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Chapter

Valgus Deformity Correction in Total Knee Replacement: An Overview

Melvin J. George

Abstract

Valgus deformity in total knee replacement is a much lesser encountered problem than varus deformity. The deformity can be caused by either bony or ligamentous pathology or both. Bone defects like lateral cartilage erosion, lateral condylar hypoplasia and metaphyseal femur and tibial plateau remodeling along with soft tissue pathologies like tight lateral collateral ligament (LCL), posterolateral capsule (PLC), popliteus tendon (POP), hamstring tendons, the lateral head of the gastrocnemius (LHG) and iliotibial band (ITB) can add to the magnitude of valgus deformity. Various sequences have been described to achieve balancing while doing a total knee replacement. Proper preoperative planning, clinical examination, necessary implant backup and good operative skill are mandatory to manage bone deformities or soft tissue pathology or both in valgus deformity. Obtaining an accurate axis restoration, component orientation and joint stability in a valgus knee with combined bony and ligamentous pathology may be a difficult task. The long-term results in valgus knees are relatively inferior to those with varus deformity. This chapter structure wise describes the pathology, classification of valgus deformity, radiographic planning, surgical approaches, method of valgus deformity correction, implant selection, associated deformities, precautions and intraoperative complications.

Keywords: valgus, total knee replacement, deformity, balancing, hypoplasia

1. Introduction

Mechanical axis and anatomical axis are the two alignment parameters in the lower extremity. Mechanical axis is the axis or the line of weight bearing through the bone. In the case of straight bone like the tibia, both mechanical and anatomical axes are the same. Mechanical axis of the femur is different from that of anatomical axis. The former is at 5–7° valgus to the anatomical axis (**Figure 1**). Mechanical tibiofemoral angle (1.3 ± 2° varus) or anatomical tibiofemoral angle (6 ± 2° valgus) can be used to denote normal knee joint alignment. Normal mechanical axis of the knee is defined as a line that passes from the centre of the hip to the centre of the ankle. Normal alignment is defined when this line passes through the centre of the knee. A line that falls towards the lateral side of the knee indicates that the lower extremity is in valgus. Varus alignment is more common in males than in females. Valgus deformity is usually defined when the anatomical tibiofemoral angle is equal to or greater than 10°. Since the weight-bearing axis of the lower limb follows

