Knee replacement is the definitive operation for the treatment of a painful arthritic knee. Essentially, the worn out ends of the bone are replaced with metal and plastic, thus re-creating a functional joint again. During the procedure, any deformity that is present is corrected and, the end result, should be a knee that is well aligned, moves well and causes minimal symptoms.

Types of replacement
There are many types of knee replacement available today, with most of these resembling each other very closely. When this happens, it becomes clear that we have come close to stabilising a design, and that we are not searching for radical changes anymore. It suggests some consensus between all the companies who research and design these products. It suggests that the product is quite good and that future improvements will probably be small.

Total knee replacement - is the more usual operation. Not only because it is more predictable in its outcome and survival, but also because most people have wear in more than one part of the knee, and hence need more than one part of the knee replacing. In this procedure, both ends of the bone are replaced with metal, and a plastic tray is inserted between these to keep the friction low, and to absorb impact. The kneecap (patella) may also be re-lined with a plastic (or a metal and plastic) button.

Over the years many designs have been tried. It has been found however, that the best designs, are those that recreate the normal knee most precisely. In general, the nearer the design approaches the normal knee, the better the results, both in the short and in the long term. For this reason, all the old hinge type designs are no longer used. A replacement nowadays is really just a resurfacing of each of the bone ends. This, unfortunately, does not mean that we can entirely duplicate normal knee anatomy. Indeed, because of some altered ligament function that occurs during insertion of the prosthesis (the ACL or anterior cruciate ligament is lost), it is still not yet possible to totally simulate the normal joint.

Hemi-arthroplasty - is where only half of the joint is replaced. This is most usually performed where one side of the joint is worn out, either due to injury, or due to earlier removal of the meniscus, leading to arthritis (wear) on that side. It is only suitable if the rest of the knee is in very good condition, and if all the ligaments are intact. The advantage of this procedure is that it most nearly re-creates the function of a normal knee. Part of the reason for this is that the anterior cruciate ligament (which has to be removed for total knee joint replacement) is left intact. As might be expected therefore, the end result can be very good. It generally produces a knee which has a near normal or very good range of motion, and that range is often achieved reasonably quickly.
This sort of knee replacement is most suitable for the inside half of the knee (the medial side) where it is often referred to as medial compartment resurfacing. Like total knee replacement, there is a replacement of the worn out ends of the bone with metal and plastic bearing surfaces, only here it is only applied to the medial compartment of the knee. The lateral compartment is not replaced, and nor is the patellofemoral compartment (underneath the kneecap).

The big disadvantage of this sort of operation is that the current range of prosthetic devices have a less predictable outcome than do total knee replacements. The Australian Joint Registry shows that survival of these prostheses is considerably less than that of a total replacement, mostly due to a significant revision rate in the first 7 years. It must be said however, that whilst a few revisions occur for failure of the prosthesis, a good number are for pain and on-going problems with the rest of the knee, the parts that have not been replaced. This emphasises the importance of restricting this operation to those who really do have wear in only one part of the knee. It should not be considered where there is any wear in the other side of the knee, or where there are symptoms from the kneecap. This means that, if there is no mechanical reason to explain why there is wear in only one part of the knee (injury, menisectomy, mal-alignment etc.), then it should be assumed that the wear is just maximum in that part of the knee, and that the rest will follow given time.

In this situation, if only one part of the knee is replaced, the remainder will eventually wear out with time.

Premature failure of a partial replacement, be that due to prosthetic failure or, more likely, on-going issues with pain, can only be treated by revision to a total knee replacement. Whilst this is possible to do, that conversion is not always simple and, the end result, may not be as good as if a total knee replacement had been performed in the first place.

The bottom line for hemi-arthroplasty is that, whilst it is very good when it works, the failure rates are not insignificant. The evidence would suggest that not that many people are really suitable for it, meaning that the outcome for a good percentage will be one of on-going issues, perhaps leading to revision. Good results are only likely where all the right indications and criteria are fulfilled. For this reason, surgeons who perform a large number of joint replacements each year, tend to use a total replacement for most people, using uni-compartmental replacements sparingly. The outcome is then more predictable.

Cement or no cement?

Traditionally joint replacements have been cemented into the bone. Theoretically this would seem to be a good idea. It means that the prosthesis is solidly glued into the bone at the outset, and that recovery should therefore be fairly quick. In addition, the cement seals the ends of the bone which cuts down the bleeding. Hence, there is less bruising and swelling after surgery, so motion should return more quickly.

The problem with this approach is that bone is living and, unlike wood, bone is constantly being removed and replaced. Whether, during this cycle of constant rejuvenation, it grows back as strong as it was depends on a number of factors, including local forces through the bone.

