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Revision Knee Replacement

Revision knee replacement refers to the procedure to repair or replace a failed first knee replacement. The surgical procedure to resurface a worn out, painful knee with prosthetic components (primary total knee replacement) is one of the most successful operations in providing pain relief and returning patients to a normal, productive life. Over the past 40 years, millions of patients in the U.S. have benefited from this procedure and as people live longer and younger patients require better function, the demand for knee replacements is growing astronomically. Current data estimate knee replacement surgery in this country is performed on ~800,000 patients each year with projected growth to ~3.5 million patients per year by 2030 according to one oft-quoted study [1] . Fortunately, experience over the past 30 years also tells us that of the knees put in 20 years ago, approximately 85 – 90% of them are still functional.

Nevertheless, as people live longer and more people receive knee replacements at younger ages, it is expected that an increasing number of those implants will wear out and / or fail for some reason. In these cases, a second operation will be necessary to replace or revise the failed first replacement and this procedure is referred to as revision knee replacement. The increasing demands placed on these implants by patients in terms of longevity and durability; and expectations of patients to maintain their active lifestyles even with a knee replacement has presented a considerable reconstructive challenge to the surgeon.

Why revision knee replacement is needed

The most common events leading to the need for revision knee replacement are infection, mechanical loosening and instability. It has been projected that by the year 2030, infection will account for 65% of all revisions being done [2] . Wearing away of the polyethylene bearing (plastic surface in the knee) is one of the more prominent causes leading to failure of the knee replacement through a complex biologic process that stimulates resorption of the bone supporting the metal parts of the knee implant which in turn become loose.

Current data estimate between 5% and 10% of primary knee replacements will require revision within 10 – 15 years due to these and other complicating events. Recent data indicate ~40,000 revision total knee surgeries are performed each year currently with

projections in 20 years to be at a rate of ~270,000 cases / year if current trends in surgery continue, which is a 625% increase in this procedure [1,2].

Symptoms of a failed knee replacement

In almost all cases the presenting symptom of failure of a knee implant is PAIN! This is especially true if the implant is coming loose or there is an infection around the implant. Associated symptoms include stiffness of the joint or a persistent limp caused by the failing joint.

Unfortunately, it is estimated that 10 – 15% of total knee replacements that function well and have no observable or discoverable problems still have persistent pain. In other cases, the knee feels like it wants to give out or has a general feeling of being unstable. Again, sometimes a prosthetic knee will have strange feelings or pain, even if it is mechanically working correctly.

Each of these symptoms should be evaluated by the surgeon to help determine if the knee replacement has something wrong with it or is functioning as expected. A variety of tests are available to the surgeon and often many of them are necessary to sort out the issues that have left the primary knee replacement dysfunctional. Many of the common causes for failed total knee which would lead to the need for a revision of part or all of the implant are discussed below.

Infection

In several studies which assess the causes of primary knee replacement failure, infection of the joint is the most common and devastating cause with 25% of all replacement knee revision surgeries being done for this reason [3]. If an artificial joint becomes infected, the pain is typically more constant than with a loose, but non-infected joint. Along with pain, symptoms include a stiffening of the joint, making movement quite difficult. Depending upon the infecting organism, the infection may have been present for a long time – sometimes years – before the symptoms become noticeable. Low-level, tolerable pain in a joint can be deceptive to patient and surgeon.

Infection in a prosthetic joint is a devastating complication as it regularly leads to the removal of all parts of the knee replacement so that the infection can be cleared. This is the first operation required to remove the infected implant and place an antibiotic-laden cement spacer into the space previously occupied by the metal implant. This spacer serves to keep the soft tissues stretched out to proper length and provides antibiotic which leaches out of the cement spacer directly to the infected area over time. In addition, 6 – 12 weeks of IV antibiotics are given, depending upon the infecting organism. Once this treatment is completed, it is commonly possible, through a second operation, to implant a new knee replacement into the sterilized knee area.

