Revision Total Knee Replacement is, unfortunately, now becoming more common. Knee replacement has been performed in some numbers for over 30 years, and hence, many of the earlier ones have now worn out, come loose or failed: situations that all lead to a revision procedure. In addition however, revision may be required for a variety of other reasons including: premature prosthetic failure (usually polyethylene wear), component loosening, pain due to alignment issues, infection, and so on. Revision replacement is, without doubt, a major undertaking. It can be difficult to remove the old prosthetic components, bone may be fractured or similarly damaged, and stems and augments are often required to replace bone that has been lost. Nevertheless, most replacements can be revised, and there is both a good deal of equipment, and a wide range of specialist prosthetic options, available to do this.

Reasons for revision

There are many reasons for which revision knee replacement may be undertaken. Perhaps the most common is for wear of the polyethylene components, but it can also be done for loosening of the components, infection, instability, pain, mal-alignment and so on.

Polyethylene wear is an inevitable consequence of replacement. Like all wear, it is dependent on use. The heavier the person, and the more active the person, the less time a replacement will last. We now know, based on over thirty years of experience with this sort of surgery, that in those over 60 years of age most replacements will last at least 20 years. For those who had an implant put in at the age of 40, the life expectancy of the implant is about 2/3 of that time—that is about 14-15 years.

Wear of the polyethylene tibial component
This is 20 year old polyethylene, not crosslinked. It starts to wear by a sub-surface delamination that then breaks down further.

Those figures are based on the Australian National Joint Replacement Registry (NJRR) data which, of course, is historical data. What the data tells us about 20 year old knees is therefore, necessarily, what happened to knees that were designed 20 years ago using materials from 20 years ago. Since then, technology has improved, both in terms of design and materials. Among those improvements has been the introduction of better polyethylene components.

Current tibial tray components are still polyethylene, but the material is highly crosslinked; a process that fuses the long molecular chains together thereby increasing toughness and decreasing the wear rate. Indeed, it is now thought that these components will last 50% longer than those made 20 years ago: hence, particularly if ceramic or ceramic coated femoral components are used (Verilast technology), the joint
and the hope is that, with today’s hardened plastics and better designs, it will be a rare occurrence.

**Loosening** of one or other component is now less common than it was, and probably because there is less polyethylene wear. Prostheses can become loose for various reasons and, in understanding this, it is important to remember that they are attached (cemented or otherwise) to living bone. That bone undergoes constant remodelling, so bone is removed and replaced as an ongoing process. As such, the bone to which the cement is attached can be absorbed, or become weakened, thereby leading to loosening.

The cause of such loosening is not always apparent. It can be due to mal-alignment which leads to abnormal stresses in the bone, hence building up bone in areas that are under increased pressure, and removing bone which is shielded from such stress. It can also be due to poor fixation in the first instance, though that is often hard to determine retrospectively. The commonest reason however, is due to polyethylene wear, which is something that we do now understand.

When the polyethylene tibial tray starts to wear, small particles of polyethylene debris start to be shed into the joint itself. Initially, these just float around but, ultimately, most get lodged in and attached to the synovial lining tissue of the knee. The knee, in response to this, produces chemicals (prostaglandins) to try and dissolve and remove these particles. As one can imagine however, these particles are not very amenable to such attack, the plastic being very indigestible. The chemicals produced however, are not benign. They have the power to dissolve bone, a process that begins at the edges of the joint just underneath the metal components.

As the dissolution process continues, more and more bone is removed, eventually leading to loosening of the components. This can be seen with a CT scan of the knee, showing areas of bone loss due to the polyethylene wear.

**Volumetric wear of various knees**

- The left group is standard polyethylene (PE)
- The middle group is highly crosslinked PE
- The right knee is ceramic (Oxinium) on highly cross-linked PE (so called Verilast technology).