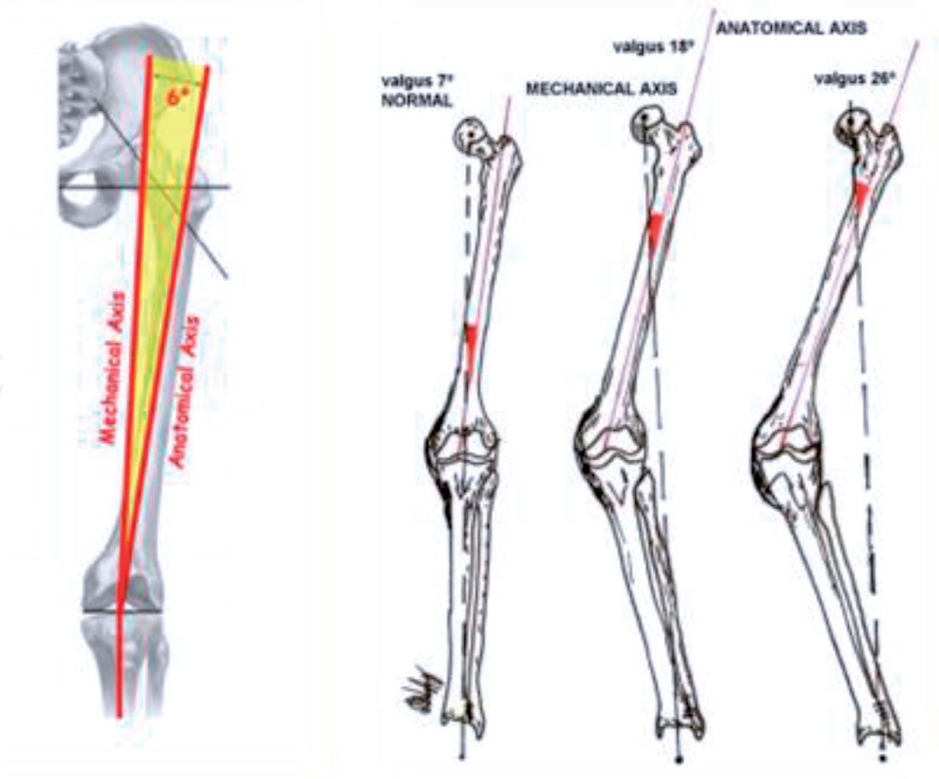


Figure 1.
The method of measuring valgus angle at the knee.

the mechanical axis, a valgus alignment will increase the load in the lateral compartment of the knee. According to Paley and Tetsworth [1], the knee joint is not perpendicular to the mechanical axis of the lower limb but internally rotated at 3°.

In this chapter, let us discuss about the etiology, clinical examination, radiological examination, pre-op planning for total knee replacement, intraoperative steps and precautions to take and complications.

2. Valgus deformity in total knee replacement

2.1 Aetiology

Varus or valgus malalignment has a tremendous influence on the loading of the articular surfaces of the knee. This malalignment results in an increased rate of progression of osteoarthrosis in the knee is proven in animal models. The causative factors for valgus deformity of the knee are described as many.

It can be congenital or secondary to osteoarthrosis, rheumatic diseases and post-traumatic arthritis and due to an over-correction consequent to a valgus osteotomy. Valgus deformity in adults is most commonly seen in patients with inflammatory arthritis, tibial malunion, physeal arrest or tibial plateau fracture [2–6]. Persistence of genu valgum from childhood may exist secondary to metabolic disorders, such as rickets and renal osteodystrophy [7]. But in those patients who undergo total knee replacement, osteoarthrosis remains the most common cause.

The pathologic structures which cause the valgus deformity are mainly bony and soft tissue related. Bone factors consist of lateral cartilage erosion, lateral condylar hypoplasia and metaphyseal femur and tibial plateau remodeling. Soft tissue factors include tightening of lateral structures: lateral collateral ligament, posterolateral capsule, popliteus tendon, hamstring tendons, the lateral head of

the gastrocnemius and iliotibial band. Rarely, the long head of the biceps femoris is also affected. Lax medial structures (mainly MCL) can add on to the deformity. In addition, these deformities can cause tibial external rotation and to a certain extent patellar lateral subluxation [8]. All these factors in varying severity coexisting around a knee make valgus correction a challenging task during total knee replacement.

2.2 Classifications

Ranawat et al. [9] have described three grades of valgus deformity.

Grade I is where the deformity is less than 10° and it is not a fixed deformity. In Grade I the medial collateral ligament is intact; hence the deformity is passively correctable.

Grade II is featured by a range of deformity from 10 to 20°, whereas the MCL is stretched out but still functional.

Grade III patients have deformity more than 20°. The medial stabilizers are typically not functional, and hence it calls for a constrained implant [9, 10].

Since Ranawat's classification did not take into consideration the extra-articular and multiplanar deformities, Mullaji and Shetty [11] modified it into six types:

Type I—Correctible valgus and an intact MCL.

Type II—Fixed valgus deformity with an intact MCL.

Type III—Valgus and hyperextension deformity with an intact MCL.

Type IV—Valgus and fixed flexion deformity (FFD) with an intact MCL.

Type V—Severe valgus with a lax MCL.

Type VI—Valgus secondary to extra-articular deformity.