On the tibial side it is usual for a rigid base plate to be used, this being a tray for the polyethylene bearing surface. Independent of how accurate the bone cuts are and how good the cementation is, the tray will always sit on some slightly high points putting extra pressure on those areas and hence lowering pressure on other areas. This leads to high stress areas where the bone builds up to support the tray and low stress areas where the bone may just be resorbed (osteolysis). Generally, these variations of bone strength, whilst seen on x-ray, are not a good clinical problem. Sometimes however, in high demand patients, the high stress areas can develop stress fractures and stress reactions which can be painful. The opposite effect, where bone that is shielded from stress gets resorbed, can lead to prosthetic loosening; though this is unusual.

For the above reasons, engineers continue in their quest for a reliable, cement free joint replacement. In most cases, this involves having a special porous surface on the back of the metal prosthesis which allows the bone to grow into it. If this occurs, then the stresses that go through the joint should be much more like normal, and hence, bone may not only not disappear from under the metal, but rather may even build up and become stronger. Many such surfaces have been developed and all seem to work to a variable degree. Bony ingrowth however, is still not guaranteed: and sometimes, microscopic loosening may occur which is symptomatic.

Dr Holt currently cements all his prostheses in, having had some recent failures from uncemented versions. Different prostheses however have different mechanics, and different ingrowth surfaces, and hence, some are more suited to being used in their uncemented versions. Accepting all this variation, the literature is still unclear as to whether the long term outlook for a cemented joint is any different from an uncemented one. At this stage therefore, this remains the surgeons preference, depending on his experience with the prosthesis he uses.

Patella or no patella?

Resurfacing of the patella (kneecap) with a polyethylene button is one of the most controversial areas in knee replacement surgery. Most studies in the literature show that, at least in the first 5 years or so, there is no difference in the results whether the patella is replaced or not. In the last few years however, longer term results are starting to show that patella replacement may be advantageous. Kneecap pain is a not infrequent problem after replacement, whether or not it has been resurfaced. The incidence of this problem may be up to 25% in some designs when un-resurfaced, but in no designs is it completely avoided, even with a polyethylene button on the bearing surface.

Most big surveys of knee replacements are now showing that the ability to be able to climb and descend stairs is enhanced by having the patella resurfaced. Given the low complication rate of patella replacement therefore, it would
replacement, it is 7 - 8 days. This means that if you come into hospital one knee replacement this is 5 - 6 days, and for bilateral surgery, the number of days in hospital for a given procedure. For this reason, the admission on admission into hospital on the day of surgery whenever possible and, for cost reasons, they discourage earlier admission. Because of the DRG (Diagnostic Related Group) system that health funds now use, they will only pay for a certain number of days in hospital for a given procedure. For single knee replacement this is 5 - 6 days, and for bilateral replacement, it is 7 - 8 days. This means that if you come into hospital a day early, you will have one less day to recover before your fund will stop paying for you.

**Anaesthesia:** In general, our anaesthetists like to see all patients undergoing replacement surgery, in their office before hand. Sometimes, because of time constraints or other reasons, this does not happen. If this is the case, then the anaesthetist will visit you on the ward on the morning of surgery, just to make sure that everything is satisfactory. If, at the time of booking surgery, there are any concerns regarding suitability for anaesthesia, a pre-operative review will definitely be arranged with the anaesthetist. If necessary, this will be scheduled well before surgery so as to enable any special tests to be carried out, assessed, and acted upon, in time for surgery.

Most people prefer a general anaesthetic, but the procedure can be performed equally well with an epidural or a spinal anaesthetic (usually with some adjunctive sedation). If you have a preference for spinal or epidural anaesthesia we can arrange for such, and we can arrange for you to have an anaesthetist who has experience with this. Our current preference is to use general anaesthesia with adjunctive nerve blocks and local anaesthetic infiltration into the joint. Having bilateral simultaneous knee replacements however, we will often choose epidural anaesthesia as an adjunct to general anaesthesia. Ultimately though, this is a decision to be reached between you and the anaesthetist, and you should discuss it with him or her.

**Blood transfusion.** Most people (95%) do not require blood transfusion for knee replacement. For those who do however, they can be reassured that bank blood in Australia is very safe. The blood is well tested when obtained, and then re-tested at specific intervals after that. The likelihood of this blood carrying hepatitis or AIDS therefore, is extremely remote. All patients having knee replacement will have blood taken for blood grouping, either at the pre-op clinic, or when they come into hospital. Serum will then be held so that, if necessary, they can be cross-matched against suitable blood.

