Surgery of the rheumatoid knee

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The knee is the most commonly affected major joint in rheumatoid arthritis. Fleming *et al* showed that one or both knees eventually become affected in 90% of patients, with unilateral involvement in 30-35%.¹ This compares with a 40% incidence of hip involvement in patients with rheumatoid arthritis.

This high level of knee disease clearly has great significance in relation to the need for knee surgery. As a result it has become the most commonly replaced joint on the rheumatoid arthritis service at the Princess Margaret Rose Orthopaedic Hospital in Edinburgh.

Pathology

The earliest pathological lesion in rheumatoid arthritis is synovitis, which leads to pain and swelling. Continuing synovitis produces marginal erosion of the articular cartilage and then a more widespread loss due to the progression of pannus across the joint surface and to the liberation of lysosomal enzymes. The breakdown of hyaluronic acid plugs between the synovial cells leads to the transudation of large molecular weight substances like fibrinogen into the joint. This leads to the production of intra-articular fibrin or rice bodies, which are commonly seen at surgery.

The ligaments are protected from direct synovial invasion. Loss of articular cartilage, however, leads to laxity of the ligaments with subsequent instability of the joint. Ligament preservation is of great significance in knee reconstruction because by the use of tibial components of variable thicknesses a spacer effect is created with the ligaments being stretched out to regain their normal length. Not only does this allow full stability to be achieved but it also allows the ligaments to contribute to the attenuation of the considerable loading which occurs across the joint during activity.

Popliteal cysts are common and are usually semimembranous bursae. A one way passage of fluid occurs through a valvular mechanism in the posterior capsule allowing the cysts to reach a large size. Occasionally, they extend to the ankle, causing great discomfort due to their sheer volume. Rupture of these cysts presents as an acutely painful episode difficult to differentiate from a calf thrombosis. The differential diagnosis can be resolved by arthrography with demonstration of contrast leaking into the calf.

Flexion deformities commonly occur because in this position the intra-articular volume is largest. Valgus is the most common form of axial malalignment. This is sometimes combined with flexion and external rotation of the knee, all of which require correction at the time of surgery.

Function of the knee

In the standing position it is desirable that the knee is maintained straight to achieve full stability of the joint, and to reduce the need for quadriceps contraction. Standing with a flexed knee requires greater quadriceps effort, which results in a greater load being transmitted across the joint.

Only 30° of knee flexion is required for level walking but more is necessary to rise from a chair. This activity requires that the centre of gravity of the body, which is sited at the level of the second piece of the sacrum, is brought over the foot. This function is greatly assisted by the patient having sufficient knee flexion to allow the foot to be brought posteriorly towards the axis of the centre of gravity. Without 105° of flexion the patient will have great difficulty in getting out of a chair without using the upper limbs to propel the body forwards.²

Preoperative assessment

The knee should not be considered in isolation from the other joints in the lower limb. A flexion contracture of the hip will lead to a similar deformity in the knee, producing increased stress across the joint. An adduction deformity at hip level may also produce a valgus axial malalignment at the knee. It is also important to consider the ipsilateral foot. Failure to correct a fixed varus or valgus deformity of the hindfoot may lead to the patient walking on one border of the foot subsequent to hip or knee surgery.

The circulation of the limb is also of fundamental importance. Major vessel obstruction is a contraindication to total knee replacement. Skin breakdown is also a contraindication, whether this is due to varicose or vasculitic ulceration. Skin breakdown over the toes due to abnormal pressure in association with a forefoot deformity is also common. These lesions can act as a significant portal of infection, which may jeopardise the joint replacement. They should all be dealt with before knee reconstruction.

Surgical management in the early stages of rheumatoid arthritis

SYNOVECTOMY

The initial hope that surgical excision of synovitis within the knee joint would eradicate the disease process has not been substantiated. Synovectomy was first introduced by Volkmann at the end of the nineteenth century and later established in clinical practice by Swett.³

Surgical synovectomy entails an 85% clearance of the synovium through a limited anterior

approach to the joint. Not only is the synovium incompletely excised but there is much evidence to support the fact that it regenerates very rapidly. Mitchell and Shepherd have shown that human synovium re-forms in eight weeks and contains both a and b cells at an early stage.⁴ There was some evidence that it was more highly collagenised, making it immunologically less competent. Other workers have shown that with the passage of time the synovium becomes almost indistinguishable from that seen in the acute disease.

The commonest current indication would be in a young patient with a well preserved knee joint who had hypertrophic synovitis with persistent pain and swelling which had proved resistant to medical treatment for at least six months.

