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Illustration of Implants in Total Knee Replacement

Nithyakala P[1], Naramdha S[2], Neelufer Naz D[3], Niveda S[4], Parwin Banu M[5], Priyadharshini A[6]

Abstract:- Knee replacement surgery replaces the injured or worn-out knee joints. The surgery can help ease pain and make the knee work better. One of the most familiarized surgical practices for patients with severe knee arthritis is total knee replacement (TKR), which is also known as Total knee arthroplasty (TKA). The primary difference is whether the implant replaces the entire joint or only a part of it. Both types of implants have merits and demerits on the current clinical practice. The most specific illustration of the implants varies from person to person which highly relies on their individualized diseased and patient's health condition which also accommodate with their comorbidities which may reject the implants or may also results to metallic sepsis condition. Hence these numerous implants distinguished with their own features, stability (for a period of time) and economy. Physicians selects the implants from the above criteria along with the concern form from the patient. This review article aims to demonstrate the illustration of implants in Osteoarthritis Patients.

I. INTRODUCTION

Knee replacement surgery replaces parts of injured or worn-out knee joints. The surgery can help ease pain and make the knee work better. During the surgery, damaged bone and cartilage are replaced with parts made of metal and plastic. To decide whether a knee replacement is for a specific person, a surgeon checks the knee's range of motion, stability, strength, X-ray helps show the extent of damage[1].One of the most popular surgical procedures for patients with severe knee arthritis is total knee replacement (TKR), also known as Total knee arthroplasty (TKA). Annual primary TKA volume increased by 16% between 1991 and 2010, from 93,230 to 24,3802, and by 109%, from 96,502 to 19,871.Although they are already more than 150 brand-name implants and custom prostheses available, they can be categorized into 3 groups: Connected prostheses, resurfacing implants, and conforming implants.Also it is one of the most economical and consistently successful orthopedic procedures is Totalknee arthroplasty(TKA). It offers dependable results for people with advanced degenerative knee osteoarthritis.[2] It can specifically reduce pain, restore function, and improve quality of life. This activity discusses Total knee arthroplasty indications, risks and methods while highlighting the importance of the interprofessional team in the treatment of patients undergoing this procedures.[3]

II. TYPES OF IMPLANTS

There are various different knee prostheses are exist. The primary difference is whether the implants replaces the entire joint or only a part of it. Both typesof implants have merits and demerits. The most suitable type will depend on numerous factors. There are a few different kinds of knee implants which are used in the TKR procedure. The different types of implants are categorized by the materials that rub against each other when we flex our knee. Those implants are listed below:

- Metal on plastic
- Ceramic on Plastic
- Ceramic on Ceramic
- Metal on metal

And other such metals involved are Cobalt-chromium or metal alloys/ strong plastic parts/cement fixation/plastic spacer.[4]

Fig. 1: METAL COATED IMPLANT[5]

Fig. 2: CERAMIC COATED IMPLANT[6]