In genetral, blood transfusion is not required for hemiarthroplasty, bilateral hemiarthroplasty or single total knee replacement. It is more likely with bilateral knee replacement but, even here, it is quite uncommon. Those most likely to need blood are those who are iron deficient and have longstanding low haemoglobin levels to begin with. If you are in this group, then elevating iron levels pre-operatively is advised. This can be done with iron tablets which are available over the counter at the chemist, and are taken once a day for about a month. If iron levels are really low, and are chronically so, then an iron infusion is often the best remedy. This needs to be organised some time ahead of surgery so that it will have had the desired effect by the time of operation. Often this can be organised through one’s GP. If necessary however, Dr Holt can organise for you to be seen by a haematologist for this purpose.

At the time of surgery, Dr Holt uses tranexamic acid, instilled into the knee joint, to decrease bleeding. This can also be given intravenously and by tablet. If there are bleeding risks, then such extra treatment can be given both intra-operatively and post operatively. Tranexamic Acid prevents clotted blood from being broken down, and hence, considerably reduces blood loss in Knee Replacement. As such, it has largely removed the need for blood transfusion, even in bilateral knee replacement.
**Knee replacement - the procedure**

The procedure of knee replacement is now well established and the instruments that come with the replacement are reliable and reasonably accurate. This means that the procedure can be performed with a short anaesthetic (generally 1 hour per knee), and that any mal-alignment of the leg can be corrected to within two or three degrees of normal. The operation is done through a wound on the front of the knee and leaves a long, straight, vertical scar which fades over a period of about 1 year.

**Knee replacement - post surgery**

**Ward stay:** During your hospital stay, physiotherapists will help you regain motion in the knee, and will get you walking again. The aim is to get 90° of motion by the time of discharge, to be able to walk to the toilet or fridge and back, and to be able to get in and out of bed by yourself. Most people will use crutches for 5 - 6 weeks, but these are not compulsory.

**A drain in the knee** will be removed on the second day after surgery, and the intravenous drip in the arm is generally removed on the third or fourth day. The intravenous line is used for pain relief via a pump that you will be able to control (PCA - patient controlled anaesthesia). It will not be removed until you are able to cope with oral medication and this is usually on day 3 or 4.

**Pain medication** will be provided at the time of discharge. The stronger analgesics however do not come with repeats, so most people will require more scripts after discharge. These can be arranged through the office and we can both fax scripts off, and post the originals, to the chemist of your choice. Most people will need some night time medication for nearly 3 months. During this time, the aim is to reduce the demand for the narcotic drugs that are used initially, moving to less problematic medication. Getting adequate pain relief that does not cause nausea and does not interfere with bowel function can be quite hard and, in some people, this may take a fair bit of change and adjustment of their drugs. We would generally hope that this will be all sorted out by the time of discharge.

**Standing** may happen on the first day post surgery but will certainly have happened by the second day. Walking with a frame usually begins on the third day. By the end of the stay, crutches will be used, mobility slowly improving each day. For those who have to negotiate stairs at home, special instruction on getting up and down them will be given.

**Crutches** are generally required for 5 - 6 weeks, until confidence is regained. After that, a stick can be used until normal walking is achieved. Generally, by 3 months, most people can walk better than they did pre-operatively (1 kilometre or so) and some can even play a round of golf (50% of people can play 9 holes at 3 months and 10% can play all 18. The rest take a bit longer). Improvement then continues for 9 - 12 months with the swelling taking at least 9 - 12 months to fully settle.

Note that hospitals no longer supply crutches. It is therefore advisable to organise these before coming into hospital. For most people, because of the length of time that they will need them, it is cheaper to buy them rather than hire them. This is particularly so if they are then sold after use.

**Driving** is allowed when you can manage without crutches. This usually happens at about the 6 week mark and, for legal reasons, 6 weeks post surgery seems to be about the right time.

**Time off work,** on average, is 2 - 3 months, but may occasionally be less if the job is relatively sedentary. It is best not to push to get back to work too early, and not to try and be better than average. Rest is a very important element in recovery, and is essential to allow early reduction of swelling. This, in turn, is important to maximise the amount of flexion that the knee can achieve post surgery.

**Physiotherapy**

Whilst in the hospital there will be on-going physiotherapy to help with recovery. This will include CPM (constant passive motion), to gently take the knee through a range of motion. It will focus on gaining as much motion as possible. It is to be remembered that gaining motion is important whereas walking is not. Too much activity will cause swelling which, in turn, will decrease motion. This means that a balance has to be struck between doing too much and not doing enough. Most people will find that by about day 5 they will go backwards a bit because of their increased activity and exercises. This then means having a day or two off therapy until the knee settles down again. More is not better, and the concept of getting enough rest is important.

When leaving the hospital, a home exercise program is provided. In some instances, further physiotherapy will be ordered but, for a lot of people, this is not necessary. Indeed, it has been shown that the benefits of working the knee hard diminish after leaving hospital, particularly if travel (to and from a therapist) is involved which may cause the knee to swell more. It has also been shown that at 2 years following surgery, there is no difference in results between those who have had intensive therapy compared to those who have not.

