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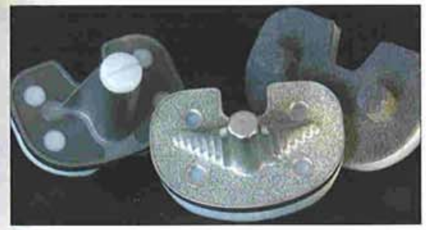


Tibial base plates made of titanium, cobalt-chrome and tantalum, respectively.

Technology in total knee replacement

The aim of total knee replacement (TKR) is to relieve significant and disabling pain caused by severe arthritis. Night pain and reduction in quality of life due to pain (with or without significant deformity), are important factors in patient selection. X-ray findings usually correlate closely with the clinical impression. All non-operative measures should have been exhausted before surgery is considered. These include weight loss, activity modification, analgesic and anti-inflammatory medications, bracing, walking stick and gentle exercise. Thanks to significant advances in technology and our understanding of knee mechanics over the last 30 years, refinements in TKR have made it the successful procedure we know today. With appropriate patient selection, the positive effect on the quality of life of the recipient is indisputable.

Evolving technology

Surgery has been used to deal with arthritis of the knee since the 1860s when Fergusson first performed a resection arthroplasty. Later, others tried interposition arthroplasty with a variety of materials.

TKR became a viable surgical option in the 1940s when mouldings were applied to the distal femur. Hinged prostheses were introduced in the 1950s but suffered from a high failure rate.

Since 1971, when Gunston recognized that the knee did not move like a hinge on a single axis but that the femoral condyles rolled and glided on the tibial plateau, there has been significant advancement in the understanding of knee mechanics. This led to changes in the design of TKR prostheses, which has prolonged their lifespan.

Nevertheless, TKR has limited longevity that is shortened by increasing activity levels.

The average life expectancy of a TKR is approximately 15 years. Failure modes include infection, periprosthetic fracture, and aseptic loosening. Aseptic loosening – the most frequent cause of failure – is usually due to wear of the polyethylene spacer. Polyethylene particles infiltrate the interface between bone and the prosthesis, set up an inflammatory response leading to bone resorption. Bone resorption results in loosening of the prosthesis, with further bone loss and pain.

Increased activity levels lead to increased numbers of wear particles occurring earlier than would otherwise be the case. Earlier loosening is the result. Whilst older patients are usually selected as TKR candidates, in part due to their reduced activity levels, younger patients with significant disability remain candidates. These younger patients are more likely to require a revision TKR because of increased rates of wear due to the increased activity of youth.

Stress shielding. Demonstrated here is clear loss of bone at the medial and lateral edges of the tibial plateau.

TKR materials

TKR prostheses are usually manufactured from cobalt chrome alloy for the femoral component, titanium for the tibial plateau, and highly cross-linked polyethylene for the bearing 'spacer'. The spacer is an integral part of the bearing with the femoral component articulating on it.

The latest development in tibial plateau fixation is tantalum mesh, also known as trabecular metal. Tantalum is an inert metal. This mesh is of an ideal porosity to allow the ingrowth of bone into the baseplate, securing it to the tibia and reducing the opportunity for wear particles to infiltrate and cause loosening.

The mechanical characteristics of the tantalum baseplate demonstrate a very similar modulus of elasticity to bone. The load of weight bearing is spread through it directly to the underlying bone as a result.

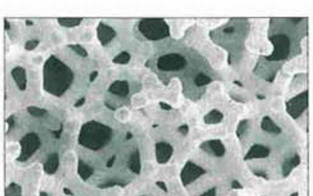
As bone reacts directly to the forces placed through it, if load is shielded, the underlying bone resorbs over time. With traditional baseplates, there is stress shielding of the underlying bone. This leads to loss of strength, a predisposition to fracture, and a faster rate of bone loss once aseptic loosening begins. Tantalum mesh thus has the potential to reduce the rate of development of aseptic loosening and therefore delay the development of failure.

Traditionally, bone cement – poly methyl methacrylate (PMMA) – has been used for the fixation of all three components of a TKR. In order to eliminate PMMA, various ingrowth surfaces have been developed and have found degrees of favour. Whilst PMMA is widely used, there are problems with the material including:

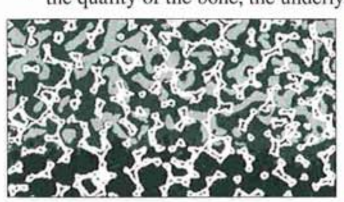
- Patient hypotension during its initial application
- Small particles of loose cement left in the joint may lead to an increased rate of wear of the spacer as these particles act as a grinding paste.
- Increased surgical time required by the use of cement results in longer tourniquet time and the increased morbidity of a longer anaesthetic.

There is an ongoing debate as to which of the fixation methods is best. Traditionalists prefer PMMA due to its known 'track record'. Others believe that there are such clear advantages of the of the new ingrowth surfaces that they should be used. As with most options, the specific recommendation for any particular patient must include consideration of the quality of the bone, the underlying diagnosis, patient age, and lifestyle.

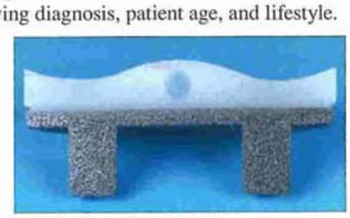
X-ray of a trabecula metal tibial base plate (note, no stress shielding).



Electron microscope view of tantalum mesh.



Light grey areas indicate bony ingrowth into the tantalum mesh, with intimate integration.



Cross section shows how the polyethylene spacer is moulded into the tantalum base plate.