THE MODERN APPROACH IN THE TREATMENT OF FRAGILITY FRACTURES OF THE PELVIC RING
SUMMARY OF THE DOCTORAL THESIS

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The doctoral thesis comprises:

- The general part structured on 4 chapters, with the afferent subchapters (42 pages)
- The personal part that contains 9 chapters on 96 pages
- 252 references
- The illustration, represented by 98 figures and 32 tables

Note: This abstract selectively reproduces the bibliography and iconography in the text, respecting the content and numbering of the thesis.
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CHAPTER V
MOTIVATION AND
OBJECTIVES OF THE STUDY

Currently, osteoporosis is a bone disease found in the elderly population and the major consequence of osteoporosis is the risk of fractures called fragility fractures (FF). Fragility fractures are serious medical problems due to both the high cost of treatment and the severe decrease in the patient’s quality of life.

The most common fragility fractures are found in the vertebrae, femur, proximal humerus or distal radius. A particular case is the pelvic fragility fracture (FFP) whose incidence has increased recently (155). It can be said that the most debilitating of all these fractures is the fragility fracture of the pelvis. This type of fracture raises additional problems compared to the others due to the difficulties of diagnosis, surgical approach and long recovery period.

In the case of pelvic fragility fractures, the literature recommends, as a general rule, conservative treatment, as long as it allows mobilization and no secondary movements occur. Surgical treatment is recommended only if the pain prevents the patient’s mobilization or when the fractures are unstable. The priority in the treatment of pelvic fragility fractures is pain control and restoring mobility.
As an alternative, for the surgical approach, pharmacological therapy is used which can reduce the risk of fracture by 30% to 40%, by using: anti-osteoporotic drugs, bone anabolics or supplementation with Ca and vitamin D (156).

Therefore, due to the pathological change of the morpho-functional unit of the bone, the therapeutic approach of this type of fracture is implicitly a complex one that involves the concomitant use of surgical treatment, drugs, but also supplementation with essential nutrients to the bone system, such as calcium, vitamin D3.

So far, in Romania, there are no studies on the mobility, level of independence and survival rate of elderly patients with fragility fractures of the pelvis.

The specific objectives targeted during the research carried out within the doctorate were the following:
- evaluation of the capacity of some compounds to be used as osteosynthesis materials in the variant of the surgical treatment option
- investigation of the forces acting on the normal and osteoporotic pelvis in the purpose of anticipating the fracture site
- the influence of anti-osteoporotic therapy on the evolution of FFP recovery and mobility
- assessment of pain intensity and degree of disability in patients with pelvic fragility fractures
- assessment of the level of independence and mobility of patients 1 year after discharge
- evaluating the mortality rate and establishing the correlations between the type of fracture and the scores obtained.
CHAPTER VI
MECHANICAL STUDY FOR EVALUATION OF IMPROVEMENT OF FIXING BY SYNTHETIC POLYMERS

The mechanical study performed to evaluate the improvement of the fixation by coating with synthetic polymers comprises two stages:
- synthesis of new polymers, namely acrylate polyurethanes and then their improvement by incorporation of hydroxyapatite
- mechanical testing following the application of these polymers to different types of screws used to fix osteoporotic bone.

VI.1. Synthesis of new polymers (polyurethane acrylates)

VI.1.1. Introduction
In this study, polyurethane polymers were chosen due to the fact that they have great versatility in simulating the structures of different layers that make up the bone such as the cortical area, spongy, therefore are compounds of choice in biomechanical testing. In addition, polyurethanes have biocompatibility. The high versatility of PU is due to the multiple variants of obtaining through the polymerization process. Therefore, based on polyurethane materials, the normal and pathological bone model for the femur and pelvis were standardized (approved). Using a standardized synthetic bone for the femur and pelvis, V. Shim et al. (154) validated the model in order to anticipate the location of the fracture of the
femur, acetabulum and pelvis and to compare the stability of the fracture fixation procedure. PUs have been used alone or in combination with other synthetic polymers to obtain different types of synthetic bones that simulate both normal bone tissue and certain pathologies. A type of synthetic bone, which simulates the structure of normal bone, is obtained by combining rigid PU foam (distributed on the surface for the bone cortex) which is associated with spongy PU foam (distributed inside the device for the spongy area). This combination of polyurethanes is used to mimic the femur and tibia.

