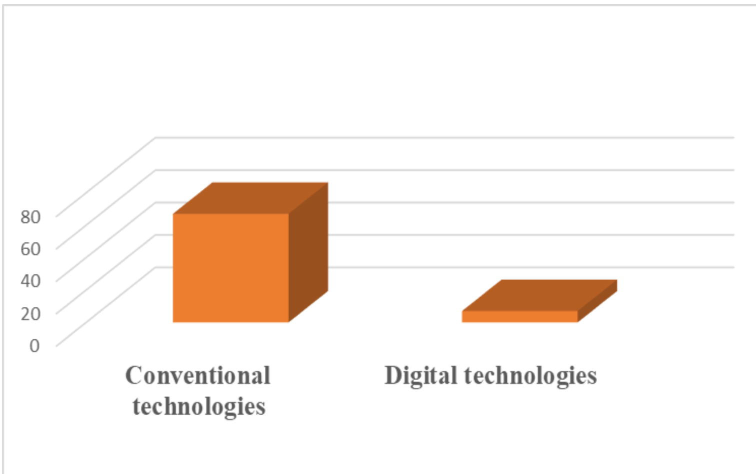


Fig. 52 Technological methods for full dentures realization

Within conventional technologies, 52 respondents (70.28%) prefer heat-curing resins for removable dentures and only 22 technicians (29.73%) use self-curing acrylic resins (fig53).

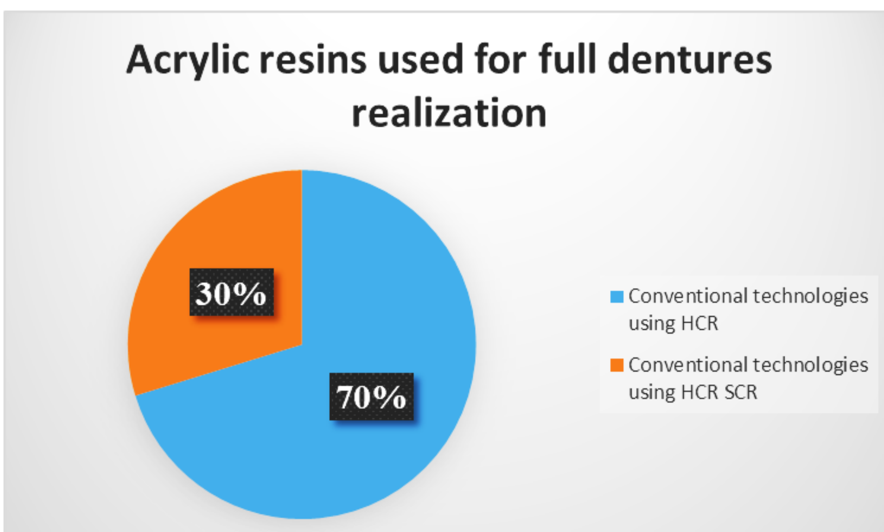


Fig.53 Acrylic resins used in conventional methods

In recent years, several types of self-curing acrylic resins have appeared, which have optimized mechanical parameters and are used in the technology of making removable prostheses. Dental technicians who answered our questionnaire consider, in proportion of 81.08% (60 respondents) that heat-curing resins are better for these type of prosthetic devices and only 18.92% (14 respondents) believe that self-curig resins are indicated for full dentures (fig.54).

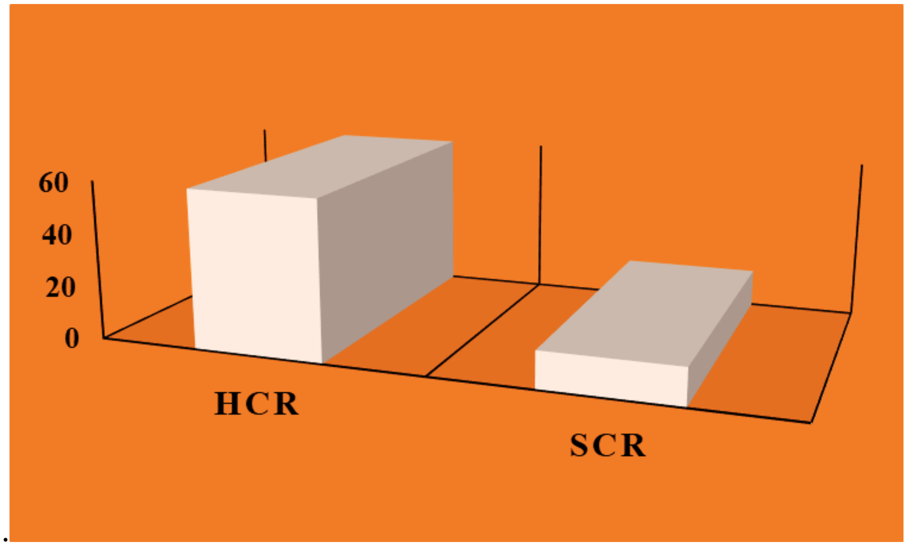


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Fig.54 Opinions on use SCR utilization for full dentures realization

Only 7% of respondents (69) believe that self-curing resins have a great longevity over time compared to heat-curing resins (fig. 55)

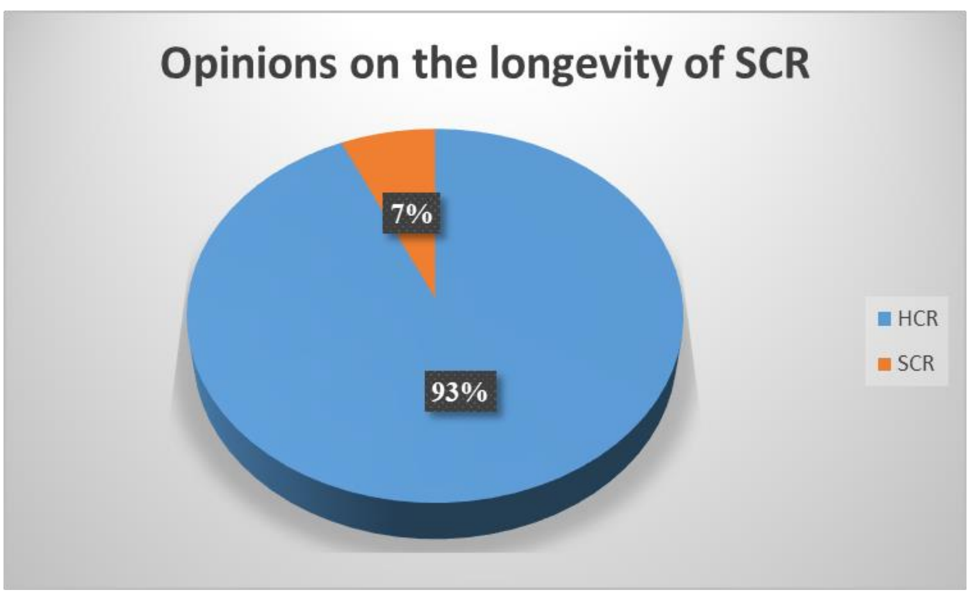


Fig.55 Longevity of self-curing and heat-curing resins

Many researchers in the dental materials field noticed that self-curing materials have a higher porosity compared to materials polymerized by other methods, therefore, recommend self-curing resins for temporary prostheses. Technicians who answered this question agreed in percent of 79.73% (59 respondents) that self-curing resins should be used exclusively for temporary restorations (fig.56).

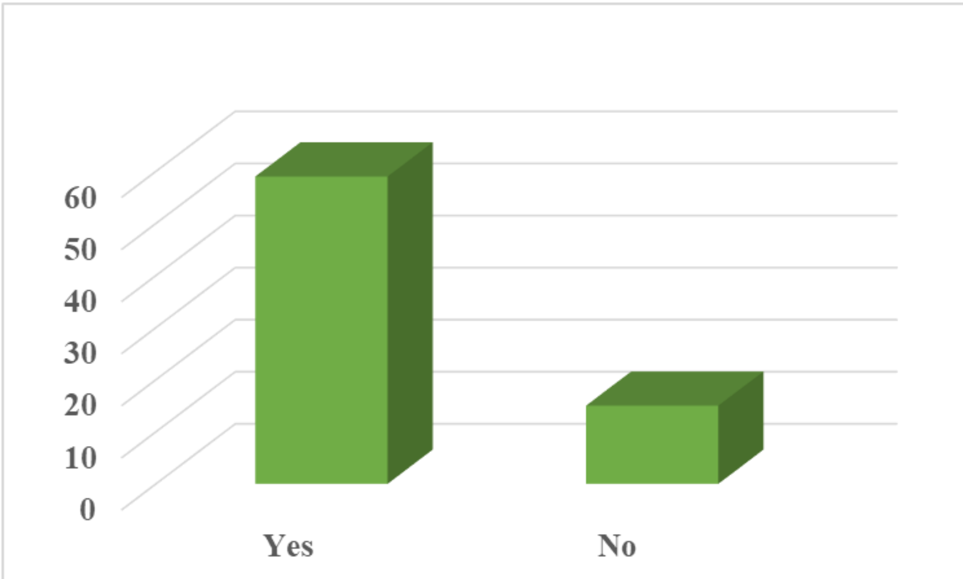


Fig.56 Opinion on the SCR utilization for temporary restoration

At present there are very few studies to compare adaptation of CAD-CAM and conventional denture. Some experts believe that digital complete dentures have a perfect marginal fit, while others say that the stability and fit of digital dentures is poor. 73% of technicians (54 respondents) state that conventional prostheses are better adapted to the prosthetic area compared to removable prostheses made by digital methods (fig 57).

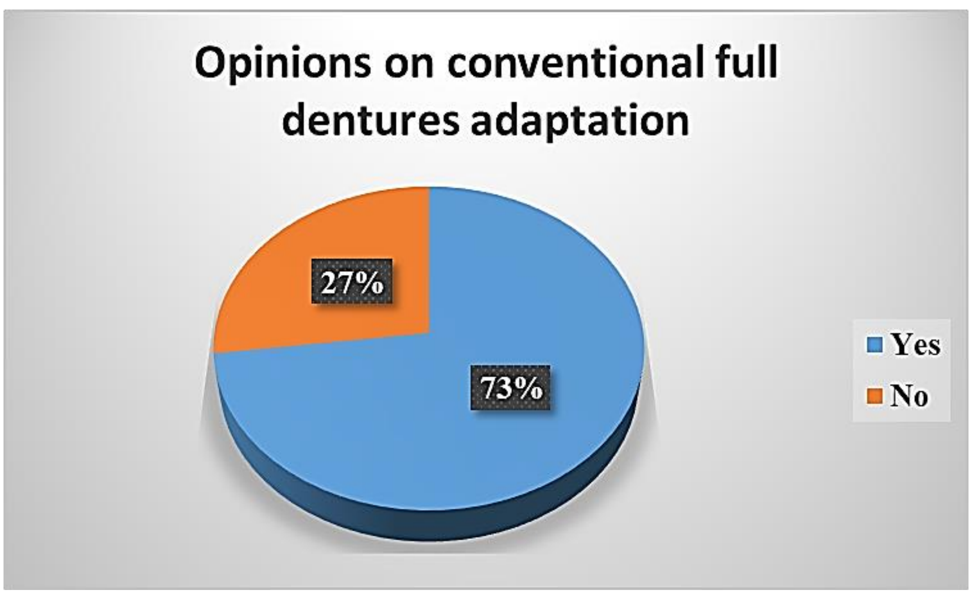


Fig. 57 Opinions on the marginal adaptation of prostheses made by conventional and digital methods

Digital technologies for removable prostheses realization can be subtractive or additive methods. Subtractive technologies involve the use of resin discs, from which, based on the information received from the CAD component, the elements of the full denture will be milled. Additive technologies involve an superposition of the material, layer by layer, until the complete edification of the prosthesis morphology These methods allow to obtain a prosthetic construction with complex spatial geometry and very compact internal structure. The technicians who use the digital methods in the laboratory answered in this questionnaire, in proportion of 81.08% (60 respondents) that the additive methods are superior to the subtractive ones and allow to obtain more precise prostheses (fig.58).

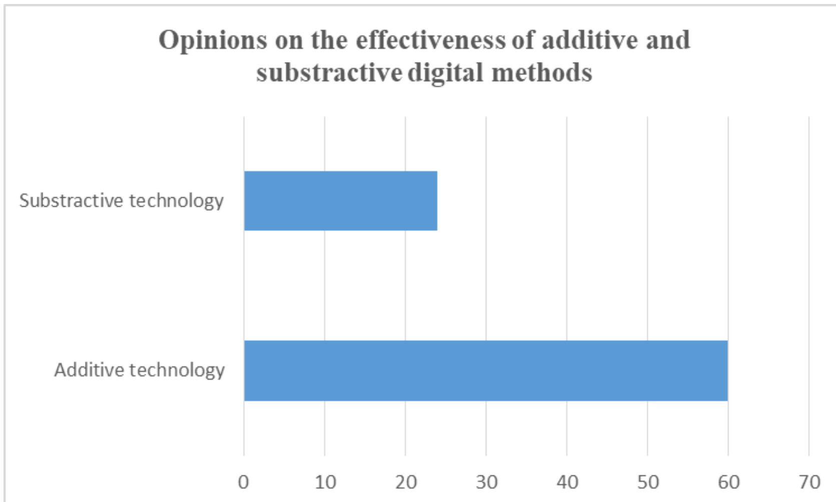


Fig. 58 Opinions on the effectiveness of additive and subtractive digital methods

57% of technicians (44 respondents) stated that, despite the advantages, it is not justified to introduce digital systems for removable full denyures realization in the dental laboratory (fig.59).

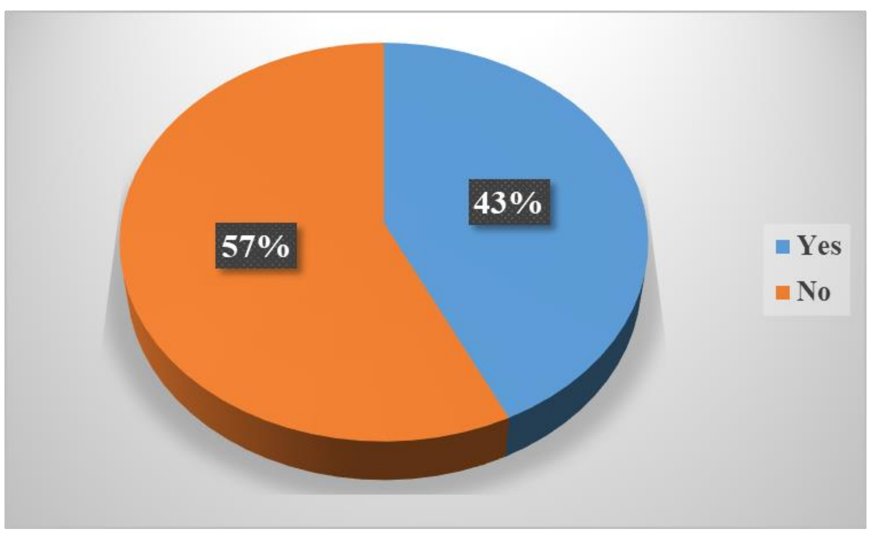


Fig.59 Opinions regarding the usefulness of acquiring CAD-CAM systems for complete denture realization

The conventional technology of full dentures realization involves a multitude of laboratory stages, during which errors can occur; a mistake during a technological step is transmitted and amplified in the next step that can eventually lead to an incorrect adaptation of the denture on the prosthetic area, incorrect occlusal repports or reduced mechanical strength. Researches had also shown that conventional acrylic resins, based on methyl polymethacrylate, in addition to the many advantages, also have a number of disadvantages.

Therefore, as new materials emerged and technologies evolved and diversified. Systems for injecting the resin into the mold became increasingly popular in practice, a method that has several advantages over the manual introduction of acrylate.

Currently, full dentures can also be made from new generation self-curing resins, with cold polymerization, under 60 °C (Palapress, PalaXpress, Palapress Vario / Kulzer) that have comparable or even superior properties to thermopolymerizable ones: chromatic stability over time, resistance to bending, shock and elasticity. They can be molded both by pressing and injection.

Digital systems are also used to make total mobile prostheses.

Computer Aided Design / Computer Aided Manufacturing (CAD-CAM) methods have the advantage of eliminating a lot of laboratory steps and reducing the cost and the risk of errors.

In recent years, CAD / CAM technologies for the complete dentures realization became better known and more available, and methods and materials are now more efficient, allowing to obtain prosthetic constructions that satisfy the highest functional requirements. These procedures offer significant benefits to the dentist, dental technician and also to patients.

CAD / CAM technologies follow three important steps: data acquisition, by using intraoral scanners or by scanning a plaster model from a conventional impression, designing the virtual prosthetic construction and digital realization of the prosthesis, using new generation materials.

The resins used in digital technologies are industrially produced, have a high impact and distortion resistance, color and dimensional stability. The pre-polymerized acrylic resin is produced under high pressure and heat and no polymerization shrinkage occurs, the porosity is reduced and the microbial adhesion to the base of the prosthesis is low. The lack of polymerization contraction associated with these types of prostheses results in a very precise adaptation of the prosthesis and optimal maintenance and stability.

Not only the base of the prosthesis can be made by digital methods, but also artificial teeth, being able to obtain artificial arches with a superior morphology, strength and aesthetics.

Some methods get the base, saddles and arch artificially in one step, while other technologies recommend making the base and saddles at one time and the artificial teeth at another time, and the two elements will be assembled in one subsequent step.

Subtractive technologies involve the use of resin discs, and, based on the information received from the CAD component, the elements of the full denture will be milled.

Additive technologies represent another possibility of making total prostheses by computerized methods. These methods allow to obtain a prosthetic construction with complex spatial geometry and very compact internal structure.

In the manufacturing process by the additive method the prosthesis will be made by superimposing the material layer by layer, until the complete edification of the morphology. The main stages of prosthetic construction are: deposition of resin layers in the horizontal direction and their successive polymerization, in vertical orientation, removal of rods necessary to support the device during construction, removal of unpolymerized material and completion of prosthetic work. After the polymerization is completed, the prosthesis is finished and polished.

In the subsequent stage, the artificial teeth are fixed into the saddles and fixed with light-curing resin. The 3D Printing method has several advantages compared to conventional technology: superior precision, superior reproduction of details, increased work efficiency (more prostheses can be done simultaneously), less material and a shorter work-flow.

The results show that dental technicians prefer conventional technologies and heat curing acrylic resins for complete dentures, even though digital methods offer a number of advantages that make it easier for practitioners to work.

Conclusions

The differences between digital and conventional technologies are much discussed by specialists, each method having undeniable advantages, but also disadvantages.

The conventional technology, using heat curing for complete dentures was the oldest and earliest techniques; with the appearance on the market of new materials, with improved properties, the tendency is to replace these classic methods with new and more advanced production systems.

Digital technologies, initially used to make crowns and dental bridges, began to be used for removable partial and full prostheses.

The main motivations for accepting or rejecting these technologies include the relative advantages they offer compared to the classical method, and these can be represented by time saving

On the other hand, prostheses made by conventional methods have stood the test of time, demonstrating good mechanical behavior and satisfactory biocompatibility.

Our conclusions from this analysis are that, at least at this time, for the manufacture of complete dentures, technicians prefer conventional methods, even if the working algorithm involves a large number of clinical and technological steps, and increased risk of errors.

CAD-CAM systems still have a high price and their purchase would increase the costs of prosthetic devices, given that complete dentures are usually therapeutic solutions addressed to elderly patients or patients with limited financial possibilities.

Dental technicians should consider that it is mandatory to know the stages of realization and the advantages of conventional prostheses, but, at the same time, it is necessary to know the benefits of modern technologies, in order to adapt the therapeutic solutions to the particularities of each clinical situation.

3.2 ANALYSIS OF THE MECHANICAL PARAMETERS OF THE COMPLETE DENTURES REALIZED BY DIFFERENT POLYMERIZATION TECHNOLOGIES

Introduction

The characteristics of denture base resins play a significant role in prosthetic clinical performance and aesthetics. Some changes in denture base resin structure and different procedures for fabricating complete dentures have attempted to improve their mechanical properties. Denture base resin is often initiated by mixing the recommended proportion until a doughy mass is prepared, and the associated flask is filled, placed under pressure in a warm water bath or microwave, or the resin is allowed to be cured by chemical composition.

A lot of studies have investigated the effects of various factors on denture properties, such as commercial types of resin, their composition, filler, finishing and polishing mode (Oleiwi JK *et al.*, 2018;Salih SI *et al.*, 2015).

PMMA acrylic resin is the most common material used in dentistry, and is classified into heat-cured, chemical, lightcured, and microwave groups according to their chemical reactions. The polymer and monomer are mixed together and the mixture needs curing; the conventional heat-curing polymerization cycle is a long procedure (Ardelean LA *et al.*, 2017).

Many studies show that heat cured denture base material exhibited higher tensile strength as compared to self-cure denture base material. Also, the rigorous non-observance of the technological parameters within this method can lead to defects, most frequently observing the appearance of porosities (Lee DJ *et al.*, 2019) Porosity may be due to many factors such as the presence of residual monomer, air entrapment during mixing, monomer contraction during the polymerization, monomer vaporization associated with exothermic reaction. The mean percent porosity was related to the specimens' weights and the absolute density of acrylic resin (Rickman LJ *et al.*, 2017; Singh S *et al.*, 2013)

Many types of equipment developed for simplifying the curing procedure and to produce better properties for the cured acrylic resin.