For this reason, for most people, no formal physiotherapy is required upon discharge. It may be required subsequently however, and if so it is easily organised. For most however, some gentle knee bending with lots of rest is the best policy.

A home mobility program where the knee is bent and swung, sitting on a high chair or table, 3 times per day, is generally all that is required. To aid this, you can use a skateboard or similar device, pushing it back and forth under the chair. Once the knee is settled enough to travel, some pool therapy is often helpful. This may or may not be supervised, and again, the emphasis is on bending the knee not exercising it.

Those who need formal therapy are, those who are not getting 90° knee bend by the time of discharge, and those who have trouble doing the exercises themselves at home. Similarly, if you find that you are slipping behind when at home, and are losing the knee flexion that you gained in hospital, then you will need to see a physiotherapist to get back on track.

Once the knee settles somewhat, and once it will tolerate traveling short distances, some hydrotherapy can be very helpful. Of all the activities, this seems to be the most helpful, allowing easy motion whilst keeping the swelling to a minimum. Again, more is not better, so the aim is not to walk lots of laps in the pool; rather it is to bend the knee in a good environment.

**Home help etc.**

If you think you are going to need home help or the installation of home aids, the earlier these are organised the better, so that it does not delay your discharge. The pre-op
clinic is a good place to start this process off, and the staff there can advise if asked.

Whilst you are in hospital, it will become clear whether or not you will need help at home. If this looks necessary, then the ward staff can have the Discharge Nurse come and visit you (and your family). She has considerable experience with joint replacement patients, and will be able to offer advice on home aids as well as home support. She can organise high chairs, rails, showering aids, walking aids and so on.

Nursing staff can sometimes organise silver chain visits but, resources such as this are very limited and are becoming increasingly hard to obtain. Unfortunately, such limited resources cannot be counted on, and help from family and friends is a better option.

If you already have Silver Chain support at home, let them know when you are coming into, and leaving hospital, so that they can be ready for you.

If it is not possible to organise your home set-up and home care in time for your expected date of departure from hospital, then delay the surgery rather than hope that the hospital and your health fund will allow you to extend your stay.

**Rehabilitation:** Most big hospitals now have a rehabilitation unit. This is run by the Geriatricians and space is always limited. In order to be considered for a period in the rehabilitation ward, you have to assessed by those physicians, and the reason for admission has to be medical. This cannot be organised ahead of time and you cannot be pre-booked into this ward. If it seems necessary to prolong your stay because of medical reasons however, then Dr Holt will have one of the physicians come up to the Orthopaedic ward to assess you.

Please note that not all health funds will support a period in a rehabilitation ward and, even those that will, require a documented medical reason before they will cover such. If that reason is present however, then Dr Holt will organise a review by the appropriate physician. That can, and will, be organised as soon as it becomes clear that it is necessary.

**Expectations and results**

**Pain Relief** is, for most people, the single biggest reason to consider replacement: and results of the larger series do indeed show that the vast majority are pain free or have minimal aches and pains in the longer term. Overall however, it must be said that a knee replacement is not quite as pain free as say a hip replacement, and does not recover as fast. This may be due to the fact that the knee is relatively superficial, and not surrounded by muscle like the hip. It may also be because of the complexity of this joint in comparison to a hip. Either way, the results, at least in the short term (the first year), are probably not quite as good as a hip replacement.

The graphs shown opposite are derived from pain studies published under the title:

**Knee pain during the first three months after unilateral total knee arthroplasty. A multi-centre prospective observational cohort study.**

Morze, C, Johnson, N, Williams, G, Moroney, M, Lamberton, T, McAuliffe, M.

The concern with knee replacement is the group that have difficulty managing their pain (~10%), and who still have 5 out of 10 ‘best pain’ scores at 3 months. In the first 6 weeks this group are barely better than they are in the first week post surgery. Various strategies for this are now being used, but only time will tell if they are effective.

This group is then in complete contradistinction to the group at the other end of the scale who have almost no pain by 6 - 8 weeks (~10%). The reasons for this are unknown, and it does not always seem to relate directly to swelling, stiffness or other operative factors, albeit that these may be the cause of some of this problem. One of the indicators for being in either the best or the worst group, is the degree and extent of arthritis that exists pre-operatively. We know for instance, that those people who have tolerated a really bad knee for a long time, will tolerate a knee replacement: and hence are expected to do well. On the other hand, those who come to replacement with significant on-going pain, and yet do not have a particularly arthritic knee, generally will not do so well.