Another recently introduced classification system based on the bone affected and the soft tissue status is by the International Society for Technology in Arthroplasty. The JST Classification [12] of valgus knees is as follows:

2.2.1 Femoral deformity

Type F1—Valgus in extension only

- F1a—Intra-articular deformity, loose LCL
- F1b—Extra-articular deformity, normal LCL

Type F2—Valgus in both flexion and extension: Intra-articular deformity, tight lateral collateral ligament, lateral femoral condyle hypoplasia

2.2.2 Tibial deformity

Type T1—Intra-articular deformity, lateral tibial plateau deficiency

Type 2—Extra-articular deformity, tibial metaphyseal or shaft

2.3 Clinical examination

From the history, the most important part is the functional disability the patient is facing and the severity of the pain. Pain, limitation of daily living activities, increasing angular deformity and worsening instability are the usual complaints. The treatment is based on the severity of the symptoms. The co-existence of other pathologies affecting joints like rheumatoid arthritis (RA) and gout has to be evaluated and treated simultaneously.

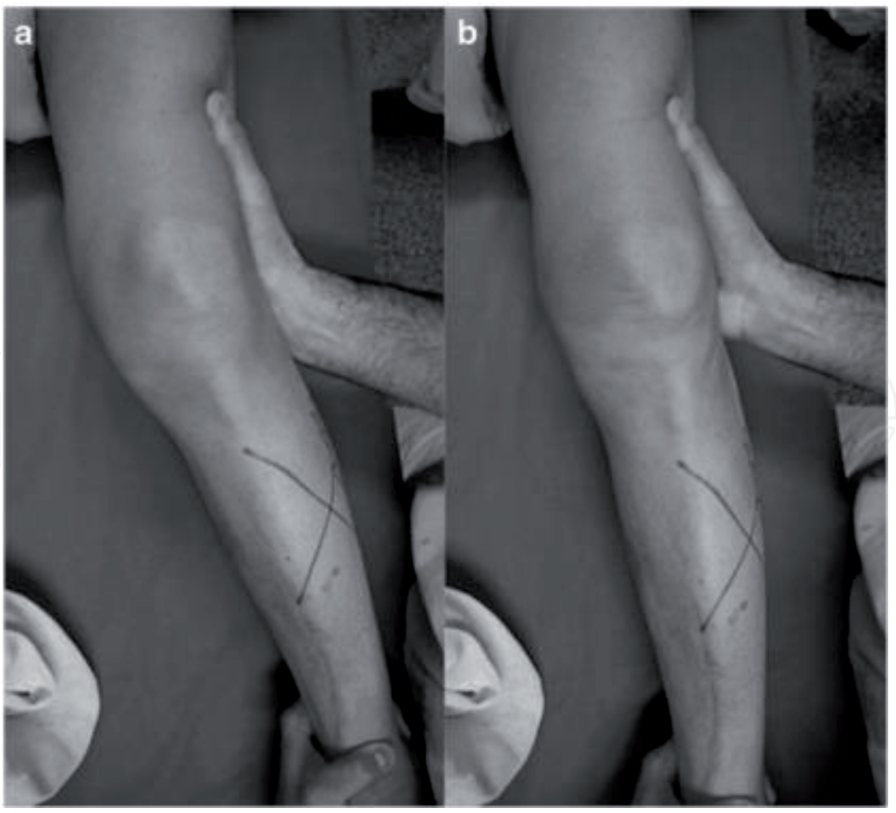


Figure 2.
The valgus deformity corrected with a varus stress test.

First and foremost observation while examining an end-stage degenerative knee disease is the pattern of gait. This is the best way to assess the dynamic instabilities. Due importance should be given if there is a medial thrust and recurvatum/fixed flexion deformity, the amount of deformity and its correctability. **Figure 2** shows the valgus deformity correctability in a varus stress test. The overall alignment should be assessed both in standing and supine positions. The range of motion (ROM) should be measured and recorded. The stability of the knee, anteroposterior laxity, range of motion, coronal and sagittal deformity, mediolateral instability, status of the extensor mechanism and patellofemoral articulation are important in the knee examination.