Our study aims at a comparative analysis of the mechanical parameters of two types of resins frequently used in practice for the realization of full denture: self and heat-curing resins.

2. Materials and methods

Self-curing and heat-curing acrylic resins are frequently used to make full dentures. In order to analyze the mechanical behavior of these two categories of resins we used two different types of acrylic dental resins: a heat curing (Meliodent HC/ Heraeus Kulzer Senden, Germany)) and a self-curing resin (Vertex Castavaria /Vertex Dental B.V., Yeist, Netherland) We made 60 samples, 30 for each material, that were tested from the mechanical point of view and also we analized the structure and the surface parameters. Pink wax patterns were made, 2 mm thickness, with 75 mm length, 12.5 mm width at the extremities and 4 mm in thickness in the central area.

The wax patterns were transformed in acrylic specimens according to the technology used for acrylic dentures. They were invested in dental stone (Elite Rock class IV/Zhermack) in order to obtain a mold. Then the acrylic resin pastes were prepared, following the producers indications for each type. The powder and liquid were mixed into a porcelain jar, then the acrylic resin paste was packed into the mold at the dough stage, the flask was closed and pressed. For the heat-curing resin the flask was immersed into a water bath and the temperature was rised up to 100°C, at 2-4 bar, during 20 min, and for self-curing resin reaction conditions have been 45°C, 2-4 bar, during 5 min.

After polymerization the samples were finished, polished and finally immersed in distilled water and stored at 37°C, for one week, before testing (fig.60).

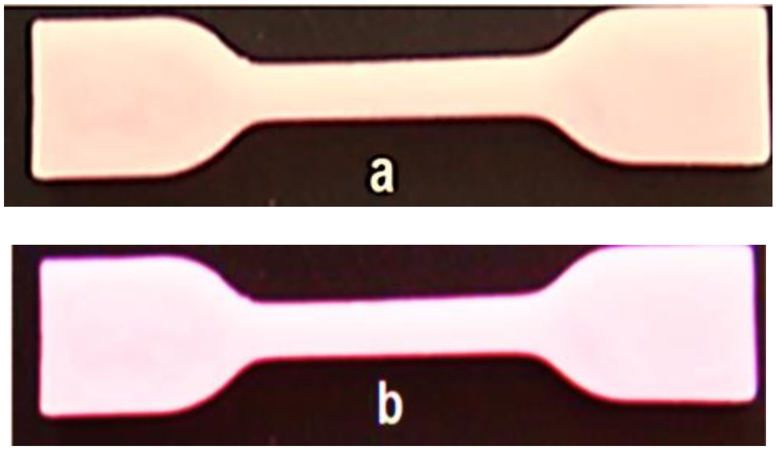


Fig.60 HCR (a) and SCR (b) samples

Tests for analyzing surface roughness

Roughness is an important characteristic of the surface quality and can be assessed by determining the micrometric profile of the finished and polished samples. For each sample Ra was registered. Ra represents the arithmetical mean of the absolute values of the profile deviations from the mean line of the roughness, and Rz - the average of all values represented by the maximum height between the maximum and the minimum profile within the assessment length, for each sample. Ra and Rz values were automatically calculated and the diagrams were recorded with the Mahr M1 Perthometer device Mechanical tests were carried out at room temperature according to the ISO 527-1: 2000 standard, using a computer-controlled testing machine (Instron 3382) equipped with a dynamic clip-on strain gauge extensometer (Instron 2620-601) for direct strain measurement. The rectangular specimens were placed and fixed between the grips of the testing machine and the tensile load was applied at a crosshead speed of 1mm/s. Young's modulus, tensile yield stress and tensile strength were determined.

Results and discussion

The shape and dimensions of the micrometric profile have an influence on the adherence and development of the bacterial biofilm at the internal surfaces of the acrylic prostheses. After analyzing the roughness, the results do not show changes in the surfaces of the samples: HCR and SCR, the specimens being processed with the same instrumentation and in the same steps.

The charts obtained after centralization the results, for both categories of resins, are not significantly different, at this stage the roughness of the surfaces being very similar. If the finishing and polishing methods were the same, the minimum difference that appears between the two values is determined by the curing mechanism (fig.61)

HCR		SCR	
Ra	**Rz**	**Ra**	**Rz**
1.983	**11.5**	**3.374**	**16.3**

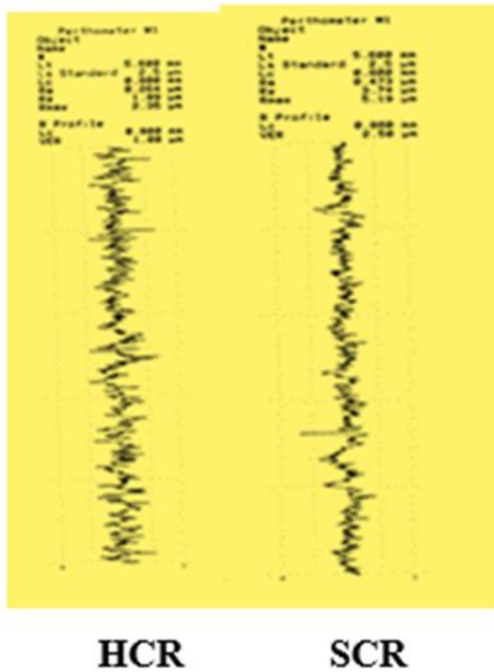


Fig.61 The roughness values registered on the resin surfaces

Young's modulus (E), was calculated according to the Hook's law E = Ϭ / ε, as the ratio between stress (Ϭ) and deformation (ε).

At a constant pressure, the decreasing of Young's modulus demonstrates a more important deformation; the lower the Young's modulus, the greater the flexibility of the material, for total prostheses being not considered an advantage. The results were statistically processed by the method of two-way ANOVA dispersive analysis and statistical significance was set at $p < 0.05$.

Analyzing the data obtained for the Young's modulus, calculated for both categories of resins, no significant differences were observed (fig.62).

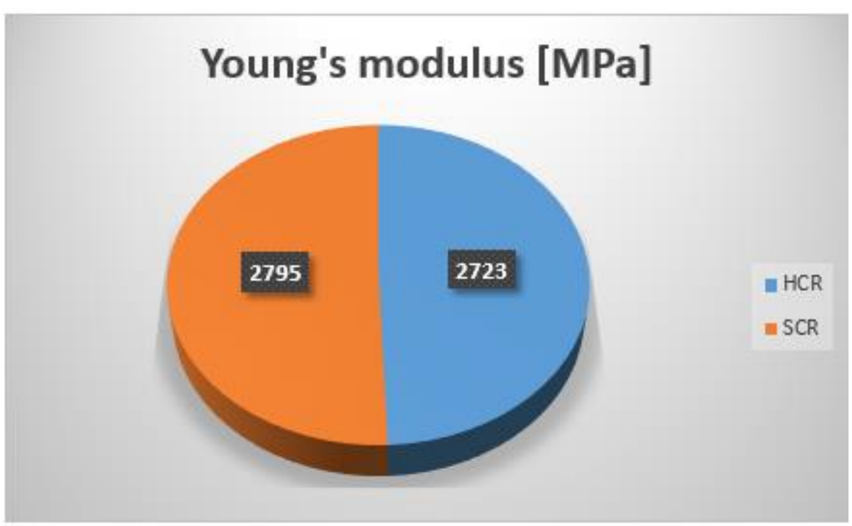


Fig.62 Young’s modulus values (MPa)

The diagrams for tensile stress and fracture strength show that, when the load is applied to the samples, it will cause changes of shape; the very first step being the elastic deformation, which is a temporary shape change, self-reversing after the force is removed.

If the action of the force continues, this change is followed by a plastic deformation and, finally by the fracture of the samples, which consists in to the separation of the material into pieces by an imposed stress (fig. 63).

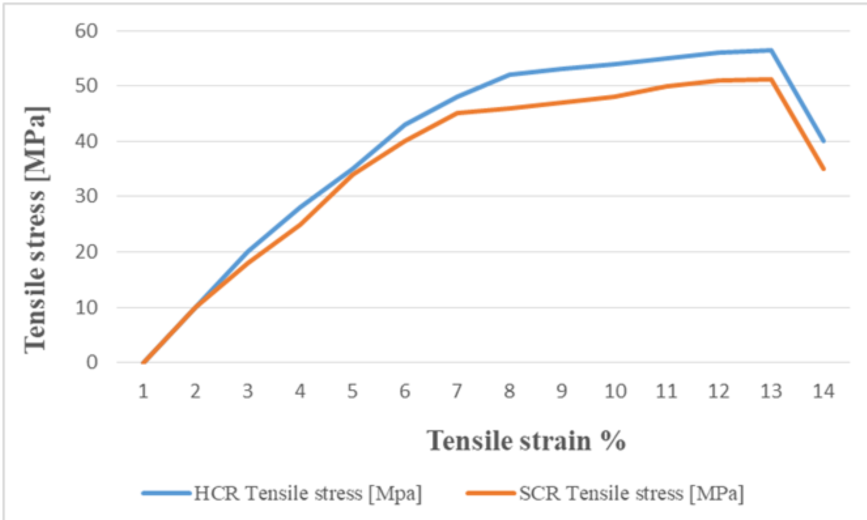


Fig. 63 Tensile tests diagrams

The maximum value for tensile stress is 44 MPa for HCR and 42 MPa for SCR (fig.64).

The ultimate tensile strength value for HCR is 56.4 MPa and for SCR is 51.2 MPa (fig.65).

The very small differences between these values show that the resins have a similar behavior at tensile forces.

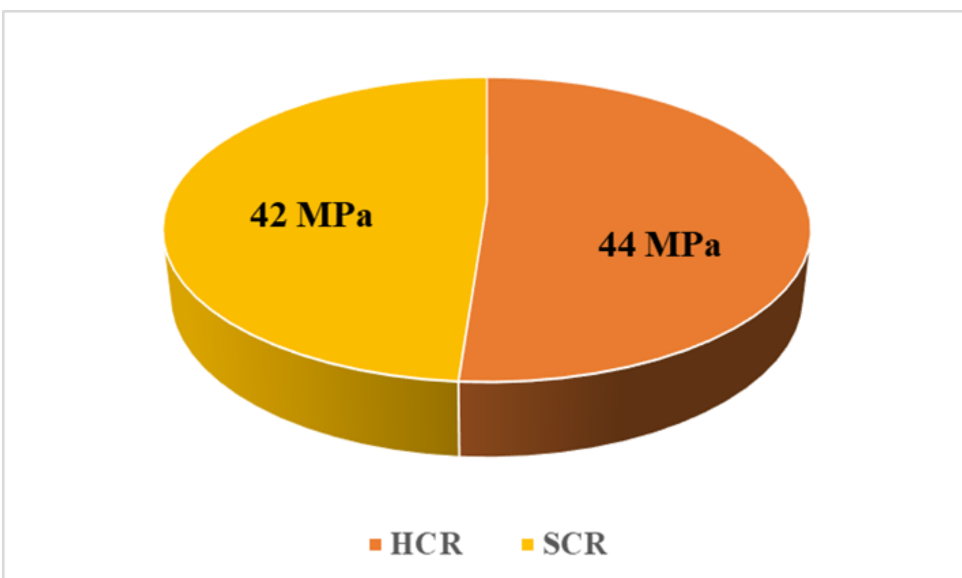


Fig.64 Maximum value for tensile stress (MPa)

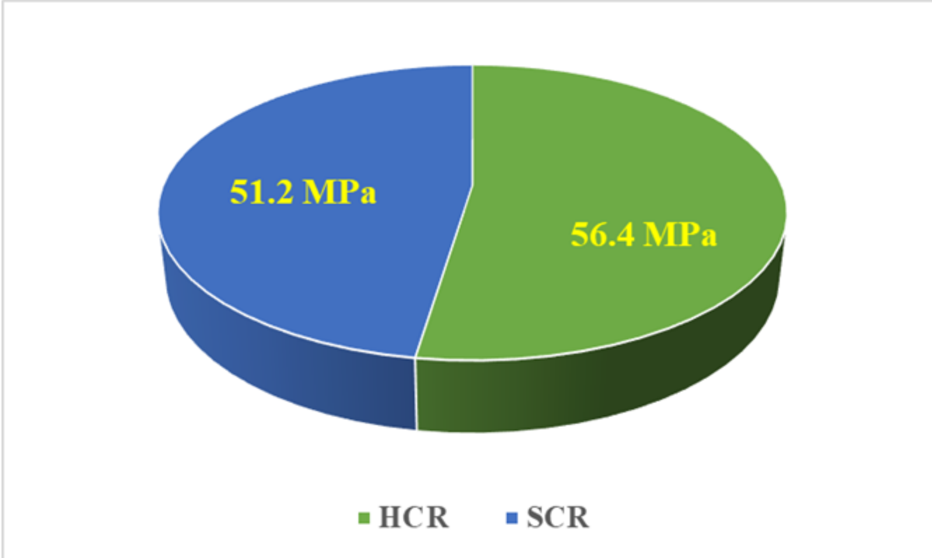


Fig. 65 Ultimate tensile strength value (MPa)

Testing the mechanical properties of the denture base resins it is an important issue. Flexural strength is useful in order to compare denture base materials because it reflects the complex stresses applied to the denture during mastication and it indicates the materials' rigidity. Since there is an A.D.A. specification designed on certain physical properties with a purpose to indicate the quality of heat-cured acrylic denture resins it is normal to employ the same tests and measurements to indicate the comparative quality of the self-cured materials designed for the same purpose.

The surface state has a major impact on the patient's comfort and the prevention of inflammation in the oral mucosa. The homogeneous structure of the material, without porosity ensures to the future prosthesis, longevity, resistance and longevity over time. Our results notice that no significant differences between the mechanical properties of the two denture base materials are registered.

Conclusions

Fundamentally the two types of materials are therefore quite similar in basic composition except the differences in essential ingredients. It is to be reasoned, therefore, that the self-cured resins for dentures may have physical and mechanical properties as good as, but generally no better than the heat-cured resins

Within the limitations of this study, the mechanical properties of acrylic resins were not influenced by the curing method. The acrylic specimens have similar mechanical characteristics and comparable values of surface roughness.

Also, no structural differences were found between both categories of resins. So we can notice that, at least in the initial stage, the acrylic samples of HCR and SCR do not show significant differences and have a similar mechanical behavior.

Since this research was limited to samples analyzed immediately after processing and finishing, further studies are necessary to evaluate the mechanical properties after a longer period of time, in which these materials have been functionally present in the oral cavity.

3.3 STUDENTS' ATTITUDE REGARDING THE IMPLEMENTATION OF DIGITAL TECHNOLOGIES IN CURRENT DENTAL PRACTICE

Introduction

Digital technologies represent a strategy for the future, which had opened a new path, both in dental medicine and dental technology. These modern methods are constantly moving in new directions, to provide innovative products and systems, with the highest quality standards. With their help, perfect clinical restorations can be achieved, with high biocompatibility, no secondary reactions, excellent esthetics and a better cooperation between dentists and dental laboratories (Anadioti E *et al.,* 2020; Baba NZ *et al,* 2016)

The digital development in dentistry brings the need for an entirely new set of skills for dental professionals. Consequently, dental education has to increase their focus on how to educate students for these new demanding. Also, more researches on the clinical behavior and biomechanical parameters of modern dental materials will be necessary for dental professionals to increase their knowledge regarding the application of new techniques (Schweiger J *et al.*, 2018; Anadioti E *et al.,* 2018)

The possibility of implementing dental prosthesis, on both natural teeth and implants, using fully digital workflows is a reality, and the advantages of the digital method are not only in terms of the new range of materials that can be used, but also allow tracking of the entire technological working flow, from impression to design, to complete prosthetic device realization.

Digital dentistry includes the broad array of technologies that bring the communication, documentation, manufacture and delivery of dental treatment under the umbrella of computer-based algorithms (Kalberer N et al., 2019; Kattadiyil MT *et al.*, 2013). CAD / CAM technologies for the complete dentures realization have become better known and more available, and methods and materials are becoming more efficient, allowing to obtain prosthetic constructions that satisfy the highest functional requirements. These procedures offer significant benefits to the dentist, dental technician and also patients. CAD / CAM technologies follow three important steps: data acquisition, by using intraoral scanners or by scanning a plaster model from a conventional impression, designing the virtual prosthetic construction and digital realization of the prosthesis, using new generation materials. Subtractive and additive technologies offer the advantage of unlimited design flexibility (Prpić V *et al.,* 2020; Favaretto M et al., 2020, Alauddin MS *et al.,* 2021; Neville P *et al.,* 2020)

Conventional technologies for making dental prosthese realization tend to be replaced by these modern methods. Although dental companies have developed additional recording tools and tray systems for recording clinical information and introduced clinical protocols for them, the traditional recording protocol is acceptable. Currently, there are few studies that compare the mechanical characteristics and the particularities of the complete denture realized by these two technologies (Clark WA *et al.,* 2021; Goodacre BJ et al., 2018; Wang C et al., 2020; Janeva NM *et al.,* 2018)

Therefore, we considered it necessary to carry out a series of studies that would give us an image of the students' attitude regarding the implementation of digital technologies in current dental practice

Material and method

The study included 123 students from the Faculty of Dental Medicine, Dental Technical Specialization, 61 on the second year and 62 on the third year

The students were asked to specify the year of study and their age. An original questionnaire was used, with 10 questions, in order to analyze the students' knowledge and attitude regarding the use of digital technology in dentistry and, in particular, in the dental laboratories. (Table XIX).

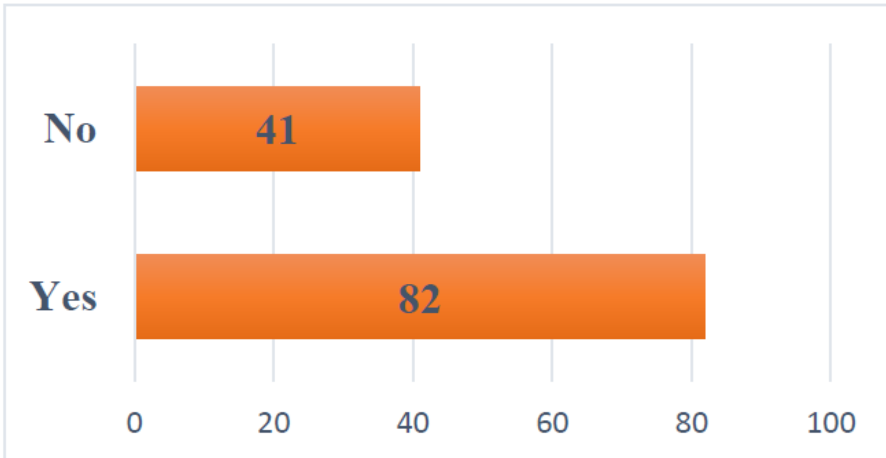
Table XIX. The questionnaire for the 2nd and 3rd year dental students

1. Do you work or practice in a dental laboratory? **Yes (period)**	**No**
2. Do you have any knowledge on CAD-CAM technology? **Yes**	**No**
3. What materials can be processed using CAD-CAM technology? **a. ceramic b. polymers c. alloys / metals**	
4. What types of prostheses can be made using CAD-CAM technology? **a. fixed prostheses b. partial dentures c. full dentures**	
5. What materials can be processed using 3D Printing technology? **a. ceramic b. polymers c.alloys/metals**	
6. What types of prostheses can be made using 3D Printing technology? **a. fixed prostheses b. partial dentures c. full dentures**	
7. Do you consider useful to introduce digital technology into the dental technology? **Yes**	**No**
8. Do you consider these digital methods to help the dental technician? **Yes**	**No**
9. Do you think digital technologies will replace the dental technician in the future? **Yes**	**No**
10. Do you think that the widespread implementation of digital technologies would have a negative impact on the number of employees in dental laboratories? **Yes**	**No**

Results and discussions

The repondents' age was between 18 and 29 years, with an average of 20 years for the second year (30 students) and an average of 21 years for the third year (34 students).

After analyzing the answers it was found that out of the total of 123 students, 82 work already into a dental laboratory (fig. 56) between one month and one year (students of the second year), and for a period between 2 months and 2 years (for third year students) (fig.66).



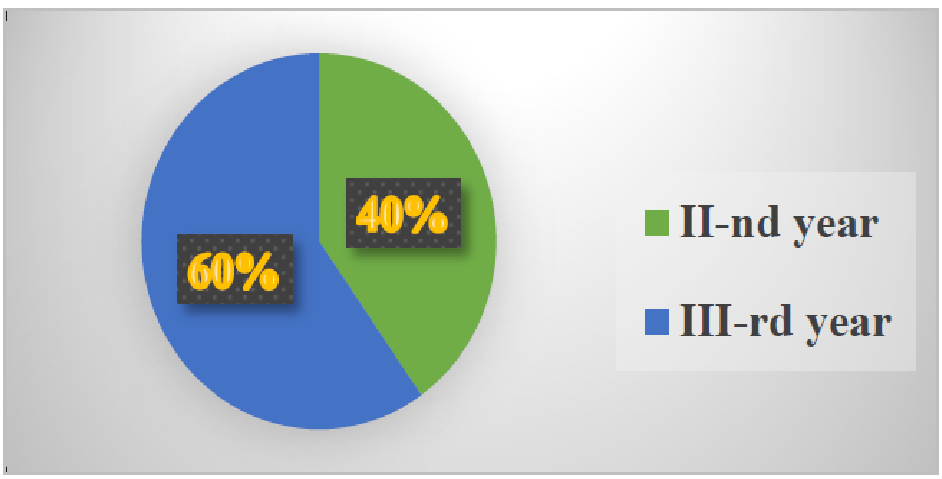


Fig. 66 The number and distribution of students who practice or work in the dental laboratories

The work experience into the dental technique laboratory offers the students an image on the difficulties of making certain dental prostheses and on the particularities of the different technologies.