The longevity of a knee replacement is probably the best of any joint that can be replaced. For most available prostheses a 90% - 95% survivorship at 15 years is expected (as the results from the Australian Joint Registry show). This means that most replacements will be functioning well at 15 years, and that some will go to 25 years or more before requiring revision. As expected, the analysis of results show that the
heavier more active patients will wear out their knees earlier: and hence, the older, lighter and more sedentary patients are more likely to be in the 90% group that will go past 15 years.

Some of the current models are now tested to out past 30 years in the laboratory, but only time will tell if these newer knees will really last that long.

Range of motion is variable and unpredictable, even from a left to a right knee in the same patient. Certainly all knees behave differently, and the results of replacement vary because of many different factors. Suffice it to say that, at one year post surgery, 120° of flexion (bend) is average. Being an average however, means that for every patient who achieves 140°, another will only get 90°. Maximum flexion is rarely achieved under 12 months and improvement may continue for up to 24 months post surgery. To end up with less than 90° of flexion however, is very uncommon but, if this happens, there are things that can be done in the post operative period to help.

It is important to realise that knee motion is restricted by the arthritic process. It is also important to understand that it is difficult to achieve a better range of motion following surgery than existed pre-operatively. Hence, a knee can be left too long before opting for replacement. The corollary is that, if you only have 90° of flexion pre-operatively, it is unlikely that you will reach the average range of 120° post-operatively.

The aim, for the most part, is to get as much motion as possible after surgery because this allows more activities to be possible. As a minimum, 90° of flexion is required to get in and out of a car with some facility, and to sit on a chair comfortably. To ride a bike usually requires 105° to 110° and, to climb stairs, requires a similar range. To climb a ladder may require 120° and, only if more range than that is obtained, can squatting down be contemplated. For most people, the thought of being unable to squat down and kneel is of little concern compared to the benefits of pain relief and mobility, however, it may be very important in those religious groups who have to kneel for prayer (albeit that the thin supple races are more likely to get better bend than the others).

Bleeding and bruising in and around the knee also affects final range of motion. Published results confirm this, and show that, for those people who have to take anti-coagulation (particularly warfarin) in the peri- and post-operative period, a stiffer knee, with a reduced range compared to the normal population, can be expected. For this reason, anti-coagulation has to be modified and carefully controlled in this period.

Kneeling is possible following replacement, but most people choose not to do this. It does not harm the joint to kneel but it just doesn't feel right, even if the range of motion will allow it. It is reported that whilst 85% of people can kneel, only 15% will choose to do so. This means that the serious gardeners will need to find a low stool or chair to use: or perhaps one of the other fancy devices that are made specifically for this purpose.

Squatting is also difficult, mostly because of the limitation of knee bend that results from the procedure. Nevertheless, most people who come to replacement cannot squat pre-operatively, so for them this will not be a change.

Skin numbness on the outside of the scar is usual after surgery. This is because the small superficial skin nerves that supply that area come from the inside of the leg and are cut during the approach to the knee. Whilst this is initially quite noticeable, over a 1 - 2 year period some sensation appears to return. Ultimately this area becomes less numb and, as a consequence, becomes less noticeable.

Complications and problems

Residual pain is rarely a major problem. Sometimes however, residual aches and pains occur which, despite the passage of 9 - 12 months, persist and are difficult to explain. Some are due to loosening, some to infection, some to mechanical problems and so on. Most however can be diagnosed, and most can be helped or treated. The problem is that this process may take time, and indeed, it is often a matter of exclusion of problems, rather than a definitive confirmation of one, that leads to a diagnosis or a treatment option. This explains why it often takes months to work out why some replaced joints are still symptomatic, and even longer to fix them.

Stiffness is perhaps the most common problem initially. Given time however, most problems relating to this resolve. Indeed, the range of motion will continue to improve for 12 or more months. If at the 2 month mark however, the knee does not have 90° of bend, then a manipulation under anaesthesia can be performed. This is generally a minor intervention and usually does not make the knee sorer. What it achieves is a breakdown of the restricting scar which, in turn, makes the knee feel freer and less sore. The best time for this is at about the 2 month stage, but it can be left as long as 3 months in some instances. After 3 months the scar gets quite thick and strong, making it harder to break down. This then makes manipulation more difficult and more risky. Accordingly, it is rarely performed after the 3 month mark.

If the knee still ends up with inadequate bend despite a manipulation, then it may be possible to remove the restricting scar from within the knee joint using the arthroscope. This is usually not performed before the 9 month mark for fear of stirring the knee up and making it scar more. Indeed, it seems that the optimal time to remove this scar is between 9 and 15 months post surgery, once the knee has settled down and become quiescent. By doing this, increased motion can usually be obtained and, although some of that motion may subsequently be lost, it is usual to maintain over 90 degrees of flexion. Even if not much more motion ensues however, the removal of scar will often make the knee feel less stiff and tight, and this in itself can be a worthwhile improvement.

