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UNICOMPARTMENTAL KNEE IMPLANTS

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List Of Abbreviations

ACL - Anterior Cruciate Ligament

AVN - Avascular Necrosis

NSAIDs - Nonsteroidal Anti-Inflammatory Drugs

OA - Osteoarthritis

PCL - Posterior Cruciate Ligament

QT - Quadriceps Tendon

ROM - Range of Motion

TENS - Transcutaneous Electrical Nerve Stimulation

TKA - Total Knee Arthroplasty

UHMWPE - Ultra-High-Molecular-Weight Polyethylene

UKA - Unicompartmental Knee Arthroplasty

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1. Summary

The knee joint, comprising four bones, and three compartments -medial tibiofemoral, lateral tibiofemoral, and patellofemoral. Ligaments, such as the ACL and PCL, enhance the stability. Knee osteoarthritis, characterized by cartilage degeneration and osteophyte formation is one of the most prevalent causes of disability. There are many risk factors – modifiable and nonmodifiable. Diagnosis based history, examination, and imaging. Treatment options range from conservative treatment to knee arthroplasty and surgeries depend on the clinical symptoms and disease progression.

Unicompartmental knee arthroplasty is indicated for cartilage degeneration limited to single compartment. Criteria include stable joints and correctable deformities. For certain patients unicompartmental knee arthroplasty shows advantages over total knee arthroplasty.

Among the various types of implants available for unicompartmetal knee arthroplasty, fixed bearing implants provide stability and simplicity, reducing the risk of dislocation and surgical complications. However, they may limit their range of motion. compared to their mobile-bearing counterparts. On the other hand, mobile bearing implants allow for more natural movement and range of motion, minimizing polyethylene wear and stress on the bone-implant interface. Those implants have a higher risk of dislocation.

Another consideration in implant selection is the design, whether single radius or dual radius. Single radius implants provide consistent motion and stability, while dual radius implants offer enhanced flexibility and range of motion. Patient activity level plays an important factor in determining suitable design.

Furthermore, all polyethylene components offer simplicity and cost-effectiveness, with potential for bone preservation, but they may experience greater wear and fixation issues. Metal-backed components, on the other hand, provide durability, stability, and flexibility, but they may pose challenges during revision surgeries and carry a risk of metal ion release.

Sažetak

Jedan od najčešćih uzroka invaliditeta današnjice je osteoartritis koljena, bolest koja se očituje u degeneraciji hrskavice i stvaranju osteofita. Za nju postoje mnogi promjenjivi i nepromjenjivi čimbenici rizika. Dijagnoza se temelji na anamnezi, pregledu i slikama, a liječenje se može provoditi u rasponu od konzervativnog do artroplastike koljena. Operativne mogućnosti ovise o kliničkim simptomima i progresiji bolesti.

Glavni je cilj ovoga rada predstaviti složenu anatomiju zgloba koljena i pružiti sveobuhvatne podatke o indikacijama i etiologijama za unikompartmentalne zamjenu koljena. Istraživanje uspoređuje različite vrste unikompartmentalne implantata za koljeno te prikazuje rezultate i rehabilitaciju nakon unikompartmentalne zamjene koljena, ističući razlike u odnosu na totalnu artroplastiku koljena. Usporedbom se nastoji pružiti vrijedne uvide u najbolji izbor implantata i očekivane ishode unikompartmentalne zamjene koljena.

Unikompartmentalne artroplastika koljena indicirana je za degeneraciju hrskavice ograničenu na jedan odjeljak, a preduvjet su stabilni zglobovi i ispravljive deformacije. Kod nekih je pacijenata pokazala prednosti u odnosu na artroplastiku cijelog koljena. Postoje različite vrste implantata, primjerice implantati s fiksnim ležajem pružaju stabilnost i jednostavnost, smanjujući rizik od dislokacije i kirurških komplikacija. Međutim, mogu ograničiti kretanje. Mobilni nosivi implantati, pak, omogućuju prirodnije kretanje i raspon pokreta, smanjujući trošenje polietilena te trenje na spoju kosti i implantata, no imaju veći rizik od dislokacije. Pri odabiru implantata u obzir treba uzeti i dizajn: implantati s jednostrukim radijusom pružaju dosljedno kretanje i stabilnost dok implantati s dvostrukim radijusom nude poboljšanu fleksibilnost i raspon pokreta. Najvažniji čimbenik u određivanju prikladnog dizajna je razina tjelesne aktivnosti pacijenta.

Nadalje, polietilenske komponente osiguravaju jednostavnost i ekonomičnost te mogućnost očuvanja kosti, ali mogu pokazivati veće znakove trošenja i imati poteškoća s učvršćivanjem, dok metalne komponente pružaju izdržljivost, stabilnost i fleksibilnost, ali mogu uzrokovati komplikacije tijekom revizijskih operacija i nose rizik od oslobađanja metalnih iona.

3. Anatomy of the Knee Joint

The knee joint is both the largest and most complex joint in the human body. The knee joint contains four bones—femur, tibia, patella, and fibula. The knee joint have of three compartments—the medial tibiofemoral, lateral tibiofemoral, and patellofemoral. all compartments share a common synovial cavity.

The knee has three articulations: medial and lateral tibiofemoral and patellofemoral. The Patella attached to quadriceps tendon and articulated with the femur. Its function is to give the quadriceps a more mechanical advantage. The fibula is located within the joint capsule but is not normally involved as a weight-bearing structure.

The joint capsule of the knee joint is composed of two layers: an external fibrous layer and an internal synovial membrane. The joint capsule is connected to the femur, tibia, and fibula. The capsule is also connected to the patella and the quadriceps tendon anteriorly, and to the popliteus and gastrocnemius muscles posteriorly.
Ligaments are fibrous structures composed of collagen fibers that serve to enhance knee stability and amplify its strength. The ligaments around the knee joint can be classified by their location within the knee: the collateral ligaments, which are the medial collateral and lateral collateral ligaments, and the cruciate ligaments, including the anterior cruciate (ACL) and posterior cruciate ligaments (PCL), are located within the knee joint. The ACL bundles comprise of the anteromedial bundle and the posterolateral bundle. The PCL bundles comprise of the anterolateral bundle and the posteromedial bundle. The ACL plays a crucial role in stabilizing the knee joint by preventing anterior slippage. It achieves this by connecting the anterior portion of the tibia to the posterior portion of the femur. The PCL plays a crucial role in preventing the backward slippage of the knee joint by connecting the posterior portion of the tibia bone to the medial portion of the femur bone. The knee contains two menisci, the medial and lateral menisci. These menisci are cartilaginous pads that serve to absorb shock and reduce the load exerted on the knee. They are connected to the joint capsule and positioned between the femur and tibia. [1] The bursa is structure that is composed

of a sac that contains synovial fluid and encloses the joint. The bursa serves as a protective layer for the knee, preventing friction between the tendons.