Another type of synthetic bone, also based on polyurethane, can be made by combining an epoxy resin for the cortical surface, together with PU foam for the spongy interior. The result is a so-called composite bone capable of generating results comparable to human bones in biomechanical tests useful in fracture fixation studies. The performance of composite polymers was tested by measuring the strength of the screw and bone assembly (at the bone-screw interface), and the biomechanical results were similar to human bone (157). Therefore, synthetic materials are widely used in orthopaedics, either as implant devices or as useful simulation models to predict the outcome of a particular surgical procedure.

VI.1.2. Purpose

The synthesis of polyurethanes had as purpose the obtaining of composite polymers that meet certain conditions of adhesion, biocompatibility, hydrophilicity and elasticity.
VI.1.3. Objectives
- synthesis of polyurethanes and selection of appropriate ones
- improving the selected polymer by adding hydroxyapatite

VI.1.4. Material and method
The polymers used in the study were synthesized at the Institute of Macromolecular Chemistry “Petru Poni”, Iasi, Department of Polyaddition and Photochemistry.

VI.1.5. Results
The structure of the polymer was confirmed by IR and 1 H NMR spectra. In IR spectrometry the polymer has the following characteristic bands: 3300 cm\(^{-1}\) (NH; OH hydrogen bridges); 2968 cm\(^{-1}\) (CH\(_2\) ca); 1695 cm\(^{-1}\) (> C = O; “amide band I”); 1540 cm\(^{-1}\) (NH and CN “amide band II”); 1448 cm\(^{-1}\) and 1395 cm\(^{-1}\) (> CH\(_2\)); 1325 cm\(^{-1}\) and 1255 cm\(^{-1}\) (> C - N and NH “amide band III”). In 1H NMR spectrometry, the polymer has the following characteristic bands: 1.7 and 2 ppm protons from -CH\(_2\)-CH <; 3.2; 3.3; 3.3; 3.4; 3.5 ppm protons from OCONH-CH\(_2\)-CH\(_2\)-N <; 3, 8; 4 ppm protons from OCO-CH\(_2\)-CH\(_2\)-OH; 7.8 ppm protons from NH urethane group.

The selected monomer A has the advantage of low temperature polymerization. Left at ambient temperature, in a free atmosphere, the monomer polymerizes. The initiation of polymerization is catalysed by the action of light and oxygen. The ability to initiate the reaction through the excited acrylate urethane portion is confirmed by the UV spectra of the acrylic monomer, which indicates the ability of the monomer to absorb radiation
with an energy of 128.25 kcal/mol sufficient to trigger the polymerization reaction. The resulting polymer is adhesive to any material, the adhesion being approximately 0.2-0.3 kgf/cm².

VI.1.6. Discussions

In the present study, in order to improve the fixation of the fragility fracture, in general, and the pelvic fracture, in particular, urethane monomers and vinyl compounds were obtained, from which a new type polyurethane called polyurethane acrylate was obtained, which subsequently, has been improved with hydroxyapatite, the natural component of bone. Acrylate polyurethane was used to cover titanium screws of different types/sizes with the purpose of improving the fixation of fragility fractures.

The main advantage of titanium is that it has low weight, very good corrosion resistance, especially in saline (due to the formation of an adhesive layer of TiO₂) but also the ability to integrate well into the bone, the main disadvantage being the low elasticity. From a larger group of polyurethanes, in a first stage, those that met the requirements of elasticity, biocompatibility and hydrophilicity were selected. The selected polyurethanes were chemically bonded, by a copolymerization reaction, to an acrylic component resulting in a particular type of polymer called acrylate polyurethane.

Hydroxyapatite is a component of natural bone involved in the process of bone mineralization and which gives it strength. Therefore, it has been estimated that this polymeric composite complex is able to provide an efficient transition between the surface of the metal and that of natural bone. Conventional polyurethanes are
generally obtained from poly-isocyanates, polyols and so-called chain extensors. When they reach the human body, some raw materials used in the synthesis of polyurethanes (aromatic poly-isocyanates) can cause serious health problems caused by their degradation products, namely carcinogenic aromatic amines (178). For this reason, an attempt has been made to develop alternative methods for the synthesis of polyurethanes (presented in this thesis). Particular attention was paid to obtaining non-isocyanate polyurethanes, from which polyhydroxy-urethanes based on multicyclic carbonates and aliphatic amines (158,159) were selected for the present study, as this type of polyurethanes, called polyurethanes acrylics (P) very hydrophilic and has a high degree of elasticity.

The structure of the macromolecular chain allows the grafting of hydroxyl (OH) end groups, thus facilitating the use of water as a solvent in a non-toxic synthesis process (158). Urethane groups can form hydrogen bonds with various other chemical groups, which will favour fixation on different types of surfaces. Another advantage of PUA is the low economic cost due to the polymerization mechanism that can take place at room temperature.