Lastly, pain due to other causes like neurovascular and lumbosacral pathologies is also to be ruled out. In fixed valgus deformity, the lateral structures are tight, and the medial ligaments are lax. So, when a standard lateral soft tissue release is done, the resulting laxity will be much more than the preoperative, and it usually requires the usage of constrained prosthesis.

2.4 Radiological assessment

A proper radiological evaluation for a valgus knee undergoing TKR includes weight-bearing anteroposterior, lateral, long leg standing, Rosenberg and Merchant views. Lateral views help you size the components and look for any posterior osteophytes. In case of correctable deformities, varus and valgus stress views are mandatory. The critical points to look for in these cases are the amount of bone stock, lateral distal femoral hypoplasia, posterior femoral condyle erosion, metaphyseal remodeling of proximal tibia and distal femur and the status of patella-femoral joint. Patella can be subluxed in case of severe valgus deformities. The depth of resection needs to be planned preoperatively. **Figure 3** shows a valgus knee with lateral tibial

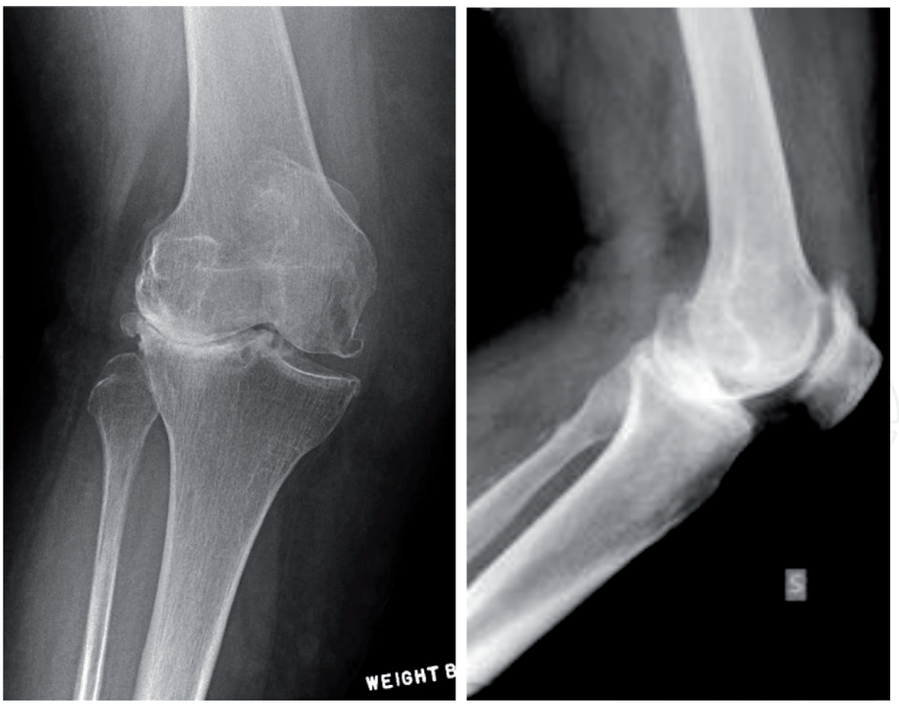


Figure 3.
A valgus knee with lateral tibial plateau defect.

plateau defect. If suspecting bony erosion, a CT scan can help you assess the dimensions of the defect more accurately in order to help you plan the augments early and back it up. Also the hypoplastic lateral femoral condyle, the eroded posterior femoral condyle and the remodeled femoral or tibial metaphysis which can lead to malalignment of the femoral component can be evaluated preoperatively in a CT scan.

Apart from evaluating the knee, plain X-rays of the lumbosacral spine would be worthwhile as a part of ruling out any spine pathology. NCV and EMG may be advised to patients who complain of associated paraesthesia and other sensory or motor symptoms.