The operation is usually carried out through a straight midline incision. The suprapatellar pouch is defined and the dissection carried into both medial and lateral compartments of the knee joint. More synovium can be removed if the menisci are excised, but it is my practice to preserve these in view of their proved shock-absorbing properties. Immediate postoperative mobilisation is carried out using a knee mobilising machine. There is much current interest in carrying out synovectomy arthroscopically. This effectively reduces the morbidity associated with the open operation, and the early results appear to be comparable.

The results of surgical synovectomy are clearly dependent on time. The best results are seen in those patients with well preserved knees at the time of surgery. These knees would of course survive longest even if surgery was not carried out. Unfortunately, preservation of the articular cartilage is no absolute guarantee of a good, longlasting result.⁵ A review carried out by Geens in 1970 of 500 cases from different centres showed that 80% of patients had some improvement after synovectomy.⁶

The results of surgery must be related to the natural history of rheumatoid disease, but in a condition which is punctuated by good and bad spells over periods of time it is difficult to assess the precise value of this operation.

Controlled trials were undertaken in the United Kingdom in 1976 in an attempt to resolve this question.⁷ Twenty two knees were followed up for three years. All the knees which were synovectomised had less pain, swelling, and tenderness, and had better looking radiographs at follow up than those of the control group. A similar controlled trial was carried out in the United States,⁸ which found less swelling but no other significant differences between the operated and unoperated knees at three years. At five years there was no difference between the two groups.

Although there are still many European protagonists of synovectomy,⁹ this operation is much less important in the management of the rheumatoid knee than it was a decade ago. On the rheumatoid service at the Princess Margaret Rose Orthopaedic Hospital in Edinburgh the number of synovectomies has fallen dramatically with a corresponding increase in the number of total knee replacements during this period. In

1987 only one knee synovectomy was carried out.

Pinder has shown that an anterior synovectomy is usually an effective way of dealing with popliteal cysts, reducing the production of synovial fluid and allowing the cyst to regress.¹⁰ Occasionally, it may be necessary to consider local excision of the cyst if it has become so large that it is responsible for local pain and tenderness. This local excision should logically be combined with either a synovectomy or joint replacement to prevent further recurrence.

FLEXION DEFORMITY

An early degree of flexion deformity can be corrected by the use of serial plasters provided that it is not accompanied by posterior subluxation of the tibia on the femur. Recently, Nelson *et al* reported the successful use of the Flowtron machine in the management of knee flexion contractures in haemophilic patients.¹¹ There is some evidence that this can also be used to correct similar deformities arising in rheumatoid disease.

If flexion contractures are very severe but are associated with a well preserved joint then posterior release may be considered. This can be done by the Wilson technique through a lateral incision with subperiosteal stripping of the gastrocnemii from the popliteal surface of the femur. Full operative correction may not be possible, but further correction can be achieved subsequently by the postoperative application of serial plasters.

Surgical management in the later stages of rheumatoid arthritis

FLEXION DEFORMITIES WITH JOINT EROSION

Flexion deformities can usually be dealt with at the time of joint replacement arthroplasty by the removal of more distal femoral bone, perhaps combined with posterior capsular release. If the flexion contractures are very severe, as may be found in bedridden or chair-bound patients, attempts at correction by extensive resection of femoral bone produce significant instability, which may require the use of a more constrained type of prosthesis. This approach will also result in the joint line being moved more proximally, producing a patellar baja. The abnormally low position of the patella will reduce the power which can be generated by the quadriceps. In these rare instances a posterior release may have to be considered before joint replacement surgery.

OSTEOTOMY

Osteotomy has little place in the correction of axial malalignment of the rheumatoid knee. This type of correction is only logical where load is transferred to a normal joint compartment. With a generalised arthropathy this is not the case. In 1976 Benjamin reported a double osteotomy of the distal femur and upper tibia, and although he reported pain relief in 75%, this operation has not been widely adopted.

MACINTOSH DOUBLE HEMIARTHROPLASTY

The insertion of metallic discs of variable

thickness on carefully resected tibial plateaux allows adjustment of alignment. The operation has the disadvantage that it replaces only one surface of the joint. Migration of the components was common and although the operation still has a few advocates, it is now largely of historical interest.

ARTHRODESIS

Because of the widespread joint involvement in rheumatoid disease it is important to preserve function wherever possible. This operation is therefore seldom carried out as a primary procedure. For an almost ankylosed but painful knee it might be considered because joint reconstruction under these circumstances can be difficult.