In addition, in order to ensure the best possible compatibility between the implanted devices and the bone matrix, the incorporation of hydroxyapatite in the polymer mass was performed.

VI.1.7. Conclusions

The polymer selected for study is adhesive to any material, the adhesion being approximately 0,2-0,3 kgf/cm².
A new polymer containing hydroxyapatite (PUA + HA) was obtained from the selected acrylate polyurethane polymer, by incorporating hydroxyapatite in two concentrations of 10% and 30%, respectively. Following incorporation, a stable hydroxyapatite suspension is obtained in the PUA. Thus, by chemical handling, it is now possible to select the qualities of each component and incorporate it into a polymer mixture/complex that is superior to the individual polymers.

VI.2. Mechanical testing of polymers on different types of screws

VI.2.2. Purpose

The mechanical tests had as purpose the evaluation of the behaviour of different screws, used as osteosynthesis material, after covering them with a polymeric film and used for fixing in block of synthetic bone that simulates the structure of osteoporotic bone.

VI.2.3. Objectives

- evaluation of the behaviour of the different types of screws (used in fixing the fractures) which were covered with a polymeric polyurethane acrylate film.
- evaluation of the behaviour of the same types of screws, covered with an acrylate polyurethane polymer film enhanced by the incorporation of hydroxyapatite.

VI.2.4. Material and method

The behaviour of the fastening assembly consisting of screw and synthetic osteoporotic bone was evaluated in terms of maximum traction force and the total displacement (at break) resulting from its application. The
tensile strength tester for the bone-screw-polymer joint is shown in fig. 6.9.

For testing, the screws were inserted into a plastic block at the top measuring 14 mm x 20 mm x 25 mm. The plastic block made it easier to attach the screw to the test device. Subsequently, the screws were screwed into the bone segment, which in turn was anchored to the test device.

VI.2.5. Results

a. Mechanical fastening test performed using acrylate polyurethane coated screws

The diagrams of the mechanical tests of the joints performed using cortical, ankle and sponge screws not covered and covered with acrylate polyurethane polymer are shown below.
b. Mechanical testing of screws coated with hydroxyapatite-enhanced acrylate polyurethane

Hydroxyapatite is a constituent of bone and gives it strength. In the coating polymer, namely the acrylate polyurethane used for testing, two different concentrations of hydroxyapatite were incorporated: 10% hydroxyapatite (PUA + 10% HA), respectively 30% hydroxyapatite (PUA + 30% HA). The process for incorporating hydroxyapatite has been shown above.

Applying the polymer to the malleolar screw can improve the properties of the bone-screw-polymer assembly compared to the simple bone-screw joint.

Fig. 6.25. The maximum tensile force and the maximum displacement determined for the malleolar screw not covered and covered with PUA and PUA improved with hydroxyapatite in a concentration of 10% and 30% respectively.

VI.2.6. Discussions

The data obtained suggest that, after the application of the PUA, the mechanical characteristics of the fastening with screws coated with polyurethane acrylate have been improved. The increased tensile strength, observed at the joints made with polymer-coated screws,
can be conferred by the ability to take part of the force applied by the elastic structure of the polymer. Under the action of the maximum force, the maximum deformation (at break) shows significant increases for all joints made with polymer-coated screws compared to those made with uncovered screws, and therefore, it appears much later.

VI.2.7. Conclusions

In conclusion, by applying a polymeric coating, an efficient transition medium between the screw and the bone is ensured, which leads to the improvement of the cohesion between them, finally increasing the stability of the fixing device in case of a fracture.

CHAPTER VII
STUDY OF THE DISTRIBUTION OF THE FORCES ACTING ON THE PELVIS BY THE FINITE ELEMENT METHOD

VII.1. Introduction

Currently, design and modelling are done digitally using specialized software for different fields, whether construction, aeronautics or biomechanics. Through this software, the physical phenomena encountered in science or practice can be described by differential equations and mathematical expressions that contain integrals.

The method currently used is called the Finite Element Method (MEF) or Finite Element Analysis (FEA) and is based on software that uses these complex mathematical equations to estimate the behaviour of a structure subjected to different stress conditions.
VII.2. Purpose
The present study aims to improve the understanding of the behaviour of the pelvis and the biomechanics of the pelvic ring in the healthy configuration compared to the osteoporotic one.

