(v) Osteotomy in the management of knee osteoarthritis and of ligamentous instability

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Summary

Traditionally osteotomy has been used for redistribution of articular surface load in osteoarthritic knees. It was becoming a 'lost art' in orthopaedics due to the success of arthroplasty, and the perceived unpredictable outcomes of osteotomy. With newer techniques and improved predictability in results, osteotomy is rightly regaining popularity. In osteoarthritis the aim is to deliberately create deformity to unload diseased joint surface and load healthy articular surface. In ligament instability osteotomy is employed so that alignment is fine-tuned in favour of stability.

A truly three-dimensional consideration of knee alignment is needed. Coronal alignment affects not only relative loading of medial and lateral tibio-femoral compartments, but stress on the collateral ligament complexes. The degree of tibial slope affects loading of the cruciate ligaments. Applying this knowledge allows enhanced results from complex ligament reconstruction of the knee.

Introduction

Given the centuries over which anatomy has been studied and the slow pace of evolution, the knowledge of lower limb alignment should be certain. Sadly this is not the case. Nevertheless certain assumptions need to be made. In an average adult for the purposes of planning osteotomy it is assumed that the weight-bearing line (WBL) joins the centres of the hip, knee, and ankle of the lower limb concerned. Unfortunately at the knee it almost certainly passes through the medial compartment.

In the coronal plane both tibial surfaces are slightly concave which is accentuated by the menisci. In the sagittal plane medially the posterior half of the tibial surface is flat and the anterior half slopes down from anterior to posterior. This overall incline accounts for the term 'posterior tibial slope' that is in common usage. Laterally the anterior and posterior tibia slopes down away from a central flat surface. Therefore the 'posterior tibial slope' that is referred to is really only relevant to the medial tibia.

Since the lateral compartment effectively produces loading of two convex surfaces (in the sagittal plane) and medial loading (especially when one considers the role of...
the relatively fixed posterior medial meniscus) is between a convex femoral condyle and concavity, it is appropriate that the WBL passes medially where there is more inherent stability.

It is generally accepted that the axes of the shafts of tibia and femur intersect at an average $5\text{°}$–$7\text{°}$ (i.e. the 'tibio-femoral angle'). The WBL passes $3\text{°}$ to the vertical in bipedal stance (i.e. ankles closer together than hips). To provide a horizontal joint line in this posture the joint line (and tibial surface) is in $3\text{°}$ of varus to the vertical/longitudinal axis of the tibia. Of course in many individuals, especially athletes, the alignment favours running where there is more varus in the proximal tibia.

In the ligament-intact limb this overall varus does not lead to any dynamic deformity (i.e. lateral/varus thrust) during the stance phase of gait because the intact proprioceptive feedback in the limb allows dynamic muscular control of deforming forces. However, when cruciate ligaments are torn, as well as losing their passive restraining effect, their proprioceptive function is lost (Figs. 1a–c).

Sometimes this is enough to allow dynamic instability (i.e. a thrust) to occur even with an initially intact lateral ligament complex whilst walking. In time, chronic overload of the lateral ligament complex causes it to stretch out and a dynamic thrust will appear (see below).

Overall sagittal alignment has not received as much study as the coronal. Nevertheless, when standing it is likely that the WBL passes slightly anterior to the mid-point of the knee so tending to maintain hyperextension.

This allows prolonged stance without the need for quadriceps activity, since knee extension is maintained passively and balanced by tension in the posterior structures including the capsule. The tensor fascia lata tightens the ilio-tibial band like a rein just to maintain slight hyperextension when needed.

**Modern osteotomy**

Osteotomy for osteoarthritis (OA) of the knee has, until recently, been in decline. This is especially true for North America and Britain where increasingly arthroplasty has been preferred in treating OA even in the younger patient. Many orthopaedic trainees in the UK, until the recent resurgence of osteotomy, were completing training having never seen a tibial nor femoral osteotomy.

'Old' osteotomy was often undertaken too late in the disease process, carried out badly, and employed poor fixation methods therefore necessitating reliance on casting with its associated problems. It is perhaps not surprising that the results were often disappointing.