Although this complex series of surgical events frequently can salvage an infected knee replacement, there is still a high re-infection rate, with some estimates giving a disappointing 20% of knees revised for infection staying infected [4]. Persistent infection in a knee joint presents difficult decisions for the patient and the surgeon and each circumstance will require unique and individualized consideration.

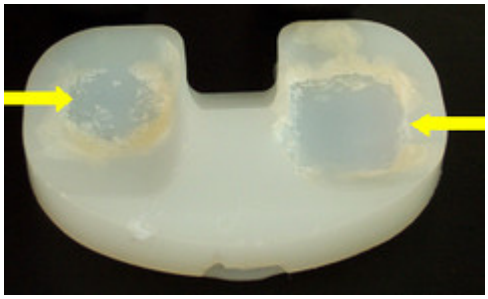
Mechanical loosening

In most total knee replacements there is a metal base plate attached to the tibia (shin bone) upon which is secured a plastic (polyethylene) bearing and a metal cap attached to the femur (thigh bone). Additionally, there is usually a plastic button that is secured to the under-surface of the kneecap (patella). Most surgeons choose to use a bone cement (methacrylate) to hold each of these components to the respective bone.

Although these components are typically very well fixed at the time of surgery, over time (usually many years) they may become loose from the supporting bone. When this happens the patient typically feels pain which can occur only with start up when the process is just beginning or with every step taken as the process worsens over time. Frequently X-ray pictures of the knee will give clues to this type of failure as separation of the metal from the bone becomes more evident.

Polyethylene wear

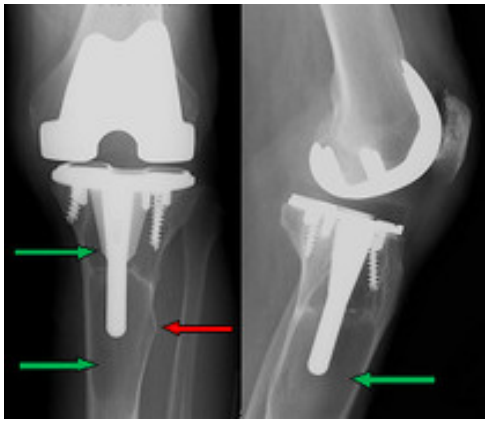
Severely worn polyethylene tibial bearing
Often the wear of the plastic bearing is associated with the loosening of the implant, but not in all circumstances. The cement that fixes implants to the bone can crack and the particles from the deteriorating cement mantle can initiate the destruction and resorption of the bone through a complex process known as osteolysis.



Severely worn polyethylene tibial bearing.

In any total knee replacement there is a highly polished femoral component that is designed to slide and rotate over a very dense piece of plastic (polyethylene) which is secured to the tibial metal base plate. When two surfaces are designed to move upon each other, there is friction between the two surfaces leading to wear. Over time the plastic starts to wear away, somewhat similar to how rubber wears off of a tire.

As the plastic is worn down, tiny particles are shed off to the periphery of the joint where a variety of normal and protective cells in the lining of the joint try to remove them. In this complex biologic process, the ingestion of the particles by these housecleaning cells causes the release of a variety of substances that actually lead to the resorption and weakening of the bone which supports the metal implants. This process is known as osteolysis and the holes left in the bone are referred to as lytic defects which can grow quite large in size and are susceptible to fracture and deformation.



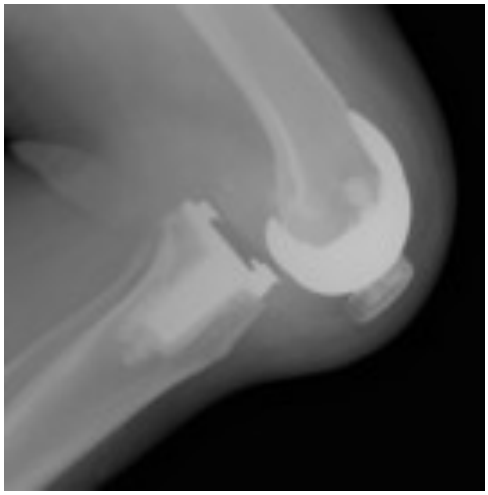
Extensive osteolysis of tibia, buckle fracture of cortex, and loose femoral & tibial prostheses.

