Total knee arthroplasty and revision

By Rick Harburn, R.N.A.

Total knee arthroplasty first began in the 1940's, but its current state of development has really only taken off since the early 70's. Today there are hundreds of different models of artificial knee joints on the market. Even so, the art of total knee arthroplasty remains imperfect, enjoying a somewhat lesser degree of recognition and success than total hip arthroplasty. In the past few years, however, medical technology has made inroads in correcting the errors of the early pioneers in the field of total knee replacement. This technology is continuously developing.

The prosthesis

A prosthesis is the replacement of a missing, damaged or chronically painful part of the body by an artificial substitute. To be satisfactory, among other attributes, a prosthetic device should provide the client/patient with relief of pain. It should adequately correct any deformity present.

An ideal joint prosthesis will correct and provide stability as well as furnish the individual with at least 90° or more of flexion. The artificial joint should be expected to maintain itself in excellent working order for several years, and in the event of prosthetic failure, should provide for easy arthrodesis (surgical immobilization of the failed joint or joint fusion) and/or revision of the prosthesis.[1]

Patient selection

Who should have a new knee joint? Total knee arthroplasty should be considered a valid surgical procedure before arthrodesis if the person would have been a candidate for arthrodesis before the advent of total knee arthroplasty.[1]

This procedure is performed for patients with osteoarthritis, rheumatoid arthritis and traumatic arthritis where the degree of articular surface destruction and joint laxity precludes the use of a simpler operation, for example, a synovectomy (the excision of the synovial membrane).

Knee joint arthroplasty is done to decrease or relieve pain, to improve joint stability and to correct deformity present in the joint. The individual being considered for a new knee joint should probably be around 60 years of age or older. The reason for this is that the long term results are not yet fully known to surgeons, with the life of current prosthetic devices appearing to be around seven to ten years.

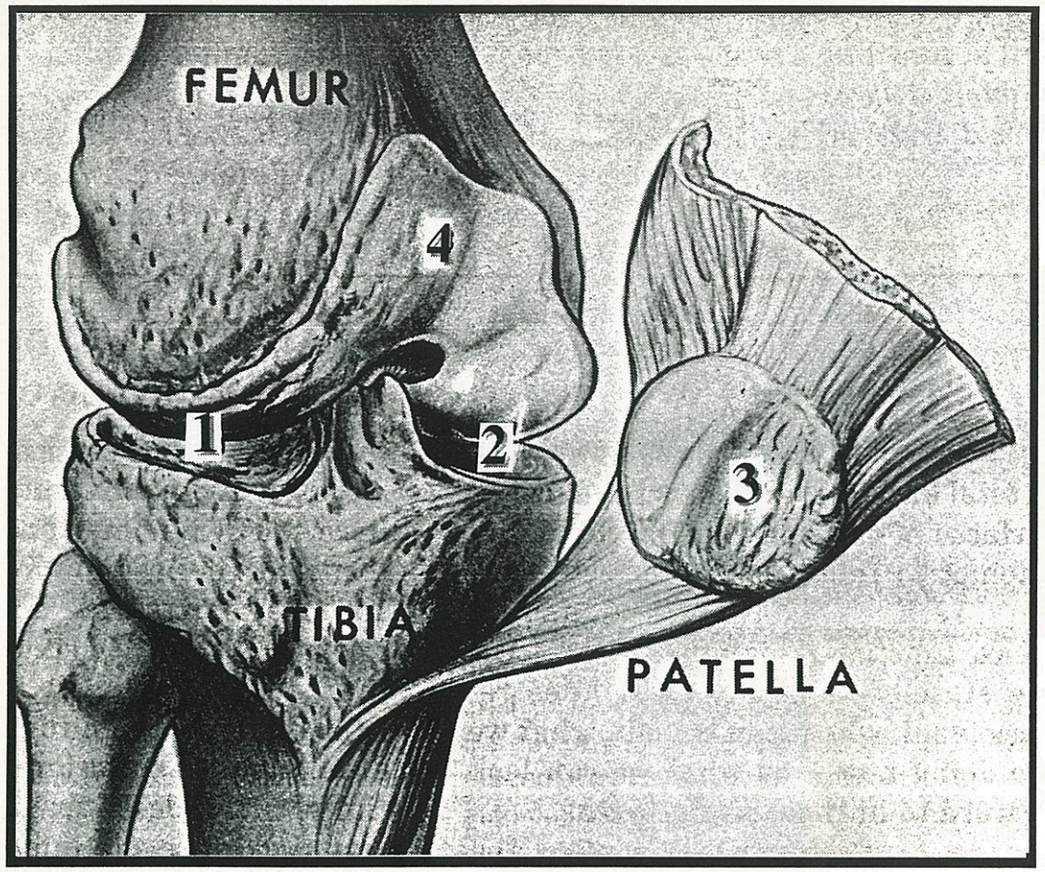
Thus, putting a prosthesis in someone 40 or 50 years old may severely limit future options if the implant fails or wears out when they are 60 years old.

