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COMPARISON BETWEEN INTERNAL FIXATION AND ARTHROPLASTY TREATMENT METHODS IN FEMORAL NECK FRACTURE PATIENTS.

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ABSTRACT

Femoral neck fractures occur widely in Lithuania and across the world. Therefore constitute a serious and common health problem among older. Various surgical treatment options are available, however, the main are: Arthroplasty and Internal Fixation. Arthroplasty the most common approach and Internal Fixation being rarely used.

We sought to compare the two main methodologies for femoral neck fractures treatment we, as well, have attempted to identify procedural related factors that increase the risk of Internal fixation failure and assembled them to establish a pattern to follow in order to achieve a successful Internal fixation procedure. This study background is, initially, 683 patients were considered out of those only 642 would pass our inclusion and exclusion criteria and form part of our research population. Those who did not fit were left behind: FNF patients with pathological fractures(malignancy, metastasis) and old fractures.572 Arthroplasty patients and 70 osteosynthesis patients.

For this study, we retrospectively evaluated radiographs from 70 patients undergoing Internal Fixation surgery and we attempted to measure key points established by other publications: Opsahl JH, Stiris M, Paulsrud Ø et al. To evaluate if the reposition was performed correctly, seven measurements were taken: fracture angle (varus/valgus); fragments step; Screw-Adams'Arch-Distance; Upper cortex-cranial screw distance; Screw-Screw- Angle; Screw-Countour-Distance and Caudal drill hole-Lesser trochanter distance. During the radiological analysis of the osteosynthesis, it was found that there were 18 re-operated patients vs 50 healed patients. The comparison between fragments step in revised and non-revised patients respectively (3.28±1.23 vs 4.15±1.68), Screw-Adams’Arch-Distance (5.00±1.86 vs 5.05±1.99), Upper cortex-cranial screw distance (5.43±2.44 vs 5.13±2.87) no statistically significant difference was observed. On the other hand, the comparison between Screw-subchondral- Distance in revised patients distance was significantly greater than in other group 5.59±2.22 vs 4.63±1.24 (p = 0.026), therefore the distance between osteosynthesis screw and subchondral area of the femoral head was observed to be relevant for the outcome in osteosynthesis reoperated FNF patients.

Secondly, we venture to compare both techniques acquiring data regarding the mortality ratio, evaluated in osteosynthesis and arthroplasty procedures, there were 6 (9%) deaths among the osteosynthesis patients within 1 year after surgery and were 89 (17%) deaths among the arthroplasty. The re-operation for arthroplasty was 36 (7%) reoperations as compared to 19 (28%) among the osteosynthesis patients. Although, Cox regression showed that the arthroplasty group had a lower risk of reoperation. Henceforth few risk factors have been acknowledged when comparing these two as the patient’s age and comorbidities, to play a key role in the surgical outcome of each patient. Noticing that the mean age at surgery was higher for the Arthroplasty patients compared to those undergoing Osteosynthesis (p=0.0001). Females were bigger in number in both surgical procedures. Concluding that most of the FNF patients were operated by arthroplasty, FNF patients treated with arthroplasty had a significantly lower risk of reoperation as compared to osteosynthesis method and that despite mortality rate is higher in arthroplasty patient group, older age was the influencing 1-year risk factor of death for all FNF patients.
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CONFLICT OF INTEREST

The author reports no conflicts of interests.

ABBREVIATIONS

FNF- Femoral Neck Fracture
KKL - Kauno klinikos Ligonine
IF - Internal Fixation
2US - 2 Ullevaal Screws
3US - 3 Ullevaal Screws
2KS - 2 Kanulated Screws
3KS - 3 Kanulated Screws
PNF - Proximal Femur Nail
ATH - Arthroplasty
THA - Total Hip Arthroplasty
HA - Hemiarthroplasty
INTRODUCTION

Femoral neck fractures (FNF) are related to high morbidity, a decrease in quality of life it is indeed a serious challenge for health care system in any part of the world. Nonetheless, there is a wide variability in treatment methods and health care management of this problem. We aimed to compare reoperation and mortality rates between internal fixation and arthroplasty treatment methods in FNF patients treated in LSMUL KK 2011-2016.

Hip fractures are a big deal in the global health problem. They are associated with one year mortality rates reported around 20 to 30% and a profound impairment of the individual’s independence and quality of life. Up to 50% of hip fracture patients do not fully rehabilitate back to their previous functional status. Currently, the disability-adjusted life-years lost as a result of hip fractures ranks in the top 10 of all cause disability all over the world. [14]

Few recent studies showed that hip fractures occurrence in the whole world has increased from an estimated data of 1.3 million patients suffering FNF a year in 1990 to 1.6 million patients in 2000. Femoral neck fractures in older patients are frequent, thus, being a great health care problem and they count as a significant impact on health insurance expenses.

Despite having a declining pattern of (age-adjusted) incidence in western countries, and still having a high incidence in eastern countries, a worldwide increase in total number of hip fractures is being expected as a result of increasing age-adjusted incidence rates in developing countries and aging populations and all this being caused or being a result of the improved global health care that has lead to an older population compared to the ancient population that used to shorter life span due to the socio-economic situation of the world and currently being important the advances in science and medicine that is leading to achieve a longer life span. [18, 19]

The health care costs that come associated with hip fracture care are considerable and quite high no matter the country or insurance.

It has been estimated that globally the annual direct and indirect costs of hip fractures amounted to $34.8 billion in 1990, and are expected to rise to an estimated $131 billion by 2050. [13]

Therefore, to find an appropriate treatment for femoral neck fractures is quite necessary for both medical and socio-economic purposes that can benefit both of these systems. Nowadays surgery is the mainstay of care. In younger patients the procedures of closed reduction and internal fixation (OS) are the most common procedure to be performed, the treatment of older patients with femoral neck fractures depends on patient’s conditions, patient profiles, surgeon’s preferences and surgical training of the doctor to be performing the surgery. This is regularly based on the surgeon’s personal believes in order to establish the management and treatment of the patients than the actual facts and evidence provided by the literature. [20, 21]

The treatment of choice for a hip fracture is based on the anatomical location of the fracture. Hip fractures can be extracapsular (i.e., inter-/subtrochanteric) or intracapsular (i.e., femoral head and neck).