More recently devices have been developed making osteotomy a more simple and reliable operation. The fixation devices have improved greatly meaning that with
certain devices, even for opening wedge techniques, weight-bearing, albeit not full, is possible immediately after surgery. Furthermore, some systems allow percutaneous techniques. As a result of these innovations the usage of osteotomy, including closing wedge techniques, has increased dramatically. There are pros and cons for opening and closing wedge techniques which should mean that the most appropriate for a given situation is carried out having considered the options. Unfortunately surgeons tend to employ either one or the other in all cases.

Other advances have been in understanding which patients are likely to benefit most, how much to realign the limb, and in which plane. The technical advances have greatly improved the rehabilitation that can be undertaken in the early post-operative period which has reduced the problems of stiffness, weakness, and infrapatellar contracture that were common after older techniques.

Preoperative evaluation

The following help identify suitable patients with OA. They are not absolute guidelines:

- chondral damage should be localized either to medial or lateral compartments;
- minimum range of movement of 15–100°;
- maximum deformity of 15–20°;
- inactive, obese, and older patients are unlikely to be suitable.

Preoperative gait analysis has also been used with some success. For cases with medial OA, a low adductor moment at the knee correlates with better results. The adductor moment reflects the medial displacement of the WBL from the centre of the knee during the stance phase of gait. The larger it is the more medial compartment loading and tendency to varus. External rotation of the foot (‘toe out’) reduces it and may be an adaptive phenomenon.

Having a low adductor moment prior to surgery correlates to better outcome after osteotomy. Some surgeons use a period of bracing prior to operation. If the brace helps symptoms then it is suggested that osteotomy is more likely to help. Unfortunately the situation is rarely as clear-cut as this.

Assessment of lower limb mal-alignment should be carried out with the aid of long leg weight-bearing films. These have limitations especially if the limbs are rotated allowing the femoral bow or tibial bow to influence ‘apparent alignment’. Fixed flexion or gross hyperextension at the knee too can be problematic. Whilst CT scanning is attractive for accuracy of measurements the findings are irrelevant to dynamic loading as they are non-weight-bearing.

The lateral radiographs will aid the assessment of the posterior tibial slope. Standard ‘standing’ AP films will allow the assessment of medial/lateral pathological joint space narrowing and opening. It is very important to differentiate the contribution to standing deformity from bone alignment, joint space narrowing/loss, i.e. chondral damage, and joint opening from ligament laxity. The most common scenario is the varus knee.

The alignment seen on standing X-ray results from one of, or a combination of, proximal tibial varus, medial joint space loss, and lateral ligament laxity. It is the former two factors which determine the degree of correction at the osteotomy. If the amount of varus secondary to lateral ligament laxity is included then the calculation of correction at the proposed osteotomy can be grossly excessive. As soon as the WBL is shifted into the lateral compartment the lateral ligament will be de-tensioned and its contribution to varus deformity disappears. Therefore on preoperative X-rays the excess lateral joint opening must be taken into account (Fig. 2).

A good way of preventing excessive correction in this situation is to apply the following. Each millimetre of lateral tibiofemoral joint opening causes approximately an additional 1° of varus deformity and this needs to be taken into account in order to avoid valgus overcorrection.

Preoperatively, the use of an image intensifier aids the correct placement of the osteotomy in both the coronal and sagittal axis. The ability to correct the WBL at the time of surgery is of the utmost importance as this is under the control of the surgeon.

Although the image intensifier helps this, its small field of view and problems with controlling limb rotation restrict accuracy. This accuracy of coronal alignment is helped by placing a skin marker overlying the femoral head under X-ray control which can later be palpated through the drapes during surgery.

Using this and applying a metal rod or diathermy lead from this point to the palpated centre of the ankle approximates to the WBL. An X-ray of the knee will then show where the WBL, as indicated by the rod or diathermy
lead, passes through the knee joint. The axial rotation of the limb needs to be carefully controlled and is problematic during this assessment.

Of course, intraoperatively the situation is not truly weight-bearing even if the surgeon applies axial load up through the foot. Therefore the preoperative plan remains key. For varus knees the osteotomy is undertaken at the tibia since it is where the pathology lies, i.e. chondral loss or proximal tibia varum. Conversely in the valgus knee the problem is in the femur. Correction at the correct bone is essential to maintain a joint-line that is horizontal.

Techniques

Closing wedge high tibial osteotomy (CWHTO)

This is the traditional procedure with modification of the technique used by Coventry. The osteotomy passes through the metaphyseal cancellous bone above the tibial tuberosity. It became clear that osteotomies below the tibia tuberosity have an unacceptable non-union rate.