Normal range of motion (ROM) of the knee joint ranges from 0 degrees in full extension to 135 degrees in full flexion. The muscle responsible for knee extension is the quadriceps mucle, while the hamstring muscle is responsible for knee flexion. [2]

The knee movement is complex, encompassing several motions in both the transverse and sagittal planes. An understanding of knee biomechanics, ROM, load distribution enables us to understand specific mechanisms of knee injuries, treating knee disorder, creating rehabilitations program and developing prosthetic implants.

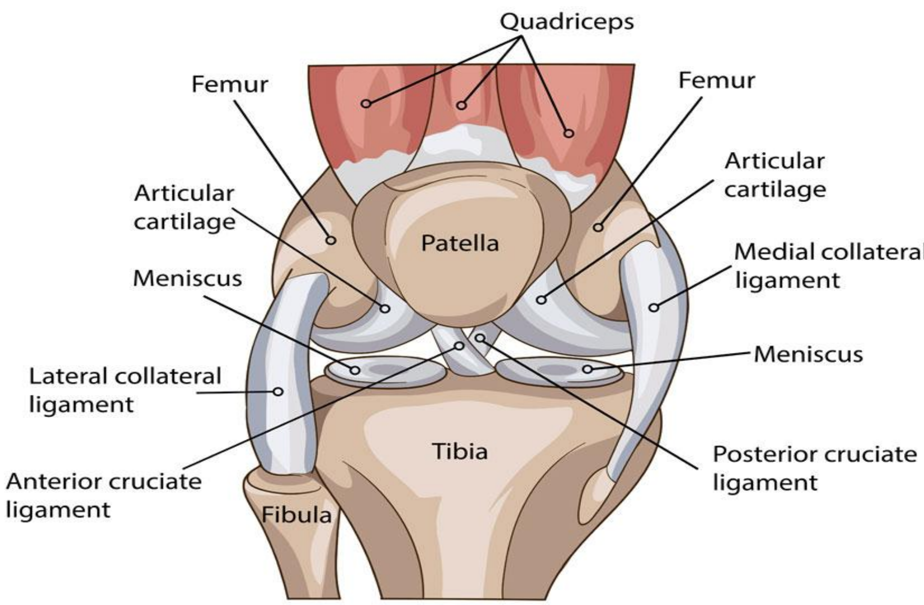


Figure 1: Knee Anatomy, Professor Adrian Wilson 2017

4. Indications for Unicompartmental Knee Arthroplasty

UKA can be indicated for patients that have limited degeneration of the knee joint confined to one of the three compartments of the knee. In order to know if a patient is suitable for UKA, the patient need to meet a strict criteria. The cause of the degenerative changes needs to be either be degenerative osteoarthritis or a result of aseptic necrosis. Rheumatoid arthritis, on the other hand, is a inflammatory disease that not included in the criteria for UKA. Age and physical activity is also important factors when deciding when to proceed to UKA. The BMI should not be greater than 30kg/m2 which indicates obesity. All the ligaments of the knee, especially the ACL and PCL need to be without defects. The presence of any pre-existing axis deformities in either varus or valgus direction should be minor. [3]

The most common etiology for UKA is OA. It is characterized by the progressive degeneration of the joint cartilage, resulting in symptoms of pain, stiffness, and reduced ROM. OA frequently affect one compartment of the knee joint, which makes this type of surgery a good therapeutical solution OA. [4]

Post-Traumatic Arthritis is another form of arthritis that is caused by knee trauma that results in fractures, ligament tears, or meniscal damage, this pathologies expose the knee joint for arthritic changes. The symptoms of Traumatic Arthritis can be described as discomfort and stiffness, which can require UKA. [4]

Another indication is Avascular Necrosis (AVN) is a condition characterized by a decreased or interruption in the blood perfusion to a bone, resulting in the loosening of bone tissue and eventual destruction of the affected joint. Etiologies include prolonged use of corticosteroids, excessive intake of alcohol, and specific medical diseases such as Lupus or HIV. AVN commonly results in intense joint discomfort and impaired ROM. In cases when the condition is limited to a specific compartment, it can be managed with a procedure such as UKA. [5]

4.1 Knee Osteoarthritis

Knee osteoarthritis (OA) is a disorder affecting the joints, that causes degeneration of the joint complex. OA prevalent etiology for disability in the USA and also globally. Additionally, it is most common joint disorder in the United States. [6] The prevalence of symptomatic knee OA is higher today compared to the past because of demographic changes, the population in developed countries became more obese and also the life expectancy is rise, these leads the prevalence of OA to become very high. [7]

The knee joint is composed of 3 compartments, OA can affect each one of them - the medial, lateral, and patellofemoral joint compartments. This disorder typically progresses insidiously over a period of 10 to 15 years, causing disruptions in all daily activities. Knee OA has multiple factors contributing to its development, Examples including family history, congenital disorders, and aging, obesity, diabetes, synovitis, systemic inflammatory mediators, autoimmunity, lower limb alignment (genu valgum and genu varum), dysplasia, trauma, and inflammation caused by metabolic syndromes. Both inflammatory and biomechanical systemic disease processes also contribute to knee OA.[8, 9, 10]

OA affect the cartilage in the of the cartilage in the joints, it causes formation osteophytes, subchondral sclerosis and formation of subchondral cysts. The risk factors associated with the development of knee OA can be categorized to nonmodifiable and modifiable. Nonmodifiable risk factors include hereditary and congenital factors. Treatments can focus on modifiable risk factors. Obesity is the most prevalent and treatable risk factor that may be changed in the United States. Each additional kg in the human body put on our joint a lot of additional stress. obesity leads to increased pressure on the joints, causing degenerative changes on weight-bearing joints, especially the knee joint and leads to degenerative changes.
The diagnosis is based on the patient's medical history and the findings from a physical

examination and can be supported by x-ray imaging. We should send to patient to general laboratory testing in order to exclude secondary causes of OA. Treatment options for OA beyond nonsteroidal anti-inflammatory medicines (NSAIDs) and acetaminophen can include braces, physical therapy, weight loss, transcutaneous electrical nerve stimulation (TENS) units, SNRI, Substance P inhibitors and intraarticular injections. One of many types of surgeries is considered the definitive treatment for severe Knee OA.[10, 11, 12, 13, 14]

Knee OA is more common in comparison to other forms of OA. Knee OA is more prevalent majority in those who are 65 years or older, with a prevalence rate of 33.6% in the United States.[6] Women have a higher prevalence rate (42.1%) than to men (31.2%).