Arthrodesis may also be considered in some cases of arthroplastic loosening where there is much loss of bone stock which cannot be reconstituted. In these cases the use of a long intramedullary nail from hip to ankle combined with transverse pins across which compression can be applied may be an effective method of obtaining fusion.¹²

With an infected knee prosthesis, where implantation is considered inappropriate, arthrodesis is indicated (see below).

UNICOMPARTMENTAL KNEE REPLACEMENT

Like osteotomy there is no indication for unicompartmental replacement in rheumatoid disease. The disease is generally widespread and progressive and cannot be adequately treated by localised replacement of this type.

TOTAL KNEE ARTHROPLASTY

Total knee arthroplasty has become the most commonly required operation for the rheumatoid knee joint. In older patients the major indication is relief of pain, whereas in younger patients it is frequently performed for correction of deformity. The patients are generally younger than those with osteoarthritis and this gives rise to some concern about the longevity of

the prosthesis. Despite the young age and the poor quality of bone available in the rheumatoid knee it is probably the reduced activity of these patients which affords a significant degree of joint protection. The function and durability of this operation outweighs the grim alternative of a wheelchair existence.

DESIGN OF PROSTHESES

Routine use of the rigid hinge type of prosthesis has now been abandoned. There may be rare occasions requiring its use in revisional surgery when adequate stability cannot be achieved with unlinked components. Condylar prostheses are currently used. One piece tibial components are usually favoured (fig 1). The high density polyethylene of the tibial component is now incorporated into a metal tray to reduce the tendency to plastic deformation. The metal tray improves the distribution of loads to the underlying subchondral bone. A central metal peg will carry 25% of the compressive loads, whereas a plastic peg will carry only a few per cent (fig 2).¹³ An adequate range of tibial widths is essential to ensure that the device sits on the lateral and medial tibial cortices. If this is not the case the device can sink into the underlying bone—an important cause of loosening.

The question of whether the posterior cruciate ligament should be retained is still widely debated. Although it is agreed that this ligament can significantly absorb shearing stresses within the joint, it may have to be dispensed with if it remains as a tight band stretched across the posterior aspect of the tibial component. There is also some doubt as to whether it is significantly functional in the absence of the anterior cruciate ligament.

The posterior cruciate ligament tends to pull the femur back across the top of the tibia during knee flexion.² If the back of the tibial component is dished, impingement can occur between the two components in flexion. Without a cruciate ligament a dished component is required and stability is afforded in both anterior and posterior directions by the shape of the tibial component itself in combination with the tightness of the collateral ligaments. A further alternative is to substitute for the posterior cruciate ligament using a posterior stabilising device with a tibial cam which, during flexion of the knee, effects roll back of the femur on a flat-topped tibial component.

OPERATIVE TECHNIQUE

Preliminary synovectomy is unnecessary. Cook has shown that the antigenic stimulus to synovitis in the rheumatoid joint probably lies within the cartilage elements.¹⁴ Provided that all these cartilage islands are excised then any residual synovitis will resolve.

Jigs have now become an essential part of the operative procedure. These are designed to allow the implantation of the femoral component at 7° of valgus to the anatomical axis of the femur. The tibia is implanted at 90° to the longitudinal axis of the tibia in both the anteroposterior and lateral planes. The resulting

Figure 1 Total condylar prosthesis in situ with patellar button everted on left.

Figure 2 Kinematic condylar prosthesis in situ with metal backed tibial component.

joint line should be parallel to the floor (fig 2).

It is also important to restore the longitudinal axis of the limb. The normal mechanical axis aligns the centre of the hip, the knee, and the ankle (fig 3B).

Caution is required in the amount of tibial plateau to be resected because the compressive strength diminishes rapidly with the resection of more than 1 cm of bone. Deep bony resection may lead to tibial component failure.

There is still much argument about the need for patellar replacement in total knee arthroplasty. Cook's hypothesis suggests that if patellar articular cartilage is also removed then the risk of postoperative synovitis will be reduced.¹⁴ Ranawat, who has considered the advantages and disadvantages of patellar replacement, generally supported the concept of patellar resurfacing.¹⁵ Abraham *et al*, however, found there was no advantage in patellar resurfacing.¹⁶ In my series of 275 total condylar knee replacements, carried out in a mainly rheumatoid population, about half had their patellae resurfaced. This group had less anterior knee pain, better subjective stability, and less reduction of bone stock in the longer term than those whose patellae were not resurfaced.

