Tibial Osteotomy for Varus Gonarthrosis: Indication, Planning, and Operative Technique

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Introduction

While the role of tibial osteotomy in the management of varus gonarthrosis has become more refined, it remains the treatment of choice for a select group of patients. The ideal candidate for a lateral closing wedge valgus tibial osteotomy is the younger, more active, heavier patient with a good range of motion and a competent medial collateral ligament with unicompartmental osteoarthritis of mechanical cause. Although the long-term results of valgus osteotomy of the tibia are modest,[1–13] these are the very patients in whom unicompartmental and tricompartmental arthroplasty results are poor. Therefore, the delay of prosthetic reconstruction for five to eight critical years is a worthy goal, provided that the subsequent reconstruction is not compromised.

The results of tibial osteotomy are directly correlated with preoperative severity of the arthritis and maintenance of postoperative alignment.[1,3–6,8,10,12,14,15] Therefore, appropriate patient selection, preoperative planning, operative execution, and internal fixation must be combined to maximize the success rate of this procedure.

Radiographic Evaluation

Because not all varus knees are best treated by lateral closing wedge valgus tibial osteotomy, carefully executed preoperative functional radiographs are necessary to select the appropriate patient and plan the surgery. The first radiograph required is a one-leg standing film taken as a screening view. This radiograph is taken in slight flexion because full extension can hide the full extent of the deformity.[16,17] For planning of the osteotomy, an orthoradiogram (full-length radiograph) of the lower extremities is taken. This radiograph is taken with 90% of weightbearing on the involved side and 10% on the noninvolved side. Putting full weight on the affected knee can throw the patient off balance, which can result in an accidental varus or valgus stress view. Ninety percent weightbearing on the involved leg affords more reliability. The next two views to be taken are the anteroposterior varus and valgus stress views. A one-leg standing lateral view of the knee in 30 degrees of flexion is important to evaluate the tibial slope and an anterior tibial translation through active quadriceps contraction; lateral stress views can also be obtained if sagittal instability is a concern. Although patellofemoral arthritis is not a contraindication of osteotomy, the status of the patellofemoral joint should be evaluated.

Preoperative Planning

Not all varus knees are best treated by tibial osteotomy, and, for the wrong patient, this osteotomy will be unsuccessful even if perfectly performed. Several radiographic criteria must be met for the patient to be a candidate for this operation. First, the varus deformity must be located primarily in the tibia. Second, the valgus stress view must show both a competent medial collateral ligament and an adequate joint space in the lateral compartment. Third, varus stress films must show narrowing of the medial compartment. Finally, the long leg film must show that the mechanical axis passes through or medial to the medial compartment. If all of these criteria are met, the patient is a candidate for lateral closing wedge valgus tibial osteotomy.

Three specific patterns of varus knee deformity should not be treated with a lateral closing wedge valgus osteotomy. The first is the varus knee caused by femoral deformity. If such a varus knee is treated by lateral closing wedge valgus tibial osteotomy, the postoperative joint line will be oblique (Fig. 1). The resulting shear can lead to subluxation and will certainly complicate later prosthetic reconstruction. The second pattern is the patient with medial osteoarthritis, a varus tibia, and a lax medial collateral ligament. These patients usually have a history of trauma. If a lateral closing wedge tibial osteotomy is performed on a patient with medial collateral ligament laxity, the instability will be unmasked by the surgery. These patients are best treated by medial opening wedge tibial osteotomy (Fig. 2). The third pattern is the young patient with ligament laxity and intra-articular erosion. This is the so-called pagoda deformity (Fig. 3).[18] Preoperatively, these patients have such severe intra-articular instability that they walk with a closed medial compartment and a gapped lateral compartment. Postoperatively, these patients walk with a closed lateral compartment and gapped medial compartment. Thus, surgery can produce either undercorrection or overcorrection. This is a very difficult problem that can only be treated by prosthetic replacement.