Many symptoms can be reported by different people, this is because each specific compartment can manifest with different symptoms. The predominant symptom of knee OA is the general sensation of discomfort in the area of the knee joint. Pain is another common symptom, it can be reported as dull, intermittent, sharp, pain. The intensity can be on any range of 1 to 10 scale, and it can result in a reduction in the ROM. OA usually don't have prolonged morning stiffness as compared to Rheumatoid Arthritis, and the pain usually become stronger with activity, and lessen during period of rest or sleep. We can hear crepitus or popping sounds in the area of the knee joint. Another important symptom is muscle weakness. Other common signs of the knee include swelling, locking, and giving way. These clinical features, primarily associated with pain, typically causes disability in everyday life, and make challenges in in mobility, such as walking, climbing stairs, and performing household tasks, as well as difficulties in maintaining an upright sitting position. These physical limitations can causes significant psychological burden and eventually result in reduced quality of life.[15]

In order to correctly diagnose and classify knee OA we should rule out many causes of OA. The classification of knee osteoarthritis is based on its cause, which can be either idiopathic (primary) or secondary. Idiopathic OA of the knee typically localized to one compartment , but it can become generalized if the OA affects two or more joint compartments. Knee osteoarthritis can also be categorized based on the specific compartment of the knee that is affected. Prior to diagnosing idiopathic knee OA, it is important to consider and rule out any secondary causes. It is important to diagnose secondary knee disorders that can progress to knee osteoarthritis. Secondary causes in this list are trauma, congenital deformities or congenital disorder gout and psedugout, Paget disease of the bone, SLE, HIV and many other disorders.[16]

Posttraumatic OA, resulting from previous fractures in the distal femur and proximal tibia, is the most common cause of secondary OA. However, it only contributes to 12% of cases of symptomatic OA. [17]

A clinical diagnosis of knee OA is supported by the presence of classical symptoms, physical examination findings, laboratory results, and imaging features. There is no clinical feature that is strictly sensitive or specific. Typically, the greater the number of clinical features, the higher the probability of the diagnosis.

Surgery is recommended when a patient is under conservative treatment for a reasonable time but still complains on significant symptoms. There is many surgical choices for treating knee OA. Surgeries in this list include arthroscopy, cartilage repair, osteotomies, and knee arthroplasty (partial and total replaement). [18, 19]

Deciding on the specific operation is based on specific location of the disorder, the amount of the degenerative changes, the severity of the OA as well as comorbidities of the patient, age, and physical activity. If the OA affect only one compartment of the joint, surgery such as unicompartmental knee arthroplasty or osteotomy may be chosen. An osteotomy is a procedure in which the surgeon redistribute the weight burden from the one affected compartment to unaffected regions, this can postpone the need for complex surgeries. Knee Osteotomy is recommended to younger and physically active people. UKA is an alternative option between osteotomy and total knee arthroplasty (TKA). UKA can be effective solutions for certain individuals who have isolated medial, lateral, or patellofemoral osteoarthritis. [18, 19, 20, 21]

However, When the OA is so severe and generalized in the knee joint, TKA may be the only therapeutic option to reduce pain and gain knee function. Today, TKA is a reliable and economical procedure that offers a pain reduction rate of more than 90%. The complication rate for TKA is very low, around 1-2%. Elective TKA made by orthopedic experts can result in over 90% of patients who receive a TKA will have good outcomes even after two decades following the procedure. [22]

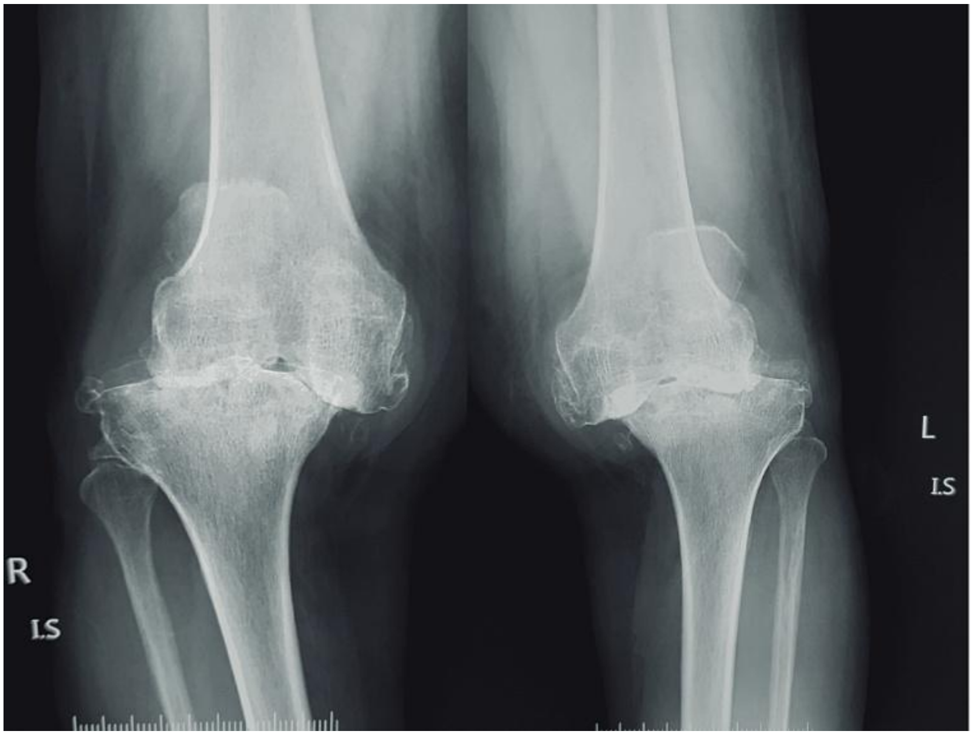


Figure 2: Anteroposterior radiograph of the bilateral knee joint in standing posture with grade IV osteoarthritis with large osteophytes, obliteration of joint space, subluxation of joint, and varus deformity of knees. Govil G, Tomar L, Dhawan P (May 12, 2022)

5. Total Knee Arthroplasty versus Unicompartmental Knee Arthroplasty

There are two types of knee replacement surgical options to treat knee pathologies. The types of knee replacement divided into Unicompartmental knee replacement and total knee replacement. The type of the specific surgery depends on the pathology itself.