Delayed and immediate complications associated with arthroplasty of the knee joint occur frequently enough for it to be considered as a last resort when all other alternatives, except arthrodesis, have been exhausted. For those individuals who have had a total knee arthroplasty, more than 50% have been satisfied with the outcome, and around 80 percent reported pain relief after surgery.

Three categories of prosthetics

Although many different models (of artificial knee joints) exist on the market today, prosthetic devices can be divided or classified into three basic categories based on degree of restraint:

1. Non-constrained
2. Partially constrained, and
3. Fully constrained[2]



Articulating surfaces of the knee

1. **Lateral femoral condyle & tibial plateau**
2. **Medial femoral condyle & tibial plateau**
3. **The articular surface of patella**
4. **Anterior surface of femur**

• The first category of prostheses are non-constrained, which amount primarily to resurfacing implants; that is, replacing one or both sides of the tibial plateau and offering very minimal restriction of movement.

• Partially constrained implants, the second category, restricts motion transversely, rotationally and in anterior/posterior directions. With partially constrained implants, only the articulating surfaces are replaced, with partial stability of the joint coming from the metal runners of the femoral component articulating with the grooved polyethylene tibial component. The patient must have stability of the medial collateral ligaments and posterior cruciate ligament if the partially constrained implant is used.

• Constrained implants by definition limit movement in all planes. Hinged type joints are used when there is marked instability and supporting ligaments are destroyed, or for revision when other attempts have failed. They are designed to give increased stability since the femoral component is fixed to the tibial component to form a hinge. Non-hinged joints are similar in principle to hip prostheses since a stainless steel femoral component articulates directly with a high density polyethylene tibial component. **(Illustration 1 - following page)**

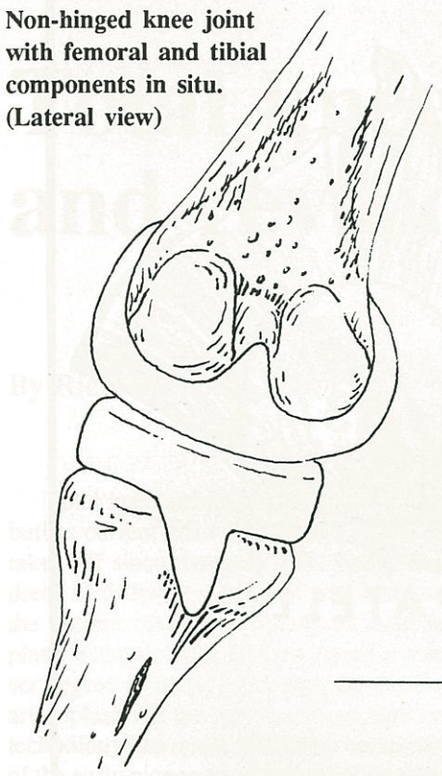
The procedure

Although each particular model of non-hinged and hinged joints will come supplied with its own particular surgical guide from the manufacturer, the procedure for the operating room technician follows a similar pattern for all.

Generally, a medial parapatellar incision is made and the patella is averted and deflected off to the side. **(Diagram above)**. Once the knee joint is exposed tissues are removed from the joint to expose the distal femur. With the knee flexed to at least 90°, an alignment guide is placed in a drill hole that has

Illustration 1.