50% approx. of all hip fractures are found to be intracapsular femoral neck fractures [22] these types of fractures can be treated surgically by internal fixation or arthroplasty. This thesis is focused on the treatment of femoral neck fracture patients with internal fixation analysis.

From meta-analyses studies, it has been reported that internal fixation normally may lead to lower infection rates, quite less blood loss and possibly a decrease in mortality, if it is been compared with arthroplasty. But on the other hand, arthroplasty significantly reduces the rate of revision surgery, which is a key advantage, as revision surgery rates for a 35% approx. after internal fixation failure. [9, 24]

Notwithstanding, femoral neck fracture patients with arthrosis, rheumatoid arthritis, or a pathologic fracture should be treated with arthroplasty, as conditions like these are contraindications for internal fixation.

In our study, we have excluded patients with pathologies in order to have a clearer and fairer perspective on the impact and its results.
1. AIM AND OBJECTIVES OF THE STUDY

The aim of the study: To investigate and compare treatment methods between Internal Fixation and Arthroplasty for femoral neck fractures.

The objectives of the study:

1. Investigate femoral fracture patients treated with osteosynthesis or arthroplasty.

2. Compare reoperation rate between the two surgical methods.

3. Analyze mortality rate between osteosynthesis or arthroplasty patients.


2. Literature review

2.1 FNF problem

Femoral neck fractures are frequent injuries in the patient population trauma-center and have a higher incidence in the general population. Femoral Neck Fractures are common injuries that appear to be suffered most commonly by older patients. Older patients have unsteadiness of gait and reduced bone mineral density, predisposing to fracture of any kind especially of hip. In osteoporotic women, these are usually common and these women are found to be at greatest risk.

It is well known that these types of injuries occur in two distinct populations. In young and active individuals that might be experiencing new changes in their activity or physical activities such as runners for example. And secondly elderly individuals with osteoporosis, which is main risk factor for the final result of the injury. Elderly may also suffer from femoral neck stress fractures, hip fractures are much more common and are often quite devastating injuries in terms of outcomes as well.

Several factors are predisposing the elderly population to these fractures. Those factors include osteoporosis, malnutrition, not much physical activity, impaired vision, and neurological conditions, lost of balance and muscle atrophy. Femoral neck fractures may have devastating outcomes in the geriatric population. The quantity of hip fractures per year will be expected to be doubled by the year 2050.

Osteoporosis prevention is the key to achieve a reduction of these numbers and predictions. As osteoporosis remains the one of the most important contributing factor to femoral neck fractures. The prevalence regardless of type and fracture location is highest among white women, followed by white men, black women, and black men.

Femoral neck fractures in elderly population happen usually after minor falls or twisting injuries, still being more common in females.

The increasingly aging population has as a challenge to face coping with the growing number of femoral neck fractures and with the increasing economic burden that it is expected to cause as the world has never faced a situation like this before and it will certainly affect the future healthcare system as the complex that it is: economics, insurance, health management.
2.2 Anatomy of the Femur

The thigh is composed by the femur as the main bone of it. It is classified as a long bone. The femur counts as the longest bone in the body. The femur’s main function is to transmit forces to the hip joint from the tibia. Is the site of origin and attachment of many muscles and ligaments. The femur is divided into three: proximal, shaft and distal.

*The proximal area of the femur:*

The proximal area of the femur plus the pelvis constitutes the hip joint. It is made of the head, the neck and two bony processes called trochanters as well as two bony ridges connecting the two trochanters. [41]

- **Head** – Forms a duet with the acetabulum of the pelvis in order to create the hip joint. Has a little depression on the medial part where the ligament of head of femur is found to be attached.

- **Neck** – Connects the head of the femur and the shaft. Has a cylindrical shape in a superior and medial direction, this allows a better movement of the hip joint.

- **Greater trochanter** – A composition of bony tissue that is originating from the anterior part, lateral to the neck. Both are located on the anterior part and posterior part of the femur.
  - Is an area for the attachment of many muscles such as gluteus medius, gluteus minimus and piriformis.

- **Lesser trochanter** – Goes all the way from the posteromedial side of the femur and goes inferiorly to the neck-shaft junction.
  - Psoas major and iliacus muscles attach to it.
- **Intertrochanteric line** – A slight line of bone that goes in an inferomedial path on the anterior area of the femur and by this connects the trochanters. Once it leaves the lesser trochanter on the posterior surface, it is named as the pectineal line.
  o iliofemoral ligament, the strongest ligament of the hip joint attaches to it.
- **Intertrochanteric crest** - This puts the two trochanters together. It is to be found on the posterior surface of the femur.

**The Neck of the Femur (collum Femoris):**

The neck is a flattened area process of bone that connects the head and the body of the femur. The angle reaches its widest during the early ages of an individual and becomes lessened during growth. During adulthood, the neck forms an angle of about 125° with the body this may vary in inverse proportion in order to develop the pelvis and the stature. In females due to the increasing width of the pelvis, the neck of the femur reaches and leads to nearly a right angle with the body than it occurs in the male. The angle if found to be decreased during the period of growth and found that after full growth has been attained and usually it does not change after that period. Hence it varies considerably in different individuals that are the same age. Being smaller in short than in long bones, and when the pelvis happens to be wider. Also to being projected upward and medial ward from the body of the femur, the neck also projects forward variably but generally from 12° to 14°. The neck of femur is the region within the articular capsule. [44]

The biomechanical of the proximal femur has historically been mentioned by PAUWELS; the classification of fractures named after him takes into consideration:
the angle the fracture line forms with the horizontal line.
In Pauwels type II (fracture angle 30° to 50°)-
the fracture and contact area is smallest, in type I the resulting force is more likely to lead to a compacted fracture,
in Pauwels type III - the shearing forces generates a slipped fracture. Garden classification added to this model, was explained with pushing and pulling forces, by observing the structures of the proximal femur and interpreting the screw-shaped component of the trabecular bones dynamically. This explains the gigantic resilience against the actual mow forces that occur in everyday life.