**Metal wear** can be seen if the polyethylene component has been allowed to wear right through such that the metal femoral component gets to articulate directly on the metal tibial component. This then causes wear and erosion of the metal components which, in turn, leads to metal filings and particles being disseminated throughout the knee, eventually invading all the soft tissues in the knee. If one or both of these components are chrome cobalt, then both chromium and cobalt particles will cover the tissues, and the ions of those particles can be absorbed, raising systemic levels of what are toxic heavy metals. Generally, in a knee, the levels do not get raised to serious heights, but it is certainly something that requires treatment early on to decrease the metal ion load on the body: and the treatment is to remove the affected synovium (synovectomy - removal of the synovial tissue lining of the knee) and to revise the knee. This, as one might expect, requires revision of all components. Fortunately, this is not seen as frequently as in the past,
bone gets removed, a process called osteolysis. Eventually, cysts in the bone develop which can get very large, ultimately leading to loss of most of the supporting bone under the prostheses. If left alone long enough, this can lead to fracture of one or other bone, a problem that can be very difficult to deal with and still get a good end result. In addition, if there is associated metal wear (metallosis of the knee), then this may require significant removal of lining tissues to get the metal particles out of the joint. It may also require removal from the bone itself; and the more tissue that is removed, the more likely it is that the revision replacement will need build ups (augments), and will need to be of constrained or hinge designs.

The second potential problem arises if the patella has been removed. Often this step is not required because it tends to wear more slowly than the tibial component but, if it has been in the knee a long time (say 15 or more years), then sometimes it is better to revise it there and then, even if it looks reasonable.

Getting the old patella out can be difficult because it is cemented in. Usually it can be cut out without removing too much bone and, if that is the case, then cementing a new one in is generally straight forward. If excessive bone is lost, or the patella fractured (very uncommon), then other measures may have to be taken. There are however, prostheses that are made for this. These have a bone ingrowth surface (usually tantalum mesh) and can be used to reinforce the remaining patella. These essentially act like a graft, healing into the remaining patella bone, and at times, bridging a fracture.

In addition to the above, there is generally some synovitis (inflammation of the lining tissue) in the knee which needs to be removed. This is due to all the wear particles from the plastic that have accumulated over time and which are trapped within the knee joint ultimately becoming attached to the surrounding knee.

**Types of revision**

**Polyethylene Exchange** is the most straightforward of the revision procedures. This is done to replace worn out or damaged polyethylene components; that is, the tibial tray and, sometimes, the patella button as well. In essence this should be fairly simple, just being a matter of opening the knee up, unclipping the worn out plastic from the tibial tray, and then inserting a new one. What can make this a bit more difficult however is the problem of obtaining adequate exposure. Often, once replaced, the knee tissues contract and the patella gets pulled down towards the tibia. All of this can make the exposure more difficult than expected, and sometimes other things have to be done to help that. Fortunately this is uncommon at this level of revision.

**A failed 20 year old knee**

Osteolysis has led to large cystic destruction of the distal femur which has fractured and collapsed leading to loss of all bone stock below the shaft. The tibia also has cysts in it.

**A Smith & Nephew Legion PS Knee**

The polyethylene tibial tray sits in a dish on top of the tibial component which locks it into the slots at the back of the component.
X-ray of A Revision Total Knee

Note that the patella was low and that a tibial tubercle osteotomy has been performed to increase exposure. This bit of bone has then been re-attached. It has also been brought upwards a bit to try and raise the patella up (note the gap at the bottom of the bone).

Patella resurfacing
Preparation for resurfacing involves the creation of the an appropriate cut out ready for cementation. The patella is then cemented in. To revise this component can be difficult if the patella is still well cemented in. It can be either cut out or reamed out, but sometimes this does not leave a lot of bone for the revision.

joint lining tissues (the synovium). Those particles irritate the lining of the knee (the synovium) causing inflammation (synovitis). This inflammation causes an increase in production of knee joint fluid and, as such, is responsible for the swelling and aching of the joint that tends to accompany polyethylene wear.