When infection is not present (which must be proven) this type of loosening is referred to as aseptic loosening. Generally this process of resorption takes many years to occur and can be seen as newly found and expanding shadow lines on the X-rays that are used to follow the knee along at routine check-ups.

Once this process has reached a tipping point where the remaining bone is barely supporting the components, the mechanical stress applied by body weight and activity results in constant pain that increases with time. The loosening implants start to move slightly within the bone during weight bearing activity, which results in pain. Typically with aseptic loosening, the pain is not present or is greatly diminished when a patient is at rest and not putting stress across the weakened bone and loose prosthesis.

Instability

One of the most difficult aspects of properly implanting a total knee is achieving correct balance of the soft tissues around the knee. If prior to surgery the knee exam indicates severe malalignment and weak soft tissues, the surgeon has a real struggle on his hands to get the knee in balance. In addition, certain medical conditions such as inflammatory arthritis (i.e. rheumatoid arthritis) or diabetic neuropathy may add to poor tissue quality and poor wound healing, all of which contribute to the challenge of achieving a well-balanced knee replacement.



Total knee unstable due to ligament and soft tissue imbalances.

A knee replacement that is unstable frequently presents a feeling of unreliability at all times during walking or when changing directions. Alternatively, it can present as a sudden, almost catastrophic giving away of the knee during routine activities. The normal function of a knee replacement critically depends upon the ligaments and other soft tissues

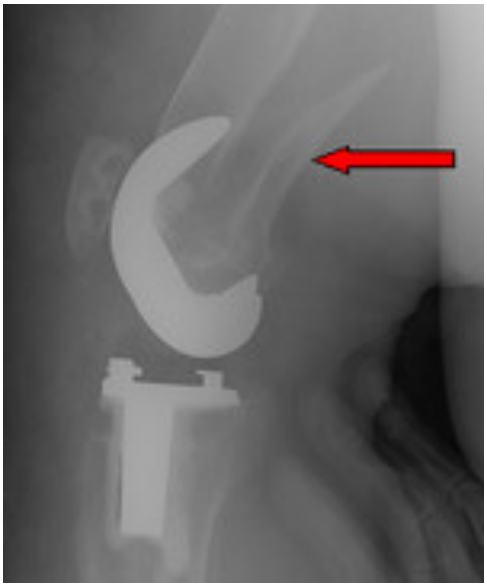
which support the knee to be working properly and in balance with each other. Patellofemoral problems are a common cause of instability and pain.

If the soft tissues were not balanced properly at the first operation or become imbalanced with time, the joint may wear out prematurely, leading to further imbalance and instability issues such as dislocation or subluxation of the joint.

In addition, correctly aligning and securing the metal implants on the bone is of great importance in achieving longevity and proper function of the implant. Malrotation and misalignment of the implants can leave the knee too tight, too loose, or just unstable. Not surprisingly, diagnosing the exact mechanism that gives a patient the feeling of instability can be extremely challenging. If a clear understanding of the problem and a plan for correcting the original problem is not established before revision knee replacement, it is improbable that the problem can be fixed and in fact, can lead to a worsening of the instability.

On occasion a simple brace to the knee can suffice to keep the knee functional and control the pain, but more often than not real instability problems will need surgical intervention to render a more permanent and satisfying solution.

A fracture may occur where the metal implants attach to the femur or tibia, which disrupts the fixation of these implants to a degree that requires the removal of part or all of the knee replacement. In these cases, a revision of the compromised knee components will need to be revised, often with a more complex knee device in conjunction with stabilizing the fractured bone. Even a simple slip and fall or twisting to the knee can lead to a significant fracture in bone weakened by osteoporosis.



Periprosthetic fracture of femur involving total knee replacement.

Stabilizing a complex fracture of the femur or tibia while providing a knee replacement that will be stable, support weight, and hold up to normal activities is among the most challenging of reconstructive surgeries undertaken by the surgeon. Poor bone quality, advanced age of the patient, and lengthy surgical times are common parameters faced by the surgeon when planning treatment for these difficult situations. Persistent stiffness of the knee joint and chronic pain problems are not uncommon after this type of revision surgery.