Students who have done more practice in laboratories equipped with high-performance devices are aware of digital technologies and realize the advantages of these methods.

In our study, all respondents, (100%), said they had knowledge about digital CAD-CAM subtractive technology, but a small number knew all the materials that can be used to make dental prostheses ussing this method (fig.67.a, fig.67.b).

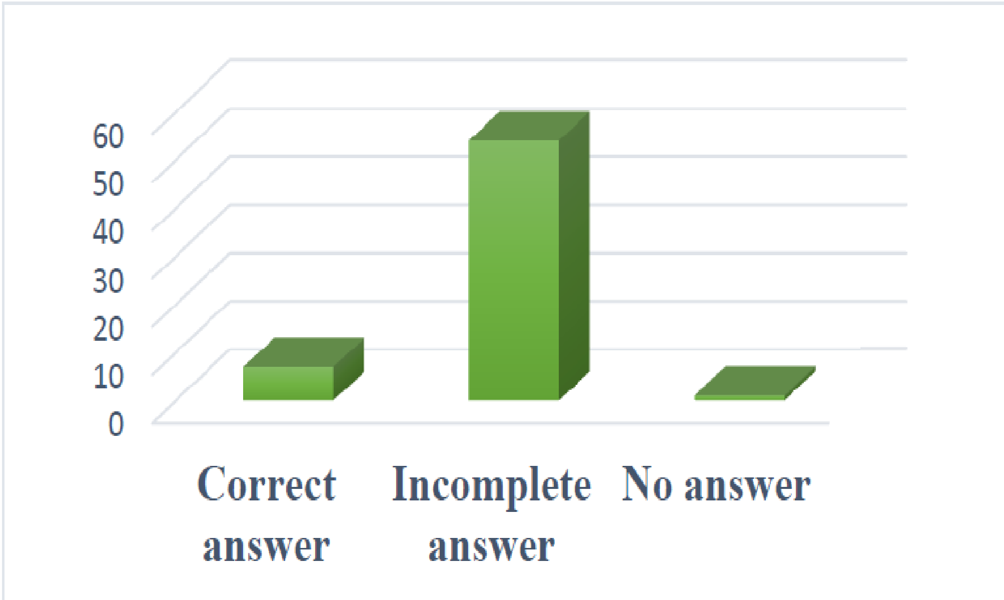


Fig.67 a Second year students'answers regarding the materials that can be used in CAD-CAM technologies

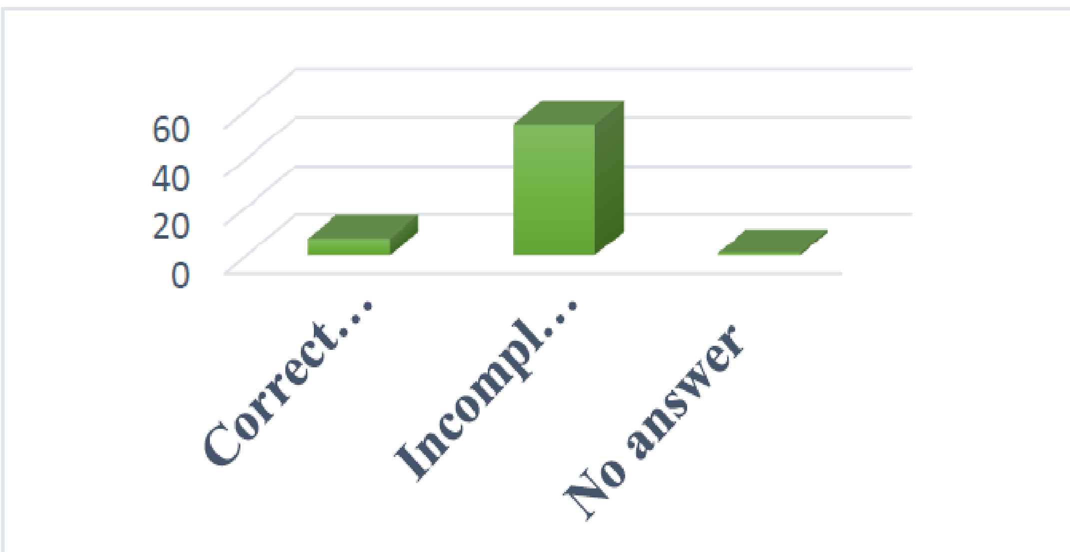


Fig.67 b Third year students'answers regarding the materials that can be used in CAD-CAM technologies

The limited experience of students in the laboratory does not give them an overview of the materials and working methods used in digital technologies.

The differences between the answers of the second year and the third year students are insignificant, which shows that they focus during the practice period on the accumulation of practical knowledge on the techniques used in the laboratories where they work and focus less on the accumulation of information on new technologies that appear or are used in the field of dental technology.

The answers for the question nr.4 show that a small number of students know all types of prostheses that can be made using CAD-CAM subtractive technology (fig.68.a, fig.68.b).

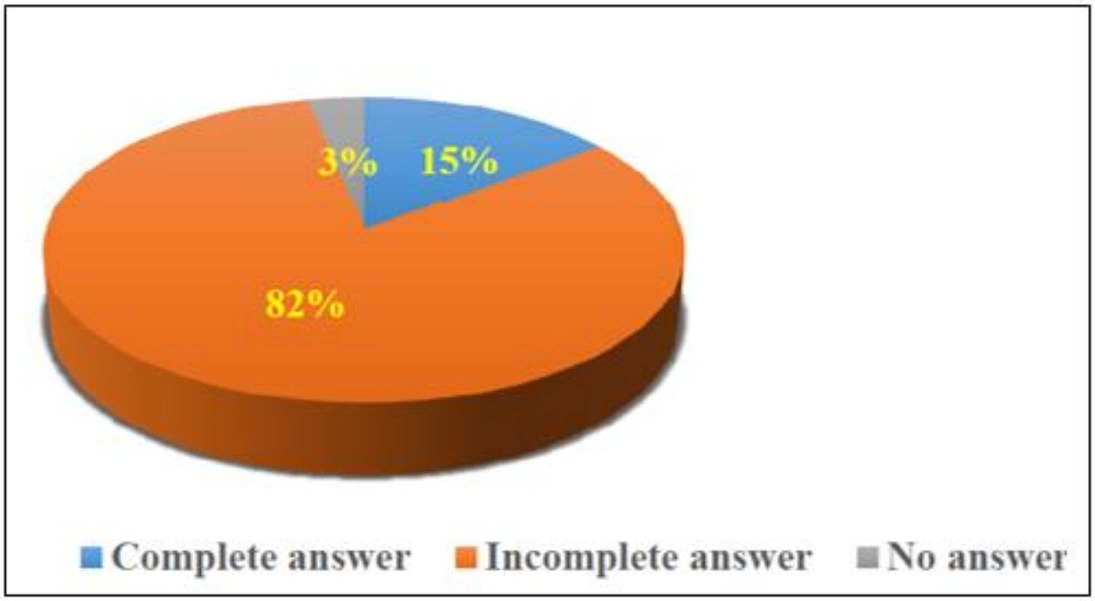


Fig.68 a. Answers of the second year students regarding the types of prostheses that can be realized by CAD-CAM technologies

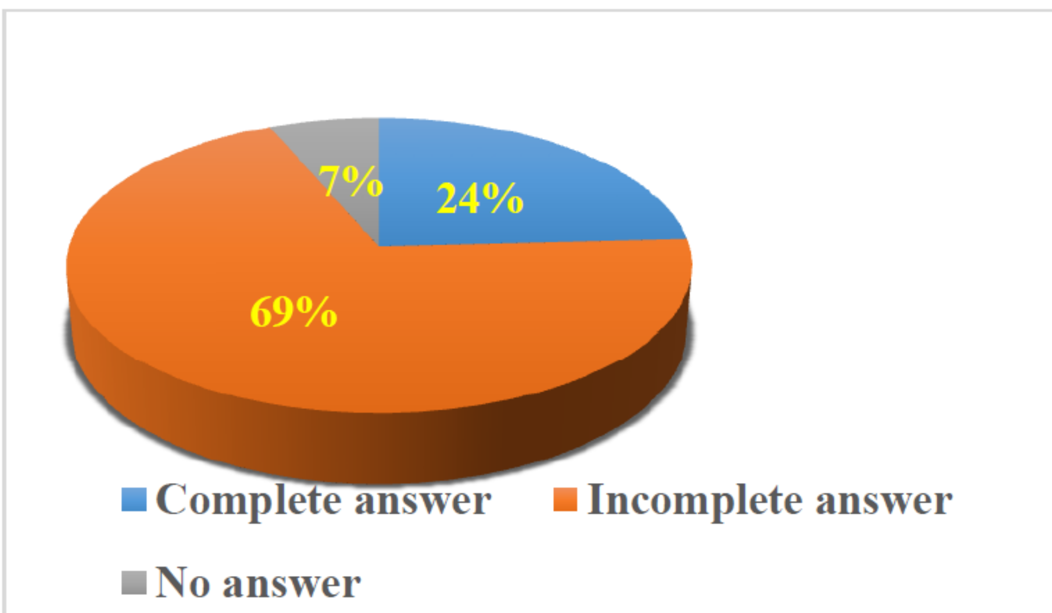


Fig.68 b Answers of the third year students regarding the types of prostheses that can be realized by CAD-CAM technologies

As for 3D Printing technology, students partially knew the categories of materials used to make dental prostheses using this method (fig.69, fig.70).

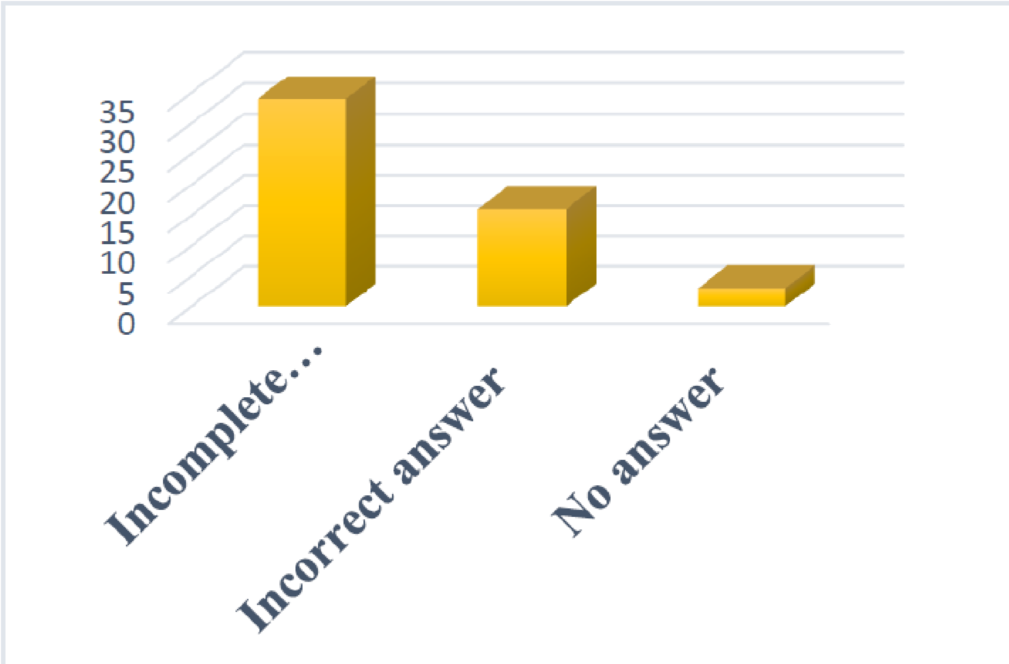


Fig. 69 Answers of the students of the second year regarding the materials that can be used in 3D Printing technologies

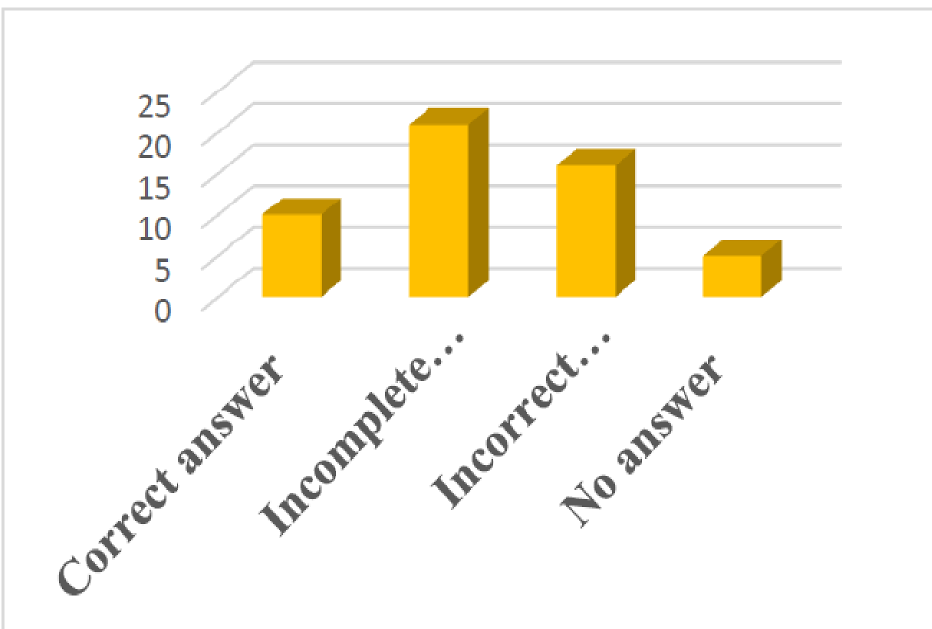


Fig. 70 Answers of the students of the third year regarding the materials that can be used in 3D Printing technologies

Even regarding the types of prostheses made by 3D Printing technology the students of the two years of studies do not have complete knowledge (fig.71 a, fig. 71 b).

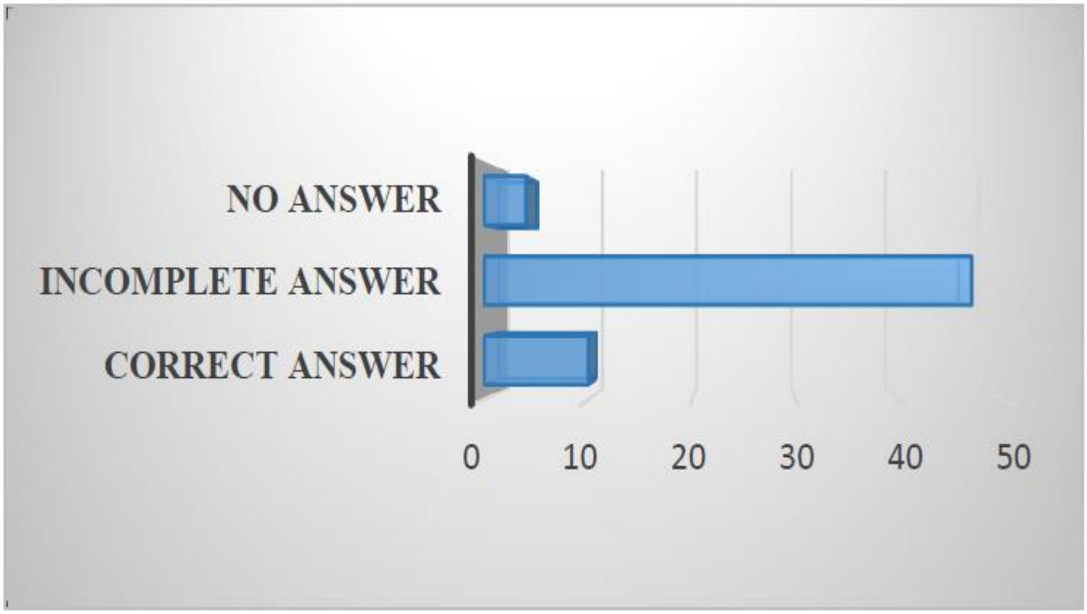


Fig. 71 aThe answers of the students of the second year regarding the types of prosthese that can be realized by 3D Printing technologies

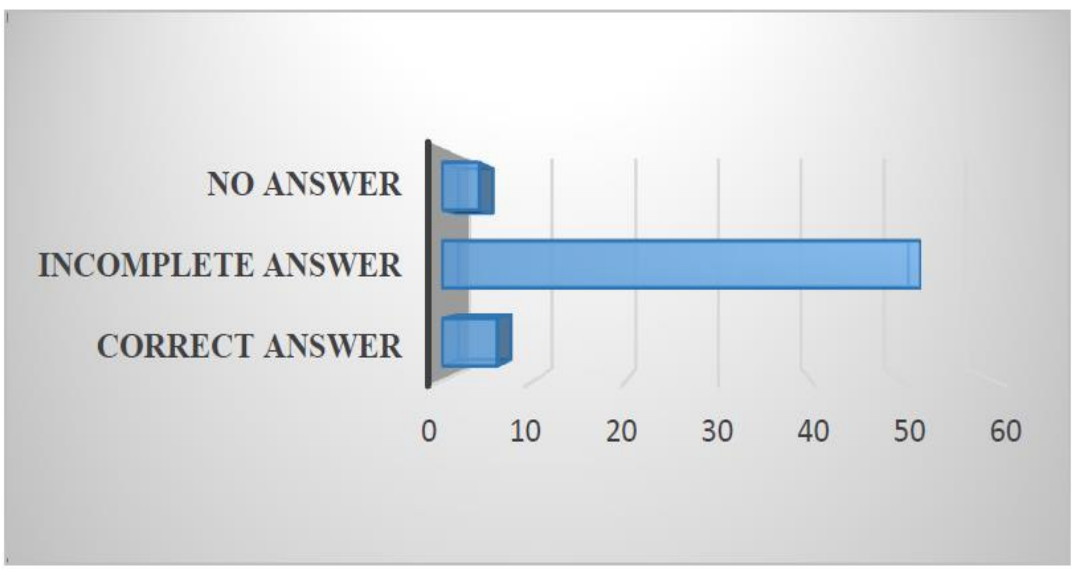


Fig. 71 b Answers of the students of the third year regarding the types of prosthese that can be realized by 3D Printing technologies

3D printing technologies are even more recently introduced in practice, and for mobile, partial and complete dentures hey are still little used; therefore, students' knowledge of these methods is even lower.

Of the 123 respondents, 120 (97%) noticed that it useful to introduce the digital technology in the current laboratory practice (59 from the second year and 61 from the third year), two students replied that the implementation of these methods is useless (2%) and one student did not answer the question (1%) (fig.72)

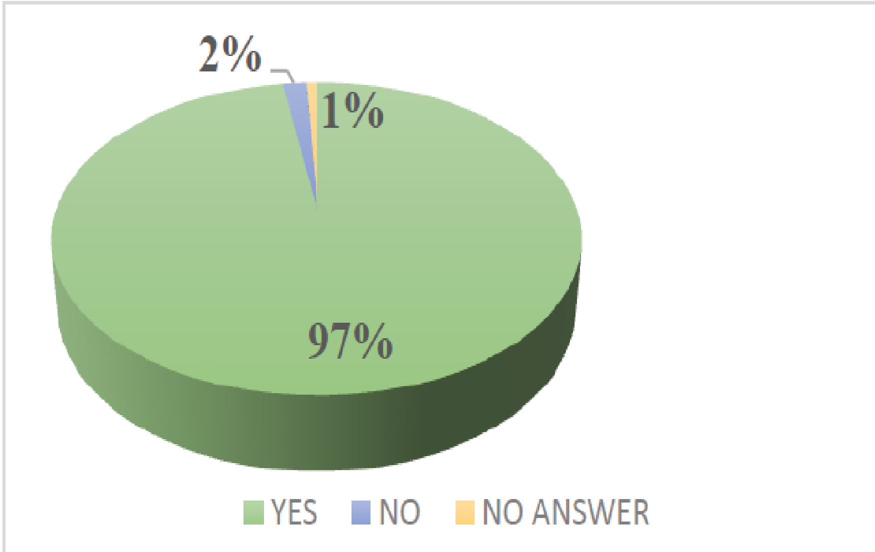


Fig. 72 Student answers regarding the usefulness of introducing digital technologies in laboratory practice

111 students (90%) considered that digital technologies are a real help in the dental technician's activity, and 12 respondents (10%) do not found these methods useful (fig.73).