The advantages of the technique over opening wedge osteotomy are provision of bone to bone contact with excellent union rates, and the potential for full early weight-bearing.

The disadvantages are creation of an abnormal shape to the bone with the tibial shaft ending up medial to the centre of the metaphysis (which has implications for future arthroplasty), loss of height, albeit offset by the lengthening effect of correction of deformity, risk to the common peroneal nerve, and the need to disrupt either the fibula or the proximal tibio-fibular joint to allow the tibial osteotomy to close. Furthermore, the operation is more demanding to surgeons who undertake only occasional osteotomy.

Opening wedge osteotomy advocates often suggest that the difficulty is more problematic than it is. With good training to learn the procedure—especially safe exposure of the anterior and posterior surfaces of the proximal tibia, and the ability to cut two flat surfaces, it is possible to perform this procedure as swiftly as its opening wedge counterpart despite reports to the contrary.

Opening wedge high tibial osteotomy (OWHTO)

The healing potential of the proximal tibial metaphysis is again harnessed. The achievement of adequate access often requires significant elevation of the medial soft tissues including superficial medial collateral ligament (MCL). These tissues heal well and since the deep MCL is intact medial instability is rare. In fact with opening of the osteotomy the medial tissues are put on tension.

Once the medial tibia is exposed the osteotomy is cut superiorly and lateral starting about the level of the tibial tuberosity and heading towards a point just below the level of the superior tibio-fibular joint. A major advantage of this technique is that neither the fibula nor superior tibio-fibular joint are violated. The common peroneal nerve should thus be at less risk.

However, care must be taken when drilling guidewires across the bone, before undertaking the osteotomy, to avoid drilling too far especially in soft bone. Once cut the osteotomy is opened whilst ‘hinging’ an intact lateral tibial cortex, which can be weakened, if needs be, by use of osteotomes.

The amount of desired correction can be made according to the preoperative plan and guided by X-ray and wedged blocks of known angle. It is said that the control of the correction is easier than with CWHTO. Adjustments are certainly easier but with the small field of view from an image intensifier the surgeon is wise to keep to the preoperative plan.

A reason for the current popularity of this procedure is development of decent implants to hold the osteotomy. Some even allow early restricted weight bearing. However, the period of protected weight bearing is much longer than with CWHTO. For all but minor corrections the ostotomy gap is best filled with bone graft from the iliac crest and/or bone substitute. The need for bone graft is a distinct disadvantage as compared to CWHTO.

An inevitable consequence of OWHTO where the whole osteotomy passes above the patellar tendon insertion is a lowering of the patella relative to the knee joint-line. By modifying the technique this can be avoided by making an oblique extension inferiorly from the main osteotomy emerging anteriorly inferior to the tibial tuberosity.

Patella baja was a frequent association of ‘old’ CWHTO and one of the reasons for difficulty in exposure at subsequent knee replacement. The actual technique causes a relative elevation of the patella and so this phenomenon was simply related to the use of plaster casting and very limited quadriceps work. Now casts and even braces are rarely needed allowing early restoration of motion and strengthening.

The tibial slope is of great importance regarding antero-posterior stability (see below). Osteotomy to deliberately alter the tibial slope alone is required infrequently, but HTO for coronal plane realignment frequently alters the tibial slope without intention. Because OWHTO requires elevation of the medial soft tissue from anterior to posterior there is a tendency to have to place the fixation device from a more anterior position.

This and importantly the fact that the cross-section of the tibia is triangular means that medial OWHTO produces more anterior opening than posterior even during what is supposed to be purely coronal correction—hence increasing the tibial slope. This and importantly the fact that the cross-section of the tibia is triangular means that medial OWHTO produces more anterior opening than posterior even during what is supposed to be purely coronal correction—hence increasing the tibial slope.

The tendency with CWHTO is the opposite, i.e. to decrease the slope by an average 5°. This has implications for anteroposterior stability (see below).

Other techniques of HTO

External fixation has been used with considerable success in obtaining correction of deformity. The technique employing the ortho-fix is established. For complex problems the Ilizarov family of frames are used. The senior author has no experience with these techniques as modern osteotomy allows acute correction with stable ‘buried’ fixation and no restriction of joint motion. When concomitant ligament reconstructions are undertaken these techniques are inappropriate. In addition there is a significant risk of infection with longer term implications.