UKA, has become more common surgical technique in the last decade due to improvement of the prosthetics, better surgical techniques and better long term results. [23]

The criteria for UKA include a stable joint, a correctable varus deformity, a fixed flexion of less than 10 degrees, and minimal lateral compartment pathology. UKA offers several advantages to TKA, including shorter operating time, decreased blood loss, faster recuperation, and improved range of motion. (53, 54).[24] [25] Furthermore, the process of revising UKA to total knee replacement is quite straightforward as compared to revising a TKA. [26]

Research has observed that 90% of patients under 60 years old achieved satisfactory or excellent outcomes in terms of pain and function, with an average follow-up period ranging from 2 to 6 years. [27]For individuals with knee arthritis in all compartments, TKA is the last resort.

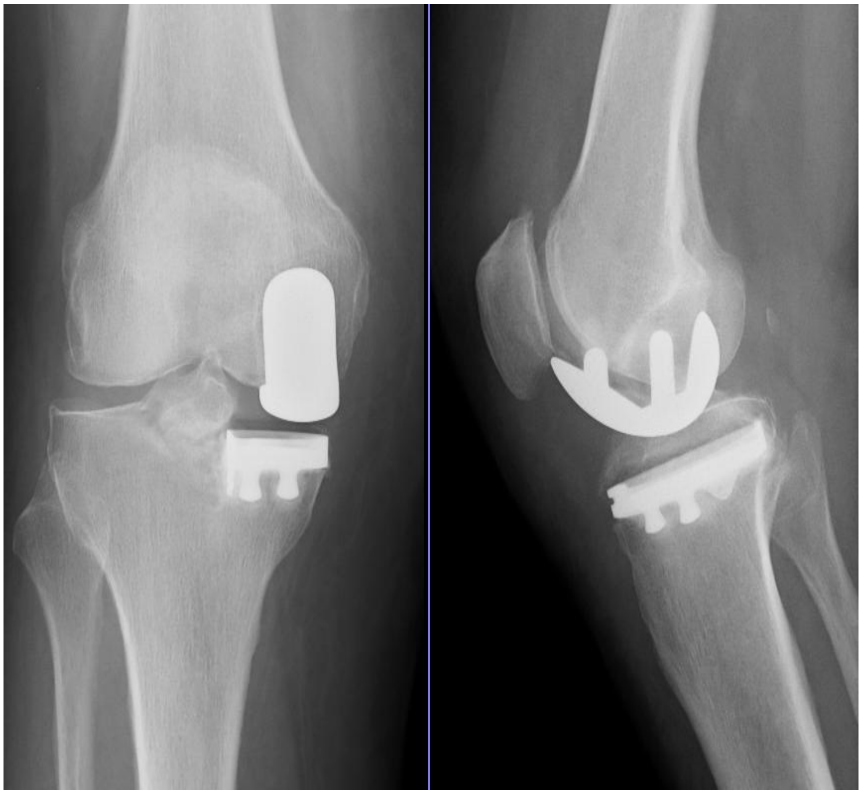
With improvements in implant design, including enhanced polyethylene wear characteristics and careful patient selection, a success rate of 96% at the 10-year has been reached. [28, 29]The optimal timing for knee replacement surgery is a subject of ongoing debate.

Intervening at the early stages of radiological osteoarthritis in symptomatic patients may result in positive outcomes.[30] The incidence of complications after primary TKR is 5% in individuals. The infection rate is approximately 1.5%, whereas the occurrence of symptomatic deep vein thrombosis or pulmonary embolism ranges from 1% to 3%. [31]

According to the Swedish arthroplasty register, one of the primary characteristics that increases the likelihood of early revision is young patients. [32] Therefore, orthopedic surgenos will not recommend immediate surgery for younger paitnets. However, recent studies have shown better outcomes in younger individuals. A study on a group of patients who were under the age of 55 when they had TKR. They found that all knees achieved a high score on the knee society score, indicating good outcomes. [33]

Figure 3: anteroposterior and lateral X-Ray of the right knee after TKA (Moser, Hirschmann 2021)

Figure 4: medial unicompartmental knee prosthesis after UKA (ICD-9-CM Volume 3)



6. Types of Unicompartmental Implants

6.1 Fixed Bearing Implants

A unicompartmental fixed bearing knee implant comprises two primary compartments: the femoral compartment and the tibial compartment. The femoral compartment is made of metal alloys such as cobalt-chromium or titanium, which are characterized by their strength as well as biocompatibility. The tibial compartment comprises a metallic tray and a fixed polyethylene inlay. The polyethylene insert is attached strongly to the metal tray and remains static in relation to the tibial part.

The fixed knee implant functions by substituting the pathologic bone and cartilage in the specific compartment of the knee that is damaged, with metal and plastic components that imitate the function of the original knee joint. The femoral component is specifically designed to match the anatomical structure of the femur, and the tibial component is specifically created to align with the structure of the tibia. The fixed polyethylene implant stabilizes the joint while permitting normal knee movement by providing the femoral component with a smooth bearing surface to glide over.