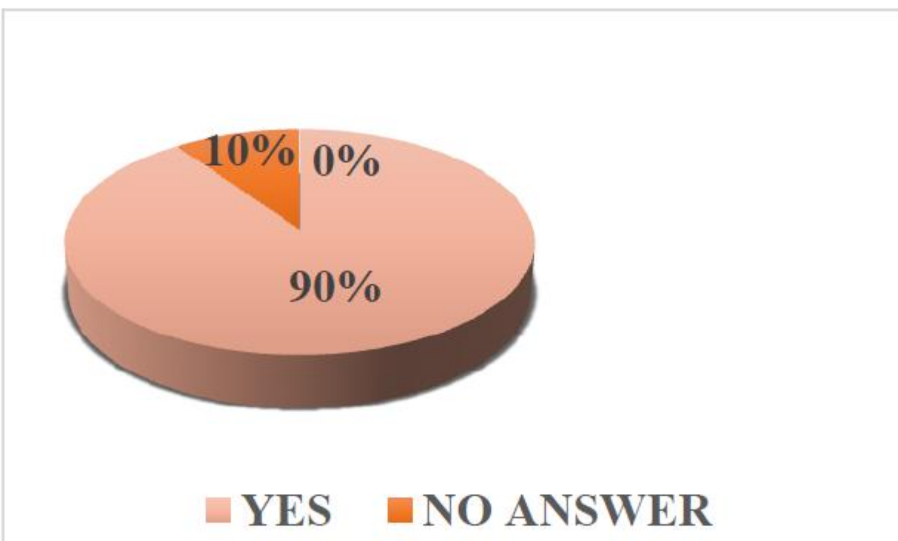


Fig. 73 Student answers regarding the efficiency of the laboratory activity by applying digital technologies

Thirtyfive respondents (28%) considered that digital technologies will replace the dental technicians in the future, and 82 (67%) did not consider these alternatives a threat to the technicians. Six students (5%) did not answer that question (fig. 74).

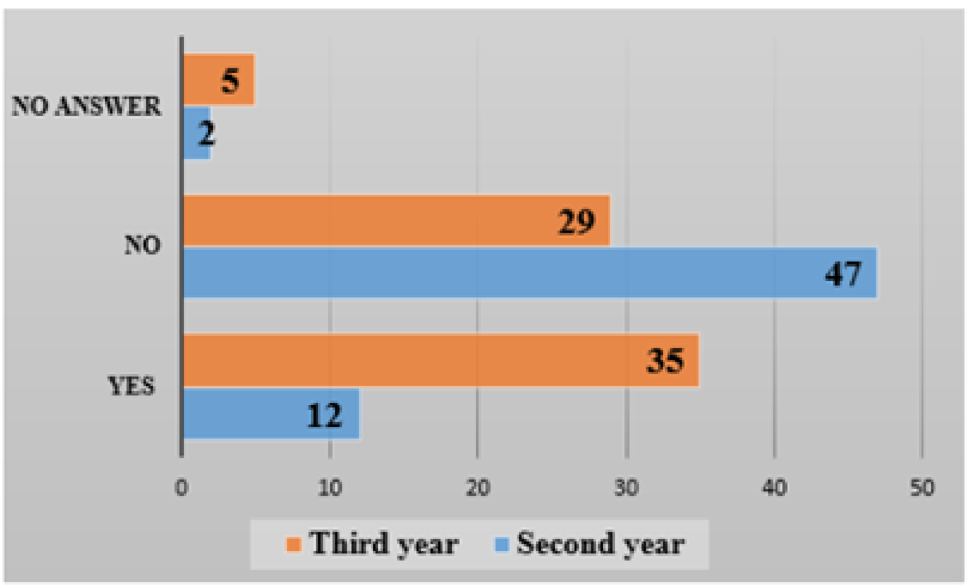
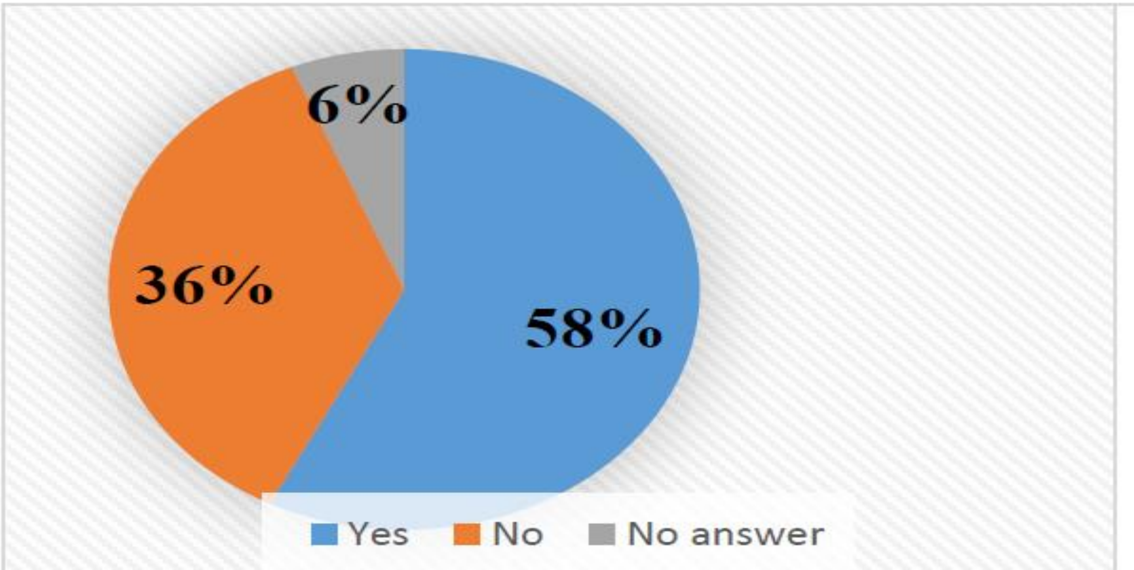


Fig.74 Opinions regarding the future replacement of dental technicians as a result of the implementation of digital technologies

Although it is useful to introduce digital technology into mainstream practice, 65 (58%) students felt that these methods would have a negative impact on the jobs in dental laboratories, 41 (36%) said that the techniques will not affect the jobs for technicians and 6 (6%) did not answer this question (fig.75).

Due to the reduction in the number of steps and working time, students are convinced that the number of jobs will be declining after the widespread implementation of digital methods in the dental laboratory



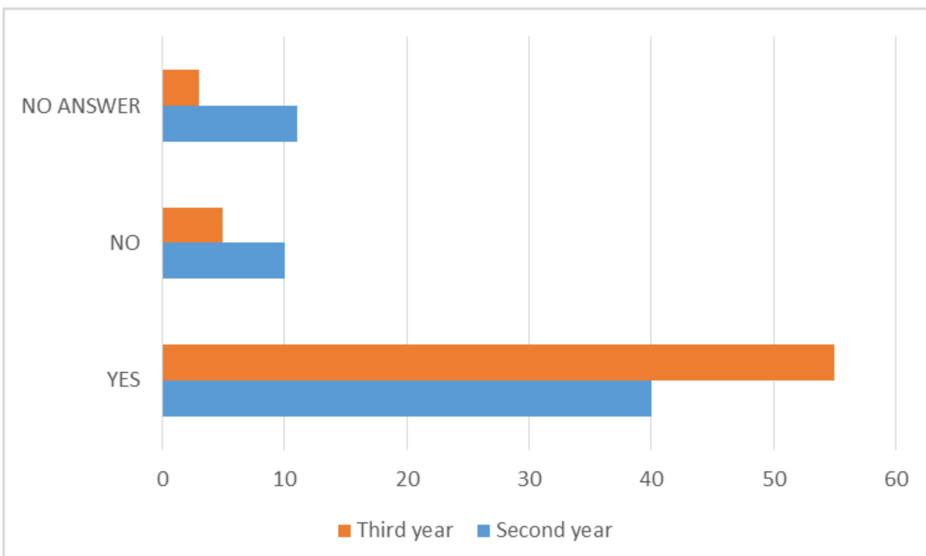


Fig. 75 Opinions regarding the future impact on dental technicians jobs as a result of the implementation of digital technologies

Analyzing the results it was found that 97% of the respondents answered that digital technologies are useful for most aspects of dental practice, due to the significant reduction of the working stages, because increase sharing of patient information, reduce the appointments, reestablish the risk of occurrence of errors and decrease material losses.

Obstacles that impede the acceptance of digital technologies include cost, lack of comfort with technology, software incompatibility, practice guides still unclear.

Following the reduction of the number of laboratory steps and the digitalization of the process of obtaining dental devices, 36% of the students believe that these methods will have as result the decrease of the number of jobs for dental technicians.

Although most students practice in dental laboratories, and absolutely everyone knows theoretically the digital technologies -CAD-CAM and 3D Printing-, just a small percentage (10%) know all the materials used in these technologies; also, 15% of second year students and 24% of third year students know all types of prostheses that can be obtained by these methods.

Conclusions

Within the limits of this study and referring only to our study group, the second and third year, dental technique specialization, we can conclude that students are familiar with the modern methods and materials used in CAD-CAM and 3D Printing technologies and consider them useful for their future activity in dental technique laboratories.

At the same time, most of them express concern that with the introduction of digital technologies, the role of dental technicians may be diminished. This research suggests that efforts should be made to improve students' knowledge base on these future methods in dental prosthetics.

All these modern technologies allow the elimination of many laboratory steps, which greatly reduces the risk of errors. In addition, these methods are using industrially manufactured materials, with a more homogeneous internal structure and a mechanical resistance that is significantly higher than the usual materials used in the laboratory.

These technologies are currently all available, but not fully integrated. Education influences dental practice and dental schools should be more concerned about training students on the use of digital technology in dentistry.

The familiarity of students with digital technology is a key feature that may positively influence the adoption of digital technology in the broader community of interest.

Technology affords to improve self-assessment and can even provide for a virtual learning environment. Consequently, dental students gain objective and visual feedback that permits enhanced self-assessment.

SECTION II
FUTURE EVOLUTION AND DEVELOPMENT PLANS ON SCIENTIFIC AND ACADEMIC CAREER

The field of dental technology is extreme lybidder for scientific research and at the same time extremely challenging, as a result of the unprecedented technological evolution in recent years in the field of dental materials and in the methods of dentla prostheses realization. New technologies do not replace conventional ones, but only complement them; therefore it is necessary to permanently analyze and compare the characteristics of existing materials and technologies with those recently proposed by the manufacturing companies.

In order to choose an optimal treatment solution, the dental team currently has a very wide range of variants, which makes the choice extremely difficult, because the information in this area is not always complete

The role of scientific research is to make available to practitioners precisely these data, necessary to take correct therapeutic decision, depending on the clinical situation.

My experience in the discipline Technology of Dental Prosthesis has shown me that the research activity cannot be separated from the didactic one and the studies we have carried out have allowed us to be constantly up to date with all the news in the field of dental technology and to be able to optimize the curricula according to the evolution of technologies and dental materials and to implement new therapeutic protocols in practice.

The permanent goal was to train specialists connected to the latest technologies able to apply and transfer in the current activity the acquired information.

In this sense, there must be a permanent correlation between the research activity and the didactic one, and this interdependence must be concretized in several directions, which aim to optimize existing curricula, by introducing new disciplines in accordance with the evolution of dental technologies and materials, implementing new technologies in practical activity, promoting the results of scientific research, attracting students in scientific research and initiating them in research methodologies.

By cultivating the appetite for research of students and young doctors, we will encourage their desire to continue their training through master's and doctoral programs and to participate to various research projects.

II.1. FUTURE DIRECTIONS IN RESEARCH ACTIVITY

The major path of my future academic research will concern directions and areas that are already in progress, involving activities that made the fundamental of my last year preoccupations.

At the same time, I propose to follow new research directions, in order to optimize the existing research base and to attract new funds and equipment in order to develop it.

Interdisciplinary and trans-disciplinary collaborations as well as partnerships with other universities in the country and abroad and with prestigious research centers will obtain valuable scientific results, increasing the academic performance of the “Grigore T. Popa” University of Medicine and Pharmacy of Iasi

II.1.1. Silver nanoparticles effect on the characteristics of dental acrylic resins

a. EXPERIMENTAL STUDIES

Studies on the long-term behavior of of acrylic resins with Nanosilver Addition

In this research area I intend to continue the studies focused on experimental research in the field of acrylic resins and removable prostheses, in collaboration with the specialists from Faculty of Medical Bioengineering “Grigore T. Popa” University of Medicine and Pharmacy of Iasi, Faculty of Materials Science and Engineering, “Gh. Asachi” Technical University and “Petru Poni” Institute of Macromolecular Chemistry of Iasi.

The research carried out so far has allowed to draw pertinent conclusions regarding the biomechanical behavior of acrylic resins with Nanosilver addition, allowing the indication of an optimal concentration and size of nanoparticles, which do not alter the parameters of these materials.

However, additional studies are needed to analyze the characteristics over time of mobile acrylic prostheses made of AgNPs enriched resins.

Polymers and polymeric composites, tend to degrade and lose their mechanical properties due to the influence of the biological environment and temperature variations into the oral cavity (Ziąbka *et al.,* 2021). Therefore, thorough investigations should ensure their functionality over a certain period of time (). Recently, many studies have described the bactericidal and fungal effects of silver nanoparticles (Ziąbka *et al*., 2019). However, there are few studies devoted to the influence of silver nanoparticles on the mechanical properties of composites over a long research period (Ranganath *et al.,* 2018).

A number of studies on the long-term behavior of resins with nanosilver show that the mechanical properties of resins - microstructural, surface and mechanical properties, are not affected by the oral environment even after a few years, and can improve physical properties of these dental materials (Machado-Santos *et al*., 2020 , Karabela *et al.* 2011).

Other studies have concluded that acrylic resins, it has a long-standing drawback that is lack of strength particularly under fatigue failure inside the mouth and also shows low abrasion resistance and microbial adhesion onto PMMA to long-term complete dentures wearers (Fouda *et al*., 2019), (Madhu *et al.,* 2021).

Therefore, some studies are still ongoing in order to solve these problems and improve acrylic polymers properties for artificial dentures (Wang *et al*.2015).

Recently, much attention has been directed toward the incorporation of inorganic nanoparticles into PMMA to improve its properties and the results showed that desired mechanical property enhancement can be achieved in those composites with small amounts of nanoparticles (Nam *et al*., 2102, Li *et al*., 2016)

The aim of these in vitro researches is to evaluate long term aspects regarding silver nanoparticles incorporation, such as antimicrobial potential, mechanical properties and cytotoxicity. We also emphasize the need for more studies to determine the optimal concentration of silver nanoparticle and it's release over time.

Studies on microbial adhesion to acrylic denture base resins silver nanoparticles enriched

Complete dentures, most realized of acrylic resin, allow microbial colonization, on the one hand as a result of their inner surface roughness and microporosity and on the other hand to poor oral hygiene (Song et al., 2019). Many types of oral bacteria (*Streptococcus mutans, Streptococcus oralis, Streptococcus gordonii, and Actinomyces naeslundii*) have been shown to contribute to the initial attachment and mature development of biofilms on acrylic denture surfaces (Philip *et al*., 2018).

Denture stomatitis still represents a challenge for dentistry, and research on the prevention and treatment of these diseases is a constant concern for specialists (Corrêa *et al.,* 2015). Although significant numbers of study that focus on developing antimicrobial agents to overcome this problem exist, most of these attempts failed to achieve desired outcomes due to the rapid degradation and fast release of antibacterial agents causing low efficiency and safety concerns (Cao *et al.,* 2017}

Antimicrobial nanoparticles are promising because of several advantages such as ultra-small sizes, large surface-area-to-mass ratio and special physical and chemical properties, but the antimicrobial mechanism of AgNPs even though it has been so intensely studied it remains unclear.

Accordingly, AgNPs have been satisfactorily incorporated into polymers used as tissue conditioners and as denture base (Suganya et *al*., 2014). Some authors attribute the antimicrobial effectiveness to the silver ions release (Jin *et al.*, 2017) and others to the direct contact between the material and the microorganisms (Liu *et al.*, 2104).

The research we conducted on the effect of AgNPs on acrylic resins used for removable dentures realization, in accordance with the results of other studies (Ghaffari *et al.,* 2015; Mahross *et al*., 2015) allowed to establish an optimal concentration and dimensions of nanoparticles that do not affect the mechanical properties of dental prostheses.

The studies that we intend to carry out further aim to analyze the antibacterial effect of the silver nanoparticles introduced in the acrylic resins used to removable dentures realization.

AgNPs used in dental materials are incorporated through distinct ways, depending on the type of material. For composite resin and adhesive systems, the most common technique is adding a monomer, usually 2-(tert-butylamino) ethyl methacrylate, in order to improve Ag salt solubility in the resin solution (Cheng et al., 2012; Meloet al., 2013).

Another difference is related to the form of AgNP obtainment. In some studies the particles are commercially available, so they are obtained directly from the producer (Kasaee *et al*., 2008; Diaconu *et al*., 2016).

In others, AgNPs are prepared by reduction of AgNO3, with NaBO4 (Flores *et al.*, 2010) polyvinylpyrrolidone (Nam, 2011), sodium citrate (Monteiro *et al.*, 2012), or gallic acid (Espinosa-Cristóbal *et al.*, 2009)

The research will follow the comparative efficiency of this process of optimization of composite materials, in the desire to establish which method provides the highest antimicrobial and antifungal potential.

In vitro studies on the cytocompatibility of dentures bacrylic resins AgNPS modified

AgNPs have been applied in several areas of dentistry, with the aim of avoiding or at least to decrease the microbial colonization over dental materials, increasing oral health levels and improving quality of life.

The antimicrobial potential of silver nanoparticles is indisputable and is demonstrated by numerous studies (Prażmo *et al.*, 2016; De Souza Neto *et al.*, 2018;) the small size of AgNPs offers them the possibility to penetrate through cell membranes more readily, resulting in higher antimicrobial activity (Park *et al.*, 2013), which is especially important since microorganisms in biofilms are very resistant to antimicrobial agents (Corrêa *et al.*, 2015)

Nanotechnology has evolved as a favorable tool in medical field and dentistry. Nanoparticles offer an attractive alternative to conventional antimicrobial agents. (Halkai et al., 2016). Among the nobel metals, silver (Ag) is considered in the field of biological system, and medicine can be effectively used as antimicrobial agents because of their broad spectrum of activity and biocompatibility (Halkai *et al.*, 2019).

Considering their unique physical and chemical properties, it is likely that these nanoparticles also possess unique toxicity mechanisms (Chaloupka et al., 2010).

Some in vitro studies, performed on fibroblast cell lines, on the antifungal activity of AgNPS against *Candida albica*ns demonstrate that PMMA denture base material containing silver nanoparticles have antifungal activity and no cytotoxic effect (Kurt et al., 2017; Sabri et al., 2021).

The addition of antifungal agents on PMMA surface or into PMMA, such as nanoparticles, , could be useful for the inhibition of oral specific pathogens. (Arenas-Arrocena *et al.*, 2017)

Other studies state that AgNPS, in certain concentrations, may have toxicity, which depends on the type of nanoparticles used (synthesized in the laboratory orindustrially obtained), their size and concentration (Awasthi et al, 2015). AgNPs toxicity involves various mechanisms, in particular the production of excess reactive oxygen species (ROS). One of the possible mechanisms proposed for AgNPs toxicity, the production of excess ROS, seems to be the most important contributor for nanotoxicity or nanocytotoxicity (Gurunathan *et al.*, 2018)

Due to the enormous uses of AgNPs in the medical and dental field, we propose that in our future studies in this direction to analyze and evaluate the use of these materials so as to avoid a potential cytotoxic effect. We also aim to determine the size and concentration that ensures optimal biocompatibility of these materials used to make removable dental prostheses.

These in vitro studies are necessary primarily to verify the results of mechanical and laboratory studies performed to date; research is also useful to analyze the long-term efficacy of modified silver nanoparticles acrylic resins, as the aim is to ensure a long-lasting antimicrobial effect in dental devices.

b. CLINICAL STUDIES

Clinical studies on the behavior over time of acrylic removable prostheses silver nanoparticles modified

Silver nanoparticles are successfully used in dental prosthetics, especially to reduce the risk of microbial colonization of revovable prostheses and to avoid inflammation of the oral mucosa, common on wearers of removable dentures.

There are many in vitro researches that analyzes the behavior of modified AgNPS acrylic resins, but there are very few clinical studies that track the performance over time of prostheses made from these materials. (Banjonga *et al.*, 2020).

The value of laboratory investigations is usefull, and by following a strict protocol for re-evaluating these studies, the quality may be determined for such an important subject matter as the use of nanoparticles for dental treatment (Adam *et al.*, 2021)
Recently, the importance and value of the research designs such as randomized clinical trials and synthesis research were gaining more exposure (Higgins et al., 2009)., serving as a guide to practitioners to improve treatment and care to patients.

Reported on materials used in dental medicine many studies start at the laboratory investigations and very few subsequently get involved with related clinical research. The reasons for this approach are probably related to how feasible the outcomes may be in clinical studies; long observation periods in clinical research; ethical requirements with patient-related research; exorbitant costs associated with clinical research and difficulties with implementing rigorous design principles. Laboratory investigations include or exclude the use of nanoparticles in dentistry depending on the quality of the included studies and their outcomes and subject matter may add great value to daily clinical practice if it is determined that nanoparticles may influence the oral effects of *Candida Albicans (*Adam *et al.*, 2021).