Clearly, the biggest problem with the arthroscopic approach, is that it has the potential to introduce infection into the knee: hence, it is only offered if the potential for improvement seems to justify that risk. Of course, antibiotics are used in the peri-operative period with this surgery, but this is not an absolute guarantee that an infection cannot be introduced.

Residual mal-alignment (a crooked knee) is not very common with today's alignment systems. Most systems can get within 2 - 3 degrees of straight on a regular basis. In order to correct a significant mal-alignment, soft tissue releases, freeing up the tight and scarred ligaments from the bone, need to be performed. This is much easier to perform in the varus (bow legged) knee than the valgus (knock knee deformity) knee because a more complete release of the affected tissues can be performed with safety. In the very valgus knee, the structures on the outside of the knee have to be released but, the lateral ligament cannot easily be released without causing instability. Accordingly, there comes a point
after which it is hard to correct this deformity without having to tighten the inside of the knee to compensate for the tight outside ligaments. This tightening of the medial ligament then needs to be protected with a splint for 6 weeks until it heals, and it may never be as tight as a normal knee. Hence, the knee may feel loose and may even require further surgery to deal with this problem.

The alternative approaches to the problem of a very valgus knee are either, to release the outside ligaments of the knee completely and to use a more stabilised knee prosthesis to make up for them, or to perform an osteotomy, cutting the bone above the replacement at the same time, and making the correction at that level. Whilst the latter is done in a few centres in the world, it increases the complexity of the surgery, and therefore, the potential for complications. Accordingly, the above solutions need to be tailored to the individual. Fortunately this is an uncommon problem.

Getting the alignment right: The currently used systems are, for the most part, computer based. These seem better than the older systems that involved the use of rods being passed up the canals in the centre of the bones (intra-medullary) in that, they are not only more accurate, but they also do not risk pushing marrow fat into the blood stream (fat embolus) by raising the pressure inside the central bony canals.

Computer navigation: The computer systems in use fall into two distinct types. The first system, known as computer navigation, involves the use of reflective arrays which are tracked by a camera (like cricket and tennis balls are now tracked so that their position and path can be assessed after delivery). In this process, each of the bones around the knee (the femur and the tibia) have 2 pins placed into them onto which the arrays are fixed. By moving the femur (thigh) around, the camera can track the array attached to that bone, and hence it can track the position of that bone in space. Because the hip is a ball and socket joint, the femur rotates about the centre of that joint. By moving the femur around in space, the computer can work out where that centre of rotation is and hence it knows where the centre of the hip is. This can be done to an accuracy of a few millimetres in most cases (see diagram of screen shot below). Using a pointer with an attached tracking array, the knee can then be mapped out and the ankle located. The computer will then adapt that information to conform to one of the standard models in its reference memory, which then leads it to be able to determine alignment and prosthetic size.

By using the information that the computer generates, and by using cutting blocks with tracking arrays attached to them, the level of the cut to be made in each bone can be determined. Similarly, the angle of that cut in both other planes, can also be determined. Using this information helps to get a well fitting prosthesis and a well aligned leg (straight, not bowed or knock-kneed). These systems are accurate to better than 3º overall in the vast majority of cases and, this small an error, has never been shown to be significant in terms of outcome.

One downside of computer navigation is the difficulty in predicting the location of the hip when it is stiff (arthritic). In this situation, where it does not move freely, the computer has much more difficulty in finding the centre of rotation of the femur, and hence the centre of the hip joint (which is required for alignment purposes). Whilst this is an uncommon problem, it is encountered. For this reason therefore, other methods of alignment are still needed, be they the older alignment methods with there known inaccuracies or newer computer methods that do not involve having to find the hip joint by calculation and estimation.

Computer designed cutting blocks: The newest alignment technology also involves the computer but, in this system, the computer is used pre-operatively and not intra-operatively (see pictures above). In this system, an MRI (or CT in some systems) scan of the knee is taken, along with long leg alignment x-rays. This does not produce either pictures or a report but, instead, digital information is acquired which is sent to the manufacturer of the prosthesis. Engineers then put this information together to develop a 3D image of the knee and leg on a computer. A virtual knee replacement is then performed on screen. Prosthetic size and placement is determined, including the level of the cuts, the angle of the cuts and so forth. Once this has been done, these pictures, including 3D models which can be viewed from any angle, are forwarded to the surgeon for approval or adjustment. Cutting blocks are then made which fit on the ends of the bones (specific for every individual patient), enabling cuts to be made (see pictures below). In this system, the accuracy is limited by the quality of the MRI scan (or CT in some cases), and the limitations of adapting a knee scan and x-ray to represent a whole leg in 3D, rather than the accuracy of the surgery. For this reason, only some scanners are approved for this type of replacement.