**The Shaft part of the femur:**

The femoral shaft goes down in a slight and medial direction.
Bringing the knees closer to the body’s centre of gravity, thus this lead to increase the stability.
Posteriorly the surface of the femoral shaft, there are coarsened and rough ridges of bone, these are name in latin: Linea Aspera.
In the proximal area, the medial border of the linea aspera turns out to become the pectineal line.
The lateral border becomes the gluteal tuberosity zone and here is where the gluteus maximus attaches to it.
Distally, Linea Aspera widens and leading to the floor of the popliteal fossa, the medial and lateral borders form the medial and lateral supracondylar lines. The medial supracondylar line reaches till the adductor tubercle, in addition here is where the adductor magnus attaches.
The Distal of the femur:

The distal end is mainly formed by the condyles, medial and lateral, these ones are articulating with the tibia and patella, leading to lead the formation of the knee joint.

- **Medial and lateral condyles** – areas that are round at the end of the femur. Its posterior and inferior surfaces fit with the tibia and with the menisci of the knee. Meanwhile the anterior surface gets is contact with the patellar area.

- **Medial and lateral epicondyles** – These are bony area elevations on the areas of the condyles that are non-articulated. These are the areas of attachment for muscles and, mainly the attachment of the collateral ligaments of the knee joint.

- **Intercondylar fossa** – An area of depression located on the posterior outer area of the femur, lies among both condyles. Containing two angles for attachment of the internal knee ligaments.

- **Facet for attachment of the posterior cruciate ligament** – Lies medially on the intercondylar fossa. Its shape is large rounded and flat faced. On this surface it is found the posterior cruciate knee ligament attaching to it.

- **Facet for attachment of anterior cruciate ligament** - Located laterally to the wall of the intercondylar fossa, being smaller than the facet on the medial wall, finding the anterior knee cruciate ligament attached to it.

Femoral vascularization

The blood supply to the proximal end of the femur consists of mainly 3 major groups. Firstly is the extracapsular arterial ring that we can find at the basal part of the femoral neck. [43] Secondly, it is to be found the ascending cervical branches: the arterial ring on the surface of the femoral neck.

And the third is the arteries for the ligamentum teres. Larger branch of the medial femoral circumflex artery is forming the extracapsular arterial ring by posterior and anterior by a branch from the lateral femoral circumflex artery.

Ascending cervical branches come up from the surface of the femoral neck anterior along the intertrochanteric line. On the posterior cervical branches run under the synovial reflection going towards the rim of the cartilage, which forms the femoral neck from its head area.

Lateral vessels are the most vulnerable to be injured during the femoral neck fractures.

Most of the femoral head vascularization suppliance does originate from the medial and lateral femoral circumflex arteries, forming an extracapsular ring around the femoral neck. Going upwards to the cervical branches passing the femoral neck proximally and entering the capsule at its insertion. Femoral Neck Fractures can disrupt the vascularity of the femoral head. Nonetheless, displaced fractures of the femoral head may occur without disruption of the medial femoral circumflex or lateral epiphyseal systems. It’s not usually seen that the collateral circulation can maintain the viability of the femoral head when the disrupted vessels are the primary vessels.

The anatomy of the upper end of the femur is also enormously meaningful, because it determines where should internal fixation devices be located during a surgery for maximum purchase in the femoral head. [42]
The strength of the proximal femur decreases with increasing age as the femoral neck cortex thins and cancellous trabeculae are being mostly resorbed. This counts as a risk of fracture with loading, leading to internal fixation prone to not success. The pattern of the trabecula allows the doctor to estimate the degree of osteoporosis and the probable success of the internal fixation, even though the subjectivity of evaluating these patterns can be somehow unreliable. Two major forces that take part in the hip joint are: abductor muscles and body weight, and when acting together they are known as the joint reaction forces. Usually, in males, the normal joint reaction forces are as much as 47 times body weight and in female’s 2.54-time body weight.

**Femoral Musculature:**

The thigh’s musculature can be split into three parts: anterior, medial and posterior. Each compartment it is formed by distinct innervation and function. Anterior compartment muscles of the thigh are innervated by the femoral nerve acting to extend the leg at the knee joint.

The main muscles of the anterior thigh:
- the pectineus, sartorius and quadriceps femoris. In addition to these, the end of the iliopsoas muscle passes into the anterior compartment. [45]

**The iliopsoas**

Formed by two muscles the psoas major and the iliacus that when come together form the Iliopsoas muscle itself.

The iliopsoas muscle does not take part on the extension of the leg at the knee level.

The psoas major origin is the lumbar vertebrae, and the iliacus origin is the iliac fossa of the pelvis. Coming both together to be inserted in the lesser trochanter of the femur.

The muscle iliopsoas flexes the lower limb at the hip joint and helps in lateral rotation at the level of the hip joint.

The psoas major innervation is provided by rami of L1-3 anterior.

The iliacus is innervated by the femoral nerve.

**Quadriceps Femoris**

It is formed by four muscles: three vastus muscles and the rectus femoris. Together they form the strongest muscle in the human body.

These muscles unite proximal to the knee and are attached to the patella by the patellar tendon.

The patella and tibia come together by the patellar tendon.

This muscle is the main extensor of the knee as well as stabilizes the patella. [33]

**Vastus Lateralis**

- This muscle’s origin is from the greater trochanter and the lateral of the linea aspera.
- It is innervated by the femoral nerve.

**Vastus intermedius**
- Attaches to the surfaces of the femoral shaft.
- Extends the knee and is innervated by the femoral nerve.

**Vastus medialis**
- Attached proximally to the intertrochanteric line and linea aspera.
- Is innervated by the femoral nerve and extends and stabilizes the knee.