Silver nanoparticles have been used in dentistry for different purposes and in different forms, for all types of materials, within different systems: composite resins and adhesive systems, acrylic resin, endodontic materials and titanium implants. Biosynthesised silver nanoparticles have been shown to be antibacterial in nature against a number of dental pathogens such as S. mutans and Lactobacilli species (Burdusel *et al*., 2018). Previous studies have reported on the incorporation of chemically synthesised silver nanoparticles into denture acrylic (Acosta-Torres *et al.*, 2012). In order to prevent denture stomatitis and treat recurrent infections, the incorporation of antimicrobial agents into denture base resin and resilient liners have also been reported (Lima et al., 2016; Ramos *et al.*, 2017)

Modification of denture bases and denture liners with silver nanoparticles present a unique opportunity to manage denture stomatitis. It is advantageous as the modified dentures are in contact with the tissue, thereby preventing re-infection. Sustained release of a drug from the denture base could further prevent the development of a biofilm and the colonisation by *Candida albicans*. Nanomedicine refers to the use of nanotechnology in the diagnosis of disease, drug design and delivery, and implants (Gendreau *et al.*, 2011).

The purpose of these future studies is to evaluate in timp clinical behaviour of removable acrylic dentures AgNPs, to evaluate the success rate and treatment outcome of these protheses, to monitor for possible damage to the oral mucosa and to determine the antimicrobial efficacy of silver nanoparticles included in acrylic dentures and in different denture liners.

We also aim to develop a protocol to guide practitioners in the unitary implementation of these clinical trials using ethical principles, which want to cover a wide range of analysis and gather as much information as possible, in order to draw relevant conclusions of practical importance.

Given that there are few long-term clinical studies on the behavior of AgNPS modified full dentures, I believe that our research could be a valuable contribution in this scientific area.

II.1.2. Comparative studies on digital and conventional technologies for complete dentures realization

In dental medicine, several digital workflows for production processing have already been integrated into treatment protocols, especially in the rapidly growing branch of IT-power CAD/CAM systems and rapid prototyping (RP) New possibilities have opened up for automated processing using artificial intelligence (AI) and machine learning (ML). Moreover, augmented and virtual reality (AR/VR) is the technological basis for the superimposition of diverse imaging files creating virtual dental patients and non-invasive simulations comparing different outcomes prior to any clinical intervention (Joda et al., 2020).

Since the conventional method of fabricating CD was established more than 80 years ago, the continuing goal was to improve all the drawbacks associated with the process of fabrication, and enhancements of the properties of PMMA material (Harini *et al.*, 2020).

From a technological point of view, full denture is easy to make (the technique being simple and the laboratory does not require high-performance equipment, but a number of problems arise when adapting it, due to important changes in the elements of the stomatognathic system and the installation of major imbalances oof the oral cavity.

The material choose for complete denture realization is very important, in order to have an optimal adaptation; therefore, implicitly, the appropriate technology must be known in detail, in order to avoid errors during the clinical and technological steps. The continuous evolution in the field of dental materials has led to the production of non-acrylic resins, clearly superior to classical materials (Diaconu-Popa *et al.,* 2020).

In certain clinical situations, the acrylic denture, in its conventional version, does not meet all the requirements or fails to properly restore the functions, due to certain features of the prosthetic field. Therefore, it is necessary to know all the possibilities of treating complete edentulism, in order to be able to choose the optimal therapeutic option (Tatarciuc *et al.,* 2020; Al-Fouzan AF et al., 2017)).

Recently, digital technologies for fabricating complete dentures have become more well-known and commercially available, and the methods and materials are more and more efficient, allowing to obtain complete dentures according to the highest requirements. These procedures offers significant advantages to the dental practitioner, dental technician and also to the patients. CAD/CAM-substractiev technology have three important steps (Burde *et al.,* 2019): data acquisition, by using intraoral scanners or by scanning a stone model from a conventional impression, designing virtual devices in order to generate data for the future restorations, and computerized realization of the full denture, using state-of-the-art materials.

A number of researches point out that the resins used in computerized technologies for full dentures are industrially produced, and therefore have a high resistance to impact and distortion, resistance to blanching, color stability and dimensional stability. They also emphasize that prepolymerized acrylic resin are produced under high pressure and heat and polymerization shrinkage does not occur, porosity is ecreased, and the adherence of Candida albicans to the denture base is decreased. The lack of polymerization shrinkage associated with milled dentures results in a highly accurate denture fit and a better retention and also, the CAD/CAM denture base milled from poly-methyl methacrylate discs, polymerized on high temperature and pressure have been reduced the risk of residual monomer (Alghazzawi *et al.*,2016; Janeva *et al.*, 2017)

Other researchers claim, there are also limitations and disadvantages of these CAD/CAM technologies, such as: incorrectly recorded intermaxillary relation, lip support and maxillary incisal edge position are challenging, difficulties in establishing the occlusal plane, the opportunity for the patient to participate during the procedure is minimal, current material and laboratory costs are still more expensive compared to the conventional techniques (Baba *et al.*, 2016)

3D printing technologies represent another possibility of realizing complet dentures by computerized methods. Additive manufacturing technologies are essentially a method of getting devices with complex spatial geometry through additive processes. Additive manufacturing is gaining rapid potential in nearly all dental fields and it is different in comparison to the formative and subtractive manufacturing, in the additive manufacturing process the device being printed by adding the material layer by layer (Kattadiyil et al., 2015). Compared to the subtractive CAD-CAM technology for the elaboration of prosthetic appliances based on computer-controlled milling, 3D printing offers the advantage of unlimited design flexibility, the elaboration of the prosthetic device being realized in a few single steps. 3D printing has several advantages compared to conventional technology - superior accuracy, developed thanks to additive technology which, compared to subtractive techniques, allows superior reproduction of details; also, the increase of the work efficiency, being able, to elaborate, simultaneously, several prosthetic works, the reduction of the consumption of dental materials and of the working time (Goodacre et al., 2016).

The disadvantages are: the high costs of digital processing programs and printers themselves, the more limited accessibility of materials for this technology, the flawless design of the future prosthesis (Bidra *et al.*, 2013).

In this context, our future studies will focus on the following research directions:

- Analysis on the mechanical parameters of acrylic prostheses performed by conventional methods and by computerized additive and subtractive methods
- Comparative studies between digital and convention full denture base adaptation, retention and marginal fit
- Comparative studies on dimensional accuracy of digital and conventional realized by additive and subtractive methods

In order to determine the most correct therapeutic solution it is necessary to know the characteristics, advantages a disadvantages of each technologie and material used for prosthetic restorations.

II.1.3. Research on the possibilities of using digital technologies in the dental laboratory

The digital technologies had a huge impact on dental workflow that led to quality improvements (more precise, effective and personalized treatments), labor cost reductions and time saving (reduced production or treatment time, shorter waiting times and higher patient satisfaction

Many laboratory prosthetic elements can be made using these digital methods - from intermediate parts - models, temporary devices, to metal, ceramic or zirconia frameworks and dental prostheses – crowns and bridges, or partial and complete dentures (Joda *et al.*, 2017; Amin S *et al.,* 2017).

The main computerized methods used in practice today are subtractive and additive systems (Topol, 2019; Alikhasi M *et al.,* 2018).

Subtractive methods are the most common manufacturing technologies whose principle is to get the prosthetic construction by milling a block of material. As soon as the CAD unit has created the digital design, it will be exported to the CAM unit, either at the dental office or at the dental laboratory, in STL format and the machining will allow the block to be shaped according to the prosthetic element. The additive technologiescharacterize with the building of one layer at a time from a powder or liquid that is bonded by means of melting, fusing or polymerization. The methods, mostly used in prosthetic dentistry include stereolithography, selective laser sintering (SLS), selective laser melting (SLM) and Electron Beam Melting (EBM).

CAD-CAM technology for model realization involves the development of a resin device that achieves high precision, better accuracy and ensures a complete transfer of clinical information to the dental laboratory (Constantiniuc *et al.,* 2021; Srinivasan M *et al.,* 2018).

The temporary bridge is an intermediate prosthetic element, mandatory in fixed prostheses work flow. Digital technologies allow obtaining such devices, in a very short time, even in the dental office, in the same appointment with the abutment preparation (Revilla-León *et al.,* 2019; Steinmassl O *et al.,* 2018).

The wax patterns can be realized by subtractive or additive digital methods. Through these computerized methods can be obtained wax patterns with uniform thickness, very precise and with very good adaptation, which facilitates a faster and easier final processing of the metallic framework.

The additive and subtractive computerized methods are also used in the laboratory for the realization of the metallic framework of the conventional bridges and for the metallic framework on removable cast partial dentures (Svanborg *et al*., 2020); the subtractive methods are also used to obtain the framework of zirconia or all ceramic bridge.

Studies on the advantages, disadvantages and particularities of dental materials and technologies are presented in the literature, ranging from the most traditional to the most modern one. A lot of advantages have been reported over conventional methods, including low cost of materials, less complex labor and good quality of the devices. But, it has been proven that CAD/CAM methods, allowing digital impressions and allowing to do away with plaster models, wax-ups, casting and firing, are able to be faster and easier than conventional technologies (Rekow *et al.,* 2020)

The quality of the CAD / CAM restorations is very high thanks to the precision of the measurements and the manufacturing, have a natural appearance and good mechanical resistance. Although the purchase price of such equipment remains a real investment, the gain in speed of design and manufacture allows practitioners to be able to make a profit after a certain number of restorations (Touchstone *et al*., 2010)

Nevertheless, the cost can just as easily be seen as a disadvantage; there are still some drawbacks concerning modern manufacturing technologies such as the high initial cost of equipment and software.

Our patients today have much differentiated needs and demands compared to previous stages and it is no longer possible to design a prosthetic treatment without considering an impeccable functional recovery. From a clinical perspective, the important aspects to be considered for prosthetic work performed by computerized techniques are long-term longevity in the oral cavity, significant reduction in working time, reasonable costs and clinical versatility.

From a technical point of view, there is still a learning time which is essential in order to master these new machines (Goss *et al.*, 2019).

In order to implement the digital systems into the laboratory of the Clinical Base of Dental Education, a series of preliminary studies are necessary, which guide us if it is justified to purchase such equipment and materials, as well as additional training of our dental technicians.

Thus, our research will focus on a comparative analysis of the characteristics of prosthetic devices, realized by digital and conventional methods, on the analysis of the possibilities of streamlining the technological steps, as well as on the usefulness of outsourcing digital lines, in order to make all types of prostheses for private laboratories.

Other future directions for the research activity:

- Development of interdisciplinary and transdisciplinary collaboration relations
-Submission of research projects in order to optimize the existing research base and attract new funds and equipment in order to develop it
-Active participation in national and international scientific events, in order to communicate the results of our own research and increase the transparency of our activity department, in order to initiate new scientific collaborations
-Elaboration of high-performance technologies, with the possibility of their implementation in the current medical activity and optimization of the professional performances of the practitioners, for the benefit of the patients
-Developing high-performance research centers in the faculty and stimulating participation in competitions for international scientific projects and accessing European funds for research by providing concrete institutional support.
-Continuing the balanced development of the existing research infrastructure and its use in the wide interest of the research teams
-Development of collaboration between university faculties as well as inter-university cooperation, in order to emphasize the interdisciplinarity of research, an essential condition for obtaining valuable results that contribute to the scientific performance of the university
-Identify all funding opportunities, from grants to independent funding
-Extension of interdisciplinary research fields,
-Identifying promising research topics
-Implementation of the most representative results into the dental practice;
-Continuous improvement of the members of the research team;

-Making national and international partnerships.
- Organizing of a defectoscopy center to analyze the quality of all prostheses made by our technicians or prostheses made in dental private practice

II.2. FUTURE DIRECTIONS IN ACADEMIC ACTIVITY

II.2.1. Academic activities regarding students and residents

A high quality educational process is of interest to both teachers and students of our faculty. The main objectives of the teaching process are, on the one hand, the training of students at the highest professional level, according to the requirements and opportunities on the labor market, and on the other hand, the increase of their own professional performances, in order to achieve the necessary practical skills. In this sense, the aim is to ensure the materials and equipment necessary for the practical activity, to provide them with theoretical support and to stimulate interest in performance, in order to train them as valuable specialists.

The development of clinical skills requires extensive knowledge and ability. Recently, the requirement is substituted by simulated training obtained through artificial intelligence (AI) – virtual reality (VR) and augmented reality (AR). The VR is creating a simulated environment, whereas AR is a division of the same, but it augments sensory perception and replicates real environment in virtual world (Huang TK *et al.*, 2018; Chander NG *et al.*, 2019)

Practical skills are only part of the skills required of future doctors, but they are a very important component that should be tested, evaluated and developed. In this sense, there is the continuous concern for increasing the quality of the didactic act, with paying more attention to the practical activity (Touati R *et al.*, 2019; Joda T *et al.*, 2019)

Theoretical and practical training of graduates must be in accordance with the needs and requirements of the national and international labor market. In order to achieve this goal, my future objectives will consist in deepening the acquired knowledge and skills, permanent self-training in order to acquire new knowledge related to educational activity, acquiring skills in related fields for interdisciplinarity, developing new approaches in my own teaching activity based on teaching strategies, developing new approaches in teaching activity, based on interdisciplinary and multidisciplinary teaching strategies, improving the ways of transferring information in courses and seminars.

Future directions regarding teaching activity for students:
The future directions for optimizing the didactic process consist in:
-ensuring access to modern information sources, ensuring the support of edited teaching material and in electronic format to the profile disciplines
- coordinating student scientific activities, involving students in research teams and stimulating their active participation in student scientific events
- implementing self-assessment and assessment of students' knowledge and stimulating them to accumulate new information through individual or team projects
-initiation of collaboration programs and inter-academic exchanges with the profile faculties from the country and abroad
- orientation of the preoccupations for the reorganization of the didactic process by restructuring the content of the study programs and of the curricula, following their connection to the norms imposed by the European Community

- creating a new dimension of undergraduate and postgraduate education by developing online distance learning
- ensuring a balance between students' expectations and the educational and managerial offer of the faculty
- the introduction in the educational process of some optional or voluntary disciplines, which would allow the students to capitalize on other values, indispensable for some professionals in the domain of medicine
-facilitating students' access to recommended bibliographic materials
--stimulating students in order to continue medical education in masters, doctorates and medical skills courses
-involvement in international mobility programmes

Future directions regarding teaching activity for residents:

- providing up-to-date information within the educational process through the consultation of existing databases, websites and specialized articles
-guide and supervision regarding the medical activity of the resident dentists of Dental Prosthetics and General Dentistry, who carry out clinical internships within the discipline;
-supervising the stages of prosthetic treatment on patients with different forms of edentulousness, both by fixed prostheses (on natural teeth or on implants), andremovable prosthesis with exclusive mucosal support, mixed or over-dentures on implants;
-stimulating residents to participate in practical skills courses, adapted to the curriculum for Prosthetic Dentistry residency;
-initiation of residents in the use of digital technologies in dentistry and their involvement in the implementation of computerized systems in the current dental activity
-stimulating residents to get involved in research, within the limits of skills and level of training; the research is carried out mainly in the discipline of Dental Technology, but collaborations with other disciplines within our university, and with other universities in the country and abroad are also encouraged.

Other strategies in the teaching field I intend to focus on:

- elaboration of didactic materials meant to facilitate the acquisition of knowledge in the field (course materials, worksheets and guidance of practical works)
- implementation of modern training means
- stimulating the active involvement of students in courses and practical activities, using teaching methods focused on learning through discovery, collaboration and team learning
- involvement of students in teaching and research activities,
- diversification of evaluation techniques for students and residents and information on the evaluation criteria of their activity
- training of young doctors able to apply and transfer the acquired information
- equipping laboratories and clinical disciplines with medical equipment, materials and instruments to ensure students and residents a medical practice at European standards, in order to achieve excellence in medical training and provide the labor market of a newly connected human resource, ready to higher level
- development of an integrated computer system to record the professional evolution of students at all levels of study

- participation to courses in the fields related to Dental technology and Dental Materials
- students' active involvement in the carrying out of courses and internships;
- new post-university courses in Prosthetic area and interdisciplinary fields;
- implementation of efficient active-participatory teaching methods in order to transform the students from information receivers into co-participants to the didactic process; these learning methods will optimally train future specialists, thus determining them to have not only useful and valuable information, but also to have their own opinions, based on rational arguments, to actively participate in finding solutions and to learn to collaborate in the team.
- initiating of research projects whose results can be capitalized in order to develop bachelor's or dissertation theses.

II.2.2. Academic activities regarding future doctoral students

The doctoral study is the basis of academic practices and previous research on doctoral education has identified several factors that contribute to the successful completion of this research project. The research proposal is probably one of the most important parts of the application process since it will demonstrate the background knowledge of the topic, methodology and the proposed research plan.

But just as important is the guidance by the supervisor of the young researchers during the project, interdisciplinar collaboration and support, in order to succesfully finalize the thesis and disseminate the results.

My 27 years of teaching experience in the Discipline of Technolgies of Dental Prosthesis and my research activity throughout this period give me assurances that I will be able to advise PhD students in order to carry out interesting research projects, the results of which can be used in current dental practice.

The directions related to PhD candidates' activity focus on:
-selection of high-performing students, with an appetite for research, with good or excellent academic record and their stimulation to continue with doctoral studies
- the support and guidance of PhD candidates in interesting research topics,
- support for the use of the most effective scientific methods necessary for conducting research and advice development of the research study protocol
-guiding doctoral students in order to achieve collaborations in the field of biomechanics, informatics, medical biostatistics, materials science and engineering
-encouraging young researchers to work in research teams
-support for writing and publishing articles in ISI-rated journals with high impact factor
- encouraging doctoral students in disseminating the results in national and international conferences and congresses
-encouraging academic mobility for PhD students
- facilitate and promote learning through active and student-centred approaches that would help PhD students to develop their research skills

Research topics specific to the field of Dental Technology can be concretized by the following aspects:

- Digital Prosthodontic Treatments

-Optimization of the biomechanical characteristics of acrylic and non-acrylic resins used for removable dentures
-Studies regarding the use of nanoparticles in order to improve the parameters of dental materials used in fixed and mobile prostheses
-Studies on perspectives of Zirconia-beased restorations (single crowns, fixed dental prostheses and implant-supported proshtheses), focusing on the incidence of framework fracture and chipping of the veneering porcelain
- Evaluation of the use of PEEK for implant-supported fixed and removable Restorations
- Research on use of PEEK in digital prosthodontics:

II.2.3. OTHER ACTIVITIES RELATING TO PROFESSIONAL DEVELOPMENT

In order to optimize the teaching and research activity, a future project consists in the elaboration of training guides, which will systematize the stages of making dental prostheses, from the simplest to the most complex, emphasizing the technological particularities that could help specialists to avoid a series of errors leading to defects of cast, acrylic and composites resins prosthetic devices..

I also propose the elaboration of a guide of good practices in the dental laboratory, which should be useful to dentist and dental technicians in order to avoid cross-infection..

1. Member in the project Prevention of school dropout and counseling in choosing the career path for first year students of Dental Medecine and Dental Technique (Be.MeDTech)
2. Member in the project "Insertion of medical graduates on the labor market, through the development of internships in practical training of practical skills-MEDPRO"

Educational projects will represent another part of my activity since and I already participated as a member in an educational projects dedicated to 1st year students of the Faculty of Dental Medicine - Prevention of school dropout and counseling in choosing the career path being in unfavorable situations (BeMedTech), and and another project dedicated to graduates from the final years (VI-th year, Dental Medecine specialization and III-rd year, Dental technique specialization- Insertion of medical graduates on the labor market, through the development of internships in practical training of practical skills-MEDPRO ". These projects have helped us to better understand the problems that students face and to help them more effectively in their training activity.

In conclusion, my future teaching and research activity will aim at training high-level specialists, encouraging young researchers in developing and finalizing projects, creating a strong research core with interdisciplinary teams.

The results of our research will be published in prestigious journals and presented at national and international congresses, which will contribute to increasing the visibility and prestige of the Faculty of Dentistry.