Non-hinged knee joint with femoral and tibial components in situ. (Lateral view)



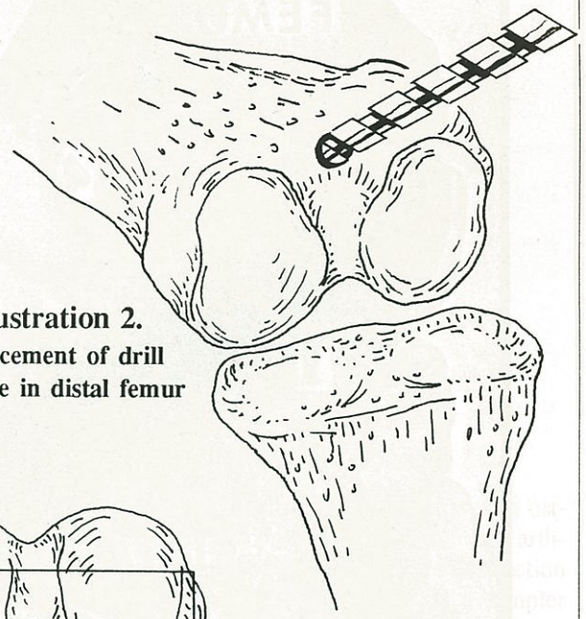


Illustration 2.
Placement of drill hole in distal femur

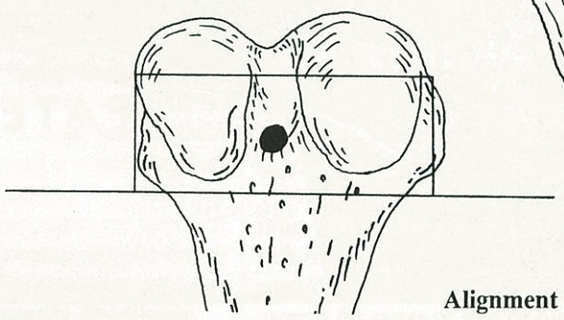


Illustration 3.
Alignment guide placement

been placed anterior to the intercondylar notch and parallel to the femoral shaft. **(Illustration 2)**

A femoral cutting guide is placed parallel to the posterior femoral condyles so that the surgeon can make correct cuts and ensure proper placement of components in subsequent steps. **(Illustration 3)**

Next, the anterior condyles are removed by using various attachments on the alignment guide. Following this, the distal femur is excised using the distal femoral cutting guide, and the lateral and medial condyles are resected.

The distal femoral surface should be checked to ensure that it is flat in order to ensure proper placement of instrumentation.

Following the femoral cuts the anterior/posterior measurements are done with the knee hyperflexed. With the measurements obtained, one can fix the femoral cuts if needed.

Next, the surgeon will progress to the tibial cuts, and after ensuring proper anatomical alignment with a tibial cutting guide, the proximal end of the tibia is resected.

Following completion of the tibia, the patella is prepared to receive its component by making sure the posterior aspect is flat. This is done by holding it firmly with the appropriate instrument and using a saw to shave it down to the level of quadriceps tendon insertion. This now completes the bone cuts necessary for the insertion of the prosthetic implants. **(Illustration 4)**

It is probably best to use a new saw blade for each case to ensure the best possible cuts. The operating room staff should note that although some 600 different saw models are available, each has the same equipment to do the basic bone cuts. These instruments may look different and be called different names, but they do the same basic things.

Alignment

Thus far, in this description of the surgical procedure for a total knee replacement, alignment is mentioned repeatedly. In order for the surgical team to achieve the goals of arthroplasty adequately, normal alignment must be reconstructed or preserved in order to maintain optimal alignment and ligamentous balance in the knee.[8,9]

As noted in **Illustration 5**, the normal stress bearing surfaces on the knee is 3° valgus (a term denoting position, meaning bent outward or twisted,