VII.3. Objectives
- finite element analysis of the free fall of the healthy pelvic assembly
- finite element analysis of the free fall of the pelvic assembly with osteoporosis

VII.4. Material and method
The material model used in this study is based on Young’s modulus or apparent bone density obtained from computed tomography data.

Finite element analysis was performed using an approved program called ANSYS.

VII.5. Results
In the healthy pelvis model, the mechanical properties of the normal pelvis and a fall height of 1 m were attributed to the studied ensemble. The body weight of the patient who acted on the pelvis was considered to be approximately 70 kg.

Fig. 7.3 Front view of the Von Mises stress distribution in the normal pelvic model
VII.6. Discussions

It is difficult to build a finite 3-D (finite element) model for the human pelvis because it has a complex structure that includes muscles and ligaments (184). Ravera et al. (185) reported that the sensitivity values for the models suggest that the stress predicted by the finite element was not very sensitive to changes in the material properties assumed in their model for cartilage and bone. Ricci et al. (186) investigated the transmission of loads in the pelvic ring under physiological loads of gait and concluded that an upper branch fracture altered the distribution of the load before and after.

VII.7. Conclusions

The results of our finite element analysis showed that the distribution of pelvic stress with osteoporosis was altered compared to the normal pelvis. In addition, in healthy bone, where the maximum stress is concentrated around the obturator foramen (anterior arch of the pelvic ring), in osteoporotic bone, maximum stress also occurs in the posterior arch of the pelvic ring (especially in the sacrum).

CHAPTER VIII

THE INFLUENCE OF ANTI-OSTEOPOROTIC THERAPY ON THE EVOLUTION, RECOVERY AND MOBILITY IN THE FRAGILITY FRACTURES OF THE PELVIS

VIII.1. Introduction

The most common fragility fractures are located in the vertebrae, femur, proximal humerus or distal radius. A
particular case is the pelvic fragility fracture (FFP), which is considered the most debilitating fragility fracture and whose incidence has increased recently (15,155).

The advanced age of the patients, the significant surgical risks, as well as the presence of comorbidities, are the factors that, in case of pelvic fragility fractures, dictate the choice of conservative treatment as a generally accepted therapeutic conduct, as long as it allows mobilization and pain relief.

The therapeutic approach to this type of fracture requires in addition to drug treatment the administration of essential nutrients to the body such as vitamin D and Ca.

VIII.2. Purpose

The present study had as purpose the evaluation of the benefits of bisphosphonate administration on the evolution of the recovery process in patients with pelvic fragility fractures.

VIII.3. Objectives

- assessment of pain during hospitalization in FFP patients
- evaluation of the mobility of patients with FFP
- highlighting the importance of anti-osteoporotic treatment in patients with PFF

VIII.4. Material and method

Clinical parameters of interest such as age, gender, comorbidities (diabetes, heart failure, renal failure, etc.), bone mineral density, fracture history, anti-osteoporotic therapy, alcohol/nicotine consumption and menopausal
hormone therapy were recorded. Informed consent was obtained from all patients included in this study. The research was conducted in accordance with the ethical principles established by the Declaration of Helsinki and by the Ethics Committee of the “Grigore T. Popa” University of Medicine and Pharmacy Iasi.

VIII.5. Results

Gender distribution of patients included in the study

Regarding gender, in group I a percentage of 86.2% of patients were female, the number of male patients being lower (13.7%). In group II 86.2% of patients were female and 13.7% male (fig. 8.5).

![Fig. 8.5 Distribution of patients by gender](image)

![Fig. 8.6 Distribution of patients according to the environment of origin](image)
Pain assessment was performed by recording the time in which the pain on mobilization subsides. For group I, the pain reduction time was 14 days for 86.3% of patients (44 patients) and more than 14 days for 13.7% of patients (7 patients). The pain reduction time for group II was 14 days in 81.7% of patients (48 patients) and more than 14 days for 18.3% of patients (11 patients).

VIII.6. Discussions

If the pain caused by mobilization was felt to be acceptable, patients began dynamic mobilization in support of their own weight. The analysed data indicate the importance of early detection of osteoporosis and early initiation of therapy. One year after discharge, no recurrent FFPs were reported, but there were three cases of fragility fracture with different location, two with femoral neck fracture and one with right forearm fracture. Currently, the literature indicates two new effective drugs, with targeted action on osteoporotic bone, teriparatide and strontium ranelate that exert anabolic activity, promoting the formation and maturation of callus. Recent research on bone fragility is trying to identify the mechanism that leads to osteoporosis. Some studies indicate the mechanism of reactive oxygen species as a possible cause of bone fragility, others consider homocysteine as a possible cause of this condition.