The ‘Dome’ HTO: via a direct anterior approach the tibia is transected from anterior to posterior to produce an arcuate osteotomy or dome. The fibula is divided through a second
incision. The distal tibia can then be rotated relative to the proximal at the ‘dome’ osteotomy site. This has the attraction of preserving the shape of the proximal tibia whilst maintaining bone to bone contact throughout. However, in the senior author’s experience the complication rate for neurovascular injury and non-union seems higher than other techniques.

Distal femoral osteotomy (DFO)

The need for this is much less common since primary OA of the lateral compartment of the knee is only 5% of the total. Furthermore, most patients with significant medial ligament laxity do not have constitutional valgus thereby making combined DFO and MCL reconstruction an uncommon event. Traditionally a medially based closing wedge osteotomy held with a blade plate device was used. New devices especially locking plates make laterally based opening wedge DFO attractive.

As with HTO there are pros and cons for OW and CW techniques and the good surgeon will chose the most appropriate for the patient concerned.

Correction of the WBL

In the treatment of OA the WBL is deliberately moved significantly to load the healthy compartment. Coventry’s work suggested that, in his series of HTOs for medial OA, undercorrection was associated with a poor outcome. He aimed for 3°–5° more tibio-femoral valgus than normal (a tibio-femoral angle of around 10° and therefore a fairly modest increase). This has been confirmed by others. Unfortunately, the message that undercorrection leads to failure has been remembered more than the fact that modest corrections yield good results. There is a tendency for surgeons to emphasize the concept that overcorrection is a good thing.

Excessive correction can lead to a feeling of instability with the knee which is usually perched on one compartment joint surface and, on occasion, a lurching of the joint contact into the other diseased compartment, as well as leading to relatively rapid overload and failure of the healthy compartment joint surfaces. In addition cosmetically the appearance is poor and a source of medico-legal claims. A reasonable guide is that the WBL should pass through the lateral ligament complex (i.e. ‘posterolateral corner’) in a knee with proximal tibia varum. Even if a sound posterolateral corner reconstruction is undertaken due to the lower limb alignment in the coronal plane there will be tension in the reconstruction when the knee is loaded. In the uninjured knee the varus is tolerated due to intact proprioception. In the ligament injured knee proprioception is lost as well as the increase in laxity. As a result a chronic overload of the reconstruction will lead to a stretching out of the tissues and failure.

The calculation of the desired angle of correction can be done in a number of ways. The simplest is to mark on the measurement X-rays the point on the knee joint-line where the WBL is desired to pass. The angle subtended by lines passing from this point to the centres of the femoral head and ankle will bring the WBL to pass through the desired point at the knee. Many surgeons undertake correction at the osteotomy applying the notion that 1 mm at the base of the wedge equates to 1°. Whilst this is a reasonable approximation it is more accurate to calculate the exact size from preoperative measurement X-rays since size of bones vary from case to case.

Tibial slope is important

The normal tibial slope is said to measure between 7° and 13°. The issue of the sagittal anatomy of the joint surface of the tibia is detailed above. It really refers to the medial side of the tibia. Since the WBL passes into the medial compartment and the medial femoral condyle is fairly stationary in the antero-posterior direction during knee flexion this overall slope has a profound influence on antero-posterior shear between the femur and tibia.

Increasing the tibial slope increases the tendency to anterior tibial translation when the limb is axially loaded (Figs. 3a-f). In contrast, decreasing the tibial slope tends to posterior tibial translation. In cases of tibial slope reduction or reversal profound posterior tibial translation can result.

By deliberately influencing the tibial slope the osteotomy can be used to favour one or other cruciate ligament. In cases in which there is an abnormal tibial slope even with intact cruciate ligaments the anteroposterior tibial translation can be dramatic, giving the incorrect impression that on or other cruciate ligament needs reconstruction.

These patients need osteotomy first and only ligament reconstruction if the tibial translation has caused attritional stretching of the ligament. If coronal plane adjustment is required as well, a biplanar osteotomy is required.