**Rectus Femoris**
- Origin from the ilium, superior to the acetabulum. It runs down the leg.
- Attaching itself to the patella by the tendon quadriceps femoris.
- Crosses both the hip and knee joints.
- Provides flexion at the hip joint and extension to the knee joint.
- Innervated by the femoral nerve.

**Sartorius**
It is the longest muscle in the human body. Its long and thin complexity goes all the way through the thigh in an inferomedial direction. It is the most superficial muscle located in the leg.
- It originates from the anterior superior iliac spine and it attachments are to the surfaces of the tibia.
- The sartorius acts as a flexor, abductor and lateral rotator. Behaves as a flexor at the knee joint. It’s innervation is provided by the femoral nerve.

**Pectineus**
The pectineus muscle is flat and it is the base part of the femoral triangle. It is considered a transitional muscle between the anterior thigh and medial thigh compartments, having a dual innervation indeed.
- Its origin if the pectineal line on the anterior surface of the pelvis. Attaching to the pectineal line on the posterior side of the femur, inferiorly to the lesser trochanter.
- Provides flexion and adduction at the hip joint.
- Innervated by the femoral nerve and as well by a branch of the obturator nerve.
2.3 Treatment options and results

Today, surgery is the mainstay of care. Younger patients osteosynthesis was performed, the treatment of older patients with femoral neck fractures widely depends on the patient’s condition, type of fracture and surgical skills of the doctors attending the injured individual. Usually the type of implant used relies on the surgical training of the doctor. It is largely known that not all surgeons manage the femoral neck fractures in older patients similar to younger ones. Younger ones are usually managed by internal fixation (IF) using cannulated screws or screws. But due to the before hand mentioned risk factors as: pathological fractures, bone density, other conditions, blood coagulation status etc. it is preferred arthroplasty in the elderly population.

For older patients, usually hemiarthroplasty (HA) - unipolar and bipolar - and total hip arthroplasty (THA) methods are more commonly used as management methods.

The optimal treatment of femoral neck fractures in the population is still under debate.

As the result of each type of surgery whether is osteosynthesis or arthroplasty varies and the outcome of it has a lot to do with the postoperative care, rehabilitation, age and individual functional-physical status of the patient. In this thesis, we attempt to determine the best pattern to follow according to the age and type of fracture of the patient according to the results of their current management.
### 2.4 Treatment algorithms

As our study is based on the classification of the fracture by Pauwels (32), based on vertical orientation of fracture line we state and specify here first the named classification:

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<th>Type</th>
<th>&lt;30 deg from horizontal</th>
<th>30 to 50 deg from horizontal</th>
<th>&gt;50 deg from horizontal (most unstable, highest risk of nonunion and AVN)</th>
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Pauwels stated that the fracture line with the horizontal plane significantly affected the prognosis of the fracture. There is an angle formation when extending the fracture line upwards to find an imaginary horizontal line drawn all the way through the iliac crest plane on AP film is named as "Pauwels’ angle." It is established that the higher the value of this angle, the greater instability of the fracture is.

So when it comes to providing a clear or absolute algorithm for the treatment that should be provided to the different patients in different situations there is, yet, no clear consensus. Therefore several guidelines in constant change and renewal appear.

To be mentioned that in 2007 the Dutch Surgical Society (NVvH) published a guideline on the treatment of hip fracture patients. [37]

The above-mentioned guideline provides a decision guide for the treatment of femoral neck fracture patients. The decisions are based or made upon evidence-based patient and fracture type and specifics that are relevant in both Europe and internationally [38,39,40]. This Dutch guideline shows surgical guidelines and behavior performed in most of Europe, again varies according to the surgeon abilities and usual performed procedures at the hospital or area.

Is possible to find a written consensus that patients with un-displaced fractures, due to the nature of this type of fracture, should be treated with internal fixation [38].

The medical field also agrees that femoral neck fracture patients with rheumatoid arthritis, arthritis or any pathological fracture is recommended to be treated with arthroplasty, as these conditions are contraindications for osteosynthesis. Surgeons and the medical community agree that elderly that presents displaces femoral neck fractures should be treated with arthroplasty.

There is no clear consensus either on the treatment of younger patients with a displaced fracture established.

Generally, it is recommended that internal fixation may be used in patients with limited comorbidity and a low ASA score (American Society of Anesthesiologists), those patients should be mobile, independent, and not cognitively disabled pre-fracture.

Patients for whom the risk of revision surgery is already pre-operatively established to be too high are recommended to be treated with arthroplasty.

Once the decision for arthroplasty or osteosynthesis has been made, the type of prosthesis is selected by the surgeon.
General Surgical Consideration:

**Surgery timing:**
- Controversial and depends widely on the establishment of the same.
- Elderly patients with hip fractures must be treated in the OR as soon as possible.
- The benefits of early mobilization cannot be overemphasized.

**Selection of the treatment:**
- Degree of displacement
- Physiologic age of the patient (young is $< 50$
- On the fracture femoral neck-priority goes to fixing femoral neck fracture in order to avoid mal-union, nonunion and/or complications of AVN.

**ARTHROPLASTY**

Total hip arthroplasty (THA) is currently one of the most successful orthopedic procedures. For patients with hip pain due to a variety of conditions, THA can relieve pain, can restore function, and can improve quality of life. Sir John Charnley, a British orthopedic surgeon, developed the fundamental principles of the artificial hip and is credited as the father of THA.

The regular hip functions as a "ball-and-socket" joint. The femoral head (articulates with the acetabulum, allowing range of motion in multiple ways. Any condition that affects any of these structures might lead to deterioration of the joint. All this can lead to deformity, pain, and loss of function of the joint.

THA is a procedure where the diseased articular surfaces are replaced with materials, allowing relieving the pain and improving joint function. THA is an elective procedure and should be considered as an option among other alternatives. The decision to proceed with THA is made with an understanding of the potential risks and benefits. A full understanding of the procedure and the anticipated outcome is a main part of the decision-making process. For the appropriate candidate, THA can be a life-altering procedure that relieves pain, improves function, and enhances quality of life.