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III. ANATOMY AND PHYSIOLOGY

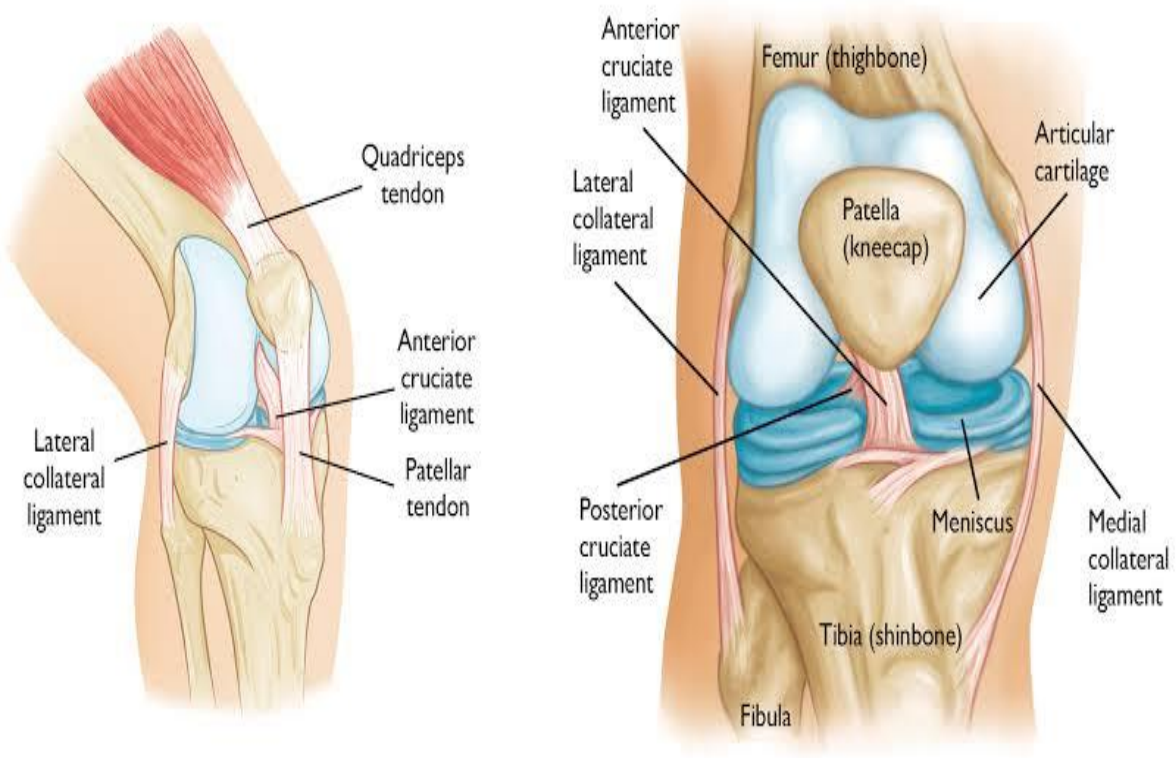

Fig. 3: ANATOMY OF KNEE[7]

In the knee, the bones of the lower and upper legs converge. You can sit, squat, walk, or jump thanks to the knee, which is thelargest joint in the body and moves like a hinge.The three following bones make up the knee .The femur, or thigh bone, which is the upper leg bone.The lower leg's front bone, sometimes known as the shin bone, is the tibia.The patella, also known as the kneecap, is a thick, triangular bone that rests on top of the other bones at the front of the knee.