2.5 Templating

With the X-rays available, preliminary templating should be done to have a rough idea on the level of resection, valgus angle to keep and sizing of the components. Twenty percent magnification is what most of the templates are made for. Most of the implant companies provide hard copies of TKR templates, or digital templating systems are available.

For the tibia, a line is drawn along tibial anatomical axis, and then a perpendicular one is drawn at the level of the lateral tibial plateau. This will provide the depth of resection to be taken. Try to avoid overhanging. Tibial slope needs to be assessed in lateral view. Some tibial jig/inserts have inbuilt slope. So, thorough knowledge of the system you use is a must to reconstruct the slope.

For measuring the valgus cut angle, the femoral anatomical axis is drawn, and then a second line is drawn from the centre of the intercondylar notch to the centre of the femoral head. The angle formed gives the desired amount of valgus cut to be taken [13] (**Figure 4**).

The sizing of the components is then conducted with the templates provided by the implant company. The femur is sized in lateral view and tibia in AP view. Try to avoid notching in the femur and overhanging in the tibia (**Figure 5**).

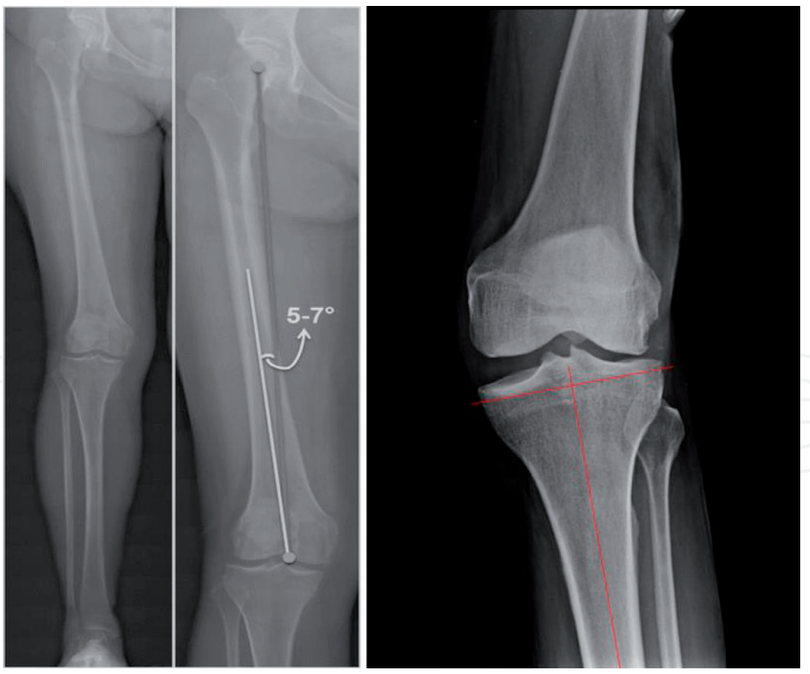


Figure 4.
Templating the bone cuts.