The synovitis itself tends to cause the tissue to get lumpy and to grow fronds such that it eventually looks like a rug rather than a smooth sheet. Those fronds enclose most of the particles that have been produced and which have been distributed throughout the knee. Thus, in order to remove them, most of that lining needs to be removed - a so called synovectomy. The lining is literally stripped from the inside of the knee and, in general, some 90% or more can be removed. Fortunately, it does not all have to be removed because the areas at the back of the joint can be very difficult to reach. These areas are also very close to the vessels that supply blood to the lower leg so any tissue removal here needs to be done carefully and with good exposure: something that is not always possible. Accordingly, and within reason, as much affected synovial lining as possible is removed: and, fortunately, this does not seem to cause much more pain or problems in the post operative period.

The synovial lining of the knee re-grows over the weeks following surgery, and it should re-grow normally without the inflammatory changes that were present prior to removal. This should then return the knee to a stable state without excessive swelling or ache.

Recovery from this procedure is usually relatively quick. Of course there has to be a moderate sized incision made to get the old plastic out and to put the new one in, but provided that the metal components do not need to be removed and replaced, there is much less trauma to the joint, much less bleeding and so on; all of which leads to a more rapid recovery than the original procedure.

Having replaced the polyethylene components, the joint should return to its previous stable state with the same range of motion and function. The pain and swelling from the synovitis should go and, hopefully, the knee will then go on to provide many more years of good service.

Longevity after polyethylene revision may not be as good as for the initial knee. This reduced longevity is based on evidence from chrome cobalt surfaced knees which undergo what is called flecking. In this process, some of the plastic debris from the worn polyethylene components gets embedded into the surface of the metal components making them slightly rough. This then causes more rapid wear of the polyethylene tibial tray than the first time around, hence decreasing longevity. There are therefore, a few advocates of always replacing the femoral component when the tibial tray is replaced. In general however, the extra risk and morbidity caused by this outweighs
any potential advantages.

If the femoral component is ceramic or ceramic coated (Oxinium or Oxidised Zirconium for instance), then flecking is thought not to occur. This is because ceramic surfaces are much harder than metal and have less porosity, thus not allowing polyethylene debris particles to be forced into the surface. If time proves this to be the case, then it may turn out that this sort of component will provide equally low wear in the revision setting, and hence identical longevity, as it did in the original knee.

**Polyethylene exchange with femoral component revision** is sometimes required if there seems to be a mal-alignment of the latter causing either pain or an abnormal wear pattern. Although an abnormal alignment (and we are usually talking about mal-rotation of one of the components) may not be obvious when the knee is first replaced, it may be clear when the polyethylene becomes worn with a wear pattern that is not symmetrical. If this is the case, then the femoral and/or tibial component may need revision at the same time as the polyethylene component so as to re-align these, thereby, hopefully, correcting the cause of the abnormal wear pattern.

Revision of the femoral component does mean cutting out the original but, even if well cemented, this can usually be done without losing too much bone. Rotation or other changes can then be made and a new component cemented in. Whilst this does add to the procedure, it is reasonably straightforward compared to removing the tibial component.

Another reason for femoral component revision is if the femoral component is being moved up to correct a fixed flexion deformity (an inability to get the knee fully straight). This sometimes occurs due to contracture of the tissues around the knee, particularly at the back of the knee. If these thicken and shorten, then they will no longer allow the knee to fully extend. One way of dealing with this is to shorten the femur by 2 - 3 mm, thereby moving the femoral component upwards a similar amount. This then, in turn, means that the tightened posterior structures become less tight by a similar amount, thus allowing the knee to become straighter. The advantage of this is that the posterior tissues are not touched, and hence, hopefully, they will not go on to further contracture.

Sometimes, if the polyethylene tibial component is thicker than the minimal size of 9mm, then it can simply be down sized to affect the same result. The difference however, is that by changing the thickness of the tibial tray, there is not only a loosening of the knee in extension (straight), but also a loosening in flexion (bent). Hence, if this consequence is not acceptable due to excessive looseness when the knee is bent, then moving the femoral component upwards may be a better procedure.