Section III
REFERENCES

1. Acosta-Torres M, Cajero-Juárez N-A, Castano VM. Cytocompatible antifungal acrylic resin containing silver nanoparticles for dentures. *International Journal of Nanomedicine* 2012; (7):4777—4786. doi.org/10.2147/IJN.S32391.
2. Adam RZ, Khan SB. Antimicrobial efficacy of silver nanoparticles against Candida albicans: A systematic review protocol. *PLOS Computationla Biology* 2021, 16(1): e0245811. doi.org/10.1371/journal.pone.0245811.
3. Agostinho AM, Miyoshi PR, Gnoatto N, Paranhos HFO, de Figueiredo LC, Salvador SL. Cross-contamination in the dental laboratory through the polishing procedure of complete dentures. *Braz Dent J* 2004; 15(2): 138-143..
4. Ajithan SL, Dathan P, AJayakumar A, Chandrathara TK, Shahin I, Nampoothiri DP, Chandrasekharan NK. The Relevance of Polishing Acrylic Dentures - An Overview. *Acta Scientific Dental Sciences* 2021, 5(5): 140-158. DOI: 10.31080/ASDS.2021.05.1109.
5. Alauddin MS, Baharuddin AS, Mohd Ghazali MI. The Modern and Digital Transformation of Oral Health Care: A Mini Review Healthcare (Basel). 2021 Jan 25;9(2):118. doi:10.3390/healthcare9020118.
6. Albaker AM. The oral health-related quality of life in edentulous patients treated with conventional complete dentures. *Gerodontology* 2013, 30:61-66. doi: 10.1111/j.1741-2358.2012.00645.x. Epub 2012 Feb 27.
7. Albanese A, Tang P, Chan WC. The effect of nanoparticle size, shape, and surface chemistry on biological systems. *Annu. Rev. Biomed. Eng*. 2012, 14:1–16. doi: 10.1146/annurev-bioeng-071811-150124.
8. Al-Fouzan AF, Al-mejrad LA, Albarrag AM. Adherence of Candida to complete denture surfaces in vitro: A comparison of conventional and CAD/CAM complete dentures. *J Adv Prosthodont.* 2017; 9(5): 402–408. doi:10.4047/jap.2017.9.5.402.
9. Alghazzawi TF. Advancements in CAD/CAM technology: Options for practical implementation. *Journal of prosthodontic research*. 2016; 60(2): 72-84. doi: 10.1016/j.jpor.2016.01.003.
10. Alheeti OAR, Jani GH, Al-E'nizy JA. The Effect Esthetic Factors in Complete Dentures Wearers Acceptances. *Indian Journal of Forensic Medicine & Toxicology* 2020; 14(4): 2034-2042. DOI: https://doi.org/10.37506/ijfmt.v14i4.11848.
11. Alla R, Raghavendra KN, Vyas R, Konakanchi A. Conventional and contemporary polymers for the fabrication of denture prosthesis: part I – overview, composition and properties. *Int J Appl Dent Sci.* 2015; 1(4):82–89.
12. Alla RK, Guduri V, Tiruveedula NBP, Rao G N, Swamy R, Vyas R. Effect of silver nanoparticles incorporation on microhardness of Heat-cure denture base resins. *Int J Dent Mater* 2020, 2(4): 103-110. doi.org/10.37983/IJDM.2020.240.

13. Alla RJ , Swamy KNR, Vyas R,Konakanchi A, Guduri V, a Gadde P. Influence of Silver Nanoparticles Incorporation on Flexural Strength of Heat-cure Acrylic Denture Base Resin Materials. *Annual Research & Review in Biology* 2017; 17(4): 1-8.
14. Allahyari S, Niakan S. Processing techniques of acrylic resin in removable and maxillofacial prosthesis: A review. *J Craniomax Res* 2018; 5(3): 99-104.
15. Al-Fouzan AF Lamya A. A, Albarrag AM. Adherence of Candida to complete denture surfaces in vitro: A comparison of conventional and CAD/CAM complete dentures. J Adv Prosthodont. 2017; 9(5):402-408. https://doi.org/10.4047/jap.
16. Al-Kheraif AA. The effect of mechanical and chemical polishing techniques on the surface roughness of heat-polymerized and visible light-polymerized acrylic denture base resins. *Saudi Dent J*. 2014; 26: 56–62. DOI: 10.1016/j.sdentj.2013.12.007.
17. Al-Mortadi N, Al-Khatib A, Alzoubi KH, Khabour OF. Disinfection of dental impressions: Knowledge and practice among dental technicians. *Clin Cosmet Investig Dent.* 2019; 11: 103-108.
18. Al-Sultani HF, Field JC, Thomason JM, Moynihan PJ. The Impact of Replacement Conventional Dentures on Eating Experience. *JDR Clinical & Translational Research* 2018; 4(1):29-40. Doi: 10.1177/2380084418803091.
19. Alikhasi M, Siadat H, Nasirpour A, Hasanzade M. Three-dimensional accuracy of digital impression versus conventional method: effect of implant angulation and connection type. *Int J Dent* 2018; 2018:3761750.
20. American Dental Association Council on Scientific Affairs and ADA Council on Dental Practice. Infection control recommendations for the dental office and the dental laboratory. *JADA* 1996, 127:672–80.
21. Amin S, Weber HP, Finkelman M, El Rafie K, Kudara Y, Papaspyridakos P. Digital vs. conventional full-arch implant impressions: a comparative study. *Clin Oral Implants Res* 2017; 28(11):1360-1367. doi: 10.1111/clr.12994.
22. Anadioti E, Kane B, Soulas E. Current and emerging applications of 3D printing in restorative dentistry. *Curr Oral Health Rep.* 2018; 5:133–139. DOI: 10.1007/s40496-018-0181-3.
23. Anadioti E, Musharbash L, Blatz MB, Papavasiliou G, Kamposiora P. 3D printed complete removable dental prostheses: a narrative review. *BMC Oral Health* 2020; 20(343).
24. Ardelean LA, Bortun CM, Podariu AC, Rusu LC. Acrylates and their Alternatives in dental applications. *Acrylic Polymers in Healthcare* 2017; 1-15. http://dx.doi.org/10.5772/intechopen.69010.
25. Arenas-Arrocena C, Argueta-Figueroa L, García-Contreras R, Martínez-Arenas O, Camacho-Flores B Rodriguez-Torres M, la Fuente-Hernández J, Acosta-Torres LS. New Trends for the Processing of Poly(Methyl Methacrylate). *Biomaterial for Dental Prosthodontic*s 2017; doi.org/10.5772/intechopen.69066
26. Aslanimehr M, Rezvani S, Mahmoudi A, Moosavi N. Comparison of Candida Albicans Adherence to Conventional Acrylic Denture Base Materials and Injection Molding Acrylic Materials. *Journal of dentistry* 2017; 18(1):61-64.

27. Ataei B, Alavian SM, Shahriari-Fard F, Rabiei AA, Safaei A, Rabiei A, Ataei M. A case-control study of risk factors for hepatitis B infection: A regional report among Isfahanian adults. *J Res Med Sci*. 2019; 24:22. DOI: 10.4103/jrms.JRMS_761_18.
28. Awasthi KK, Awasthi A, Verma R, Soni I, Awasthi K, John PJ. Silver nanoparticles and carbon nanotubes induced DNA damage in mice evaluated by single cell gel electrophoresis. *Macromol. Symp*. 2015; 357(1):210–217.
29. Baba NZ, AlRumaih HS, Goodacre BJ, Goodacre CJ. Current techniques in CAD/CAM denture fabrication. *Gen Dent.* 2016; 64:23–28.
30. Balcos C, Magda Calina Barlean MC, Bobu L, Popescu E. Evaluation of infection control knowledge and attitudes among dental technicians in Iasi. Romanian *Journal of Oral Rehabilitation* 2018; 10(1):120-127
31. Bangera MK, Kotian R, Madhyastha P. Effects of silver nanoparticle-based antimicrobial formulations on the properties of denture polymer: A systematic review and meta-analysis of in vitro studies. JProsthet Dent 2021; 25(21): S0022-3913 https://doi.org/10.1016/j.prosdent.2021.05.011
32. Banglani MA, Punjabi SK, Banglani M. Cross infection control-A study. *Pak Oral Dent J.* 2016; 36(2):286–288.
33. Banjonga P, Sankhama N, Duangngaa W, Intathaa U, Soykeabkaewa N, Sitthi Duangpheta S. The modification of acrylic denture base resin as materials for artificial teeth: Effect of hydroquinone and methyl methacrylate monomer, *ScienceAsia* 2020; 46S(1):97-101. doi: 10.2306/scienceasia1513-1874.2020.S014
34. Barenghi L, Barenghi A, Cadeo C, Di Blasio A. Innovation by Computer-Aided Design/Computer-Aided Manufacturing Technology: A Look at Infection Prevention in Dental Settings. *Biomed Res Int.* 2019; Article ID 6092018. doi: 10.1155/2019/6092018
35. Barenghi L, Barenghi A, Di Blasio A. Infection Control in Dentistry and Drug Resistant Infectious Agents: A Burning Issue. Part 2. *Rijeka: InTech*. 2018.
36. Bensel T, Pollak R, Stimmelmayr M, Hey J. Disinfection effect of dental impression tray adhesives. *Clinical Oral Investigations* 2013; 17(2): 497–502. doi: 10.1007/s00784-012-073
37. Bettencourt AF, Neves CB, de Almeida MS, Pinheiro LM, Oliveira SA, Lopes LP, Castro MF. Biodegradation of acrylic based resins: A review. Dental materials 2010; 26(5):171-180. doi: 10.1016/j.dental.2010.01.006.
38. Bhattacharjee B, Saneja R, Bhatnagar A. Effect of complete dentures on oral stereognostic ability in edentulous patients: A systematic review. *The Journal Of Indian Prosthodontic Society* 2021; 21(2): 109-115. doi: 10.4103/jips.jips_401_20.
39. Bidra AS, Taylor TD, Agar JR. Computer-aided technology for fabricating complete dentures: systematic review of historical background, current status, and future perspective. *J Prosthet Dent.* 2013; 109(6):361-366. doi.org/10.1016/S0022-3913(13)60318-2.
40. Bin Abdul Salim N, Jain AR, Varma ACU. Reliability of H.pound’s formula for anterior teeth selection. *Biomed Pharmacol J.* 2017; 10(2):1003-1008. https://dx.doi.org/10.13005/bpj/1197.

41. BommireddyVS, Malireddy R, Lodagala A, Chandu VC, Kothia NR, Reddy A. Denture care practices and perceived denture status among complete denture wearers in Guntur, Andhra Pradesh: A cross-sectional study. *Journal of Dr. NTR University of Health Sciences* 2018; 7(2): 98-102.
42. Bonnet G, Batisse C, Bessadet M, Nicolas E. A new digital denture procedure: a first practitioners appraisal. *BMC Oral Health* 2017; 17(1):155. doi:10.1186/s12903-017-0440z.
43. Bosînceanu DG, Bosînceanu DN, Luchian I, Baciu R, Tatarciuc M, Mârțu I. Complete dentures-clinical behavior and patients complaints. *Romanian Journal of Oral Rehabilitation* 2017; 9(2):5-8.
44. Boyce R, Mull J. Complying with the occupational safety and health administration: Guidelines for the dental office. *Dent Clin North Am*. 2008. 52 (3):653–668. doi: 10.1016/j.cden.2008.03.002.
45. Burde AV, Manole M, Vigu AL, Baciu S. Current knowledge and practices of dental technicians based in Romania regarding additive manufacturing. *Medicine in evolution*, 2019; 25(4):398-405.
46. Burdușel AC, Gherasim O, Grumezescu AM, Mogoantă L, et al. Biomedical Applications of Silver Nanoparticles: An Up-to-Date Overview. *Nanomaterials* 2018; 8(9): 681. doi.org/10.3390/nano8090681
47. Cao W, Zhang, Y. Development of a novel resin-based dental material with dual biocidal modes and sustained release of Ag+ ions based on photocurable core-shell AgBr/cationic polymer nanocomposites. *J. Mater. Sci. Mater. Med*. 2017, 28(7):103. doi: 10.1007/s10856-017-5918-3.
48. Carlsson GE, Omar R. The future of complete dentures in oral rehabilitation.A critical review. *Journal of Oral Rehabilitation 2010*; 37(2):143-156. doi:10.1111/j.1365-2842.2009.02039.x.
49. Carrasco-Labra A, Brignardello-Petersen R, Glick M, Guyatt GH, Neumann I, Azarpazhooh A. A practical approach to evidence-based dentistry: VII: how to use patient management recommendations from clinical practice guidelines. *J Am Dent Assoc*. 2015; 146(5):327–336. doi: 10.1016/j.adaj.2015.03.015.
50. Ch AN, Usman N, Kiran S, Zahra T, Khalid H, Akhtar MU. Cross infection control in dental institutions. *Pak Oral Dent J*. 2018; 38 (4):419–422.
51. Chaloupka K, Malam Y, Seifalian AM. Nanosilver as a new generation of nanoproduct in biomedical applications. *Trends in Biotechnology* 2010; 28(11):580–588. doi: 10.1016/j.tibtech.2010.07.006.
52. Chander NG. Augmented reality in prosthodontics. *J Indian Prosthodont Soc*. 2019; 19(4): 281–282. doi: 10.4103/jips.jips_324_19
53. Chatterjee S, Saigal S, Bhargava A, Shankar D, Khan AM, Khan SF. Hidden reservoirs of pathogens in dental settings. *Bioinformation* 2021; 17(1):73-79. doi: 10.6026/97320630017073.
54. Cheng K, Zhang M.A S, Melo MD, Weir XZ, Xu HK. Anti-biofilm dentin primer with quaternary ammonium and silver nanoparticles. *Journal of Dental Research* 2012; 91(6): 598–604. doi: 10.1177/0022034512444128.

55. Clark WA, Brazile B, Matthews D, Solares J, De Kok IJ. A Comparison of Conventionally Versus Digitally Fabricated Denture Outcomes in a University Dental Clinic. *Journal of Prosthodontics* 2021; 30:47–50. doi: 10 . 1111 / j o p r. 13273.
56. Constantiniuc M, Manole M, Bacali C, Ispas A, Popa D, Burde AV, Baciu S. Benefits of using CAD/CAM technology in dental prosthetics. *International Journal of Medical Dentistry* 2021; 25 (1):124-31.
57. Corrêa JM, Mori M, Sanches HL, da Cruz AD, Poiate E, Poiate IAVFP. Silver Nanoparticles in Dental Biomaterials", *International Journal of Biomaterials* 2015; Article ID 485275. doi.org/10.1155/2015/485275
58. Coulthwaite L, Verran J. Potential pathogenic aspects of denture plaque. *British Journal of BiomedicalScience* 2007; 64(4):180-189. doi.org/10.1080/09674845.2007.11732784
59. Dakal TC, Kumar A, Majumdar RS, Yadav V. Mechanistic basis of antimicrobial actions of silver nanoparticles. *Front. Microbiol*. 2016; 7:1831–1847.
https://doi.org/10.3389/fmicb.2016.01831.
60. Dawadi S, Katuwal S, Gupta A, Lamichhane U, Thapa R, Jaisi S, Lamichhane G, Bhattarai DP, Parajul N. Current Research on Silver Nanoparticles: Synthesis, Characterization, and Applications. *Journal of Nanomaterials* 2021; Article ID 6687290.
https://doi.org/10.1155/2021/6687290.
61. de Oliveira CE, Gasparoto TH, Dionísio TJ, Porto VC, Vieira NA, Santos CF, Lara VS. Candida albicans and denture stomatitis: evaluation of its presence in the lesion, prosthesis, and blood. *Int J Prosthodont*. 2010; 23(2):158–159.
62. De Souza Neto F.N, Sala R.L, Fernandes R.A, Xavie TPO, Cruz SA, Paranhos CM., Monteiro DR, Barbosa DB, Delbem ACB, de Camargo ER. Effect of synthetic colloidal nanoparticles in acrylic resin of dental use. *Eur. Polym. J*. 2019; 112:531–538. https://doi.org/10.1016/j.eurpolymj.2018.10.009.
63. Debattista N, Zarb M, Portelli JM. Bacterial atmospheric contamination during routine dental activity. *Malta Medical Journal* 2007; 20 (4):14-16.
64. Diaconu D, Tatarciuc M, Viţalariu A. Quantitative analysis of bacterial contamination in dental laboratory air. *Romanian Journal of Oral Rehabilitation* 2012; 4(4): 27-29.
65. Diaconu-Popa D, Tatarciuc M, Viţalariu A. Evaluation of the air quality in dental laboratory *Romanian Journal of Oral Rehabilitation* 2018; 10(3):142-147.
66. Diaconu-Popa D, Vițalariu A, Tatarciuc M. Digital technologies for complete dentures realization. *Romanian Journal of Medical and Dental Education* 2020; 9(3): 43-49.
67. Diaconu-Popa D, Comaneci R, Tatarciuc T, Murariu A, Vitalariu AM. Influence of silver nanoparticles on mechanical properties of dental acrylic resins. *Rev.chim.(Bucharest)* 2016; 67(11):2311-2313.
68. Diaz-Arnold AM, Vargas MA, Shaull KL, Laffoon JE, Qian F. Flexural and fatigue strengths of denture base resin. *J Prosthet Dent.* 2008; 100(1):47–51 doi: 10.22452/adum.vol25no2.7.
69. Dye B.A. The Global Burden of Oral Disease: Research and Public Health Significance. *Journal of Dental Research* 2017; 96(4):361-363. Doi: 10.1177/0022034517693567.
70. Durán G, Tisi JP, Rodríguez G, Henríquez I, Orellana R. The effect of different finishing and polishing procedures on the surface gloss of Bulk-Fill resin composites. *International*

journal of interdisciplinary dentistry 2020; 13(1): 17-20. DOI: 10.4067/S2452-55882020000100017.

71. Elshereksi NW, Ghazali MJ, Muchtar A, Azhari CH. Studies on the effects of titanate and silane coupling agents on the performance of poly (methyl methacrylate)/barium titanate denture base nanocomposites. *J Dent.* 2017; 56:121–32.
https://doi.org/10.1016/j.jdent.2016.11.012.
72. Espinosa-Cristóbal LF, Martínez-Castañón GA, Martínez-Martínez RE, Loyola-Rodríguez JP, Reyes-Macías JF, Ruiz F. Antibacterial effect of silver nanoparticles against Streptococcus mutans. *Materials Letters* 2009; 63(29):2603–2606.
https://doi.org/10.1016/j.matlet.2009.09.018.
73. Favaretto M, Shaw D, De Clercq E, Joda T, Elger BS. Big Data and Digitalizatio in Dentistry: A Systematic Review of the Ethical Issues. *Int. J. Environ. Res. Public Health* 2020; 17(7):2495. doi: 10.3390/ijerph17072495.
74. Felton DA. Complete Edentulism and Comorbid Diseases: An Update. *J Prosthodont* 2016; 25(1): 5-20. DOI: 10.1111/jopr.12350.
75. Figuerôa RMS, Conterno B, Arrais CAG, Sugio CYC, Urban VM, Neppelenbroek KH. Porosity, water sorption and solubility of denture base acrylic resins polymerized conventionally or in microwave. *J. Appl. Oral Sci.* 2018; 26: e20170383. doi.org/10.1590/1678-7757-2017-0383
76. Firoozeh F, Zibaei M, Zendedel A, Rashidipour H, Kamran A. Microbial contamination of pumice used in dental laboratories. *Healthc Low Resour Settings*. 2013; 1(1):18–21. DOI: 10.4081/hls.2013.e5
77. Flores CY, Diaz C, A. Rubert A, Benítez GA, Moreno MS, de Mele MAFL, Salvarezza RC, Schilardi PL, Vericat C. Spontaneous adsorption of silver nanoparticles on Ti/TiO2 surfaces. Antibacterial effect on *Pseudomonas aeruginosa*. *Journal of Colloid and Interface Science* 2010; 350(2):402–408. https://doi.org/10.1016/j.jcis.2010.06.052
78. Flores-Arriaga JC, García-Contreras R, Villanueva-Sánchez G, Acosta-Torres LS. Antimicrobial Poly (methyl methacrylate) with Silver Nanoparticles for Dentistry: A Systematic Review, *Appl. Sci*. 2020; 10(11): 4007-4016;
https://doi.org/10.3390/app10114007
79. Foong KW, Patil PG. Fabrication of maxillary single complete denture in a patient with deranged mandibular occlusal plane: A case report. *Saudi Dent J.* 2019; 31(1): 148–154. doi: 10.1016/j.sdentj.2018.10.007
80. Fouda SM, Gad MM, Ellakany P, Al-Thobity AM, Al-Harbi FA, Jorma I. Raustia VA. The effect of nanodiamonds on Candida Albicans adhesion and surface characteristics of PMMA denture base material - an in vitro study. JAppl Oral Sci. 2019; 27:e20180779. doi:10.1590/1678-7757-2018-0779.
81. Gad MM, Fouda SM, Al-Harbi FA, Näpänkangas R, Raustia A. PMMA denture base material enhancement: a review of fiber, filler, and nanofiller addition. » International *Journal of Nanomedicine* 2017; 12: 3801—3812. /doi.org/10.2147/IJN.S130722.
82. Ganesh S, Gujjari AK. Comparative Study to Assess the Effectiveness of Various Disinfectants on two Microorganisms and the effect of same on Flexural Strength of Acrylic Denture Base Resin - An In Vitro Study. *J Int Oral Health* 2013; 5(3):55–62.