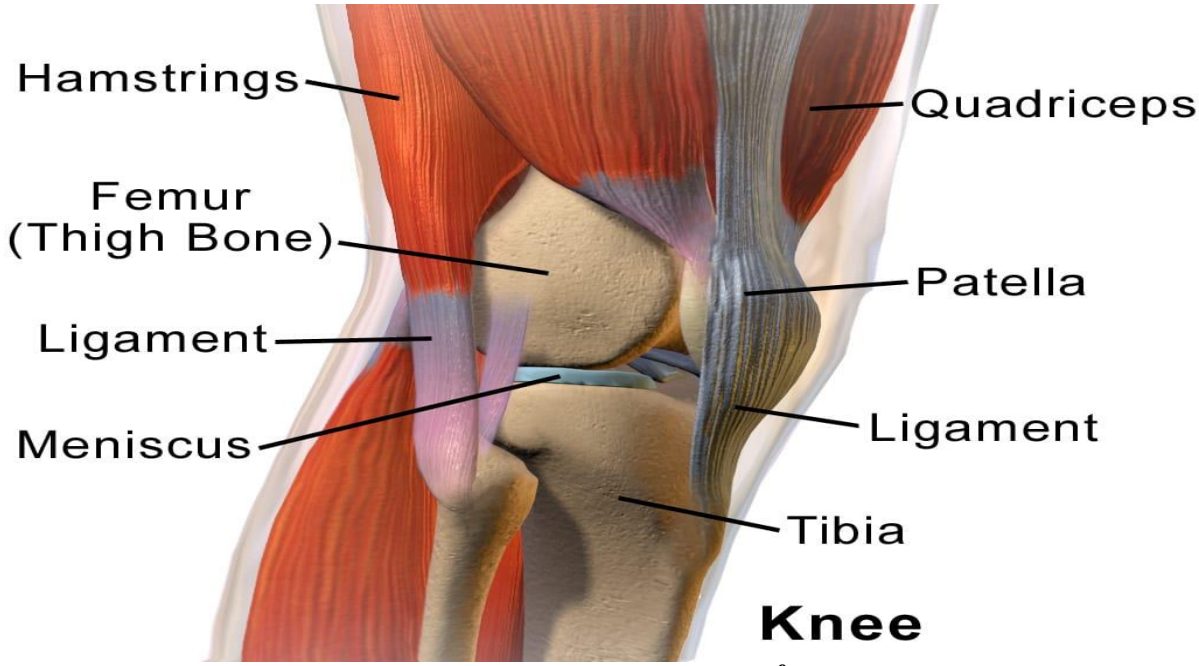

Fig. 4: PHYSIOLOGY OF KNEE[8]

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A coating of cartilage, a smooth, elastic substance that absorbs shock and enables the bones to move easily against one another, covers the ends of the bones.Two crescent-shaped cartilage pads that minimise friction and distribute the body's weight across the joint are located between the tibia and the femur bone. The lateral meniscus, which is found on the outside of the knee.The medial meniscus, which is found on the inside of the knee.The following tendons and ligaments hold the outer layer of the capsule to the ends of the bones.These medial collateral ligament (MCL), which provides support to the inside region of the knee, and the quadriceps tendon, which connects the quadriceps to the patella.Anterior cruciate ligament (ACL), which is located in the centre of the knee and prevents excessive forward movement of the tibia, lateral collateral ligament (LCL), which stabilises the outer part of theknee, and posterior cruciate ligament (PCL), which is also located in the center of the knee and prevents excessive backward shifting of the knee.The knee joints are the largest and most intricate. It supports weight both while the individual is moving and when they are standing still. It is quite difficult to comprehend the mechanisms that support the joint while standing and moving, both in health and sickness. As well as its disruption in the most prevalent illness, osteoarthritis, a few key principles and their significance for maintaining stability and movement are presented.The stability and mobility of the knee joint are impacted by a number of factors. Generally speaking, they can be classified into internal and external elements. Line and centre of gravity, size and number ofbaseof support, and body weight are the external joint parameters that control mobility and stability .[9]

IV. PROCEDURE FOR TOTAL KNEE REPLACEMENT

A knee replacement, commonly referred to as a knee arthroplasty or a total knee replacement, is a surgical operation to repair an arthritis-damaged knee. Together with the kneecap, the bones that make up the knee joint's ends are capped with metal and plastic components. For someone with severe arthritis or a serious knee injury, this surgery might be an option.The knee joint may be impacted by several types of arthritis.

Fig. 5: TKR [10]

Osteoarthritis, a degenerative joint condition that primarily affects middle-aged and older persons, can lead to the destruction of knee joint cartilage and surrounding bone. Rheumatoid arthritis, which results in increased synovial fluid and synovial membrane inflammation, can cause discomfort and stiffness. Traumatic arthritis, or arthritis brought on by an injury, can harm knee cartilage.The purpose of knee replacement surgery is to resurface the damaged areas of the knee joint and to cure persistent knee pain that is resistant to other forms of care.[11]

V. ROLE OF IMPLANTS

- Knee joint replacements are frequent and mostly successful surgeries that use implants to give patients with conditions like osteoarthritis back their mobility and reduce their discomfort.
- compared to bulk metal and ceramic alternatives, implant coatings may have better characteristics.
- In comparison to the metallic substrate, ceramic coatings have the potential to increase scratch resistance, improve wettability, and reduce wear of the articulating surfaces while maintaining the overall toughness of the implant, lowering the risk of catastrophic failure of the device.