Sometimes, release of the thickened scar at the back of the knee may be undertaken to release it. One indication might be where the femoral component is difficult to remove and a simple polyethylene tray down-sizing is either not possible or causes excessive laxity of the knee in flexion. Whilst this sounds simple, it is in fact not so. Unless the femoral component is removed at the same time, there is only a small gap to work through to do this. In addition, as previously mentioned, the vessels that supply the lower leg are within millimetres of the back of the knee and may be bound up in the scarred tissues. This therefore, is a procedure that is not without risk to those vessels. It is also not without risk of recurrence given that if there has been a tendency to form thick hard scar tissue after the first procedure, then it may just happen again after any revision. For these reasons therefore, this is a procedure that is only undertaken when there seems to be a real advantage over other techniques: and this is not commonly seen.

**Three component revision** is where both the metal tibial and femoral components are revised, along with the polyethylene tibial tray. Sometimes of course the patella is also revised, but this depends on the reason for the revision. Such a revision is a much more major undertaking than any of the above because it involves removing the tibial component as well. This is done for major mal-alignment problems, tibial component loosening, instability due to ligament damage that requires a more stabilised prosthesis, infection, etc.

Removing the tibial component can be difficult because there are parts of this that are hard to get to. Essentially, the central stem and/or the anti-rotation fins that are part of that component can limit access to the back of it. In addition, considerably more exposure is required than for the other types of revision. This means more soft tissue release from the bones, and sometimes, if that is not enough, a tibial tubercle osteotomy may be needed. In the latter, the tibial tubercle, to which the patella tendon is attached, is taken off the tibia with the tendon still attached, thus allowing the patella to be moved right out of the way. This considerably increases exposure, particularly where the patella has contracted down towards the tibia (see below), but it does require the bone to be screwed back on again so that it will heal back on.

Whilst straight forward in an unreplaced knee, tubercle osteotomy is complicated in a revision replacement because the stem of a revision prosthesis gets in the way. This means that the screws that are used to reattach the tubercle must pass each side of that stem, something that can be problematic if there is not much room left on each side. It is however, generally possible, and the bone will go on to heal over 6 or so weeks. Usually by 3 - 4 months it is solidly united and the screws can then be removed, something that often removes some of the residual ache.

If the tibial component is solidly fixed to the bone,
then it will need to be removed by a combination of sawing and chiselling. Providing the bone is not too soft, this can generally be done without excessive loss of bone stock but, if difficult, then there may be some loss of bone with or without a fracture of part of the upper tibia. Fortunately however, because of the use of stems in revision surgery, the prosthesis is much less reliant on the upper bone surface than in the primary situation; hence, whilst making the surgery a bit more complicated to do, it may not be all that important in the end.

The skill of revision surgery is to balance the knee such that it has equal tightness throughout the range of motion, without being either too loose or too tight. Because of the requirement for soft tissue releases to gain exposure, and because some bone loss, the balance (tightness) will not be the same as it was in the original replacement knee. What has to be done therefore, is to put the tibial component in, often with metal augments to replace the lost bone, and then try to balance the femoral component on it.

The size of the components will be determined by the size of the bone, but the positioning can be varied. In general, the standard revision technique is to initially get the knee balanced with it at 90° of flexion. This is done by raising or lowering the tibial component. Once the tibial height is established (by adjusting the tibial component thickness), and the rotation of the femoral component has been adjusted so that the tightness of the joint is equal on both sides, again with the knee at 90° of flexion, then the knee is straightened to adjust the tightness in that position. This is done by moving the femoral component up and down until the correct tension is achieved.

Fine adjustments are made using various augments to the components. These are small wedges of metal which attach to various parts of the femoral and tibial components to make up for lost bone. Initially this adjusting is all done with trial prostheses but, when this is all worked out, such augments are used with the definitive prosthesis.

In almost all 3 component revisions, stems that pass up the canals in the middle of the bones are added. These provide extra stability to the prostheses and better fixation. These are usually press fit, so they do not always need to be cemented into place. This however, is something that can only be decided at the time of revision, and it depends upon strength of bone, tightness of component fit, and the nature and type of the prosthetic replacement being undertaken.

What is known, is that the use of revision components (stems etc.) leads to a higher success rate in the revision situation than trying to use primary components. This means that stems should not be regarded as something to be avoided at all costs.