Hence for a combined PCL and posterolateral corner disruption in the presence of significant varus an osteotomy producing correction of the varus plus an increase in tibial slope is ideal. This can be achieved by medial plus anterior opening wedge, or lateral and posterior closing wedge osteotomies. The former is the easier to achieve. When reducing the tibial slope CWHTO is usually easier. Rather than always doing an osteotomy employing opening or closing wedge techniques, regardless of patient factors, the operation should be determined by various goals and circumstances. Using the knowledge detailed above the exact type of osteotomy for a patient should be designed for their needs and the ideal technique undertaken.

Clinical scenarios

Medial OA with normal ligaments

The standard OW or CW HTO is appropriate.
Medial OA plus ACL-deficiency

CWHTO is theoretically the best choice since, as well as off-loading the medial compartment, this osteotomy tends to reduce the tibial slope and so lessens anterior directed stress on the proximal tibia, i.e. it favours the ACL-deficiency or offloads concomitant ACL reconstruction.

The controversy is as to whether or not simultaneous ACL reconstruction should be performed. With OW or CW HTO the ACL reconstruction can be easily undertaken at the same sitting.

Figure 3  (a) Gross posterior tibial subluxation in a knee with reversal of the tibial slope in a case of premature anterior tibial physeal arrest. The patient had multiple injuries as an adolescent and spent a long period in an intensive care unit where his knees were hyperextended. In addition there was rupture of the PCL. (b) This is the same case as in (a). The major effect of the tibial slope is apparent when the posterior subluxation is corrected with restoration of the normal angle of slope. (c) The same case as in (a and b). This shows how subluxation in the sagittal plane leads to an apparent but spurious coronal plane deformity. Once the tibial slope deformity was dealt with the coronal alignment was excellent. (d) The same case as in (a–c). A subsequent PCL reconstruction was undertaken. (e and f) Same patient as in (a–d). This shows how subluxation in the sagittal plane leads to apparent but spurious coronal plane deformity. Once the tibial slope deformity was dealt with, the coronal alignment was excellent.
but whether or not it is useful is debated. The senior author tends to believe so. There are advocates for both points of view, but those in favour of a combined procedure in carefully selected patients prevail.\(^8,9\) The osteotomy is performed first and therefore care has to be taken, if using an arthroscopic technique, that irrigation fluid does not fill the calf due to leakage across the osteotomy via the tibial tunnel.\(^10\)

**Varus plus posterolateral corner insufficiency**

In acute cases of posterolateral corner disruption repair or reconstruction of all injured structures is possible within 2–3 weeks from injury and seems to provide a better outcome than waiting until the situation is chronic. There are some knees with marked varus who present with an acute multiligament injury including the posterolateral corner disruption. In this scenario the question of whether or not an early “protective” osteotomy should be undertaken arises.

It is our philosophy not to undertake osteotomy early for two reasons. Firstly the added insult of an osteotomy would not be well tolerated, in view of the major injury and major ligament surgery. Also, in the acute scenario, the emphasis is on repair of tissues (even cruciate ligaments can be repaired and be expected to heal in such treatment of dislocated knees). The repairs may need to be augmented with grafts, but there is much more potential for maintaining intact proprioception in the repaired tissues. Hence, there is more likelihood of avoiding a dynamic varus thrust.

In the chronic situation, secondary problems develop such as stretching out of soft tissue restraints such as the capsule and lateral ligament complex. Therefore, the anatomical abnormalities have to be defined to customize the osteotomy and concomitant procedures to combat all abnormalities present.

With this in mind the following concept is useful. Noyes\(^11\) was the first to describe the concept of primary, double, and triple varus knees in order to classify anatomical abnormalities of the knees concerned. These terms take into account underlying bony malalignment, abnormal knee movement, subluxations and ligamentous insufficiency. Chronic ACL insufficiency leads to increased anterior translation of the tibia and shearing forces. Initially the kinematic consequence is lateral.\(^12\) The medial compartment kinematics are unchanged if the medial meniscus is competent.

The meniscus is, however, subject to more load and in time will fail. This leads to medial compartment OA and hence deformity: ‘primary varus’. If the medial meniscus is torn or absent, the chances of medial compartment OA increase even further.\(^13\) The narrowing of the medial compartment leads to a medial shift of the WBL which increases strain on the posterolateral structures which may become lax: ‘double varus’. The term alludes to the fact that there are two reasons for the double varus knee, i.e. bone/joint alignment plus lateral ligamentous opening and lateral condyle ‘lift-off’.