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- Furthermore, coatings can function as barriers to prevent corrosion-related ion leakage from the underlying material.
- While most coatings fall into the latter category, a select few coated implants have been successfully commercialised and are now usable in the clinic for a limited number of applications.
- titanium nitride (TiN), titanium niobium nitride (TiNbN), oxidised zirconium (OxZr), and zirconium nitride (ZrN) based coatings are commercially available for implants, current research is also centred on coatings made of diamond-like carbon (DLC), silicon nitride (SiN), chromium nitride (CrN) (TaN and TaO)[12].
- The complete knee replacement implant design has a significant impact on postoperative functionality, hence it should be optimised.
- Comprehensive understanding of how the design influences knee kinematics and, in turn, the overall implant performance, is the key to an optimum implant design[13.]

VI. INDUSTRIAL COATINGS

For clinical purposes, there are now three different kinds of coated or surface-treated hip and knee joint implants commercially accessible, namely:

- Titanium nitride (TiN) and titanium niobium nitride (TiNbN) produced by a number of businesses, such as Implantcast, Cellumed, medical technology from OHST, Orthopaedics via link, Corin
- Aesculap (B Braun): zirconium nitride (ZrN)
- Smith and Nephew (OxZr) oxidised zirconium

Both a Ti6Al4V and a CoCrsubstrate are available for TiN coated implants, and the coated surface is typically partnered with PE in the articulating surfaces. These implants have been demonstrated in tests to be stable over time, and they are intended for young, active patients, particularly those with metal sensitivity.

The commercial availability of TiN, ZrN, and OxZr makes it practical to research patient outcomes. Long-term follow-up studies conducted since OxZr implants' introduction have revealed that they operate well, have low revision rates and are equivalent to uncoated CoCr implants. As evidenced by retrieved implants, the implant has performed better than CoCr, with reduced rates of corrosion and fretting wear. Consider all of these outcomes.Updated implants and coated implant follow-up research. One needs to be mindful that revision-retrieved samples are failures and may deviate from the cohort's performance as a whole.Nonetheless, it has been documented that retrieved implants in both TiN and OxZr cases had surface degradation, including an exposed substrate. The oxidised surface of the femoral heads in these trials displays damage and metallic transfer that was probably brought on by contact with the metallic shell after dislocations, despite the fact that they were paired with a PE liner. The authors came to the conclusion that individuals who are at risk for joint instability shouldn't utilise femoral heads made of oxinium.

VII. SUITABLE COATINGS FOR WEAR RESISTANCE

The potential for various coatings to lessen wear in joint implants is being researched. The published research will be analysed in the section that follows. It has been divided into six groups based on the composition of the coatings: diamond-like carbon, silicon nitride, chromium nitride, zirconium-based, titanium-based, and tantalum-based.(hardness, Young's modulus, and adhesion) in the supplemental information provide an overview of the parameters (surface roughness and wear properties). Young's modulus ranges from 100 to 466 GPa, whereas hardness varies from 8 to 44 GPa. The tribological parameters, such as wear rates, were determined using several setups, with variations in contact pressure and counter surface, resulting in significant inherent variation between samples and making it challenging to compare the results.[13]

VIII. DISCUSSION

In the market, coated implants are accessible. These implants have TiN, TiNbN, ZrN coatings, and Zr that has been surface treated and then oxidised.Researchers are looking into a number of potential coating materials, including those based on carbon, silicon nitride, chromium nitride, titanium, zirconium, tantalum, and alumina. Coated implants have similar survival rates to uncoated implants, but the foundation for comparison is restricted because revision rates are often low and follow-up periods are short.Surfaces like modular interfaces might benefit from coatings.

IX. CONCLUSION

The knee is a complicated joint with numerous internal articulating spaces. To support the movements of the knee joint, the ligaments and tendons that are connected to it cooperate in a certain manner. A review would assist us in comprehending the precise pathophysiological mechanism underlying the development of disorders affecting the knee joint, such as osteoarthritis. TKR implants varies on their features and cost depending on the metals used.Physicians select the implants accordingly to the patient economy level.In Further expanded on are the meniscal architecture, tests to identify osteoarthritis, and the function of a healthy gate in preventing degenerative joint illnesses. After the TKR procedure an interprofessional team is primarily needed to manage the other complications.Hence after implanting the metals continuous monitoring and follow-up is required.

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