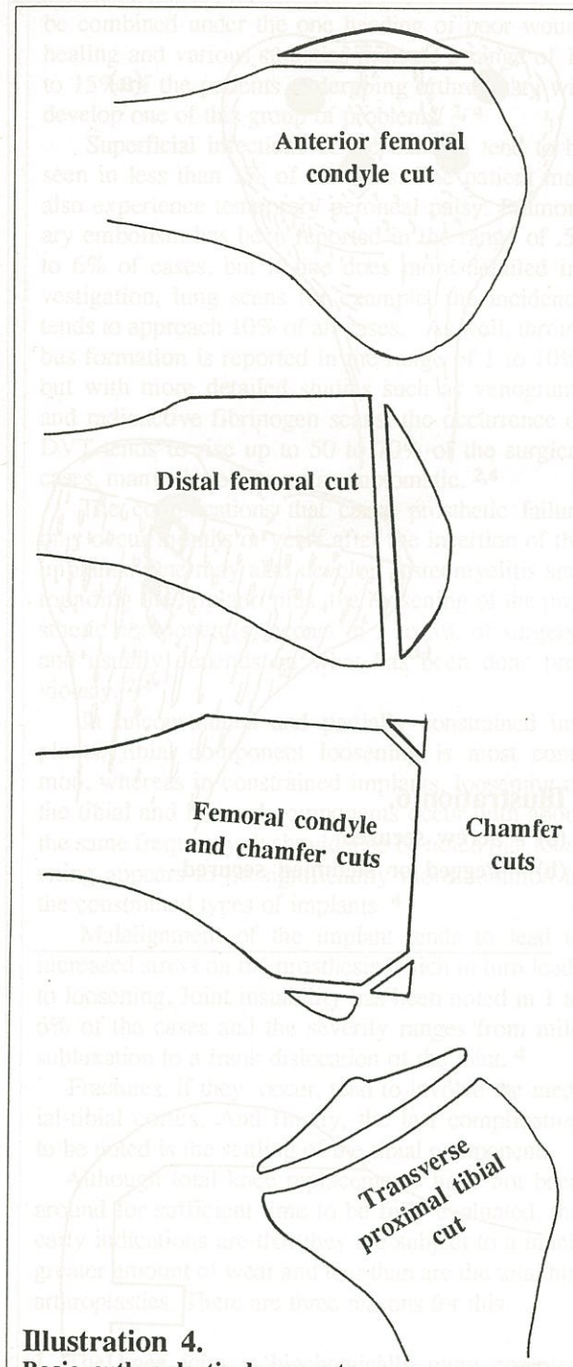


Illustration 4.
Basic arthroplastic bone cuts

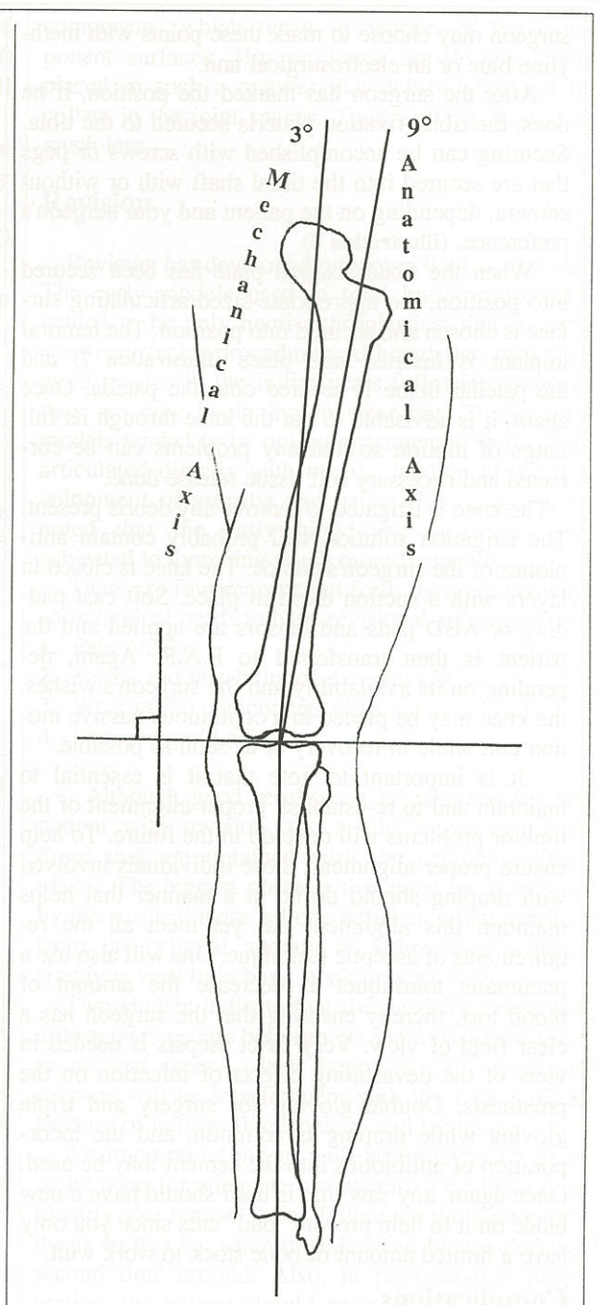


Illustration 5.
Maintaining proper alignment

and away from a identifiable midline or axis) with the anatomical axis of the femur approximately 9° valgus. The normal tibial surface is about 3° valgus. So, the implants must be inserted correctly to maintain this proper alignment to avoid problems in the future. The measurements allow the surgeon to cut the distal femur perpendicular to the mechanical axis and ensures a parallel cut in relation to the proximal tibial surface.