VIII.7. Conclusions

The study highlights the importance of anti-osteoporotic treatment in the prevention of pelvic fragility fractures and highlights the serious consequences of late detection of bone fragility. The present study showed that
the previously instituted anti-osteoporotic treatment has definite benefits in case of a new fracture. Awareness of the early pathological process, namely osteopenia, is mandatory to prevent the further development of osteoporosis.

CHAPTER IX
THE INFLUENCE OF VITAMIN D ON SYSTEMIC CALCIUM STATUS AND THE PROCESS OF HEALING OF THE FRAGILITY FRACTURES OF THE PELVIS

IX.1. Introduction
Among the endogenous factors involved in bone metabolism are: parathyroid hormone and calcitriol, hypercalcaemic hormones and calcitonin, hypercalcaemic hormone. Calcium and vitamin D3 are part of the category of exogenous compounds necessary for bone tissue homeostasis, the adequate intake of which ensures bone mineralization. Although vitamin D3 is brought in through food, it can be synthesized in the body under the action of UV rays as a result of sun exposure. In the case of the elderly who have digestive disorders and for whom sun exposure is a risk, vitamin D3 levels may become deficient. Deficiency of calcium and vitamin D3 has severe consequences on bone mineralization.

IX.2. Purpose
The purpose of the study was to evaluate the role of calcium and vitamin D in the healing process of patients with pelvic fragility fractures.
IX.3. Objectives
- assessment of calcium and vitamin D levels
- correlation of pain intensity with calcium and vitamin D concentrations

IX.4. Material and method
The study was performed on patients who had a pelvic fracture, admitted between January 2016 and September 2019 at the “Sf. Spiridon” Emergency Hospital, Iasi, Romania. Informed consent was obtained from all patients included in this study. Group I contains 22 patients aged 63-85 years (16 women, 6 men). Group II contains 31 patients aged 60-81 years (23 women, 8 men). Patients were monitored briefly during hospitalization, in our clinic or in the specialized recovery department, after 14 days and 1 month after fracture. During hospitalization, the time required to reduce pain was monitored using the visual analogue scale (156).

IX.5. Results
The healing process of any fracture, including fragility, involves the participation of calcium and vitamin D. To assess the influence of these factors on the healing process, calcium and vitamin D levels were determined in the patients included in the present study. The influence of calcium levels on the healing process of osteoporotic fracture is assessed by correlating its serum profile with the reduction of pain intensity. Regarding vitamin D levels, they were determined at hospitalization for all patients in groups I and II and month after discharge only for patients who presented for reassessment.
Fig. 9.11 Correlation of calcium and vitamin D with pain intensity

Radiographs and CT images of some patients included in the study are presented in fig. 9.12.

Fig. 9.12 Radiographs and CT images of some patients included in the study
IX.6. Discussions

The literature states that the administration of bisphosphonates is effective in preventing fractures in 40% of osteoporotic patients over 70 years (data reported for the femur), but that it does not show similar improvements at the age of 80 years and over (213, 214).

In the case of any fracture, including FFP, the reduction of pain is an indication of the favourable evolution of the healing process. The intensity of the pain can be evaluated with the VAS score whose interpretation according to Jensen was presented in subchapter VIII.4. Serum calcium levels decrease after fracture in both groups. Regarding vitamin D, the optimal level indicated in the literature is between 25-80 ng/ml, with values below 30ng/ml in vitamin insufficiency and with values below 20ng/ml in vitamin deficiency (212). The values recorded in this study indicate vitamin D deficiency for group I and a vitamin deficiency for group II, both of which favour the production of fractures. The recommended amounts of calcium and vitamin D for osteoporotic patients over 50 years are 1200 mg (187) and 32 ng/ml (75 nmol/L), respectively (188). In patients with osteoporosis, post-fracture administration of vitamin D is recommended for 5-8 weeks with calcium levels checked (189). Supplementation of anti-osteoporotic treatment with calcium and vitamin D should become recommended, especially for osteoporotic patients who have suffered a fracture because they have a 2-4 times increased risk for a future fracture (189, 211).

IX.7. Conclusions

The present study revealed the therapeutic potential of calcium and vitamin D supplementation following
fragility fracture in patients with insufficient calcium and vitamin D follow-up fragility, in general, and that of the pelvis in particular.