**Increasing stability**

It is one thing to replace the metal components, and to balance the knee when the soft tissues are all still intact, but it is another when this is not the case. Frequently, in the revision situation, the knee may have to be made more stable than before because of soft tissue damage and poorly functional ligamentous structures. Sometimes this is just part of the reason for the revision, but at other times it may be due to releases having been made in order to increase exposure and get the old components out. This means that a knee that may originally have been posterior cruciate retaining (CR - cruciate retaining), may end
up being posterior stabilised (PS - posterior cruciate sacrificing with prosthetic posterior cruciate function added), constrained (to make up for the loss of either medial or lateral collateral ligaments, or both), or in some instances, converted to a hinge. Usually, this can only be determined at the time of surgery, but all the necessary components to enable this to happen are always made available, and are in the theatre, for such cases.

The Legion Hinge Knee (HK)
In this knee the components are linked together by a hinge mechanism which provides ultimate stability in all directions. It is for use in knees with extensive ligament damage or bone loss.

Final Preparation

Usually, before working on the balance of the knee, the bone ends are re-cut so as to properly prepare the bone for the cement. When the balance has been established with the trial components, the ends of the bone are thoroughly washed with a high pressure saline spray to clean them up. Once done, the real components are pieced together and cemented in.

Despite how major this is to do, the recovery may be no different to a standard first time knee replacement. The wound however, may be somewhat bigger, particularly if a tibial tubercle osteotomy has to be performed.

Recovery

In general, despite the size of the surgery and the fact that it may take 2 - 3 hours to do, the recovery is not too dissimilar to that of a primary knee replacement. Indeed, particularly for a hinge design, recovery can be surprisingly quick. Some of this is due to the fact that, in the more constrained designs, and particularly in the case of a hinge knee, the collateral ligaments (Medial and Lateral ligaments) are either not present or not functional. This in turn means that they are not under tension, and it is thought that this leads to less pain and earlier recovery of motion. For whatever reason however, most of the revisions, when done with today’s prostheses, perform very well, even if the longevity of these is likely to be somewhat less than for that of a primary replacement.

Outcome

We know from data collected by the Australian National Joint Replacement Registry (NJRR), that a revision will not last as long as a primary replacement. Of course however, looking at a big number of these will show a large spread of reasons for revision. Such a heterogenous cohort will naturally have a wide range of outcomes, varying from early failure to almost normal longevity. What we understand is that: excessive constraint of the prostheses, thereby linking the femur to the tibia more directly, will pass stresses on, via the prosthetic attachment to the bones, because there is less forgiveness at the level of the knee; and this can be a cause of premature failure.

Normally, stresses caused by everyday minor twists and turns of the leg are partly dissipated in the knee joint itself. This happens because of the normal laxity of the knee ligaments allows some movement between the femur and tibia at the knee. That is to say, there is a little bit of slop in the system. If those everyday stresses and strains are passed directly from the tibia to the femur because there is no give at the joint level, then this passes those stresses, via the prosthesis, onto the bones themselves. For this reason, stems are the preferred option in these more major revisions. By using stems, those stresses are spread over a larger length of bone and, in addition, the area of the bones around the knee that are the most liable to fracture under stress, are protected.

Summary

In most circumstances, revision can be considered as a viable option for an identifiable problem within the knee. Whilst there is a rumour, and one oft repeated, claiming that revision of a knee replacement is either not possible or can only be done once, it is fortunately just that - a rumour. Modern component sets come with a large inventory of alternatives and extras designed specifically for revision. Thus, revision of almost all failed knee replacements is possible. This ability then, represents a high likelihood of mechanical success being achieved in such cases. Like primary replacement however, establishing good mechanics does not necessarily impart any guarantee of satisfaction, something that may be limited by other factors.

Indications for revision of a replacement are many, and the best ones are those of mechanical failure of the joint. What is more difficult to fix are the problems of on-going pain and/or stiffness that may have complicated the first replacement; problems for which an identifiable underlying cause may not be found.