Whether the patella is replaced or not it must track easily and lie within the femoral groove during passive flexion and extension of the knee. No support should be applied by the surgeon's thumb to the lateral border of the patella during testing of these movements at surgery (the 'no thumb' test). If the patella does not track easily in this manner then it is necessary to resect any fibrous synovial folds lying within the lateral recess of the knee. If this

Figure 3 (A) Preoperative valgus malalignment; (B) corrected by lateral soft tissue release to restore the mechanical axis of the limb.

still does not allow unsupported tracking it is necessary to carry out an extended lateral release from within the knee under direct vision. The superior lateral geniculate vessel should be preserved, if possible, to maintain patellar vascularity.

If both knees need to be replaced due consideration can be given to synchronous replacements in those patients who are generally fit enough to withstand a double procedure. It has been reported that there are no increased complications when this is carried out and it can significantly reduce the time spent in hospital.¹⁷

SPECIAL TECHNICAL PROBLEMS

Severe malalignment This can usually be treated by adequate soft tissue release. With fixed varus or valgus deformities this is achieved by release of the contracted soft tissues on the concave side of the deformity: release of the medial capsular structures and the pes anserinus in a varus deformity or division of the iliotibial band, and the popliteus tendon perhaps com-

bined with the lateral collateral ligament in cases of severe valgus deformity (Fig 3A). This type of release combined with the insertion of an unlinked condylar prosthesis can cope with the vast majority of deformities. There is seldom a need to use a constrained prosthesis.

Stiffness This can be severe in rheumatoid disease and poses a problem in the management of the extensor apparatus in these patients. The problem is how to release the extensor mechanism in order to insert the new joint, and to maintain a functional mechanism postoperatively while preserving motion. With a very stiff knee the proximal extensor apparatus can be released by the addition of an oblique limb to the proximal end of the standard medial parapatellar incision. This creates an inverted 'V', which can be advanced, allowing more knee flexion. Bradley *et al* reported the subperiosteal release of the insertion of the patellar tendon for this problem.¹⁸ Mobilisation of stiff knees should only be attempted by surgeons with considerable experience of knee replacement surgery.

Bone deficiency The tibial component must be implanted onto a flat tibial surface. If there are bone defects it is unwise to resect deeply into the tibia to create this. The alternative is to build up the defect to achieve a flat surface. With a central defect this can be achieved by filling the cavity with small fragments of morselised bone, obtained from the resected femoral condyles. Where the bone deficiency is peripheral, affecting the cortex, consideration can be given to augmenting the defect with either a posterior condylar fragment or, alternatively, a segment of femoral head allograft from the bone bank (fig 4). The long term fate of these segmental allografts is as yet uncertain. If they remain avascular they will be subject to fatigue, whereas if they revascularise there is a risk that the soft revascularised bone may deform under load. Where the bone deficiency is excessively large, metallic wedges have been devised for use with certain prostheses. These fill the deficiency to provide a flat surface on which to implant the tibial component.

Figure 4 Femoral head allograft screwed into defect on lateral tibial plateau.

Figure 5 Passive mobilisation after total knee replacement using knee mobiliser.

Postoperative management

Rehabilitation after surgery should be adjusted to the need of the individual patient. The adequacy of capsular closure, the state of the skin, or whether any previous surgery has been carried out are all important considerations. If there is any doubt about wound healing then it is preferable to immobilise the knee in an extension splint for a few days before starting active movement. In most cases, however, I favour the early use of a knee mobilising machine (fig 5). Its use is valuable in regaining early knee motion, but studies have confirmed that in the longer term the range of movement achieved is unchanged.¹⁹

Results

There are few long term reports on the results of knee arthroplasty in patients with rheumatoid arthritis. Sarokhan *et al*,²⁰ Scott and Sledge,¹³ Stuart and Rand²¹ reported pain relief in over 90% of their patients. They also reported significant improvement in function.

My experience of 275 total condylar knee arthroplasties carried out in a group of patients with predominantly rheumatoid disease and followed up for a mean duration of 6.4 years showed that the patients were generally pleased with the surgical results.²² When the Hospital for Special Surgery scoring system was used dramatic pain relief was indicated in over 90% of the patients. This score deteriorates slightly with time. There was a mean preoperative total flexion range of 75°, which increased to 90° after operation. Joint implantation was successful in reducing the mean preoperative flexion contracture of 17°. Two cases of tibial loosening occurred.

Complications

SKIN PROBLEMS

The incidence of wound necrosis has been reduced since the introduction of midline incisions as opposed to curvilinear or parapatellar incisions. Great care must be exercised in the use of the mobilising machine immediately after surgery. A wide range of flexion at this stage can predispose to central necrosis of the wound.