**HEMIARTHROPLASTY**

A hemiarthroplasty is a surgical procedure that is used to treat a fractured hip and femoral neck fracture in our case. The surgery is quite similar to a total hip replacement, although in this case just half of the hip is replaced during surgery.

The hemiarthroplasty procedure consists of only the ball portion replacement of the hip joint but not the socket portion.

**INTERNAL FIXATION**

Internal fixation implies the surgical adherence of implants in order to repair a bone, in this case the femoral neck after the fracture. The types of fractures have to be un-displaced.

When it comes to internal fixation there is a type that is the most widely known: using three cannulated bone screws. There are some established guidelines and patterns, that we are going to mention below, that are useful to perform a proper Osteosynthesis:
The first screw is supported in the medial caudal position by the calcar bone in order to prevent tilting into a varus position. The second screw is used to secure the fixation of the dorsal position at mid-level. This is the critical area in order to stabilize the head at the sagittal level. The third screw is positioned in a cranial-ventral position to the second.

### 2.5 What are risk factors for osteosynthesis failure in FNF

The osteosynthesis failure is, regardless, all the efforts and means provided by the surgeons is the fact of not having an actual guideline that states the right distances and measurements to perform this procedure as each patient’s fractures are different from each other as well as the patient’s characteristics.

Risk factors that are not surgery-related are such as: heavy weight or obesity of the patient that will make the healing procedure a bit more risky, blood conditions, medical conditions that may interfere with the recovery, a fracture that has many tiny parts of bone that are much more difficult to heal.

Risk factors are associated to the fact of having residual bone and the mostly osteoporotic bone structures.

The timing of the operation: It is found in some researches that during internal fixation preserving the head of femur constitutes an emergency surgery and needs to be performed within 6 hours. The pressure resulting from bleeding into the articular capsule will increase after this point.

For a successful osteosynthesis it is required that the exact repositioning of the fracture in both lines. A slight valgus position may be acceptable. In younger patients, the valgus position results in a better healing process and fewer necroses of the femoral head, but after several years it will also increase the rate of arthritis.

One of the possible complications associated with internal fixation is subtrochanteric fracture, which is problematic because of its mechanical and vascular instability.

It was found in meta-analysis for osteosynthesis that the surgical procedure took less time, incurred less blood loss, and resulted in fewer wound infections at the end [42] than THA.

### 2.6 Complication rate between OS and THA/HA

36 (7%) reoperations had occurred among the arthroplasty as compared to 19 (28%) among the osteosynthesis patients. The main reason for reoperation for arthroplasty patients was dislocation 27 cases (75%) and there were 18 (95%) conversions to total hip arthroplasty in osteosynthesis patients.

### 2.7 Mortality after FNF, risk factors

The increasingly aging population of the world will have to face the challenge of coping with the growing number of femoral neck fractures and with the increasing economic burden they represent for the healthcare system in the conditions of economic uncertainty in the future.

Complications, including femoral neck shortening, non-union, and avascular necrosis, are relatively common after the internal fixation of this fracture pattern. All the complications have main serious effects on younger patients. Being the main one the fact of avoiding the conversion of the OS to arthroplasty.

But a femoral neck fracture in the older population comes along with a higher risk of actual death than other complications. These are due to the elder state of the patient’s body and its ability to regenerate,
as well as the blood loss that they may suffer. According to European Medicines Agency criteria, patients aged older than 70 years are at a higher risk of bleeding, result of a higher frequency of blood transfusions in this group of patient [43].

The mortality in our study:
There were 89 (17%) deaths among the arthroplasty as compared to 6 (9%) among the osteosynthesis patients within 1 year after surgery. The unadjusted cumulative mortality rate at 1 year after surgery was 17% (95%CI 14-20%) for the arthroplasty group and 9% (95%CI 4-19%) for osteosynthesis group (p= 0.0968). Cox regression showed that the younger age had lower risk of death but not surgical method, gender or time from trauma till surgery. Although mortality rate is higher in arthroplasty patient group, older age was the influencing factor as well.

3. METHODS

3.1 Patients and Methods

The research was performed in the hospital of Lithuanian University of Health Sciences, Kauno Klinikos, at the department of Orthopaedics and Traumatology. The research was divided into two parts according to the objectives of the research plan. I part compiles the investigation and the evaluation of the internal Fixation patients: the postoperative x-ray analysis. II part consists of the comparison and investigation of the patients that underwent osteosynthesis vs. arthroplasty.

3.2 Study Population:

642 patients were included consecutively treated and dealt with their respectively revisions. From 2011 till 2016.

3.3 Inclusion Criteria

- Patients that suffered a Fresh Femoral Neck Fracture.
- Patients that underwent Arthroplasty.
- Patients that underwent Internal Fixation.
- Patients from age 18-95 years old.

3.4 Exclusion Criteria

- Patients with old fractures.
- Patients with any malignancy or metastasis.
- Patients that suffered a fresh femoral neck fractures but refused surgery.
- Patients <18 or >95 years of age.
- Osteosynthesis patients that had no post-operative radiological image.

3.5 Allocation of the groups

Fig. 3.5.1 Study flowchart

3.6 Patients’ characteristics

Out of 642 patients fitting our research criteria 179 were male and 463 were females. Out of the 642 patients 332 of them suffered the Femoral Neck Fracture (FNF) on the Right side (dexter) and 310 of the FNF patients suffered it on the Left side (sinister).

From all the Internal fixation:
- 41 were females
- 29 were males

From all Arthroplasty:
- 422 were females
- 150 were male
3.7 Radiological assessment

2 days, maximum, after the operation long-standing radiographs were performed by assistants of the Department of Radiology using Siemens MULTIX PRO system (Siemens Medical System Inc.). The plain radiographs were performed on the phosphor plates (Regius model RC-110T, Konica Minola medical & Graphic Inc.) and digitalized (Direct Digitalizer Regius model 210, Konica Minolta Inc.). The measurements were performed on the digitalized radiographs using Cedara I-Reach™ radiology viewer (Cedara Software corp. Merge OEM).