83. Gendreau L, Loewy ZG. Epidemiology and Etiology of Denture Stomatitis. *J Prosthodont.* 2011; 20(4):251-260. doi.org/10.1111/j.1532-849X.2011.00698.x.
84. Ghaffari T, Hamedi-rad F. Effect of Silver Nano-particles on Tensile Strength of Acrylic Resins. *J Dent Res Dent Clin Dent Prospects*. 2015; 9(1):40–43.
doi: 10.15171/joddd.2015.008
85. Goodacre BJ, Goodacre CJ, Baba NZ, et al: Comparison of denture tooth movement between cad-cam and conventionalfabrication techniques. *J Prosthet Dent* 2018; 119(1):108-115. doi: 10.1016/j.prosdent.2017.02.009
86. Goodacre BJ, Goodacre CJ, Baba NZ, Kattadiyil MT. Comparison of denture base adaptation between CAD/CAM and conventional fabrication techniques. J Prosthet Dent. 2016; 116(2):249-256. https://doi.org/10.1016/j.prosdent.2016.02.017 PMid:27112416
87. Gray J. Infection control beyond the horizon. *J Hosp Infect*. 2015; 89(4):237-240. DOI: 10.1016/j.jhin.2014.11.004
88. Gross D, Gross K, Saskia W. Digitalization in dentistry: ethical challenges and implications. *Quintessence International* 2019; 50 (10):830-838. DOI: 10.3290/j.qi.a43151
89. Gupta S, Rani S, Garg S. Infection control knowledge and practice: A cross-sectional survey on dental laboratories in dental institutes of North India. *J Indian Prosthodont Soc.* 2017; 17(4): 348–354. doi: 10.4103/jips.jips_5_17
90. Gurunathan S, Qasim M, Park C, Yoo H, Choi DY, Song H, Kim J-H, K, Hong K. Cytotoxicity and Transcriptomic Analysis of Silver Nanoparticles in Mouse Embryonic Fibroblast Cells. *Int. J. Mol. Sci.* 2018; 19(11):3618. https://doi.org/10.3390/ijms1911361
91. Hakam FA, Khalil A, Khan SU, Shakir S. Cross-infection control practices in prosthodontics among undergraduate students, graduates and post-graduate students: a cross-sectional study. *Pakistan Oral & Dental Journal* 2018; 38(3):385-389.
92. Halkai KR, Mudda JA, Shivanna V, Patil V, Rathod V, Halkai R. Cytotoxicity evaluation of fungal-derived silver nanoparticles on human gingival fibroblast cell line: An in vitro study. *J Conserv Dent* 2019; 22(2): 160–163. doi: 10.4103/JCD.JCD_518_18.
93. Halkai KR, Mudda JA, Shivanna V, Rathod V, Halkai R. Biosynthesised silver nanoparticles from fungi as antimicrobial agents for endo-perio lesions – A review. *Ann Res Rev Biol*. 2016; 21(6): 662–666. doi: 10.4103/JCD.JCD_203_18
94. Halkai K.R, Mudda JA. Antibacterial Efficacy of Biosynthesized Silver Nanoparticles against Enterococcus faecalis Biofilm: An in vitro Study. *Contemp. Clin. Dent.* 2018; 9(2): 237–241. doi: 10.4103/ccd.ccd_828_17.
95. Hallier C, Williams DW, Potts AJ, Lewis MA. A pilot study of bioaerosol reduction using an air cleaning system during dental procedures. *Br Dent J.* 2010; 209(8):E14. doi: 10.1038/sj.bdj.2010.975.
96. Harini B, Kommi V, Sashank K, Roy A. A review: CD fabrication with technology different from conventional method. *International Journal of Psychosocial Rehabilitation* 2020; 24(1): 6919-6924. DOI: 10.37200/IJPR/V24I1/PR202216.
97. Harrel SK, Molinari J. Aerosols and splatter in dentistry: A brief review of the literature and infection control implications. *J.Am.Dent. Assoc*. 2004; 135(4):429-347.

doi: 10.14219/jada.archive.2004.0207.
98. Higgins JPT, Green S. Cochrane. Handbook for systematic reviews of interventions. 1st Edition. West Sussex, UK: Wiley-Blackwell 2011.
99. Hsu Y-J, Lin J-R, Hsu J-F. Patient satisfaction, clinical outcomes and oral health-related quality of life after treatment with traditional and modified protocols for complete dentures. *J Dent Sci.* 2021; 16(1): 236–240. doi: 10.1016/j.jds.2020.05.024.
100. Hsu C-Y, Yang T-C, Wang T-M, Lin L-D. Effects of fabrication techniques on denture base adaptation: An in vitro study. JPD 2020; 124(6):740-747. DOI:https://doi.org/10.1016/j.prosdent.2020.02.012
101. Huang TK, Yang CH, Hsieh YH, Wang JC, Hung CC. Augmented reality (AR) and virtual reality (VR) applied in dentistry. *Kaohsiung J Med Sci.* 2018; 34:243–248. DOI: 10.1016/j.kjms.2018.01.009
102. Idzior-Haufa M, Pilarska AA, Hedzelek W, Boniecki P, Pilarski K, Dorocka, Bobkowska B. A Comparison of Biomechanical Properties of Implant-Retain-Overdenture Based on Precision Attachment Type. *Materials* 2021; 14(10):2598-2615.
https://doi.org/10.3390/ma14102598
103. Inayati E, Redjeki S, Gofur NRP. Prevention and control of cross infection at dental laboratories in east Java province of Indonesia. *Journal of Vocational Health Studies* 2021; 4(3): 125-130. http://dx.doi.org/10.20473/jvhs.V4.I3.2021.
104. Jablonski RY, Barber M W. Restorative dentistry for the older patient cohort. *Br Dent J* 2015; 218(6): 337–342. DOI: 10.1038/sj.bdj.2015.197
105. Jain P, Ganapathy D. Awareness of safety/infection control practices followed by dental laboratory technicians in South India. *Drug Invention Today* 2019; 12 (1):105-110.
106. Janeva N, Kovacevska G, Janev E. Complete Dentures Fabricated with CAD/CAM Technology and aTraditional Clinical Recording Method. *Open Access Macedonian Journal of Medical Sciences* 2017; 65(6):785-789. doi: 10.3889/oamjms.2017.169.
107. Janeva NM, Kovacevska G, Elencevski S, Panchevska S, Mijoska A, Lazarevska B. Advantages of CAD/CAM versus Conventional Complete Dentures - A Review. *Journal of Medical Sciences.* 2018; 6(8):1498-1502. DOI:10.3889/oamjms.2018.308.
108. Jin N-Y, Lee H-R, Lee H, Pae A. Wettability of denture relining materials under water storage over time. *J Adv Prosthodont* 2009, 1(1):1-5. DOI:10.4047/jap.2009.1.1.1.
109. Jin J, Zhang L. Ti-GO-Ag nanocomposite: The effect of content level on the antimicrobial activity and cytotoxicity. *Int. J. Nanomed*. 2017; 12:4209–4224.doi: 10.2147/IJN.S134843.
110. Joda T, Bornstein MM, Jung RE, Ferrari M, Waltimo T, Zitzman NU. Recent Trends and Future Direction of Dental Research in the Digital Era. *Int J Environ Res Public Health*. 2020; 17(6):1987.d oi.org/10.3390/ijerph17061987
111. Joda T, Gallucci GO, Wismeijer D, Zitzmann NU. Augmented and virtual reality in dental medicine: A systematic review. *Comput Biol Med*. 2019; 108:93–100. doi: 10.1016/j.compbiomed.2019.03.012.
112. Joda T, Zarone F, Ferrari M. The complete digital workflow in fixed prosthodontics: A systematic review. *BMC Oral Health*. 2017; 17:124. doi: 10.1186/s12903-017-0415-0.

113. Kalberer N, Mehl A, Schimmel M, Müller F, Srinivasan M. CAD-CAM milled versus rapidly prototyped (3D-printed) complete dentures: an in vitro evaluation of trueness. *J Prosthet Dent*. 2019; 121(4):637–643. doi: 10.1016/j.prosdent.2018.09.001.
114. Karabela MS, Sideridou ID. Synthesis and study of properties of dental resin composites with different nanosilica particles size. *Dent Mater*. 2011; 27(8):825–835. DOI: 10.1016/j.dental.2011.04.008
115. Kartika UK, Agrawal B, Yadav NS, Singh PP, Rahangdale T. The effect of microwave processing and use of antimicrobial agent on porosity of conventional heat cured denture base resin: an in vitro study. *J Indian Prosthodont Soc*. 2015; 15(3):257-262.
doi: 10.4103/0972-4052.161080
116. Kasina SP, Ajaz T, Attili S, Surapaneni H, Cherukuri M, Srinath HP. To evaluate and compare the porosities in the acrylic mandibular denture bases processed by two different polymerization techniques, using two different brands of commercially available denture base resins - an in vitro study. J Int Oral Health. 2014, 6:72–77.
117. Kassaee M Z, Akhavan A, Sheikh N, Sodagar A. Antibacterial effects of a new dental acrylic resin containing silver nanoparticles. *Journal of Applied Polymer Science* 2008; 110(3):1699–1703. https://doi.org/10.1002/app.28762.
118. Kassaee MZ, .Akhavana A, Sheikh N, Beteshobabrud R. γ-Ray synthesis of starch-stabilized silver nanoparticles with antibacterial activities. *Radiation Physics and Chemistry* 2008; 7(9):1074-1078. https://doi.org/10.1016/j.radphyschem.2008.06.010
119. Kattadiyil MT, Goodacre CJ, Baba NZ. CAD/CAM complete dentures: a review of two commercial fabrication systems. *J Calif Dent Assoc*. 2013; 41 (6):407–416.
120. Kattadiyil MT, Jekki R, Goodacre CJ, Baba NZ. Comparison of treatment outcomes in digital and conventional complete removable dental prosthesis fabrications in a predoctoral setting. *J Prosthet Dent*. 2015; 114(6):818-825. doi: 10.1016/j.prosdent.2015.08.001.
121. Kattadiyil MT, AlHelal A, Goodacre BJ. Clinical complications and quality assessments with computer-engineered complete dentures: A systematic review. *The Journal of prosthetic dentistry* 2017; 117(6):721-728. doi: 10.1016/j.prosdent.2016.12.006.
122. Keshk AM, Alqutaibi AY, Algabri RS, Swedan MS, Kaddah A. Prosthodontic maintenance and peri-implant tissue conditions for telescopic attachment-retained mandibular implant overdenture: Systematic review and meta-analysis of randomized clinical trials. *Eur. J. Dent*. 2017; 11(4):559–568. doi: 10.4103/ejd.ejd_23_17.
123. Khanna G, Aparna IN. Comparison of micro hardness of three different type of acrylic artificial denture teeth: An in vitro study. Journal of Orofacial Research 2013; 3(3):181-185.
124. Kimoto S, Kimoto K, Kitamura A, Saita M, Iijima M, Kawai Y. Effect of dentist's clinical experience on treatment satisfaction of a complete denture. *J Oral Rehabil*. 2013; 40(12):940–947. DOI: 10.1111/joor.12108.
125. Kohn WG, Collins AS, Cleveland JL, Harte JA, Eklund KJ, et al. Guidelines for Infection Control in Dental Health-Care Settings—2003. MMWR Recomm Rep. 2016; 52: 1-61.

126. Köroğlu A, Sahin O, Kürkçüoğlu I, Dede DÖ, Özdemir T, Hazer B. Silver nanoparticle incorporation effect on mechanical and thermal properties of denture base acrylic resins, *J Appl Oral Sci*. 2016; 24(6): 590–596. doi: 10.1590/1678-775720160185.
127. Kurt A, G Erkose-Genc G, Uzun M, Emrence Z, Ustek D, Isik-Ozkol G. The antifungal activity and cytotoxicity of silver containing denture base material. *Nigerian Journal of Clonical practice* 2017; 20(3):290-295. DOI: 10.4103/1119-3077.181362.
128. Lamb A, Hong C, De Silva H, Thomson W, Broadbent J. New Zealand oral health practitioners' cross-infection control practices. *N Z Dent J.* 2019; 115(1):5–10.
129. Lang A, Ovsenik M, Verdenik I, Remškar M, Oblak C. Nanoparticle concentrations and composition in a dental office and dental laboratory: A pilot study on the influence of working procedures. *Journal of Occupational and Environmental Hygiene* 2018; 15(5):441-447. doi: 10.1080/15459624.2018.1432864.
130. Latib YO, Owen CP, Patel M. Viability of Candida in denture base resin after disinfection: A preliminary study. *Int. J. Prosthodont*. 2018; 31(5):436–439. doi: 10.11607/ijp.5653.
131. Lee DJ, Saponaro PC. Management of edentulous patients. Dent Clin North Am. 2019; 63(2):249–261. https://doi.org/10.1016/j.cden.2018.11.006
132. Li Z, Sun J, Lan J, Qi Q. Effect of a denture base acrylic resin containing silver nanoparticles on Candida albicans adhesion and biofilm formation. *Gerodontology* 2016; 33(2):209-216. DOI: 10.1111/ger.12142
133. Lima JFM, Maciel JG, Arrais CAG, Porto VC, Urban VM, Neppelenbroek KH. Effect of incorporating antifungals on the water sorption and solubility of interim resilient liners for denture base relining. *Journal of Prosthetic Dentistry* 2016; 115 (5): 611–616.
https://doi.org/10.1016/j.prosdent.2015.09.029
134. Lima JF, Maciel JG, Hotta J, Vizoto AC, Honorio HM, Urban VM, et al. Porosity of temporary denture soft liners containing antifungal agents. *J Appl Oral Sci*. 2016; 24(5):453-461. doi: 10.1590/1678-775720160092
135. Liu W, Su P. Synthesis of TiO2 nanotubes with ZnO nanoparticles to achieve antibacterial properties and stem cell compatibility. *Nanoscale* 2014; 6(15):9050-9062. doi: 10.1039/c4nr01531b.
136. Machado C, Sanchez E, Azer SS, Uribe JM. Comparative study of the transverse strength of three denture base materials. *J Dent*. 2007; 35(12):930–933.
doi: 10.1016/j.jdent.2007.09.006.
137. Machado-Santos L, Silika N, Baroudi K, Sinhoreti M-A-C, Brandt W-C, Liporoni P-C-S. Mechanical performance of experimental acrylic resins modified by nanoparticles after chemical and mechanical degradation. *J.Clin Exp Dent*. 2020; 12(12):157–163. doi: 10.4317/jced.57265.
138. Mahasneh AM Alakhras M, Khabour OF, Al-Sa'di AG, Al-Mousa DS. Practices of Infection Control Among Dental Care Providers: A Cross Sectional Study. *Clinical, Cosmetic and Investigational Dentistry* 2020; 2020(12):282-289.
https://doi.org/10.2147/CCIDE.S261171

139. Mahross HZ, Baroudi K. Effect of silver nanoparticles incorporation on viscoelastic properties of acrylic resin denture base material. *Eur J Dent.* 2015; 9(2): 207–212. doi: 10.4103/1305-7456.156821
140. Marachlioglou CR, Dos Santos JF, Cunha VP, Marchini L. Expectations and final evaluation of complete dentures by patients, dentist and dental technician. *J Oral Rehabil*. 2010; 37(7):518-524. doi: 10.1111/j.1365-2842.2010.02072.x.
141. Marlière DAA, Demétrio MS, Picinini LS, De Oliveira RG, de Miranda Chaves Netto HD. Accuracy of computer-guided surgery for dental implant placement in fully edentulous patients: A systematic review. *Eur J Dent.* 2018; 12(1): 153–160. doi: 10.4103/ejd.ejd_249_17.
142. Mary KM, Cherian B. Evaluation of oral stereognosis, masticatory efficiency, and salivary flow rate in complete denture wearers. *J Indian Prosthodont Soc* 2020; 20(3):290-296. DOI: 10.4103/jips.jips_453_19.
143. May LW, Seong LG. A Narrative Review of Different Types and Processing Methods of Acrylic Denture Base Material. *Ann Dent UM* 2018; 25(2):58-67. DOI: https://doi.org/10.22452/adum.vol25no2.7
144. Mathew M, Shenoy K, Ravishankar KS. Vickers hardness and specific wear rate of poly-propylene reinforced PMMA. *Int J Sci Stud*. 2014; 2(3):71-75.
145. McCunniff M, Liu W, Dawson D, Marchini L. Patients' esthetic expectations and satisfaction with complete dentures. *Prosthet Dent* 2017; 118(2):159-165. doi: 10.1016/j.prosdent.2016.10.015.
146. McLaughlin JB, Ramos V, Dickinson DP. Comparison of Fit of Dentures Fabricated by Traditional Techniques Vs CAD/CAM Technology. *J Prosthodont* 2019; 28(4):428-435. doi: 10.1111/jopr.12604
147. Melo MAS, Cheng L, Weir MD, Hsia R-C, Rodrigues LKA. Xu HHK. Novel dental adhesive containing antibacterial agents and calcium phosphate nanoparticles. *Journal of Biomedical Materials Research, Part B: Applied Biomaterials* 2013; 101(4):620–629. doi: 10.1002/jbm.b.32864.
148. Mistry R, Pisulkar SK, Borle AB, Godbole S, Mandhane R. Stability in Complete Dentures: An Overview. *Journal of Dental and Medical Sciences* 2018; 17(11): 36-41. DOI: 10.9790/0853-1711073641
149. Monteiro DR, Takamiya AS, Feresin LP, Gorup LF, de Camargo ER, Delbem AC, Henriques M, Barbosa DB. Susceptibility of Candida albicans and Candida glabrata biofilms to silver nanoparticles in intermediate and mature development phases. *J. Prosthodont. Res.* 2015; 59:42–48.
150. Monteiro D R, Gorup LF, Takamiya AS, de Camargo ER, Filho ACR, Barbosa DB. Silver distribution and release from an antimicrobial denture base resin containing silver colloidal nanoparticles. *Journal of Prosthodontics* 2012; 21(1):7–15.
151. Moodley KL, Owen CP, Patel M. Quantitative Analysis of Selected Microorganisms Present at Various Sites in a Prosthetics Clinic and Dental Laboratory during Complete Denture Fabrication. *J. Environ. Res. Public Health* 2020; 17(10):3345. doi.org/10.3390/ijerph17103345

152. Morais FAI, Mello BA, Souza IA, Ponzi EAC, Revoredo GA. Methylmethacrylate-based polymers. *Int J Dent*. 2007; 6:63–66.
153. Müller F. Interventions for edentate elders—what is the evidence? *Gerodontology* 2014; 31(1):44–51. doi:10.1111/ger.12083.
154. Mumcu E, Cilingi A, Gencel B, Sülün T. Flexural properties of a light-cure and a self-cure denture base materials compared to conventional alternatives. *J Adv Prosthodont*. 2011; 3(3): 136–139. doi:10.4047/jap.2011.3.3.136.
155. Munikamaiah RL 1, Jain SK, Pal KS, Gaikw A. Evaluation of Flexural Strength of Polymethyl Methacrylate modified with Silver Colloidal Nanoparticles subjected to Two Different Curing Cycles: An in vitro Study. J Contemp Dent Pract 2018; 19(3):262-268.
156. Nair VV, Karibasappa GN, Dodamani A, Prashanth VK. Microbial contamination of removable dental prosthesis at different interval of usage: An in vitro study. *J Indian Prosthodont Soc*. 2016; 16(4): 346–351. doi:10.4103/0972-4052.176536.
157. Nam K.-Y. In vitro antimicrobial effect of the tissue conditioner containing silver nanoparticles. *Journal of Advanced Prosthodontics* 2011; 3(1):20–24. doi: 10.4047/jap.2011.3.1.20
158. Nam KY, Lee CH, Lee CJ. Antifungal and physical characteristics of modified denture base acrylic incorporated with silver nanoparticles. *Gerodontology*. 2012; 29(2):413-419.
doi: 10.1111/j.1741-2358.2011.00489.x.
159. Naz A, Hanif S, Kumar B, Musharraf H, Lone MA, Tariq N. Evaluation of cross infection control awareness and practices in dental laboratories. *Pakistan Oral & Dental Journal* 2020; 40(2):98-102
160. Neville P, van der Zande MM. Dentistry, e-health and digitalisation: A critical narrative review of the dental literature on digital technologies with insights from health and technology studies. *Community Dent Health.* 2020; 37(1):51-58.
doi: 10.1922/CDH_4664Neville08.
161. Nitschke I, Wendland A, Weber S, Jockusch J, Lethaus B, Hahnel S. Considerations for the Prosthetic Dental Treatment of Geriatric Patients in Germany. *J Clin Med*. 2021; 10(2):304. doi:10.3390/jcm10020304.
162. Oleiwi JK, Hamad QA. Studying the Mechanical Properties of Denture Base Materials Fabricated from Polymer Composite Materials. *Khwarizmi Engineering Journal* 2018; 14(3):100- 111. https://doi.org/10.22153/kej.2018.01.006
163. Oosthuysen J, Potgieter E, Fossey A. Compliance with infection prevention and control in oral health-care facilities: a global perspective. *Int Dent J.* 2014; 64(6):297-311. doi: 10.1111/idj.12134.
164. Oyar P, Sana FA, Durkan R. Comparison of mechanical properties of heat-polymerized acrylic resin with silver nanoparticles added at different concentrations and size, *J. Appl. Polym. Sci.* 2018; 135(6): 45807–45812. doi:10.1002/app.45807.
165. Ozdemir DD, Ozdemir AK, Polat NT et al. Prevalence of respiratory abnormalities and pneumoconiosis in dental laboratory technicians. *Tuberk Toraks* 2010, 58:135–41.
166. Pacquet W, Benoit A, Hatège-Kimana C, Wulfman C. Mechanical properties of CAD/CAM denture base resins. *Int J Prosthodont*, 2019; 32(1): 104-106. DOI: 10.11607/ijp.6025