Patients with osteoarthritis or other degenerative joint disorders that affect only one compartment of the knee are usually good candidates for unicompartmental fixed knee implants. Optimal candidates include individuals who possess a satisfactory degree of mobility, undamaged ACL, and a stable knee joint. Patients with a reduced amount of daily physical activity and who do not participate in activities that are high impact are additionally considered suitable candidates, as these implants are well-matched for less physically demanding situations. [34, 35]

Fixed knee implants provide numerous benefits. One of the main benefits is the stability of the implant, which is a result of the fixed nature of the polyethylene insert. This design decreases the likelihood of dislocation, a problem that is more prevalent in mobile-bearing designs. [36] The use of a fixed bearing design in the surgical technique has been shown to decrease in operating time and a lower risk of surgical complications. [37]

Fixed bearing implants have demonstrated good prognosis- favorable long-term survival rates in terms of endurance. Research indicates that these implants can achieve similar levels of durability as mobile-bearing versions. Research demonstrated that fixed bearing implants exhibit reliable long-term results, mostly due to their lower number of movable components, thereby minimizing the risk of failures caused by wear. [38]

Although fixed knee implants offer advantages, they also possess certain disadvantages. An important issue to consider is the possibility of concentrated polyethylene wear. Due to the immobility of the insert, the polyethylene in that region experiences most of the mechanical stress during motion, resulting in gradual wear and tear over a period of time. The study highlighted that wearing and subsequent osteolysis may require additional surgery. [39]

A further disadvantage is the modestly decreased range of motion in comparison to mobile-bearing implants. The fixed design may limit the natural range of motion of the knee, which may be a factor to consider for people who are more physically active. Although fixed bearing designs offer stability, they may not allow for the same level of rotational mobility as mobile-bearing implants, which could affect the functional outcome for certain patients. [40]

When selecting a fixed knee implant for unicompartmental knee implant, certain criteria need to be considered. The patient's level of activity is of is one of the most importance; fixed implants are typically advised for patients who are less physically active and have a more sedentary lifestyle, who exert less stress on their knee joints. This particular group of patients experiences advantages from the stability and simplicity of the fixed design. [41]

Anatomical factors are also essential. Individuals who possess healthy structure of bones, and have knee anatomy that is appropriate are considered optimal candidates for fixed bearing systems. The intact knee ligaments play a crucial role in ensuring the success of these implants by providing natural stability. The surgeon's proficiency and extensive experience with fixed bearing implants can greatly impact the selection and result of the surgery. Surgeons with extensive experience generally get superior outcomes as a result of their knowledge of the operation and implant design. [42]

6.2 Mobile Bearing Implants

The unicompartmental Mobile Bearing implant has 3 components- the femoral component, the tibial tray, and a mobile polyethylene bearing. The femoral component is often made from cobalt chromium alloy or titanium elements, these materials are known to have excellent strength and biocompatibility. The tibial tray, usually composed of similar metal elements, serves as the basis I which the polyethylene bearing is placed.

The main feature of the mobile-bearing implant is the polyethylene insert, this part is not fixed to the tibial tray but has the ability to move and rotate to some degree. This movable feature enables a natural ROM in the knee joint, which enables translational and rotational movements. The main goal of the moveable bearing implant is to decrease the stress on the polyethylene insert and decrease stress between the implant and bone by enabling a load distribution that is similar as possible to the natural knee physiology.

The candidates for unicompartmental mobile knee implants include patients with OA that is limited to only one out of three compartments of the knee. Mobile implants enable active lifestyle and enable better ROM compared to other implants. Optimal candidates should have good bone density, intact ligaments system especially the ACL and PCL.

The mobile-bearing implant is particularly advantageous for younger and more physically active patients because it enables greater ROM and more natural movement of the knee. Furthermore, those who require a significant level of knee functionality in their everyday tasks may achieve more favorable results with mobile-bearing implants. [36]

Mobile knee implants offer a significant pro, it enables more natural movement and in ROM. The mobile-bearing design enables rotational motion, closely mimicking the natural movement of the knee joint. This mobile design minimizes the likelihood of incorrect knee movements and can result in better functional outcomes. [41]

Another notable benefit is the decreased deterioration of the polyethylene implant. By permitting the bearing to move and rotate, the load is distributed more uniformly, potentially reducing the damage and deterioration on the implant. Research has demonstrated that the use of mobile-bearing implants can result in reduced rates of polyethylene wear, which has the potential to prolong the lifespan of the implant.

Mobile-bearing implants can decrease the amount of stress experienced at the interface between the implant and the bone. The polyethylene insert's capacity to undergo movement allows for the dissipation of forces produced during motion, which may potentially decrease the likelihood of bone resorption and implant loosening. [43, 37]

Although movable knee implants offer certain benefits, they also possess certain limitations. A major problem is the possibility of dislocation of the implant. Because there is less fixation of the polyethylene insert, there is possibility of displacement from its location, which can result in implant instability and repeated surgery. This complication is rare, but still a serious problem that can occur with mobile-bearing implants. [36]

An additional disadvantage is the complexity of the surgical technique. A very high accuracy is needed to alignment and balancing when implanting a mobile-bearing knee prosthesis to enable proper movement of the bearing without excessive stress. The intricacy of the procedure can result in extended surgical time and a more challenging learning process for orthopedic surgeons. [44]

Mobile-bearing implants is not suitable for every patient require UKA. Individuals with unstable knee ligaments or those who do not need a wide ROM may not find the mobile-bearing design beneficial and may get more favorable outcomes with fixed-bearing implants.

When selecting a movable knee implant for unicompartmental knee replacement, it is important to consider several factors. First, the physical activity level of the patient is a prominent factor. Patients who are more physically active and participate in sports intense physical activities may gain benefits from the wide ROM and more natural movement that the mobile-bearing implants provide. In contrast, patients who are less physically active may not be given all its benefits and may be more prone to complications such as implant dislocation.

Another factor to take into account is anatomical compatibility. Mobile-bearing implants are most appropriate for patients with stable ligaments and good bone density. This is important because the stable ligaments, especially the ACL and PCL, provide the necessary stability for the effective functioning of the Mobile bearing. The surgeon's experience and knowledge in using mobile-bearing implants can have a significant impact on the implant selection and success of the surgery. Surgeons with extensive experience and knowledge of the intricacies of mobile-bearing designs are more capable of managing the intricacies and ensuring ideal alignment and balance. [45]

6.3. Single Radius and Dual Radius Implants

Having a comprehensive understanding of the design principles of femoral components is essential in the field of knee replacement surgery to ensure the selection of the most suitable implant for each patient. The terms "single radius" and "dual radius" pertain to the geometric structure of the femoral component, which has a major effect on the biomechanics, stability, and general functionality of the knee after surgery. These designs have a direct correlation with both fixed and mobile-bearing implants and can have an influence on the results of unicompartmental knee replacement.