Preparation for revision knee replacement

Since each failed knee replacement has a different reason for its failure, preparing for the revision knee replacement is also going to be unique. Specialized CAT scans or MRI tests may be needed to evaluate bone loss around the current implant or rotational position of the prosthesis relative to the knee and ankle. Various laboratory or nuclear tests to check for infection may be indicated such as CBC, CRP, Sed. Rate, or Bone Scan. Finally, consultations with other medical or surgical specialists may be required to evaluate the medical condition or special circumstances of the patient prior to surgery to optimize the outcome.

Despite thorough preparation, the risks involved in revision knee replacement surgery are increased several fold from the level of risk of a primary knee replacement. The surgery is more difficult and time-consuming; the soft tissues, nerves, and blood vessels more difficult to mobilize and protect; and the prostheses are more complex to implant properly into the joint. The soft tissues become more difficult to stretch and the pain of revision surgery can be an obstacle to full mobilization of the joint. Notably, it is important that patients realize that the revised knee frequently never reaches the same level of function as did the first knee replacement. Complications and chronic pain is far more common with revision knee replacement surgery than it is with primary knee replacement.

Surgical Procedure

The approach into the knee is usually through the same incision used to put in the primary knee replacement. Often the incision must be extended in one direction or the other to expose the knee joint adequately. Dense scar tissue is always found surrounding the old knee prosthesis and much time and care is devoted to the removal of as much of this deep scar tissue as is needed to allow the knee joint to be positioned to allow access to the implants to be removed. There are several clever techniques that each experienced surgeon knows to gain maximum exposure while disrupting as little of the supporting bone, muscles, and ligaments as possible.

Severe polyethylene bearing weight, osteolysis, and loose prosthesis (See post-op, below).

Once the knee is exposed, the very important step of removing the old knee replacement is begun. When the reason for the revision knee replacement surgery is aseptic loosening with extensive osteolysis of the bone, one or all components that are not well-fixed to the supporting bone can be removed with relative ease. Unfortunately, when this is the case, there will be large cavitary bone defects that will need to be

reconstructed in some manner to fill in these holes in the bone with either bone cement or bone graft.

When the reason for the revision knee replacement is infection or instability, the implanted components are usually very well-attached to the supporting bone and the removal of the prosthesis can be quite laborious and time-consuming. Great care is taken so that while removing the prosthetic implant as little supporting bone as possible is removed. The bone of the more senior patient is often quite osteoporotic, and the process of removing the implant can result in fractures of the supporting bone, thereby complicating the situation greatly and leading to the need for a more complex implant than was originally intended.

Once the implant is separated from the bone on both sides of the joint, samples of the biologic material that has developed in the defects of the bone may be sent off to the hospital lab for immediate analysis, especially if an infection is suspected. Sometimes, even when pre-operative lab studies to assess for infection are negative, presentation at surgery may lead the surgeon to have concern that a low-grade infection is present. The material that is harvested from the area directly between the implant and the bone is often the best and only way that these occult infections can be found. If there is evidence that such a low-grade infection exists, the surgeon will not proceed with the re-implantation of a new, revision knee replacement at that time. Rather, an antibiotic spacer will be left in the knee temporarily, the operation ended, and treatment will proceed to clear the infection.

Revision knee replacement surgery is much different from that of performing primary knee replacement surgery as there are many variables that occur during surgery that, while anticipated, can change the course of the surgical procedure to one of increasing difficulty and operative time. For instance, in almost all revision knee replacement surgeries there will be bone loss around the implant. This occurs from either a biologic event such as osteolysis, where the bone is dissolved away through a complex series of biologic interactions between the plastic or cement debris and the cells of our bodies that clean up such things; or from infection, where the offending organism chews away at the bone; or from the resultant fracture of weakened bone in the removal of the implant.