The purported benefits of computer generated cutting blocks are many but, when the first 200 of these were reviewed by Dr Holt, it became clear that this method did not always get it right. Also, there was no way of checking the alignment in the theatre at the time of surgery: hence, if it is incorrect, that may not be known until after surgery. Currently therefore, Dr Holt’s preferred method is to use the in-theatre computer navigation system, which, in his hands, have produced the best alignment results.

Swelling is normal within the knee and may last 6 - 9 months. Swelling of the leg and foot also occurs and sometimes this is more chronic. Generally, this relates to poor venous or poor lymphatic drainage after surgery. Anyone with bad veins, or who has had swelling in the legs before hand, is at significant risk of having permanent swelling in the leg afterwards. Fortunately however, even when this occurs, it is usually relatively minor.

Infection is fortunately uncommon. In most series it occurs in about 2 per 1000 cases, but is higher in those at risk (diabetics, haemophiliacs, those on anticoagulation and so forth). To decrease the risk, all patients are given antibiotics at the time of, and after surgery, and the cement that is used generally contains an antibiotic that leaches out into the joint over several weeks. Special lamina flow air-conditioning systems are required for this type of surgery, which means that not all hospitals, and not all operating theatres, are suitable for this. Other precautions, such as the wearing of fully enclosed space suits, are also taken.

Whilst the knee can become infected at the time of surgery, late infection is probably more common. It is thought that the organisms reach the prosthesis through the blood and land on the metal. Because the metal is not living, the organisms can hide from the body’s defences: and hence can grow and multiply to the extent where a significant infection is caused.

If infection occurs, and it is treated acutely, it can generally be treated with washouts of the knee and antibiotics. It is however, hard to totally eradicate the infection, which can
sometimes mean life-long suppression with antibiotics. Sometimes the polyethylene liner also needs changing to improve the chances of success, and this does seem helpful in the more acute situations.

If this approach does not work, or the problem is chronic, then a 2 stage revision can be undertaken. This is a major undertaking, initially requiring removal of the prostheses and implantation of cement spacers (which contain antibiotics which leach out into the knee over time). This is combined with prolonged intravenous antibiotic therapy which typically lasts 2 months. The antibiotics are then stopped and, if the infection does not return or flare up, the spacers are removed and a new knee is inserted. This has a high chance of success but it is not 100%, and the new knee may never be as good as the first.

D.V.T.’s (deep venous thromboses) can also occur, and are relatively common if no preventative treatment is given. These represent clots in the deep veins of the leg, usually the calf. They may occur at the time of surgery and then get slowly bigger over several days, or they may come on sometime thereafter. If symptomatic, it is usually as an ache in the calf at the back of the leg. If this is thought to be occurring, then a doppler (ultrasound) scan can be used to investigate it, and, if confirmed, appropriate treatment then organised.

P.E. The concern of having clots in the vein is always that they may spread to the lungs (pulmonary embolism or P.E.). This is a rare event but does represent a major and serious complication of this and other lower limb surgery. In the majority of cases, like DVT’s themselves, it is treatable by thinning of the blood. This prevents new clot from forming and allows the body time to slowly dissolve the clot that is present.

Because of the risk of these complications, almost all patients will be given some form of preventative treatment. This usually means a thinning of the blood with a low molecular weight heparin, such as clexane, for the first 5 days. After this, an oral anti-coagulant can be used. Mostly this just means low dose aspirin (100mg taken once a day - e.g. Cartia - for 6 weeks). If the risk is higher than normal, then other treatment may be advocated. This most usually means changing over to a factor 10a inhibitor such as Rivaroxaban (Xarelto), or Apixaban (Elequis), both of which are approved on the PBS for use after knee replacement. These are tablets which are used for 15 days after the clexane. We have previously tried to use these drugs immediately after surgery rather than clexane injections, but they can cause excessive bleeding and bruising if given too early. For that reason, we still use clexane for the first 5 days before moving to an oral agent.

The above prophylaxis significantly decreases the number of D.V.T.’s but, as a consequence, it does increase the amount of bleeding and bruising; albeit to a variable degree. Unfortunately, even though such partial anti-coagulation lowers the risk of getting a D.V.T. to less than 5%, the risk of getting a pulmonary embolus may be unchanged (currently less than 1%). Unfortunately, only full anticoagulation can change the incidence of P.E., and such treatment has serious complications of bleeding which are both detrimental to the knee in the longer term, and pose significant risks of bleeding elsewhere in the body. Hence, whilst Surgeons in the United States once used to advocate full anti-coagulation after Joint Replacement Surgery (to try and prevent pulmonary embolism at all cost), there now seems to be a more realistic approach similar to what is advocated in this country. This emphasises that the risks should not exceed the benefits.
Fat embolism probably occurs more often than is usually thought. In this problem, fat (from the marrow in the centre of the bone) is forced into the circulation by pressure increases in the marrow at the time of surgery. Modern instruments are designed to minimise this problem but, occasionally, it still occurs. It is difficult to diagnose, and there is no specific test for this problem. Most usually however, there is a change in oxygen uptake and/or conscious state (like a stroke), presumably because the fat in the circulation blocks off some of the blood vessels to the lung and/or brain. Most commonly it resolves over about 1 - 2 days and, unlike a real stroke, it is rare that full resolution does not occur.