CHAPTER X
EVALUATION OF PAIN INTENSITY AND OF THE DEGREE OF DISABILITY

X.1. Introduction

Fragility fractures have an increased incidence due to increased life expectancy of the population.

The priority in the treatment of pelvic fragility fractures (PFF) is pain control and restoring mobility. Bone strength and morphology can be restored through conservative or surgical treatment. Bone resorption is limited by pharmacotherapy using anti-resorptive agents, such as bisphosphonates, denosumab, selective oestrogen receptor modulators, oestrogen hormone therapy (raloxifene), and anabolic agents that promote bone mass formation such as teriparatide and abaloparatide. Anti-osteoporotic agents have side effects that induce the risk of osteonecrosis of the jaw, atypical fractures of the femur (bisphosphonates), thrombotic events (hormone therapy) and kidney stones in hypercalcemia.

FFPs are common in the elderly and are injuries that cause pain and disability, affecting quality of life. Many studies in the literature indicate prolonged periods of immobilization and loss of independence in patients with fragility fractures (228, 229). FFP treatment focuses on reducing pain, restoring mobility and patient independence. The treatment indicated for patients with
FFP is conservative or surgical, depending on the type of fracture and the associated comorbidities.

**X.2. Purpose**

The purpose of our study was to assess the intensity of pain and the degree of disability in patients with PFF in the first year after trauma.

**X.3. Objectives**

- assessment of pain in patients included in the study using the Von Korff questionnaire
- assessment of the degree of disability in patients with fragility fractures of the pelvis
- establishing the correlations between the type of fracture and the scores obtained

**X.4. Material and method**

In this study, were included all patients aged ≥ 65 years with FFP hospitalized in the Orthopaedics-Traumatology Clinic, “Sf. Spiridon” Hospital Iasi, between September 2016 and January 2020.

**X.5. Results**

The age or gender of the 156 patients included in the present study is two of the demographic parameters included in the statistical analysis. The distribution of patients according to age is shown in fig. 10.1.

![Age distribution of patients](image)

**Fig. 10.1** Age distribution of patients
According to the Rommens and Hofman classification (44), of the patients included in the study, 46% had a FFP Ia type fracture (73 cases), a category followed as a percentage by patients with FFP IIc type fractures (31 cases, 19.9%). The statistical analysis of the Von Korff questionnaire carried out during the time interval in which the patients included in the study were followed, objectified a decrease in the average value of both components, both the intensity of pain and the degree of disability.

The distribution of pain and disability scores with specific activities in the first year after trauma is presented in fig.10.9. and fig.10.10.

![Graph showing pain scores distribution](image)

**Fig. 10.9** Distribution of pain scores according to the Von Korff questionnaire during the study

The severity of pain above 75 points decreased considerably at 6 months of follow-up, from 25.98% to
3.68% of patients (p < 0.005) and increased at 12 months of follow-up to 3.19% of patients.

**Assessment of pain intensity and disability of the patients included in the study according to the FFP classification**

The assessment of pain intensity of the patients included in the study according to the type of fracture indicates a percentage of 34.56% during hospitalization and 1% one month after discharge, in patients with FFP IA. In the case of patients with FFP IIIC and FFP IVB, the intensity of pain remained high at the evaluation after 6 months and 1 year after discharge with a score higher than 75 points. In patients included in the study, scores lower than 25 points during hospitalization were obtained only in FFP I and FFP II.

**Fig. 10.11** Distribution of pain intensity according to the type of fracture during hospitalization
X.6. Discussions
In our study, the incidence of FFP in women (74.4%) was significantly higher than in men (25.6%). In a retrospective analysis of 245 patients with FFP, a similar distribution was found when patients were divided by gender (95). Numerous studies on the follow-up of patients with FFP have focused on mortality rate and functional assessment (234-238). In general, pain is indirectly described as a cause of immobilization and loss of independence. Hoch et al (79) evaluated the outcome and survival rate of conservative and surgical treatment in patients with PFF. Our study indicates a statistically significant decrease in pain intensity at 6 months according to the von Korff questionnaire (55.63 ± 16.40) compared to baseline (77.54 ± 16.46, p <0.005). One year after admission, the pain intensity score (52.76 ± 16.56) was low compared to the initial value (77.54 ± 16.46, p <0.005), but did not change statistically significantly compared to the value obtained when evaluating patients after 6 months from admission. Although the intensity of the pain decreased significantly compared to the first questionnaire, a certain degree of pain persisted, which had a negative impact on the quality of life. Our study highlights the importance of diagnosing osteoporosis and instituting treatment to reduce the risk of PFF. In order to limit future healthcare costs, it remains important to pay attention to the prevention of falls and osteoporosis among older adults.