The operating room nurse can now prepare the tibial trial and femoral trial components that the surgeon will use. Once the surgeon has the tibial and femoral trial components properly situated, he/she should put the knee through its full range of movement and check the ligament stability. As the surgeon puts the joint through its range of motion, the tibial and femoral trial components will seat themselves into their ideal position; at this point the

surgeon may choose to mark these points with methyline blue or an electrosurgical unit.

After the surgeon has marked the position, if he does, the tibial fixation plate is secured to the tibia. Securing can be accomplished with screws or pegs that are secured into the tibial shaft with or without cement, depending on the patient and your surgeon's preference. **(Illustration 6)**

When the tibial fixation plate has been secured into position, the appropriate-sized articulating surface is chosen and secured into position. The femoral implant is inserted into place **(Illustration 7)** and the patellar dome is secured onto the patella. Once again, it is advisable to put the knee through its full range of motion so that any problems can be corrected and necessary soft tissue release done.

The knee is irrigated to remove any debris present. The irrigation solution will probably contain antibiotics of the surgeon's choice. The knee is closed in layers with a suction drain in place. Soft cast padding or ABD pads and tensors are applied and the patient is then transferred to P.A.R. Again, depending on its availability and the surgeon's wishes, the knee may be placed in a continuous passive motion unit while in recovery or as soon as possible.

It is important to note that it is essential to maintain and to re-establish proper alignment of the limb or problems will develop in the future. To help ensure proper alignment, those individuals involved with draping should do so in a manner that helps maintain this alignment but yet meet all the requirements of asceptic technique. One will also use a pneumatic tourniquet to decrease the amount of blood lost, thereby ensuring that the surgeon has a clear field of view. Very strict asepsis is needed in view of the devastating effects of infection on the prosthesis. Double gloving for surgery and triple gloving while draping is common, and the incorporation of antibiotics into the cement may be used. Once again, any saw that is used should have a new blade on it to help prevent "bad" cuts since you only have a limited amount of bone stock to work with.

Complications

As with any procedure, the total knee arthroplasty is not without its complications. Complications can be divided into two different categories, the first being early complications and the second, late complicatiosn or those that lead to failure of the prosthesis. General anaesthesia in and of itself has potential serious problems for the patient as well.

Early complications include haematoma formation, necrosis of the skin since the knee doesn't take kindly to multiple criss-cross incisions and sterile drainage. These three separate problems can