The design of a single radius knee implant ensures that the curvature of the femoral component remains constant throughout the whole range of motion. This implies that the point around which rotation occurs remains consistent, resulting in a singular curved path as the knee flexes and extends. The purpose of this design is to imitate the natural movement of the knee, ensuring consistent and predictable patterns of motion.

The design with a single radius has multiple benefits. By ensuring a consistent axis of rotation, the distribution of weight on the polyethylene insert becomes more evenly spread, which may lead to a decrease in wear and tear. The uniform distribution of load is especially advantageous in fixed-bearing implants, where the insert remains stationary in relation to the tibial tray. The use of a singular radius design improves the perception of stability during motion, a critical factor for patients in rehabilitation and individuals with less physically active lifestyles. Moreover, the simplified mechanics of a singular radius configuration enable the establishment of uniform ligament tension over the whole range of movement, hence enhancing overall knee functionality and patient comfort. Single radius designs enhance the biomechanical function of the knee by offering more authentic kinematics and stability in comparison to designs with dual radii. The constancy is particularly valuable in fixed-bearing implants, where stability and simplicity are of utmost importance. [45]

On the other hand, a dual radius knee implant is characterised by a femoral component that has two clearly different curvatures. Usually, there is one radius that controls the movement in the beginning stage of knee flexion, and then a different radius becomes dominant as the knee flexes more. This design is meant to closely imitate the intricate and natural movement of the knee, providing an optimal combination of stability and an expanded range of motion.

The dual radius design offers numerous advantages, especially for highly active individuals or those needing a greater range of knee flexion. The presence of a dual radius facilitates an easy shift from extension to deep flexion, hence improving the extent of movement and potentially offering a more accurate sensation of knee motion. The presence of two radii in the implant allows for a more accurate imitation of the knee's natural movement, resulting in enhanced functional results for patients who require increased knee flexibility for demanding tasks. The ability to customize motion is especially beneficial in mobile-bearing implants, since it allows for the full utilization of increased movement possibilities.

Dual radius implants provide enhanced deep flexion capabilities and more accurate reproduction of natural knee movements when compared to single radius versions. This increased movement can be crucial for individuals who engage in high levels of physical activity, as it gives them the essential range of motion to perform various physical activities. [46]

The principles of single and dual radius designs are crucial for the performance of both fixed and mobile-bearing implants. Regarding fixed implants, these designs have an impact on stability, wear properties, and overall patient results.

Fixed-bearing implants are highly compatible with single radius designs because of their inherent stability and predictability. The uniform curvature and even distribution of load minimise the likelihood of excessive wear on the immovable polyethylene insert, potentially enhancing the durability of the implant. Patients with lower activity levels can benefit from the stability provided by a single radius fixed implant, which can result in better functional outcomes and a decreased likelihood of complications.

Although dual radius designs can also be utilised in fixed-bearing implants, their benefits may be less prominent in comparison to mobile-bearing designs. The presence of two radii can enhance the range of motion and improve the natural kinematics, potentially providing advantages to patients requiring increased flexibility and mobility. Nevertheless, the elevated complexity of the dual radius design may pose difficulties in providing uniform wear and sustaining long-term stability in a fixed-bearing implant.

When deciding between single radius and dual radius implants for unicompartmental knee replacement, it is important to consider many clinical considerations. The patient's level of activity is an essential factor to take into account. Patients with lower activity levels may experience greater advantages from the stability and simplicity provided by single radius designs, particularly in the context of fixed-bearing implants. Those patients generally exert less stress on their knee joints and can benefit from the reliable stability offered by a single radius design. [47]

Anatomical and kinematic requirements also have a major influence. Individuals with particular anatomical factors or those in need of increased flexibility may find the dual radius design advantageous, as it more accurately replicates the natural motion of the knee. The dual radius design is capable of improving flexion and mimicking natural movement, making it ideal for highly active patients who require a wider range of knee function for both everyday tasks and sports.

The surgeon's proficiency and understanding of the intricacies of single and dual radius designs are essential for maximizing patient outcomes. Surgeons with expertise in this field, who possess knowledge about the mechanical and kinematic distinctions among various designs, are able to select the most suitable implant for each patient, thereby guaranteeing the best balance, alignment, and function.

6.4. All polyethylene tibial components

The all-polyethylene tibial component is a prosthetic implant which designed for replacing the tibial plateau in the affected compartment in unicompartmental knee arthoplasty. The all-polyethylene component is composed only from ultra-high-molecular-weight polyethylene (UHMWPE), in contrast to metal-backed tibial components which have a metal baseplate with a polyethylene insert. This material is chosen based on its durability, biocompatibility, and robustness.

The tibial component made entirely of polyethylene serves the purpose of offering a smooth and low-resistance surface that interacts with the femoral component of the knee implant. This joint's function is essential for regaining the knee's natural movement and enabling painless mobility. The design of the implant commonly incorporates elements such as a central keel or pegs, which improve fixation to the bone, guaranteeing stability and minimizing the likelihood of loosening in the future.

Unicompartmental all-polyethylene tibial components are suitable for individuals who have osteoarthritis confined to only one compartment of the knee, either the medial or lateral compartment. Optimal candidates should possess excellent bone density and fully intact ACL, in order to guarantee stability of the knee. Patients with advanced age, decreased physical activity, and lower body mass index are more suitable candidates for this implant as they exert less stress on the joint, as well as patient who have other medical issues that make more comprehensive surgery not recommended may also find the less invasive UKR with all-polyethylene components beneficial. [47]

A benefit of all-polyethylene tibial components is their easy to use and simplicity. The lack of a metal baseplate decreases the implant's total profile, which can be advantageous for preserving bone. Preserving bone stock is crucial in younger patients who may need future revision surgery, as it ensures that there is an adequate amount of bone accessible for later treatments.