VENOUS THROMBOSIS

Venous thrombosis commonly occurs after knee replacement. Lotke showed a 72% incidence of

calf thrombosis²³ and Stulberg and his colleagues reported an 83% incidence of calf thrombi, which was reduced to 59% by the introduction of preoperative anticoagulation.²⁴ The overall incidence of pulmonary embolus appears to be of the order of 1.7 to 1.9%.^{24, 25} Whereas McKenna and his colleagues found an increased incidence of venous thrombosis in osteoarthritic patients compared with those with rheumatoid disease,²⁶ Stringer *et al* found no difference between the two groups.²⁵ Stringer recommended that all patients over 40 having a total knee replacement should be given adequate prophylaxis. It is generally agreed that full postoperative anticoagulation should be reserved for those who develop thigh thrombi.

INFECTION

There is an increased incidence of late infection in rheumatoid patients as opposed to those with osteoarthritis. The actual incidence of postoperative infection after total knee arthroplasty varies between 0 and 4%.

In those cases of infected knees without draining sinuses or Gram negative infections the possibility of reimplantation can be considered. In my view this should be done as a staged procedure. The arthroplasty is removed and the joint debrided. Gentamycin beads are implanted and eight weeks later the arthroplasty is reimplanted. High rates of prosthetic salvage are reported for periods of up to five years following this technique.^{27, 28} In my experience with nine cases followed up for an average of five years there have been no failures to date. The average range of flexion, however, is reduced in these cases.

Where the reimplantation is deemed to be unsatisfactory, arthrodesis can be considered. This is carried out using multiple pin fixation. The pins are retained for eight to 10 weeks if possible. With this technique I have obtained an 80% satisfactory fusion rate. This compares well with other series reported by Brodersen *et al*,²⁹ Rand and Bryan,²⁸ and Noble and Fahmy.¹²

LOOSENING

Surprisingly low rates of loosening have been reported in this group of patients. Despite the technical problems fixation seems to be adequate.^{13, 20, 21, 30}

PATELLAR COMPLICATIONS

Patellar complications are some of the commonest problems after total knee replacement. Patellar instability after surgery can be due to tight lateral structures, particularly in those with a preoperative flexion and valgus deformity, and if the limb is aligned in too much valgus maltracking can again occur. This usually requires treatment by realignment of the limb. Internal torsion of the tibial component will increase the Q angle and predispose to patellar subluxation. Internal rotation of the femoral component, even in the presence of good axial alignment of the limb, can cause tilting in flexion, which will again create patellar instability.³¹

Domed patellar components are subjected to high shearing stresses. The incidence of patellar

fractures has increased as the range of movement after knee replacement has increased owing to design improvements. Provided that these fractures do not occur in association with quadriceps disruption they can be treated conservatively in a plaster cylinder for four weeks (fig 6).

PERONEAL NERVE PALSY

Peroneal nerve palsy occurs in about 3% of patients and usually in those who have had a significant preoperative fixed valgus deformity. In such patients operative decompression of the common peroneal nerve is recommended to reduce the incidence of this complication. I have found that all eventually recover, but may take up to six months to do so.

STRESS FRACTURE OF THE FEMORAL NECK

For those patients who have not walked for a long time sudden return to activity after knee replacement surgery can induce a stress fracture through the neck of the femur. This may sometimes be misleading because it may present with referred pain into the knee and the unwary surgeon may be misled into believing that the problem lies with the replacement. The hip radiograph may be normal, but a bone scan will usually resolve the diagnosis.

Multijoint programme

Multiple joint replacement in the lower limb of patients with rheumatoid disease is now commonplace. In these patients attention should first be directed towards correcting the forefoot by arthroplasty in order to eradicate any areas of potential infection on the dorsum of the toes or

Figure 6 Patellar fracture after total knee replacement.

Figure 7 Porous coated anatomical uncemented knee replacement. Mechanical axis of limb is restored.

under the metatarsal heads. The hips should be replaced first to correct fixed flexion deformities at that level. It is much easier for the patient to mobilise with two painful knees below two pain free mobile hips than it would be if the knees were replaced first.

Uncemented prostheses

There is considerable current interest in the application of uncemented knee prostheses to improve the longevity of knee replacements (fig 7). Ryd has shown a significant incidence of subsidence in all types of uncemented tibial components on long term evaluation.³² This problem is more significant in those with rheumatoid arthritis, and I consider that cemented components are preferable in this group of patients.

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