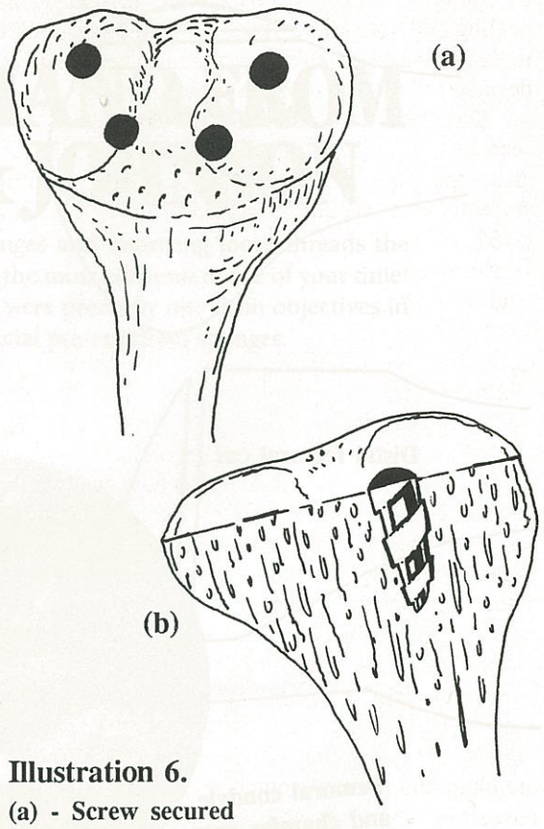


Illustration 6.
(a) - Screw secured
(b) - Pegged or stemmed secured

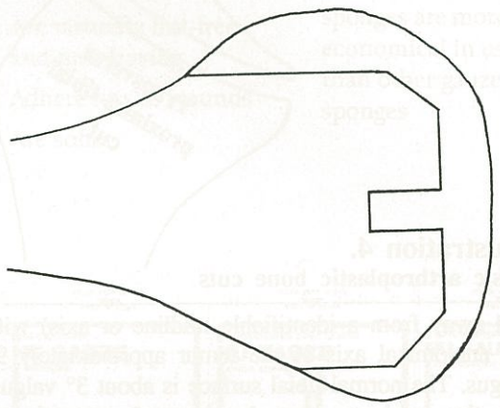


Illustration 7.
Femoral component attached

be combined under the one heading of poor wound healing and various statistics indicate a range of 10 to 15% of the patients undergoing arthroplasty will develop one of this group of problems. [2, 4]

Superficial infections of the incision tend to be seen in less than 1% of all cases. The patient may also experience temporary peroneal palsy. Pulmonary embolism has been reported in the range of .50 to 6% of cases, but if one does more detailed investigation, lung scans for example, the incidence tends to approach 10% of all cases. As well, thrombus formation is reported in the range of 1 to 10%, but with more detailed studies such as venograms and radioactive fibrinogen scans, the occurrence of DVT tends to rise up to 50 to 70% of the surgical cases, many obviously are asymptomatic. [2,4]

The complications that cause prosthetic failure may occur months or years after the insertion of the implants. One may also develop osteomyelitis surrounding the implant; plus, the loosening of the prosthetic component(s) occurs in 3 to 5% of surgery, and usually depends on what has been done previously. [2,4]

In unconstrained and partially constrained implants, tibial component loosening is most common, whereas in constrained implants, loosening of the tibial and femoral components occur with about the same frequency. It should also be noted that loosening appears to be significantly more common to the constrained types of implants. [4]

Malalignment of the implant tends to lead to increased stress on the prosthesis which in turn leads to loosening. Joint instability has been noted in 1 to 6% of the cases and the severity ranges from mild subluxation to a frank dislocation of the joint. [4]

Fractures, if they occur, tend to involve the medial-tibial cortex. And finally, the last complication to be noted is the settling of the tibial component.

Although total knee replacements have not been around for sufficient time to be fully evaluated, the early indications are that they are subject to a much greater amount of wear and tear than are the total hip arthroplasties. There are three reasons for this:

1. The knee joint is biochemically more complex than the hip joint. The ball and socket of the hip allow mainly rotational movement, while with the knee, one must contend with sliding, rotational and flexion/extension movements.

2. The knee joint is subjected to a wide variety of stress-producing forces.

3. The basic component design of knee prostheses causes debris to become entrapped in between the components which result in erosion of the component surfaces. Hip protheses are designed and placed in such a manner that debris tends not to collect in the joint spaces. Thus, surface erosion is much less.

Revision

Revision has developed only over the past decade. The early models used in total knee arthroplasty tended to be only hemi-arthroplasties; that is, they were resurfacing procedures. Although they provided good service in the initial years following surgery, they are now beginning to wear out. These early models tended to be uni-compartmental; thus, bone articulated directly with metal, leading to the development of arthritis and pain. Also, it has been noted that the early hinge-type prostheses are subjected to loosening much more frequently.

There are four reasons put forth by surgeons why an individual needs to have revisional arthroplasty:[6]

1. Pain *(42%)*
2. Sepsis and instability of the joint *(32%)*
3. Wear of the components *(16%)*
4. Loosening *(12.5%)*

Although good results can be obtained for the patient with revision, the results never approach those that are obtained with the original arthroplasty. The biggest obstacle that must be overcome by the surgical team is bone deficiency that resulted from the original attempt at arthroplasty - there simply is very little bone stock to work with.

Two studies indicate that the need for revisional arthroplasty occurs between 10 and 13% of the time in original cases.[5] It is hoped that the need for revision will be less frequent with the later models because of improved technology and technique.

An important concept with arthroplasty revision is the need for adequate pre-operative evaluation to identify the reason(s) for failure of the first prosthesis so that the same mistakes can be avoided the second time around. Also, in pre-operative preparation, the patient should have weight-bearing X-rays in order to evaluate the amount of bone likely to be left when failed components are removed.