Another notable benefit is the cost-effectiveness. All-polyethylene tibial components are typically more affordable than metal-backed components, making them a cost-effective choice for healthcare systems and patients. The reduction in cost does not compromise performance; multiple tests have demonstrated comparable or even greater results with all-polyethylene components. The revision rates of all-polyethylene tibial components in UKR were lower, and their functional outcomes were similar to those of metal-backed components. [48]

The biocompatibility and wear properties of UHMWPE also play a role in the long-term effectiveness of these implants. The material's durability decreases the likelihood of polyethylene debris-induced osteolysis, which is frequently cause in implant malfunction. Moreover, the lack of metal decreases the likelihood of metal ion release, which can cause to local and systemic reaction.

Although all-polyethylene tibial components offer certain benefits, they also come with disadvantages. there is a possibility of greater wear and tear in comparison to components with metal backed, especially in patients who are more physically active. Without a metal backing, there is a possibility of more stress being directly apply to the polyethylene, which might cause faster wear and necessitate additional surgery.

The fixing of all-polyethylene components might also be a source of contention. Although newer designs have enhanced the stability and fixation of these implants, they may still be less reliable than metal-backed components, particularly in patients with decreased bone quality. Under such circumstances, there is a potential for component loosening, which may undermine the durability and performance of the implant.

When selecting an all-polyethylene tibial component for unicompartmental knee replacement, certain clinical criteria need to be considered. The level of physical activity of the patient is a critical factor. Patients who are less physically active, especially senior adults, are considered to be great candidates for the use of all-polyethylene components. This is because their lower level of physical activity puts less strain on their joints, which is compatible with the durability of all-polyethylene components. These patients are unlikely to participate in high-impact activities that could speed up wear and result in early implant failure.

The quality of bones is another important factor to take into account. Patients who have a sufficient quality of bone tissue are more likely to achieve effective fixation with all-polyethylene components. On the other hand, individuals with low bone density may have a greater chance of experiencing implant loosening and could potentially benefit from the additional reinforcement provided by a metal-backed component.

The proficiency and experience of the surgeon with all-polyethylene implants also have a substantial impact. These factors are crucial for the implant's long-term effectiveness. [49]

6.5. Metal-Backed Tibial Components

The metal-backed tibial component in unicompartmental knee replacement consists of two primary components, the metal baseplate and a polyethylene insert. The metal baseplate is commonly constructed from durable substances such as cobalt-chromium alloy or titanium, renowned for their robustness and resistance to destruction caused by chemical reactions. The purpose of this implant is to offer a secure and steady foundation for the polyethylene insert, which is composed of ultra-high-molecular-weight polyethylene (UHMWPE). These characteristics aid in the uniform distribution of the load on the tibial bone, hence decreasing the amount of stress that can cause bone resorption and loosening of the implant. The polyethylene insert is firmly attached to the metal baseplate, creating a smooth and frictionless surface that moves along with the femoral component of the knee implant. The objective of this combination of materials and design is to reinstate typical knee movements and enable movement without experiencing pain. Unicompartmental metal-backed tibial components are usually recommended for patients who have osteoarthritis limited to only one region of the knee. Young and active patients with strong functional demands on their knee joints may benefit from durability and stability by using metal-backed components. Tibial components with a metal backing offer benefits to patients who are highly activate and practice high impact activities or who need higher levels of knee stability. These patients frequently experience advantages from the strong assistance and decreased chance of polyethylene deterioration associated with metal-backed designs. [49]

Metal-backed tibial components offer significant benefits in terms of their robustness and extended lifespan. The metal baseplate ensures a stable and durable support for the polyethylene insert, minimizing the likelihood of deformation and deterioration. This is especially crucial for physically active people. The metal baseplate's strong and sturdy design aids in the uniform distribution of loads, which may decrease the likelihood of implant failure and the necessity for additional surgery.

Another notable benefit is the improved stability offered by the metal baseplate. The use of design elements such as keels and pegs enhance both the initial stability and long-term fixation of the implant, especially in patients with dense bone. This enhanced stabilization can result in better clinical outcomes and a reduced probability of implant loosening. Research supports this claim, showing that patients with metal-backed tibial components have reduced rates of revision and improved functionality compared to those with all-polyethylene devices. [50]

The metal-backed tibial components modular design provides flexibility in addressing the individual anatomical and biomechanical needs of each patient. Surgeons have the option to select various sizes and arrangements of polyethylene inserts that correspond to the patient's anatomy, thereby improving the overall fit and functionality of the implant. [51]

Although metal-backed tibial components offer benefits, they also possess certain limitations. An important disadventage to consider is the possibility of increased bone loss during the process of revising the surgery. Having a metal baseplate can complicate revision surgeries, typically necessitating the removal of more bone tissue to accommodate a new implant. This might be a significant challenge in younger individuals who may need to undergo many revisions during their lifespan.

Another drawback is the potential for the release of metal ions. While infrequent, the metal components have the potential to experience wear and corrosion, resulting in the release of metal ions into the nearby tissues and bloodstream. These consequences can occur at the local and systemic levels and include metallosis, hypersensitivity responses, and systemic toxicity. Continuous screening of patients with metal-backed implants is necessary to promptly identify and address any unfavorable reactions.

The increased expense of metal-backed components in comparison to all-polyethylene designs may be a factor to consider, especially in healthcare systems with limited resources. Nevertheless, the expense can be justified by the possibility of enhanced longevity and decreased necessity for subsequent surgical procedures. [51]

When selecting a metal-backed tibial component for unicompartmental knee replacement, certain clinical factors need to be considered. The patient's degree of activity is a critical factor. Active individuals, especially those involved in sports or physically demanding jobs, may experience improved durability and stability with the use of metal-backed components. These individuals are more prone to exerting greater functional load on their knee joints, which can be effectively supported by the strong and durable metal baseplate.

Additionally, the quality and structure of bones are crucial factors to take into account. Patients who have strong bone structure and stable knee ligaments are more likely to have effective attachment and achieve favorable long-term results with metal-backed components. [52]

7. Prognosis and Rehabilitation of Unicompartmental Knee Arthroplasty

The prognosis of UKA is positive, this treatment often leads to significant pain reduction and improved knee functionality in many patients. Many factors can influence effectiveness of the UKA over a long time, such as the careful selection of candidates, the expertise of the surgeon, and appropriate rehabilitation.