Then the postoperative radiological evaluation was performed.

With these radiological means we evaluated the THA, HA and IF patient’s radiological images.

The Internal Fixation radiological images: Valgus, Varus, Step (mm), Calcar-Caudal pin distances (mm), Upper cortex-cranial pin distance (mm), Paralel status, subchondral distance (mm), Level of the Caudal Pin (in the LT region, if not: above or below in mm).

The main references and parameters to create our personal criteria had been obtained from article from Norwegian Literature Opsahl JH, Stiris M, Paulsrud Ø et al. [7] and literature Manninger et al. [11] Internal Fixation of femoral neck fractures an atlas.

Fig.3.7.1 "Manninger,J. (2007) Internal Fixation of femoral neck fractures, An atlas. SpringerWienNewYork. [Figure] [11]

[Recovered, from:https://books.google.es/books?id=lr0MEsp8MC&pg=PA99&hl=es&source=gbs_toc_r&cad=4#v=onepage&q&f=false]

Schema of the parameters for the evaluation of internal fixation
The valgus and varus disposition was evaluated by measuring the angle degree.
3.8 Study part I (Study of the internal fixation patients)

Our comparison between internal fixation and arthroplasty treatment methods in FNF has been evaluated from the period of 2011 to 2016. Evaluating the FNF classification, the time from the trauma till the ER, the time from the ER till the surgery was appropriately performed, the trauma mechanism if it was low or high trauma, the methodology of the operation, we as well evaluated the duration of the hospital stay and we did not forget the importance of including the risk factors (as age, gender etc.) either. The two main factors that seemed to not match our classification values in most of radiological analysis were the Upper cortex cranial pin distance and the Calcar-Caudal pin distance. Although the results obtained from measuring the parallel situation of the pins after surgery, the subchondral region location and the caudal level of the pin were found within our classification values "perfect" or "average", for them.

**X-ray criteria for assessing the reduction of the fracture and placement of the hip pins.**

*Our personal Strategy to evaluate the success of the IF procedure in FNF.*

<table>
<thead>
<tr>
<th></th>
<th>Perfect</th>
<th>Average</th>
<th>poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>varus</td>
<td>no</td>
<td>Minimal 5</td>
<td>&gt;5</td>
</tr>
<tr>
<td>valgus</td>
<td>&lt;15</td>
<td>15-20</td>
<td>&gt;20</td>
</tr>
<tr>
<td>step</td>
<td>&lt;2mm</td>
<td>2-4mm</td>
<td>&gt;4mm</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcar-caudal pin</td>
<td>0-2mm</td>
<td>2-4 mm</td>
</tr>
<tr>
<td>distance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper cortex-cranial</td>
<td>0-2mm</td>
<td>2-4 mm</td>
</tr>
<tr>
<td>pin distance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paralel</td>
<td>yes</td>
<td>Minimal 5</td>
</tr>
<tr>
<td>Subchondral distance</td>
<td>&lt;5mm</td>
<td>5-10mm</td>
</tr>
<tr>
<td>Level Caudal pin</td>
<td>In LT region</td>
<td>Lower 5mm</td>
</tr>
</tbody>
</table>

In our study it was evaluated the outcome of the surgery, if there was any re-operation performed. Radiological analysis of postoperative x-ray was performed for osteosynthesis. Patients who were revised where compared to others. To evaluate if the reposition was performed correctly, seven measurements were taken:
Fracture angle (varus/valgus); fragments step; Screw-Adams'Arch-Distance; Upper cortex-cranial screw distance; Screw-Screw-Angle; Screw-Countour-Distance and Caudal drill hole-Lesser trochanter distance.

3.9 Study part II (Comparison of Arthroplasty and Osteosynthesis methods.)

In this part of the study these patients were compared according to the correlation between the results of the gender, age, the time from the trauma till the ER, the time from the ER till the surgery was appropriately performed, the methodology of the operation, mortality rate and revision or re-operation rate in Arthropalsty patients and Osteosynthesis patients.

3.10 Statistical Analysis

For descriptive statistics, frequencies, means ± standard deviations were used. For statistical analysis t-test, chi-square, Fisher exact tests were performed. For implant survival analysis, we used reoperation for all reasons as an end-point. Also, we performed survival analysis for mortality within 1 year after surgery.
4. RESULTS

The 642 patients who met the inclusion criteria 572 were Arthroplasty operated patients and 70 were Osteosynthesis operated patients.

The mean age at surgery was significantly higher in arthroplasty group as compared to osteosynthesis group (p=0.0001). Reoperations for arthroplasty occurred 36 (7%) as compared to 19 (28%) among the osteosynthesis group. The main reason for reoperation for arthroplasty patients was dislocation 27 cases (75%) and there were 18 (95%) conversions to total hip arthroplasty in osteosynthesis patients.

The unadjusted cumulative reoperation rate for any reason was 8% (95%CI 6-11%) for the arthroplasty group and 37% (95%CI 23-57%) for osteosynthesis group (p= 0.0001). There were 89 (17%) deaths among the arthroplasty as compared to 6 (9%) among the osteosynthesis patients within 1 year after surgery.

4.1 I Study Part (Study of the Internal Fixation Patients.)

Out of the total number of OS patients 68 post-operative radiological images were available to analyze, it was found 18 re-operated patient’s vs 50 healed patients.

Comparing fragments step (3.28±1.23 vs 4.15±1.68), Screw-Adams ‘Arch- Distance (5.00±1.86 vs 5.05±1.99), Upper cortex-cranial screw distance (5.43±2.44 vs 5.13±2.87) respectively and no statistically significant difference was observed.

Table 4.1 Proportion of Valgus vs. Varus among the OS patients

From total number (52) of patients that fit the criteria for Valgus state in the radiological analysis: 9 patients fit the criteria perfect <15 deg, 29 patients fit the criteria average 15 to 20 deg, 14 patients fit the criteria poor >20 deg.