Revision problems

The amount of bone stock left from the previous surgery may influence the surgeon's choice of prosthesis that will be used. The surgeon will also want to determine if sepsis is present prior to surgery by the use of physical findings, CBC, sed rate, gram stains and cultures of joint fluid. In revision, the team will encounter three problems:

1. bone loss
2. previous bone-cement interface with its resultant sclerosis, and
3. soft tissue scarring

Surgery begins with special attention given to the skin and soft tissues. The revision incisions will be made through the previous incisional scar. Special care is given to prevent patellar tendon avulsion (tearing away of the structure). The underlying muscles are divided to allow for good exposure of the field. The old implant is carefully removed so as to preserve as much bone as possible and to protect ligamentous structures.

Once the team has carefully removed the old implant, removal of any remaining cement and interposed fibrous membranes that have formed is done so that there will be no barriers to bone-cement interfacing when the new prosthesis is implanted. Inserting new cement under pressure while it is less viscous ensures better penetration into the cancellous bone present, thus, hopefully, resulting in a more secure interfacing. Once the surgeon has removed the old implant, he will have a better idea of the type of implant that will be used for the revision. Therefore, before surgery, operating room staff must ensure that a full range of implants are available. Generally, the least constrained device possible that adequately rectifies the problems will be used.[4] The goal is to ensure proper seating of the component on as large an area of bone that is possible. The use of thick stemmed tibial components help to compensate for this bone loss.

Proper closure of the revision is equally important. Bone grafting ligament release or advancement may be needed in order to regain balance of soft tissues and stability. Balancing of the quadriceps mechanism is important for proper patellar tracking, as is attachment of the vastus medialis. All this ensures or helps to ensure the stability of the joint similar to that found in a healthy knee. Postoperative care regime is similar to that followed for the initial arthroplasty.[7]

Conclusion

For the older or more sedentary patient, the goals of total knee arthroplasty include pain relief, improved stability of the joint and correction of deformity. Thus, improving the patient's independence and well-being appears to have the same success as that approaching or associated with hip arthroplasty.

For the younger, more active patients, the development of porous coated prostheses that promote biological fixation by boney growth similar to that of cementless hips, and the use of better equipment and techniques, holds great promise for the future. The use of these new types of prostheses in younger patients (under 60 years of age) appears to overcome the limited life expectancy of current models, thus giving a better quality of life to more people.[4] ■

References/Bibliography

1. Bently, G., Operative Surgery - Fundamentals, International Techniques of Orthopaedics, 3rd Edition, Butterworths Press Inc., 1979.
2. Lurek, S.L., Orthopaedics, Principles and their Applications, 4th Edition, Lippincott & Son, 1984.
3. Cruess, R.L., Rennie, W.R.J., Adult Orthopaedics, Churchill-Livingston Publishing, 1984.
4. Crenshaw, A.B., Campbell's Operative Orthopaedics, 7th Edition, C. V. Mosby, 1987.
5. Orthopaedic Clinics of North America, Vol. 13, No. 1, 1987; C. Mosby Co., St. Louis, Mo.
6. Clinical Orthopaedics and Related Research, Norman W. Scott, editor, No. 205, April; Lippincott & Son, 1986.
7. Clinical Orthopaedics and Related Research, Cracchiolo, Andrea, Editor; No. 170, October, 1982; Lippincott & Son.
8. Zimmer Corporation, product information on Miller/Galante Total Knee System, Warsaw, Ind.
9. Howmedica, Product Information on P.C.A., Total Knee System, Ruthorford, New Jersey.

Autobiography

Rick Harburn, R.N.A., received his diploma from Assiniboine Community College in Brandon, Manitoba. He is a graduate of the Post Graduate Operating Room Technique Program at Hotel Dieu Hospital in Kingston, and is currently an operating room technician at the Ottawa General Hospital.

Newfoundland OR nurses announce dates for 10th Annual Conference

The Newfoundland and Labrador Operating Room Nurses Association (NLORNA) will be holding its 10th Annual Conference at the Glynmill Inn in Corner Brook, Newfoundland. Dates for the conference are June 1 to 3. For more information contact:

Angela Lemoine, R.N.
Chairperson - P.R. and Hospitality
P.O. Box 67 W.E.P.S.
Corner Brook, Nfld. A2H 3J0