X.7. Conclusions
Patients included in our study reported long-term pelvic pain and described that this pain was disturbing and
affected their daily activities. Our results indicate the association of FFP with the loss of independence and social and physical autonomy. In this context, efforts are needed to prevent fragility fractures of the pelvis.

CHAPTER XI

EVALUATION OF MORTALITY AND THE LEVEL OF INDEPENDENCE FOR PATIENTS WITH FRAGILITY FRACTURES OF THE PELVIS IN THE FIRST YEAR AFTER INJURY

XI.1 Introduction
In communities with a high life expectancy, the incidence of pelvic fragility fractures exceeds that of pelvic trauma due to high energy. The data presented in the literature suggested that it is necessary to improve the efficiency and quality of treatment for pelvic fragility fractures and their prevention. The FFP classification provides suggestions on the extent of surgery and the type of fixation. Of all FFPs, one-fifth of pubic branch isolate fractures (44). They are described as FFP type I in the Rommens and Hofmann classification (44). A combination of fractures between the anterior pelvic ring and those of the posterior pelvic ring is present in more than 80% of FFP. These combinations of fractures are described as FFP type II, III or IV in the same classification (44).

XI.2. Purpose
The purpose of our study was to assess mortality, mobility and the level of independence in patients with pelvic fragility fractures in the first year after injury.
XI.3. Objectives
- evaluation of the mobility of the patients included in the study by PMS
- assessing the level of patient independence through EMS
- evaluation of the mortality rate

XI.4. Material and method
This study included patients aged ≥ 65 years with pelvic fragility fractures hospitalized in the Orthopaedics-Traumatology Clinic, “Sf. Spiridon” Hospital Iasi, between September 2016 - January 2020. We included in the study only patients who underwent conservative treatment. Fractures were confirmed by radiographic imaging or computed tomography. We excluded patients with pelvic fractures that occurred after a high-energy trauma or due to oncological conditions. All patients received information about the study. To assess the functional level of patients we used the PMS questionnaire (243) (Parker Mobility scores). The Mobility Score for the Elderly (EMS) is a physical assessment of function and has a maximum score of 20. EMS is an ordinal scale designed to provide a physiotherapy-oriented measure for the elderly and is complementary to other scales (244).

XI.5. Results
Demographic characteristics of patients
The mean age of all patients included in the study was 78.85 ± 8.72 years. There were no statistically significant differences in age between men and women (p> 0.05). The gender of the 156 patients included in the
present study is another demographic parameter included in the statistical analysis. Thus, 74.4% of patients were women (116 cases), the percentage of male patients being lower, of only 25.6% (40 cases). The place of origin completes the list of demographic parameters included in the statistical analysis, 53.2% of cases residing in rural areas (83 patients) (fig. 11.1).

![Fig. 11.1 Distribution of patients according to the environment of origin](image)

**Evaluation of the PMS score**

The PMS score was determined for the patients included in the study both during hospitalization and at one month, 6 months and 12 months after discharge. During hospitalization we observe a percentage of 24.81% of patients with a score of 0, which indicates that they have no walking skills at all.

![Fig. 11.2 Percentage distribution of patients according to the PMS score in the hospital](image)
EMS score evaluation

Similar to the parameter presented above, the assessment of this score was performed periodically, both during hospitalization and after one month, 6 months and 12 months after discharge. Regarding the maximum percentage highlighted by the statistical analysis at the evaluation performed during hospitalization, it went to patients with a score of 8 points (27 cases).

Investigating the mortality rate

The list of parameters included in the statistical analysis presented in this paper also includes the evaluation of the percentage of deaths that occurred during the study, 13.5% of cases dying (fig.11.13.)

![Fig. 11.13 The share of deaths in the statistically analysed group](image)