With time, excessive lateral stresses lead to pathological hyperextension and external rotation as the posterolateral capsule and ligamentous structures stretch: ‘triple varus’. Triple varus can also occur in a varus ACL-deficient knee with an acute injury to the posterolateral complex.

Hence, when assessing a varus knee clinically it is important to see if the deformity is bone/joint alone (‘primary varus’), or has associated lateral laxity (‘double varus’), and even hyperextension/external rotation (‘triple varus’).

**ACL deficiency and varus malalignment (no OA, i.e. tibia varum)**

These may, in time, fit into Noyes’ double varus group as the varus, in the presence of reduced proprioception allows stretching of the lateral ligament complex (see below). ACL reconstructions in the presence of uncorrected varus malalignment can lead to graft failure (Fig. 4). In addition, in a varus ACL-deficient knee there are high adduction moments which lead to increased loading of the medial compartment and place stresses on the lateral ligaments.\(^14\)

A recent study recommended HTO together with ACL reconstruction in cases of ACL deficiency with varus malalignment.\(^19\) This combined procedure can stabilize the knee, reduce pain and stop premature OA.\(^15\) In patients with ACL deficiency the importance of the tibial slope must not be underestimated and it should not be increased. Decreasing the tibial slope, although of proven benefit, is difficult with an OWHTO. The aim of the surgery in these patients is to avoid varus thrust and to reduce the stresses acting on lateral ligaments on ambulation.

The correction provided by the osteotomy is therefore limited to provide a WBL in neutral at the knee. The difficulty is to decide when to undertake an osteotomy as usually a mild proximal tibial varum in the presence of isolated ACL tear usually does well with ACL reconstruction alone. In other words: when is too much varus present? This is not known and therefore considerable reliance on experience based judgement of the surgeon is required. It is correct to say that whenever such a scenario presents the potential for osteotomy should be considered.

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**Figure 4** This is an example of a patient with an isolated ACL tear reconstructed alone without dealing with the varus alignment years previously. In time the lateral ligament complex stretched: ‘double varus’. Subsequently the patient dislocated the other knee requiring ACL plus PCL plus posterolateral corner reconstruction and HTO. Whilst the knee with only an isolated ACL tear developed dynamic thrust on walking, the more severely injured knee was well aligned and more stable.
Multiligament injury/triple varus

These knees have gross instability. If the posterolateral structures were injured acutely with one or both cruciate ligaments at the same time then the knee has often actually dislocated at the time of injury. When the injury has become chronic HTO is needed if there is unfavourable varus.

If CWHTO is chosen it has the advantage of allowing access laterally for posterolateral ligament reconstruction. In addition common peroneal nerve injury is not uncommon and neurolysis is often needed. However, it must be remembered that, to prevent proximal migration of the fibular head which will slacken off the posterolateral structures, it is best to divide the fibular shaft rather than disrupt the proximal fibular joint. This can be undertaken via a more distal lateral incision, or, perhaps safer, through the neck of the fibula, if the nerve is dissected off it first. An OWHTO will require a second lateral incision for access to the posterolateral corner of the knee for ligament reconstruction/neurolysis.

During the osteotomy the tibial slope can be altered to favour whichever cruciate ligament is reconstructed at the same time. If both cruciate ligaments are reconstructed, as they frequently are, the tibial slope should be left unaltered. Once the bony alignment is optimal the cruciate ligament(s) is/are reconstructed.

Usually the osteotomy and cruciate ligament reconstructions can be completed within a safe tourniquet time and the extra-articular posterolateral reconstruction can then be undertaken without tourniquet if necessary. Of course a simultaneous HTO plus reconstruction of the posterolateral corner and one or both cruciate ligaments is demanding and may be lengthy.

In experienced hands it is reasonable to aim for a single operation, as the patient avoids another procedure, but it is wise to stage procedures if time demands. The HTO is undertaken first and the ligament reconstructions delayed for a few months.

Preoperative physiotherapy can be employed to improve the strength of lower limb musculature. In addition, gait training can be applied to those patients with hyperextension deformity, in order to avoid the patients waking with the hyperextension gait postoperatively, which would place a strain on the reconstructed ligaments. This preoperative optimization can lead to a reduction in joint pain and improvement in gait.