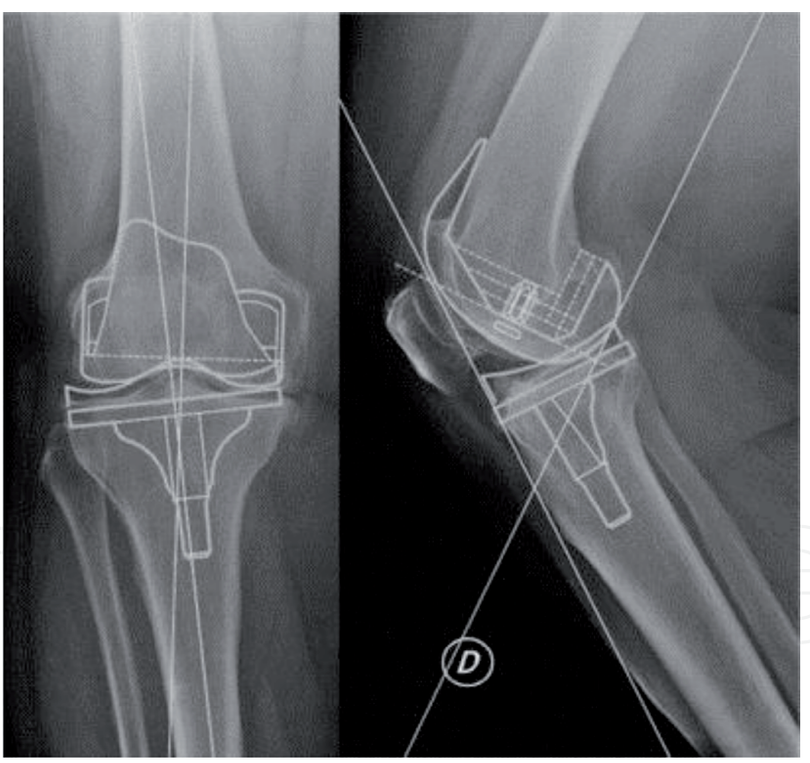


Figure 5.
The digital templates for sizing the components.

2.6 Component selection

Component selection should be made based on the clinical evaluation and the radiological examination. Adequate armamentarium should be ready in the operation theatre (OT) including constrained knee/hinge knee based on the severity of the deformity and its correctability. The final decision is made after bone cuts and soft tissue balancing. If proper soft tissue balance is restored, one can get away with

normal components. In a Grade-III valgus deformity, medial soft tissues are not functional, and hence, a higher constrained prosthesis is mandatory to achieve a stable knee [9].

One of the main controversies is regarding the choice and design of the implant to be used in valgus deformities. There are proponents of both the cruciate retaining (CR) and posterior stabilized (PS) designs in existing literature, and they have their valid reasons too. I tend to lean towards PS designs in valgus deformities. PCL is a secondary stabilizer and it is often found contracted intraoperatively [14]. This can limit the deformity correction and almost always end up in resecting PCL too. PS designs are found more stable because of the post-cam mechanism. Also, PS designs allow better lateralization of the components which in turn improve patella tracking. PS prosthesis provides some degree of posterior stabilization as well as protection against posteromedial and posterolateral translation. But the mediolateral laxity is not supported by the PS designs.

Extreme valgus knees will have a deficient lateral femoral condyle. Such knees will require the use of component augmentation if the femoral component is being cemented. The lateral femoral condyle may or may not have distal femoral bone resected like in the chamfer and posterior cuts, as well.

2.7 Intraoperative considerations

The dictum in such complex cases is "plan your work, work out your plan". The plan starts right from the clinical examination. We need to assess whether the valgus deformity is fixed or correctable and the presence of a coexisting deformity—mostly hyperextension. Lateral release should be minimal in case of a fixed deformity because that can make the knee unstable necessitating a constrained prosthesis.

2.7.1 Approach

The knee can be approached both anteromedial and anterolateral. Too much of debate exists on the choice of approach in extreme valgus knees and is often chosen based on the surgeon's preference. The advantages of anterolateral approach as explained by Keblish [8] are better visualization of the tight lateral tissues; lateral release happened with the arthrotomy. Also, if a lateral retinaculum release is necessary, the patellar vascularization will not be compromised. Functional and radiological outcomes in TKA approached either ways have been studied by Sekiya et al. [15]. They found no significant differences in ROM but better postoperative flexion in the anterolateral group. The author is of the opinion that if the residual surgical valgus is more than 15°, it is easier to correct with an anterolateral approach.