The risk of fat embolism is highest where the alignment jigs include rods that are passed up the centre of the bones (intra-medullary), thereby increasing the pressure in the marrow cavity, and hence squeezing the fat into the venous system. Whilst this method of leg alignment is currently the most used in the world, Dr Holt has not used this since 1990 for primary knee replacements, rather favouring the safer alternatives of x-ray screening of the hip or, in recent years, using the computer navigation.

Revision knee replacement, and difficult primary knees requiring the use of stems, are different. In this situation entering the canal cannot be avoided. Fortunately, the chance of this giving rise to a significant problem is small.

Foot drop occurs when one of the nerves that cross the side of the knee is stretched, usually in correcting a very valgus (knock kneed) knee. This occurs some 2 - 4% of the time and usually is transient, generally resolving over a period of days to weeks. Long term or permanent foot drop is rare, virtually all having recovered by 3 months.

Vascular injury is uncommon, but the artery at the back of the leg, the one that supplies all of the leg below the knee, is just millimeters behind the exposed back of the knee: theoretically therefore, it is at risk. The reality however, is that direct injury to this is rare, most problems relating not to surgical mis-adventure, but to poor blood supply in the first place. This particularly applies to smokers and diabetics and, if the blood supply to the foot in these people is poor, then the limb is at some risk. Despite this however, problems are rarely encountered, hence it would be unusual for poor circulation to actually preclude replacement surgery.

Failure of the prosthesis does occur for various reasons. Usually it relates to wear of the polyethylene (plastic) which is still an unsolved problem. Modern polyethylene however, will last 15 - 20 years (and maybe even 30 years) if the knee is well aligned and well looked after. The polyethylene undergoes straight forward mechanical wear and hence, younger more active people will wear it out more quickly than older more sedentary people. That having been said, in most prosthetic systems, worn plastic can be replaced without having to replace either of the metal components.

Debris from polyethylene wear may cause reactions in the tissues about the replacement. In its mildest form this means some irritation of the synovial lining of the knee causing some minor aching and swelling. This is usually the first real sign of wear and should indicate the need for a review of the knee to see if polyethylene replacement is indicated. This process can go on for months or even years before any significant damage is caused, but sometimes these signs can appear quite late in the process, suggesting that earlier review rather than later, is a good idea.
Unusually in the knee (but more commonly in the hip due to the smaller size of the polyethylene debris particles) the metal components may come loose due to bone resorption (osteolysis). In this process, the irritating debris particles in the joint incite the body to make chemicals (prostaglandins) which, in turn, try to remove or dissolve those particles. As one could imagine however, the plastic is relatively immune to this sort of attack, whereas the bone is not. Hence, with time, the bone around the edges of the prosthesis may gradually be eroded, eventually leading to large cysts in the bone, and loosening of the components. Should this happen to a significant degree then, eventually, either the replacement will come loose, or the bone will fracture, or both. All of these situations require a full revision of all components.

Osteolysis (bone dissolution) and component loosening is, fortunately, very uncommon in knee replacement. This why we sometimes advocate this procedure in younger people if their arthritis is bad enough. We know that for the most part, even in this group, revision is only going to be a matter of a polyethylene exchange and not a major component revision.

With any suggestion of wear (increased pain and swelling) it is important to seek early consultation. Even if osteolysis is not occurring, the plastic can wear right through, causing one metal component to articulate directly on the other metal component. This in turn leads to scratching and wearing of the metal components, which then have to be replaced as well. Whilst this can be done, it is much bigger to do and, because bone is lost during removal of well integrated metal components, there is less bone to support the new components. This is one of the reasons why revisions do not do as well in the longer term as primary replacements: hence, if revision of the metal components can be avoided, it leads to a better long term outlook.

Summary
Knee replacement is a commonly performed and generally very successful procedure. It does have complications but most of these can be avoided, minimised or treated. For those with severe arthritic pain or deformed knees, the risks are generally well outweighed by the benefits.

Further information can also be obtained on this and other related topics, such as:
- Pain management after knee replacement
- Rehabilitation after knee replacement
- Knee replacement after discharge

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