Research has chosen the optimal candidates for the surgeries will show greater outcomes. Optimal candidates are those who exhibit osteoarthritis confined to a single compartment of the knee, patients with intact ligaments, including the ACL, and acceptable bone quality. The operation may be advantageous for younger and more physically active patients, as long as their knee condition meets certain specific parameters.

The careful selection of patients has a major impact on the longevity of the implant. Research of patients who underwent UKA found that those with suitable criteria for the treatment achieved a 10-year survival rate of over 90%. The significance of a comprehensive preoperative assessment in determining the appropriateness of UKA for each patient is shown by the high percentage of success seen. [52]

The surgical method is crucial in determining the prognosis of UKA. Accurate placement and alignment of implants are essential for ensuring the procedure's long-term effectiveness. Malalignment can result in uneven degradation of the implant, destruction, and eventually, malfunction. The accuracy of implant placement has been enhanced by advancements in surgical procedures, such as the utilization of computer-assisted navigation and robotic-assisted surgery. The use of robotic-assisted UKA led to superior alignment and a reduced number of early complications when compared to traditional procedures. This ultimately contributed to enhanced outcomes. [53]

Postoperative care and rehabilitation are crucial for maximizing the prognosis of UKA. Early mobilization and planned rehab programs have the potential to optimize healing and promote long-term knee function. Patients who complied with a thorough rehabilitation program achieved superior functional outcomes and reported higher rates of satisfaction. [54]

Rehabilitation is an essential element of the recovery process following UKA. An effectively organized rehabilitation program seeks to restore knee functionality, enhance muscular strength, and facilitate a seamless reintegration into normal activities. The process of rehabilitation can be categorized into multiple phases, each with distinct objectives and interventions.

The primary objective of the immediate postoperative phase is to effectively control pain, minimize edema and begin early mobilization. Patients are often advised to initiate weight-bearing exercises promptly, and frequently on the day of the surgery. Continuous passive motion machines and cryotherapy are effective in pain and edema management. Prompt mobilization is essential in order to prevent problems such as deep vein thrombosis and facilitate the healing process.

In the initial stage of rehabilitation, the main objectives are to regain the full range of motion in the knee and initiate exercises to enhance strength. Physical therapy often begins within a few days following surgery, with an emphasis on modest ROM exercises, strengthening the quadriceps muscles, and training in gait patterns. Starting physical therapy at an early stage can have a substantial positive impact on knee function and lead to a decrease in the duration of hospitalization. [55]

The primary objective of the intermediate rehabilitation phase is to escalate the intensity of workouts in order to enhance both muscle strength and endurance. The postoperative phase usually begins 2-4 weeks after the surgery and involves performing activities including leg presses, step-ups, and balance training. Utilising resistance bands and weights can effectively increase muscular strength, which is essential in strengthening the knee joint and enhancing overall functionality. Patients who participated in progressive resistance training exhibited superior results in terms of knee strength and function when compared to individuals who adhered to a conventional rehabilitation plan. [56]

The late stage of rehabilitation, which typically begins 6-8 weeks after the surgery, emphasizes intensive strengthening of muscles, functional training, and achieving the same level of physical activity as before the operation. Patients are advised to participate in exercises that imitate their everyday motions, such as climbing stairs, performing squats, and engaging in low-impact sports. The objective is to guarantee that the patient can execute routine tasks without experiencing discomfort or restrictions. Patients who engaged in a well-organized late-phase rehabilitation program experienced greater satisfaction ratings and achieved superior long-term functional outcomes. [57]

Long term rehabilitation and aftercare include ongoing activities to sustain knee functionality and minimise future complications. Patients are recommended to participate in consistent low-impact exercises, such as walking, swimming, and cycling, to preserve joint health and general physical fitness. Regular and extended monitoring by healthcare professionals is crucial to assess the state of the implant and quickly deal with any arising problems .

8. Conclusion

This thesis investigated the complexities of UKA, emphasizing its significance as a potential therapy choice for patients with knee osteoarthritis in single a compartment.
I initiated my thesis by analysis the knee anatomy and the indications that require UKA.

Knee osteoarthritis continues to be a major medical problem, often requiring surgery when non-surgical treatments are ineffective. UKA provides a less intrusive option for total knee replacement, conserving a greater portion of the patient's natural knee structures. This can lead to shorter recovery periods and a more natural knee function post operation.

The primary objective of this thesis was to compare various types of unicompartmental knee implants, specifically examining fixed bearing implants, mobile bearing implants, all-polyethylene tibial components, metal-backed tibial components, as well as single radius and dual radii implants, and comparing their features. Fixed bearing implants, noted for their stability and relatively simple installation, yield dependable results but might occasionally be linked to elevated rates of wear. On the other hand, mobile bearing implants provide better alignment and could reduce friction, but they necessitate more accurate surgical procedure and may pose a danger of bearing dislocation.
All polyethylene tibial components are known for their simplicity and cost-effectiveness, providing good clinical results, especially in older patients with lower levels of physical activity. Tibial components with a metal backing have the potential to be more long-lasting and suitable for younger, more physically active patients. However, they also come with their own difficulties, such as increased expense and the possibility of issues associated to the metal.

The prognosis and rehabilitation outcomes after undergoing UKA are often favorable, with a great number of patients reporting notable reduction of pain and increase in knee functionality. Rehabilitation plays a vital role in the success of the treatment, focusing on early mobilization and strength training to achieve the best possible results.
UKA is a notable progression in the surgical management of knee osteoarthritis. The selection of the implant should be customized to suit the unique requirements of each patient, considering

parameters such as age, amount of physical activity, and special anatomical varients. Further research and advancements in the materials and design of implants, as well as improvements in surgical procedures, are expected to increase the long-term effectiveness of UKA.

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11. Biography

Yotam Chen is soon to be a medical doctor who is studying in the sixth and finalyear in the international medical program in the faculty of medicine, University of Zagreb, Croatia.

Yotam was born in 07/08/1995, in Kfar Saba, Israel. During high school, his majors were Biology and Geography. After completing his 3-year obligatory military service in the Israeli defense force (IDF) as a combat-medic in the special forces, he traveled around the world, and at that point in time he decided to become a medical doctor.

After living for six years in Croatia and passing all his exams, he is ready to begin a new chapter in his medical future.