The 16 patients fitting the Varus state in the radiological analysis: 8 patients were included in the Minimal Varus status <5 deg and other 8 patients were included in the group of patients presenting >5 deg of varus.
Table 4.2 The parallel situation of the pins among the OS patients according to the criteria

<table>
<thead>
<tr>
<th>Parallel PINS</th>
<th>POOR (No parallel)</th>
<th>AVERAGE (minimally parallel)</th>
<th>PERFECT (yes parallel)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>31</td>
<td>33</td>
</tr>
</tbody>
</table>

Comparing Screw-subchondral-Distance in Re-operated patients distance was significantly greater than in other group 5.59±2.22 vs 4.63±1.24 (p = 0.026).

Table 4.3 Screw-subchondral- Distance among OS patients.

<table>
<thead>
<tr>
<th>SUBCHONDRAL DISTANCE</th>
<th>&gt;10 mm</th>
<th>5-10 mm</th>
<th>&lt;5 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>25</td>
<td>42</td>
</tr>
</tbody>
</table>
4.2 II Study Part (Comparison of Arthroplasty and Osteosynthesis methods.)

The mean age at surgery was significantly higher in arthroplasty group as compared to osteosynthesis group patients (p= 0.0001).

*Table.4.4 Osteosynthesis patients Mean age 67±17*

![Graph showing age distribution for Osteosynthesis patients with mean age 67±17.]

*Table.4.5 Arthroplasty patients Mean age 79±11*

![Graph showing age distribution for Arthroplasty patients with mean age 79±11.]

Table 4.6 Minimum and Maximum age of the total number of patients according to their operation procedure.

<table>
<thead>
<tr>
<th>Operation Procedure</th>
<th>Minimum Age</th>
<th>Maximum Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteosynthesis</td>
<td>22</td>
<td>95</td>
</tr>
<tr>
<td>Arthroplasty</td>
<td>30</td>
<td>99</td>
</tr>
</tbody>
</table>

The influence of gender in the two different surgical procedures was observed to be higher the incidence of FNF in women compared to males.

Table 4.7 Mean among females and males in OS and ATH.

The mean follow-up was 32±23 months for arthroplasty group and 28±21 months for osteosynthesis.
Table .4.8 Total of Reoperations among OS patients and ATH patients

36 (7%) reoperations had occurred among the arthroplasty as compared to 19 (28%) among the osteosynthesis patients. The main reason for reoperation for arthroplasty patients was dislocation 27 cases (75%) and there were 18 (95%) conversions to total hip arthroplasty in osteosynthesis patients. The unadjusted cumulative reoperation rate for any reason was 8% (95%CI 6-11%) for the arthroplasty group and 37% (95%CI 23-57%) for osteosynthesis group (p= 0.0001).

Cox regression showed that the arthroplasty group had lower risk of reoperation.

Table .4.9 Mortality Percentage in OS procedure and ATH procedure.

As shown above there were 89 (17%) deaths among the arthroplasty as compared to 6 (9%) among the osteosynthesis patients within 1 year after surgery. The unadjusted cumulative mortality rate at 1 year after surgery was 17% (95%CI 14-20%) for the arthroplasty group and 9% (95%CI 4-19%) for osteosynthesis group (p= 0.0968).

Cox regression showed that the younger age had lower risk of death but not surgical method, gender or time from trauma till surgery involved.
5. DISCUSSION

As we analyze the results we find results that were previously stated by other publications and research that show the importance of the age to whether perform one procedure or the other. There are published many articles regarding the FNF type of surgery indicated according to age and type of fracture available. Studies regarding the existence of a common pattern, method or guideline to perform a successful Osteosynthesis in the case of Femoral Neck Fracture are not that common to find or establish.

In this study we have aimed to evaluate and report some key points in order to achieve an accurate method to establish a pattern that could be used to perform internal fixation in case of FNF. Among the Orthopaedic surgery field, it is widely accepted that younger patients would be better candidates for Osteosynthesis due to their better capability to heal and older patients are usually more suitable for arthroplasty methods.

In this study, we have acknowledged that young and elderly patients have been candidates for both surgical procedures being Osteosynthesis performed in patients as old as 95 years old and Arthroplasty surgery being performed in patients as young as 30 years old. Our evaluation in this analysis showed that arthroplasty procedures are commonly performed in older patients that osteosynthesis being the mean age at surgery significantly higher in arthroplasty group as compared to osteosynthesis group patients. With this in mind, Keating, JF et al. [46] study have shown the same predisposition in the preference or final decision of the surgeons to perform arthroplasty in the elderly and stated that "older patients results of the study show a clear advantage for arthroplasty over fixation; arthroplasty was more clinically effective and less costly over a 2-year period post-surgery" [46, 47].

Despite the age, is a key factor for arthroplasty to be preferred over osteosynthesis in the elderly, the patient’s condition and comorbidities are considered as well like coagulopathies, heart conditions etc. Henceforth in our study, we excluded any patient with pathologies that might interfere with an objective analysis of the outcomes of both surgeries. Our exclusion criteria did not fit for those who presented with old fractures, any malignancy or metastasis. Nevertheless no exclusion criteria were established for those with hematological or heart conditions in this study, but there are studies [50] Baumgaertner ,M et al. that concluded in a study that concluded that in patients with intertrochanteric fractures, the intramedullary device was associated with 23% less surgical time and 44% less blood loss, so for the older patient with hematological or vascular/heart problems intramedullary fixation for the treatment of intertrochanteric hip fracture seems to be an option as well, whenever the fracture type allows it for this surgical procedure. Overall, this study did not consider heart comorbidities.