2.7.2 Bone cuts

Femur—It is useful to reduce valgus degrees of resection from 5 to 7° to 3° in order to accommodate the distal femoral metaphyseal remodeling. Lateral condyle distal femoral resection can be minimal (1–2 mm) or absent in severe valgus deformity. Femoral resection should be no more than 10 mm in the medial condyle (usually 7–8 mm). Special attention is to be given to lateral condylar hypoplasia that can determine the rotation of the components if a posterior reference is used. In cases of severe trochlear dysplasia, the Whiteside line can be extremely difficult to identify: in these cases the epicondylar axis or parallel to the tibial cut technique should be used to assess a correct femoral rotation.

Tibia—The tibial cut has to be perpendicular to the tibial long axis. The depth of resection should be limited to 6–8 mm in the medial compartment. In cases of severe bony deformity of the tibial plateau, almost no bone is resected on the lateral side to avoid medial over-resection or malaligned cuts.

2.7.3 Soft tissue release

The lateral structures are contracted in valgus knees, and the most important ones to be considered in deformity correction are iliotibial band, posterolateral corner, posterior cruciate ligament, lateral collateral Ligament, popliteus tendon and lateral head of gastrocnemius.

Again controversy exists regarding the sequence and extent of lateral release. Krackow et al. [10] suggest ITB-LCL-popliteus-PLC sequence, whereas Ranawat [9] on the other hand advocates PCL-ITB-LCL technique. Krackow and Mihalko [16] published a cadaveric study in which they studied the amount of correction achieved with each release step of two different sequences, comparing it in flexion and extension. They concluded that LCL release caused largest correction and popliteus, and ITB should be considered to grade the release.

Regarding the technique of release, most of the surgeons do a subperiosteal release from the tibia. In severe valgus deformities, performing a lateral parapatellar approach automatically releases ITB from Gerdy's tubercle and helps in deformity correction to an extent. Ranawat's pie-crusting technique is also done widely. With the knee in extension and lamina spreaders to open up the extension gap, the tight lateral structures are palpated and released by multiple stab incisions with a No. 15 blade (**Figure 6**).

Lateral epicondylar osteotomy as described by Brilhault et al. [17] can be useful in severe valgus deformities. A sliding osteotomy along with the femoral insertion of LCL and popliteus insertions is made, and the bone block is mobilized distally and fixed with screws.

In case of severe valgus deformity, if MCL is attenuated, division and imbrications can be done to tighten the medial structures. Other options are distalizing the PLC insertion from the tibia and fixation with trans-osseous sutures. In all those cases requiring such measures, a constrained condylar prosthesis is the norm.

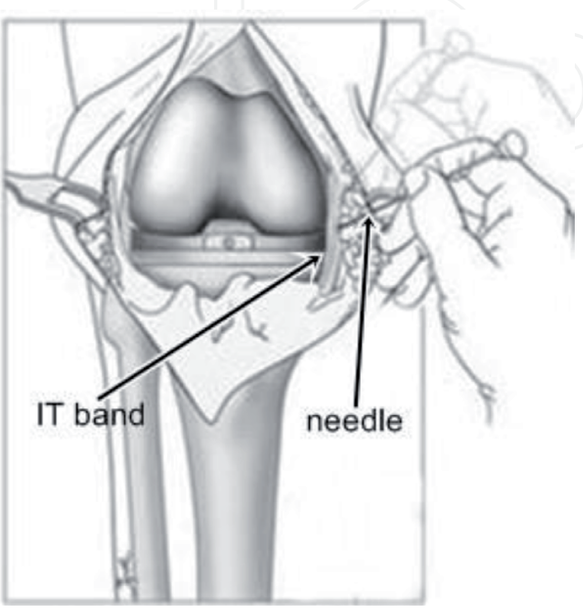


Figure 6.
Ranawat's pie-crusting technique for extensive lateral release.

Based on JST Classification of valgus knees, an intraoperative algorithm is given below [12].

2.7.3.1 Type F1a

Deformity is due to tight ITB and posterior-lateral capsule instead of LCL and popliteus tendon. Releasing ITB and posterior-lateral capsule can correct the deformity. Additionally, a bony graft or a metal block may be used to augment the hypoplastic lateral distal femoral condyle.