**Fig. 11.13** The share of deaths in the statistically analysed group

XI.6. Discussions

This is the first and only study on the mobility, level of independence and survival rate of elderly patients with pelvic fragility fractures in Romania. The results of this study show that pelvic fragility fractures are serious adverse events for the elderly because they have a distinct
influence on mobility, level of independence and survival rate. The age and gender ratio of the patients included in our study was similar to that presented in other publications. The average age of the patients in the presented papers varies from 73 to 84 years, the gender ratio has always been in favour of women. The variation of the gender ratio can be explained by the different inclusion criteria used. The demographic data of our 156 patients include an average age of 78.85 ± 8.72 years and a percentage of 74.36% women and 25.64% men. Only 5.1% of our patients were presented without comorbidities. The very high rate of comorbidities is a direct sign of the vulnerability of these patients. Hypotensive drugs, visual disturbances, dizziness, impaired gait and analgesic use may be causes of falls. In a multidisciplinary approach, the reasons for falls should be explored and addressed as much as possible. Multidisciplinary co-management prevents recurrent falls and subsequent deterioration of the patient’s condition. The one-year mortality rate of the patients included in our study was 13.46%. Results similar to those obtained by us were reported by Leung et al. (250). They assessed the mortality rate at one year, for 60 patients with pelvic fracture, over 60 years of age and obtained a percentage of 12%. For patients with FFP I over 80 years of age Ting et al. (251) reported a mortality rate of 20% at 1 year of assessment.

XI.7. Conclusions
It was found that there is an increased mortality rate in patients with pelvic fragility fractures compared to the general population of the same age. The results obtained
in our study indicate a significant reduction in the level of independence for patients with FFP.

CHAPTER XII

FINAL CONCLUSIONS

1. Synthetic materials are widely used in orthopaedics, either as implant devices or as useful simulation models to predict the outcome of a particular surgical procedure. From the synthesized compounds, the selected polymer is adhesive to any material, the adhesion being about 0.2-0.3 kgf / cm². In aqueous environment, acrylate polyurethane has a high swelling capacity, which in the perspective of its use in vivo would facilitate the access of calcium and phosphate favouring bone mineralization, osseointegration. Therefore, the use of polymeric material could avoid one of the phenomena encountered, namely damage to the assembly or osteosynthesis material.

2. By applying a polyurethane acrylic polymer coating, an efficient transition medium between the screw and the bone can be ensured, which can improve the cohesion between them, finally increasing the stability of the assembly in case of a fracture.

3. The addition of hydroxyapatite, a component of bone, to the polymer mass has advantages, especially for the 10% concentration. Increasing the hydroxyapatite concentration to 30% alters the cohesion of the bone-screw-polymer fixation complex, probably due to the hydroxyapatite crystals that introduce possible points of instability that disrupt the continuity of the transition
medium between the fixation assembly and the bone. However in vivo the higher concentration of apatite could provide mineralization points by accelerating bone mineralization which is a perspective of the study.

4. Finite element analysis of the healthy and osteoporotic pelvis model showed that the stress distribution in the case of the pelvis with osteoporosis was changed compared to the normal pelvis. The maximum stress is concentrated around the obturator hole (the anterior arch of the pelvic ring) in the normal pelvic model, and in the osteoporotic one, the maximum stress also appears in the posterior arch of the pelvis (especially in the sacrum).

5. The results obtained highlight the importance of anti-osteoporotic treatment in the prevention of pelvic fragility fractures and highlight the serious consequences of late detection of bone fragility. Anti-osteoporotic treatment instituted prior to injury has definite benefits in case of a new fracture. Awareness of the early process, namely osteopenia, is mandatory to prevent the further development of osteoporosis.

6. The present study revealed the therapeutic potential of calcium and vitamin D supplementation following fragility fracture in patients with low calcium and vitamin D levels. The present study highlighted the use of vitamin D levels as a good predictor of the evolution of pain intensity, its low levels correlate with severe forms of pain. The administration of these compounds can prevent systemic bone loss and reduce the risk of secondary fractures but mainly ensures better recovery.
7. The incidence of pelvic fragility fractures was significantly higher in women (74.4%) than in men (25.6%). Patients who were very active before the fragility fracture reported that they were not able to achieve similar levels of endurance and intensity of physical activity.

8. The results obtained indicate the association of FFP with the loss of independence and social and physical autonomy. In this context, efforts are needed to prevent fragility fractures of the pelvis.

9. The patients included in the study scored low on the mobility assessment, which means that most of them needed help with activities in their daily lives. In this context, the quality of life is severely affected and, therefore, the prevention of fragility fractures of the pelvis becomes a major medical goal.

10. Given that only 5.1% of patients presented without associated conditions, the high rate of comorbidities is a direct sign of the vulnerability of these patients.

11. It has been found that there is an increased mortality rate in patients with pelvic fragility fractures compared to the general population of the same age.

12. Currently, due to the increase in life expectancy of the population, the incidence of pelvic fragility fractures is rising and the therapeutic approach to this type of fracture is a complex one that must involve a multidisciplinary team of orthopaedic doctors, geriatricians, anaesthetists and physiotherapists.
Selective reference list


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