PCL deficiency

When combining an HTO and PCL reconstruction, it is useful to increase the posterior tibial slope, usually by placing cortical bone graft, or a fixation device (some have metal spacers built in) more anteriorly.

This will decrease the load on a newly reconstructed PCL. In a case of pre-existing reversed tibial slope, as most commonly occurs with premature anterior physeal arrest, marked posterior sag of the tibia can be present. In addition hyperextension occurs at the knee joint. This is made cosmetically more obvious by extension deformity (precurvatum) just below the joint in the proximal tibia where growth arrest has occurred.

The injury to the anterior tibial physis nowadays is usually secondary to direct trauma but previously was not uncommonly associated with prolonged hyperextension applied to the knee as a consequence of long periods of traction in childhood such as in the treatment of hip disorders (‘Frame Knee’). In these cases anterior OWHTO is the key to treatment. Unless there has been major disruption of the PCL reconstruction of that ligament is rarely needed.

Injuries including medial collateral ligament (MCL) disruption

As an advantage for medial OWHTO it is often said that in cases of MCL deficiency, the distraction offered by an opening wedge osteotomy can tension the lax ligaments. The combination of varus alignment plus MCL insufficiency is rare and in any case the osteotomy will cause valgus alignment so further stressing the subject MCL! Uncontrolled MCL laxity can be a very difficult problem to deal with. Arthroplasty surgeons appreciate this problem especially.

The problem is that the stresses involved in walking tend to exacerbate the situation further. During stance phase when the foot tends to be externally rotated relative to the line of propulsion (i.e. the ‘progression angle’) the knee is subject to a combined valgus and external rotation stress. This tends to stretch the MCL. The whole situation is worsened if the subject’s natural alignment at the knee is valgus and there is significant foot pronation (which produces further valgus and external rotation forces at the knee).

This knowledge can be applied for treating MCL injuries. After an acute MCL rupture (usually but not always treated in a brace) for 6 weeks the subject should consciously internally rotate the limb so that during the stance phase the foot points forward without rotation or slight internal rotation. This minimizes the forces described above.

Usually chronic MCL laxity can be dealt with by suture plication of the lax by medial ligament complex. In cases where the soft tissues are very attenuated or revision surgery is needed then graft (hamstring autograft or whole patellar tendon allograft with patella and tibial tuberosity) can be fixed into the medial knee.

The need for a varus DFO is needed if there is significant bone/joint valgus or the gait is so poor it drives progression of the deformity and further MCL stretching.

The latter problem often accompanies a neurologic limb such as that in lower limb cerebral palsy (Figs. 5a and b).

Postoperative rehabilitation

This is complex and lengthy. Each patient needs a customized programme taking into account a number of factors. Weight-bearing status, range of motion restrictions, muscle strengthening, proprioceptive retraining, and soft tissue care (dealing with swelling and the avoidance of fat pad contracture) should be defined.

Outcomes

The importance of realistic treatment goals cannot be overemphasized. Patients need to be aware of the likely outcome of the surgery, and the low probability of return to a high level of sporting activity.

Return to sports is certainly feasible after an HTO combined with an ACLR alone. In one study half of the patients studied...
warned that it is often best to ‘quit whilst they are ahead’. Control, chondral damage is in such activity which is not resisted by normal neuromuscular proprioceptive deficit must not be overlooked. Even osteotomy, do get back to sporting activity. However, the dislocations followed by multip.

Figure 5 (a) A case of absent ACL plus chronic stretching of MCL in a patient with spina bifida and contralateral below knee amputation. Her gait forced the knee into gross valgus plus external rotation. (b) The same case as in Fig. 5(a). The problem was dealt with by combining, at a single operation, distal femoral osteotomy, and allograft ACL and MCL reconstructions. The bone blocks of the patellar tendon allograft were impacted into recesses made in the tibia and femur.

returned to leisure sports, and 91% of all patients were satisfied with the results of the surgery. Patients who have had dislocations followed by multiple ligament reconstruction, and even osteotomy, do get back to sporting activity. However, the proprioceptive deficit must not be overlooked.

This means that with the extra stresses to the knee occurring in such activity which is not resisted by normal neuromuscular control, chondral damage is likely. The patient should be warned that it is often best to ‘quit whilst they are ahead’.

Conclusions

Osteotomy is an invaluable tool to be used in treating complex knee ligament problems as well as OA.

References