167. Panáček A, Kolář M, Večeřová R, Prucek R, Soukupová J, Kryštof V, Hamal P, Zbořil R, Kvítek L. Antifungal activity of silver nanoparticles against Candida spp. Biomaterials. 2009, 30:6333–6340. doi: 10.1016/j.biomaterials.2009.07.065
168. Pankhurst CL, Coulter WA. Basic Guide to Infection Prevention and Control in Dentistry. 2nd. UK: Wiley Blackwell; 2017.
169. Park H.J, Park S, Roh J, Kim AS, Choi K, Yi J, KimY, Jeyong Yoon J. Biofil inactivating activity of silver nanoparticles: a comparison with silver ions. *Journal of Industrial and Engineering Chemistry* 2013; 19(2): 614–619. DOI10.1016/j.jiec.2012.09.013
170. Parvez K, Parvez K, Sultan R, Aliuddin AM. Oral Complaints of Complete Denture Wearing Elderly PatientsAnd Their Relation with Age & Gender. *JPDA* 2020, 29(3):140-143. DOI: 10.25301/JPDA.293.140
171. Patel J, Jablonski RY, Morrow LA. Complete dentures: an update on clinical assessment and management: part 1. *British Dental Journal* 2018; 225:707–714.
doi: 10.1038/sj.bdj.2018.866.
172. Patel M. Infection control in dentistry during COVID–19 pandemic: what has changed? *Heliyon* 2020; 6(10):e05402. doi: 10.1016/j.heliyon.2020.e05402.
173. Pfeiffer P, Rosenbauer E-U. Residual methyl methacrylate monomer, water sorption, and water solubility of hypoallergenic denture base materials. *The Journal of prosthetic dentistry* 2004; 92(1): 72-78. DOI: 10.1016/j.prosdent.2004.04.003
174. Philip JM, Rebecca LJ, Jeyanthi L, Abraham HM, Venkatakrishnan CJ, Chandran CR, Anbuselvi S. Current trends in reducing microbial adhesion to acrylic denture base resins. *Drug Invention Today* 2018; 10(6):946-940.
175. Pradhan D, Shrestha L, Lohani J, Munankarmi J. Practice of Cross-infection Control for Dental Impression in Commercial Dental Laboratory. *J Nepal Soc Perio Oral Implantol.* 2019; 3(6):58-61. DOI: https://doi.org/10.3126/jnspoi.v3i2.30884
176. Prażmo EJ, Kwaśny M, Łapiński M, Mielczarek A. A. Photodynamic Photodynamic therapy as a promising method Used in the treatment of Oral Diseases. *Adv. Clin. Exp. Me*d. 2016; 25(4): 799–807. doi: 10.17219/acem/32488.
177. Prpić V, Schauperl Z, Ćatić A, Dulčić N, Čimić S. Comparison of mechanical properties of 3D-printed, CAD/CAM, and conventional denture base materials. *J Prosthodont.* 2020; 29(6):524–528. https://doi.org/10.1111/jopr.13175
178. Qayyum S, Khan AU. Nanoparticles vs. biofilms: a battle against another paradigm of antibiotic resistance, *MedChemComm* 2016; 7:1479–1498.
179. Rao DC, Kalavathy N, Mohammad HS, Hariprasad A, Kumar CR. Evaluation of the surface roughness of three heat-cured acrylic denture base resins with different conventional lathe polishing techniques: A comparative study. *J Indian Prosthodont Soc*. 2015; 15(4): 374–380. Doi:10.4103/0972-4052.164910.
180. Radke UM, Gundawar SM, Banarjee RS, Paldiwal AS. Single complete denture: a case report. *Int J Clin Dent Sci*. 2012; 3(1): 76–80.
181. Ramos AP, Cruz MAE, Tovani CB, Ciancaglini P. Biomedical applications of nanotechnology. *Biophysical Reviews* 2017, 9(2):79–89. doi: 10.1007/s12551-016-0246-2.

182. Rasam S, Apte K, Salvi S. Infection control in the pulmonary function test laboratory. *Lung India* 2015; 32(4):359–366. doi: 10.4103/0970-2113.159571.
183. Raszewski Z, Nowakowska-Toporowska A, Nowakowska D, Więckiewicz W. Update on Acrylic Resins used in Dentistry. *Mini-Reviews in Medicinal Chemistry* 2021; 21(15): 2130 – 2137. DOI : 10.2174/1389557521666210226151214
184. Ravalec G, Sadoun L, Rohman G, Pacquet W, Hatege-Kimana C, Hollmann C, Desruelle O, Wulfman C. A comparison of conventional and machinable PMMA materials for denture. *Computer Methods in Biomechanics and Biomedical Engineering* 2020, 23(1): 253–254. https://doi.org/10.1080/10255842.2020.1815325
185. Rekow ED. Digital dentistry: The new state of the art-Is it disruptive or destructive? *Dent. Mater.* 2020; 36(1):9-24. doi: 10.1016/j.dental.2019.08.103.
186. Revilla-León M, Özcan M. Additive Manufacturing Technologies Used for Processing Polymers: Current Status and Potential Application in Prosthetic Dentistry. *J. Prosthodont.*2019; 28(2):146–58. doi: 10.1111/jopr.12801.
187. Rickman LJ, Padipatvuthikul P, Satterthwaite JD. Contemporary denture base resins: part 1. *Dental Updat* 2017; 9(1). https://doi.org/10.12968/denu.2012.39.1.25
188. Roumanas ED. The social solution-denture esthetics, phonetics, and function. *J Prosthodont.* 2009; 18(2):112-115. doi: 10.1111/j.1532-849X.2009.00440.x.
189. Russo LL, Salamini A. Removable complete digital dentures: A workflow that integrates open technologies. *J Prosthet Dent* 2018; 119(5):727-732. doi:10.1016/j.prosdent.2017.06.019.
190. Sabri BA, Satgunam M, Abreeza NM, Abed NA. A review on enhancements of PMMA Denture Base Material with Different Nano-Fillers. *Materials engineering* 2021;8(1): 1-25. doi.org/10.1080/23311916.2021.1875968
191. Sacoor S, Chana S, Fortune F. The dental team as part of the medical workforce during national and global crises. *Br Dent J.* 2020; 229(2):89-92. doi: 10.1038/s41415-020-1854-6.
192. Saha A, Dutta S, Varghese RK, Kharsan V, Agrawal A. A survey assessing modes of maintaining denture hygiene among elderly patients. *J Int Soc Prevent Community Dent* 2014; 4(3):145-148. doi: 10.4103/2231-0762.142007
193. Sakaguchi RL, Powers JM. Craig's restorative dental materials: e-book. St Louis (MO): Elsevier Health Sciences 2012.
194. Salih SI, Oleiwi JK, Hamad QA. Numerically and theoretically studying of the upper composite complete prosthetic denture. *Eng. & Tech. Journal, Part (A),* 2015; 33(5):1023- 1037.
195. Salvia ACRD, Matilde FS, Rosa FCS, Kimpara ET, Jorge AOC, Balducci B, Koga-Itoa CY. Disinfection Protocols to prevent cross-contamination between dental offices and prosthetic laboratories. J. Infect. Public Health 2013; 6(5): 377–382. https://doi.org/10.1016/j.jiph.2013.04.011.
196. Samejo I, Gotam S, Gotam D, Haseeb M, Muhammad R, Hussain W. Infection control practices. *Professional Medical Journal* 2018; 25(12):1933-1936. doi: 10.29309/TPMJ/18.4957

197. Santos BF, Santos MB, Santos JF, Marchini L. Patients' Evaluations of Complete Denture Therapy and Their Association with Related Variables: A Pilot Study.*J Prosthodont.* 2015; 24(5):351-357. doi:10.1111/jopr.12286.
198. Saponaro PC, Yilmaz B, Heshmati RH, et al. Clinical performance of CAD-CAM-fabricated complete dentures: a cross-sectional study. *J Prosthet Dent* 2016; 116(3):431–435. doi:10.1016/j.prosdent.2016.03.017.
199. Saponaro PC, Yilmaz B, Johnston W, et al. Evaluation of patient experience and satisfaction with CAD-CAM-fabricated complete dentures: a retrospective surveystudy. *J Prosthet Dent* 2016, 116(4):524–528. doi: 10.1016/j.prosdent.2016.01.034.
200. Schierz O, Müller H, Stingu CS, Hahnel S, Rauch A. Dental tray adhesives and their role as potential transmission medium for microorganisms. Clin Exp Dent Res. 2021, 1–4. doi: 10.1002/cre2.432
201. Schweiger J, Stumbaum J, Edelhoff D, Guth JF. Systematics and concepts for the digital production of complete dentures: risks and opportunities. *Int J Comput Dent*. 2018; 21(1):41–56.
202. Schweiger J, Guth JF, Edelhoff D, Stumbaum J. Virtual evaluation for CAD-CAM fabricated complete dentures. *The Journal of prosthetic dentistry* 2017; 117(1):28-33. oi: 10.1016/j.prosdent.2016.05.015.
203. Schwindling FS, Stober T. A comparison of two digital techniques for the fabrication of complete removable dental prostheses: A pilot clinical study. *J Prosthet Dent*. 2016; 116(5):756-763. doi: 10.1016/j.prosdent.2016.03.022.
204. Sedky NA. A comparative study of practicing cross-infection control of dental prostheses and implant components among prosthodontists and dental echnicians in Qassim province, *Saudi Arabia. Int J Infect Control* 2019; 15((3):1-14 doi: 10.3396/ijic.v15i4.016.19.
205. Sedky NA. Evaluation of practice of cross infection control for dental impressions among laboratory technicians and prosthodontists in KSA. *Int J Infect Control*. 2014; 10(3):1-12. https://doi.org/10.3396/ijic.v10i3.12576
206. Sharma P, Bhumika Sharma B. Unconventional Dentures: A Manifestation of New Vision in Prosthesis Construction. Journal of Advanced Oral Research, 2020, 11(1): 101–108. doi: 10.1177/2320206820918738
207. Sheba M, Comnick C, Elkerdan T et al. Students' perceptions and attitudes about digital dental technology is associated with their intention to use it. J*ournal of Dental Education* 2021; 85(8):1427-1434. doi: 10.1002/jdd.12610
208. Sheth N, Ali R, Mistry G, Shetty O. From conventional to unconventional–the denture journey. *Int J Life Sci Scienti Res.* 2018; 4(3): 1801–1804. doi:10.21276/ijlssr.2018.4.3.10
209. Simiyu N B. Infection Control Mechanisms Employed by Dental Laboratories to Prevent Infection of their Dental Technicians/Technologists. *Oral Health Craniofac Sci*. 2016; 1: 001-011. doi: 10.29328/journal.johcs.1001001
210. Singh S, Palaskar JN, Mittal S. Comparative evaluation of surface porosities in conventional heat polymerized acrylic resin cured by water bath and microwave energy

with microwavable acrylic resin cured by microwave energy. *Contemp Clin Dent*. 2013; 4(2): 147–151.doi: 10.4103/0976-237X.114844

211. Sivakumar A, Thangaswamy V, Vaiyapuri Ravi V. Treatment planning in conservative dentistry. *J Pharm Bioallied Sci*. 2012; 4(2): 406–S409 doi: 10.4103/0975-7406.100305
212. Sivakumar I, Sajjan S, Ramaraju AV, Rao B. Changes in oral health-related quality of life in elderly edentulous patients after complete denture therapy and possible role of their initial expectation: a follow-up study. *J Prosthodont. 2015*; 24(6):452–456. doi: 10.1111/jopr.12238.
213. Soares GP, Valentino TA, Lima DANL, Paulillo LAMS, Silva FAP, Lovadino JR. Esthetic analysis of the smile. *Brazilian J Oral Sci*. 2016:1313-1319
214. Sodagar JA, Kassaee MZ, Akhavan A, Javadi N, Arab S, Kharazifard MJ. Effect of silver nano particles on flexural strength of acrylic resins. *J. Prosthodont. Res*.2012; 56: 120–124.
215. Soygun K, Bolayir G, Boztug A. Mechanical and thermal properties of polyamide versus reinforced PMMA denture base materials. *J Adv Prosthodont*. 2013; 5(2):153-160. doi:10.4047/jap.2013.5.2.153.
216. Srinivasan M, Gjengedal H, Cattani-Lorente M, et al. CAD/CAM milled complete removable dental prostheses: An in vitro evaluation of biocompatibility, mechanical properties, and surface roughness. *Dent Mater J* 2018; 37(4): 526-533. doi: 10.4012/dmj.2017-207.
217. Steinmass O, Dumfahrt H, Grunert I, Steinmass P-A. Influence of CAD/CAM fabrication on denture surface properties. *J Oral Rehabil* 2018; 45(5): 406-413. doi: 10.1111/joor.12621.
218. Suganya, S.; Ahila, S.C. Evaluation and comparison of anti-Candida effect of heat curepolymethylmethacrylate resin enforced with silver nanoparticles and conventional heat cure resins: An in vitro study. *Indian J. Dent. Res*. 2014; 25(2):204–207. doi:10.4103/0970-9290.135923.
219. Suja J, Thomas S, Suja M, Cherackal GJ, George AK. Characterization of complete denture - 11 Case reports. *SRM Journal of Research in Dental Sciences* 2015; 6 (1): 60-64. doi:10.4103/0976-433X.149597
220. Svanborg P, Hjalmarsson L. A systematic review on the accuracy of manufacturing techniques for cobalt chromium fixed dental prostheses. *Biomater Investig Dent.* 2020; 7(1):31-40. doi: 10.1080/26415275.2020.1714445
221. Swamy KNR, Alla RK, Mohammed S, Konakanchi A. The Role of Antifungal Agents in Treating Denture Stomatitis. *Research Journal of Pharmacy and Technology* 2018; 11(4):1365-1369. doi: 10.5958/0974-360X.2018.00254.8
222. Sykes LM, Said M, Ehlers M, Mateis SM, van Dyk C, Dullabh HD. Microbial contamination of denture polishing equipment. *S. Afr. Dent. J.*, 2019, 74(3):117-122. http://dx.doi.org/10.17159/2519-0105/2019/v74no3a2
223. Takahashi T, Gonda T, Maeda Y. The influence of reinforcement on strain in maxillary complete dentures: A preliminary report. *Int J Prosthodont*. 2011; 24:273–276.
224. Tarvade SM, Agrawal G. Smile analysis: A review Part I. *Int J Contemp Dent Med Rev.* 2015; Article ID 200115:1-4. doi:10.15713/ins.ijcdmr.64

225. Tatarciuc M, Vițalariu A, Diaconu-Popa D. Technological possibilities for full dentures realization, *Romanian Journal of Medical and Dental Education* , 2020; 9(4):95-102.
226. Tellier R, Li Y, Cowling BJ, Tang JW. Recognition of aerosol transmission of infectious agents: A commentary. *BMC Infect.Dis*. 2019; 19: 101.
227. Thomas RJ. Particle size and pathogenicity in the respiratory tract. *Virulence* 2013; 4(8): 847–858. doi: 10.4161/viru.27172.
228. Topol E.J. A decade of digital medicine innovation. *Sci. Transl. Med*. 2019; 11(498):eaaw7610. doi:10.1126/scitranslmed.aaw7610.
229. Touati R, Richert R, Millet C, Farges JC, Sailer I, Ducret M. Comparison of two innovative strategies using augmented reality for communication in aesthetic dentistry: A Pilot study. *J Healthc Eng.* 2019; 2019: 7019046. doi: 10.1155/2019/7019046
230. Touchstone A, Nieting T, Ulmer N. Digital Transition: the collaboration between dentists and laboratory technicians on CAD/CAM restorations. *Journal of the American Dental Association.*2010; 141(2):15S-9S. doi: 10.14219/jada.archive.2010.0353.
231. Urban VM, Machado AL, Oliveira RV, Vergani CE, Pavarina AC, Cass QB. Residual monomer of reline acrylic resins. Effect of waterbath and microwave post-polymerization treatments. *Dent Mater.* 2007; 23(3):363-368.
232. Vafaee F, Radan P, Firouz F, Heidari B , Izadi A, Khoshhal M, Basami M. Microbial Contamination of Pumice Powder and Slurry in Dental Laboratories of Hamadan.Avicenna *J Dent Res.* 2013; 5(2): 37-40. doi: 10.17795/ajdr-1937.
233. Vázquez-Rodríguez I, Estany-Gestal A, Seoane-Romero J, Mora MJ, Varela-Centelles P, Santana-Mora U. Quality of cross-infection control in dental laboratories. A critical systematic review. *International Journal for Quality in Health Care* 2018; 30(7):496–507. doi: 10.1093/intqhc/mzy058.
234. Verran J, McCord JF, Maryan C, Taylor RL. Microbiological hazard analysis in dental technology laboratories.*Eur J Prosthodont Restor Dent*. 2004; 12(3):115-20.
235. von Fraunhofer JA, Loewy ZG. Factors involved in microbial colonization of oral prostheses. *Gen Dent*. 2009; 57:136–143.
236. Wang C, Shi YF, Xie PJ, et al. Accuracy of digital complete dentures: a systematic review of in vitro studies. J Prosthet Dent 2021; 125(2):249-256. doi:10.1016/j.prosdent.2020.01.004.
237. Wang W S Liao S, Zhu Y, Liu M, Zhao Q, Fu Y. Recent applications of Nanomaterials in Prosthodontics. *Journal of Nanomaterials* 2015; Article ID 408643: 1-11. doi.org/10.1155/2015/408643.
238. Weintraub JA, Orleans B, Fontana M, Phillips C, Jones JA. Factors associated with becoming edentulous in the US health and retirement study. *J Am Geriatr Soc* 2019; 67(11): 2318-2324. doi: 10.1111/jgs.16079.
239. Wenjing Song, Shaohua Ge Application of Antimicrobial Nanoparticles in Dentistry. *Molecules* 2019; 24(6):1033. doi: 0.3390/molecules24061033.
240. Williams DW, Chamary N, Lewis MA, Milward PJ, McAndrew R. Microbial contamination of removable prosthodontic appliances from laboratories and impact of clinical storage. *Br Dent J.* 2011; 211:163–166.

241. Wong KK, Cheung SO, Niu J, Tao Ho CM., Che CM, Tam PK. Further evidence of the anti-inflammatory effects of silver nanoparticles. *ChemMedChem*. 2009; 4(7):1129-1135. doi:10.1002/cmdc.200900049.
242. Wulfman C, Bonnet G, Carayon D, Batisse C, Fages M, Virard F, Daas M, Rignon-Bret C, Naveau A, Millet C, Ducret M. Digital removable complete dentures: a narrative review. *French Journal of Dental Medicine* 2020, 1-9.https://doi.org/10.36161/FJDM.0005
243. Xie Q, T. Ding T, Yang G. Rehabilitation of oral function with removable dentures-s till an option*?. J Oral Rehabil* 2015; 42(3):234-242. doi:10.1111/joor.12246.
244. Yadav B K, Rai A K, Agarwal S, Yadav B. Assessment of infection control practice in private dental hospital. International Journal of Research in Medical Sciences. 2017; 5(11):4737-4742. doi: 10.18203/2320-6012.ijrms20174687.
245. Yamaga E, Sato Y, Soeda H, Minakuchi S. Relationship between oral health-related quality of life and usage period of complete dentures. *Int J Prosthodont* 2019; 32(4): 327-332. doi: 10.11607/ijp.6173.
246. Yurdasal B, Bozkurt N, Bozkurt AI, Yilmaz O. The evaluation of the dust-related occupational respiratory disorders of dental laboratory technicians working in Denizli Province. *Ann Thorac Med. 2015*; 10(4): 249–255. doi: 10.4103/1817-1737.167073
247. Zafar MS, Khurshid Z, Najeeb S, Zohaib S, Ur Rehman I. Chapter 26 - Therapeutic applications of nanotechnology in dentistry:Nanostructures for Oral Medicine 2017; Elsevier Inc., ISBN 9780323477215. https://doi.org/10.1016/B978-0-323-47720-8.00027-4
248. Zarco MF, Vess TJ, Ginsburg GS. The oral microbiome in health and disease and the potential impact on personalized dental medicine. *Oral Dis*. 2012; 18(2):109–120. doi: 10.1111/j.1601-0825.2011.01851.x.
249. Zhang X-F, Liu Z-G,1 Shen W, Gurunathan S. Silver Nanoparticles: Synthesis, Characterization, Properties, Applications, and Therapeutic Approaches. *Int J Mol Sci.* 2016, 17(9): 1534 doi: 10.3390/ijms17091534.
250. Zebarjad SM, Sajjadi SA, Sdrabadi, TE, Yaghmaei A, Naderi B. A Study on Mechanical Properties of PMMA/Hydroxyapatite. Nanocomposite. *Engineering 2011;* 3:795-801. doi:10.4236/eng.2011.38096.
251. Ziąbka M, Dziadek M. Thermoplastic Polymers with Nanosilver Addition-Microstructural, Surface and Mechanical Evaluation during a 36-Month Deionized Water Incubation Period. *Materials (Basel)*, 2021; 1314(2):361. doi: 10.3390/ma14020361.
252. Ziąbka, M, Dziadek M, Królicka, A. Biological and Physicochemical Assessment of Middle Ear Prosthesis. *Polymers* 2019; 11(1): 79. doi: 10.3390/polym11010079.
253. Zomorodian K,Haghighi NN, Rajaee N, Pakshir K, Tarazooie B, Vojdani M, Sedaghat F, Vosoghi M. Assessment of Candida species colonization and denture related stomatitis in complete denture wearers. *Med. Mycol.*2011; 49(2):208–211.doi:10.3109/13693786.2010.507605.