Our study was interested as well in the incidence of reoperation in both surgical procedures in order to encounter and acknowledge if there was a reason or common pattern for this to happen, due to the methodology of the operation etc. Hence, there were found more reoperations among the arthroplasty as compared to fewer among the osteosynthesis patients. Consequently the main reason for reoperation for arthroplasty patients was dislocation in most of and there were mostly conversions to total hip arthroplasty in osteosynthesis patients. The unadjusted cumulative reoperation rate for any reason was 8% for the arthroplasty group and 37% for osteosynthesis group. Cox regression showed that the arthroplasty group had lower risk of reoperation.

When the radiological evaluation of the post-operation images for the osteosynthesis patients was performed we found that comparing Screw-subchondral- Distance in Re-operated patients distance was significantly greater than in other group.
Our findings match the criteria that we looked up to evaluate the osteosynthesis images [7] from Norwegian Literature Opsahl JH, Stiris M, Paulsrud Ø et al. that established that the criteria for a proper osteosynthesis in femoral neck fracture one the key points is the insertion of the pin to subchondral bone, less than 5 mm from the cartilage.

In Manninger, J et al,[pag.106] [11] is as well stated that a precise placement of the screw in the subchondral bone is a prerequisite for an adequate stabilization and that this stability can be increased by a greater diameter of the screw or the fact of using more screws.

Manninger, J. et al. [11] established that "The caudal implant should rest on Adam’s arch. Only in manner can the implant prevent a loss of reduction in varus because of the implant’s two-arm lever effect."The study [11] concludes "if the implant is located on Adam’s Arch one obtains a three-point buttressing effect instead of a two-point loading which reduces considerably the loading of the implant".

In our study Screw-Adams Arch- Distance was established to be considered as acceptable if no more than 2mm. Our findings were: (5.00±1.86 vs 5.05±1.99) for Screw-Adams ‘Arch- Distance and therefore found no statistically significant for us to establish if the distance influenced the osteosynthesis patients that underwent revision.

It has been recommended [11] that in order to avoid the tilting in varus can be further achieved by the design of the implant end.

The compression of the fracture is only guaranteed if the screws are located in a parallel position. Several studies have mentioned that the amount of screws do not affect the success.[41] It has been recommended in some studies to place washers in order to keep the screws in their place.

This criteria Opsahl JH, Stiris M, Paulsrud Ø et al. [7] also stated that both pins must lie parallel with the femoral neck. In our evaluation we find that this criteria can be appreciated in 33 patients out of the 68 total radiological images evaluated for osteosynthesis patients.

This study finds a correlation between Screw-subchondral- Distance being more than 5mm and the re-operation for osteosynthesis statistically significant and of relevant, as well the parallel placement of the pins.

Regarding the mortality in this study there were 17% deaths among the arthroplasty as compared to 9% among the osteosynthesis patients within 1 year after surgery. The unadjusted cumulative mortality rate at 1 year after surgery was 17% for the arthroplasty group and 9% for osteosynthesis group.

When trying to compare this data in inevitable to address the age influence for both procedure, as previously mentioned in this discussion, being higher for the arthroplasty method than for osteosynthesis regardless the type of fracture and statistically significant. Cox regression showed that the younger age had lower risk of death. It has to be addressed that the younger would have less risk of death due to the less presence of comorbidities, the physical activity after surgery, the bone healing process etc. The type of injury that these two different groups of patients may suffer as well influences these wide thoughts. As in younger population is commonly observed that high impact traumas are the most common cause of FNF.

In the elderly the inevitable degeneration of the human body [5, 10] leads to loss of stability and equilibrium and less speed to react to a fall or obstacles in the way leading to traumatic falling and injuries that might have not been that dramatic in younger patients.

Researchers [50, 51] found that preoperative factors, such as advanced age, decreased muscle grip and the number of medications taken pre-fracture, were indicators for a longer, more complicated rehabilitation after hip surgery. [16] It is known that the older the patient is at time of FNF leads to the recovery outcome to decline. Adults in their late eighties have a poorer outcome after the treatment of a hip fracture (Kannus et al., 1996; Melton III, 1996; Young et al., 1997) [53, 54, 18].

Other studies [49] have shown that for hip implantation in the elderly several things have to be taken into consideration in order to avoid the risk factors that may influence the death of the patient in the future: thromboembolic complications be reduced by avoiding occlusion Barden,B. et a[49] concluded that: "Doppler sonography helps guaranteeing venous drainage. A modified leg position should be
aimed at especially in increased BMI and age." this states the other risk of death after FNF surgical treatment regardless the good performance of the surgery.

In this study the analysis of the mortality rate is related to the patient’s age at the time of the femoral neck fracture and what involves it: the bone healing capability being lower than in the younger who underwent osteosynthesis, the comorbidities that come with age, the post-operative care and rehabilitation and reoperation rate.

This study shows that re-operation in arthroplasty main factor was the risk of dislocation, which occurred in 27 cases out of the 36 in total of arthroplasty patients.

As for the re-operation in osteosynthesis the main cause was conversion of the osteosynthesis to total hip arthroplasty in 18 out of the 19 OS patients that underwent the re-operation.

All things considered, a drawback of this study is that when comparing Osteosynthesis to Arthroplasty procedures the patient’s age at the time of fracture plays a key role (statistically significant) in determining the possible outcome affecting the mortality rate, possibility of re-operation.

**6. Conclusions**

1. Majority FNF patients were operated by arthroplasty.

2. FNF patients treated with arthroplasty had a significantly lower risk of reoperation as compared to osteosynthesis method.

3. Although mortality rate is higher in arthroplasty patient group, older age was the influencing 1-year risk factor of death for all FNF patients.

4. Significantly greater distance between osteosynthesis screw and subchondral area of the femoral head was observed in reoperated FNF patients.
7. References

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53. Older adult’s recovery from hip fracture: A literature review David J. Healee RGN, MA (Doctoral Candidate, Nursing Lecturer), Antoinette McCallin PhD (Director, National Centre for Interprofessional Education and Collaborative Practice), Marion Jones PhD (Associate
Professor and Associate Dean, Postgraduate) AUT University, Private Bag 92006, Auckland, New Zealand

54. Kannus et al., 1996; Melton III, 1996; Young et al., 1997