2.7.3.2 Type F1b

Deformity is at the level of supra-condylar region. Three options are used based on the severity of deformity.

Option 1—Lateral condyle distal sliding osteotomy is done to convert an F1b deformity into an F1a deformity. The procedure brings the deformity level into the collateral ligament level.

Option 2—Soft tissue release + constrained prosthesis.

Option 3—One-stage or two-stage supra-condylar osteotomy + TKA.

F1b valgus knee is due to supra-condylar deformity; a supra-condylar osteotomy (SCO) can aid in balancing. SCO + TKA can be done in a single stage, but be careful about the cortical break while inserting the IM rod. Also femoral stem extension may be needed in such cases; hence there can be a serious compromise in the blood supply to the osteotomy site causing non-union.

2.7.3.3 Type F2

Both the distal and posterior parts of LFC are deficient; LCL is contracted. The release of lateral soft tissues, including LCL and popliteus, may become essential.

2.7.3.4 Type T deformity

This is rare and mostly seen in rheumatoids or post-traumatic cases. The reconstruction of the plateau can be done with augments in T1 knee, and corrective osteotomy may be required for a T2 knee.

2.8 My preferred technique

Approach—Medial parapatellar approach. Careful not to release medial structures much, minimizing medial dissection to fully expose the tibia. If under anesthesia valgus correction is more than 15°; lateral parapatellar approach is preferred.

Implant—PS only. It is important to keep the condylar knee constrained and rotate the hinge knee as back up based on the severity and pathology of valgus.

Femur first—Reduce the valgus degree of resection to 3°; the entry point for IM rod in a valgus knee is usually more medial than in a standard knee. Ascertain the point with preoperative radiographs. With regard to anteroposterior cuts, watch out for hypoplasia of the lateral femoral condyle, and check the posterior condylar reference cutting block position with both Whiteside line and transepicondylar axis. Also, with the cutting blocks fixed, further check the balancing in flexion before performing the cuts.

Perform the tibial cut, perpendicular to the anatomical axis, allowing 3–5° posterior slope using an extramedullary rod. Try to remove the least possible bone amount, especially from the lateral side.

Extension gap is assessed using lamina spreaders and limited lateral release—pie crusting or ITB release is done to make it rectangular. Popliteus has to be preserved as it is a stabilizer in flexion. Varus-valgus stability is assessed in extension. Once the knee is balanced in extension, the flexion gap can be evaluated and assessed. When the knee is balanced, femoral chamfer cuts are made, and the trial components can be tested.

With trial femur, tibia and insert, it is important to assess patella tracking. If needed, a lateral retinacular release can be done inside out at this stage.

2.9 Complications

Complications which can happen in correcting a valgus deformity in TKR include tibiofemoral instability, residual valgus deformity (most common ones), restricted ROM, wound dehiscence, patella fracture, patella maltracking and peroneal nerve palsy. Correction of a severe valgus deformity can induce peroneal nerve injury due to traction or ischemia.

So, it is of utmost importance to specifically mention these complications to the patient and bystanders and get a well-informed consent prior to surgery.

2.10 Clinical outcomes

Revision rates following TKA for valgus knees at 10–15-year follow-up have been reported at between 0 and 17% [18]. Failure rate is more when the preoperative deformity is more or the residual valgus is more. The long-term results of TKA in valgus knees are reported to be not up to that of varus knees.

3. Conclusion

Valgus deformity correction in total knee replacement is not everyone's cup of coffee. Associated bone defects and ligamentous contractures add to the difficulty. Sequential release of the lateral tight structures, correcting the deformity and balancing the knee, is a tricky job. A thorough planning, surgical skill, adequate implant back up and an active physiotherapy team are mandatory to achieve the desired functional results in a valgus knee TKR.

Conflict of interest

There is no conflict of interest to declare.

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