In all of these cases, the resultant structural bone defect must be reconstructed. Sometimes smaller defects can be filled in with the cement that is used to fix the implants to the bone, while other times processed bone graft or even large pieces of bone are required to fill in defects for more biologic support. Large pieces of bone must often be shipped in prior to surgery and thus the preoperative planning for this need is just one of the many things the surgeon must anticipate for these complex reconstructions.

In conjunction with the reconstruction of any bone defects, the surgeon will need to determine which of the many revision prostheses available is right for the current situation. In most systems used today for this type of surgery manufacturers of these implants have multiple and variable attachments to the implants which allow the surgeon to create the tightest and most stable construct possible while maximizing the normal motion of the knee.

There are trial components that allow the mixing and matching of parts and attachments so that the components can be brought back to the level of the original implant, despite bone

loss that may have shortened the femur or tibia. More importantly, achieving the correct joint line is critical to allow the very important interface with the patella (kneecap) to be at its anatomically normal position. If this important articulation is not addressed properly, the knee motion can be quite restricted or worse, highly unstable. Further adjustment is made by changing the thickness of the plastic tibial bearing upon which the femoral prosthesis rides. The goal is to gain a stable balance between the knee at full extension and full flexion. This is really tricky and is a potential pitfall in the procedure, even for an experienced surgeon.

Once the trial implant has been developed by trial and error, it serves as a template to the creation of the real implant that will be permanently fixed into the knee. Typically the surgeon will be adding extension stems and metal augments that allow the implant to be fixed well into the shaft of the femur and tibia where the bone is normal and stronger.

Revision total knee with stem extensions, condyle augments well-balanced, well-aligned (See pre-op, above).

The true implants are held in place through a combination of press-fit and cement techniques to maximize both biologic and mechanical fixation methods as each situation dictates. The goal of any revision knee replacement reconstruction is to gain immediate stability of the implant so that the patient can bear weight on it as soon after revision knee replacement surgery as possible.

Once the implants are fixed, stable, and the motion of the knee satisfactory, the often difficult procedure of closing up the wound is then undertaken. The stiff, immobile tissue around this new implant sometimes cannot be stretched to cover an implant that is bigger or wider than the one removed. If tissue is forced into an overly stretched position, it will rip once the knee is moved. This is a disaster as it leads to the wound splitting open and exposure of the underlying tissues or worse, the implant itself.

In these cases, plastic surgery techniques may be necessary where muscles or tendons are moved from one area on the leg to cover any defect that needs to be covered. There are many tricks that the surgeon can utilize in this situation, but it is always a challenge when trying to close wounds over revision knee replacements. As the goal is to allow full motion to the revised knee immediately after surgery, a wound must be able to hold up to this stress. The experienced surgeon can usually judge if the tension on the closure is at risk to open up and will take steps to prevent this.

Revision Knee Replacement Summary

From the patient's perspective, the recovery from a revision knee replacement can take much longer than what the patient remembers from the original knee surgery. In fact it can take up to a year after surgery before the patient finds routine daily activities easy to do. Some patients will require some form of walking assistance in the form of a cane or walker for the rest of their lives. The final maximum range of motion achieved is often less than what the patient remembers their first knee replacement had reached and in fact, stiffness is quite common with revision joints.

Finally, revision total joint surgery has a less predictable longevity. Typically, a revision knee surgery done for loosening or instability is secured to less healthy bone and as such will not bear up as well to the stresses of living as well as when the bone was of better quality when the patient was younger and more active. Additionally, if the revision was done for an infected knee replacement, the risk of a re-infection is high, with studies that indicate from 14 – 20% of the joints become infected again [4]. Re-infected joint replacements are particularly difficult challenges for the patient and the surgeon.

Despite the complexity for the surgeon and the prolonged rehabilitation for the patient — if the underlying cause for the failure of a total knee replacement can be determined and a well thought out plan executed well, a satisfactory outcome of revision total knee replacements can be as high with up to 90% of patients having a good to excellent result. It is important to have an experienced surgeon and support staff to take on the difficulties inherent to this type of surgery in order to improve the chances of achieving this high rate of success.

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