Finally, consideration should be given to the sagittal

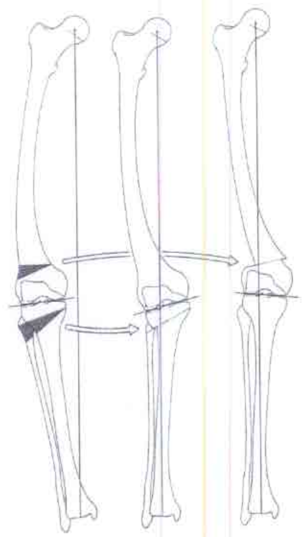

Fig. 1 Tibial osteotomy for a primary femoral deformity will produce an oblique joint line while femoral osteotomy will produce a horizontal joint line.

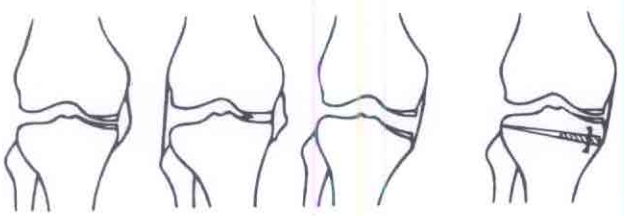

Fig. 2 The pattern of a varus tibia and medial ligament laxity is best treated by medial opening wedge valgus tibial osteotomy inserting tricortical grafts from the iliac crest and securing it with a T-plate. (Reproduced with permission from Jakob RP: Instabilitätsbedingte Gonarthrose—spezielle Indikationen für Osteotomien bei der Behandlung des instabilen Kniegelenkes, in Jakob RP, Stäubli HU (eds): *Kniegelenk und Kreuzbänder.* New York, Springer Verlag, 1991, pp 555–578.)

plane and anteroposterior instability. If the candidate for lateral closing wedge valgus tibial osteotomy has a posteriorly sloping tibia and some anterior instability, a biplane correction can be performed to decrease the posterior slope (Fig. 4).[19] If instability remains following full rehabilitation, staged ligament reconstruction can be performed. The same principles apply to posterior instability in the presence of decreased posterior or even anterior sloping.

Osteotomy Level and Orientation

Once it has been determined that a patient is a candidate for a lateral closing wedge valgus tibial osteotomy, the surgical technique must be selected. Osteotomy above the tibial tubercle is a time-honored technique familiar to many surgeons.[3,4,12] At this osteotomy level, however, the amount of angular correction is limited. Osteotomy above the tubercle can also lead to problems with intra-articular hardware, intra-articular fracture, and osteonecrosis of the subchondral

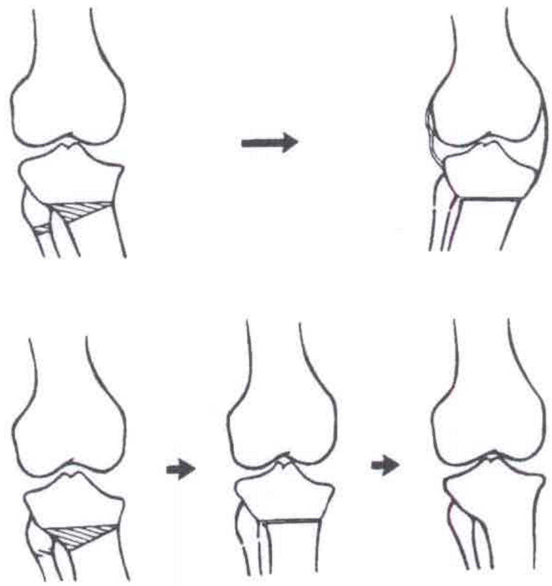

Fig. 3 The pagoda deformity. These patients have intra-articular erosion and weightbearing on one compartment or the other. This intra-articular problem is not readily solved by bony realignment, because of risk of overcorrection or undercorrection. (Reproduced with permission from Cartier P: Stellenwert der unikompartimentären Prothese bei der Femorotibialarthrose mit insuffizientem Zentralpfeiler, in Jakob RP, Stäubli HU (eds): *Kniegelenk und Kreuzbänder.* New York, Springer Verlag, 1991, pp 588–600.)

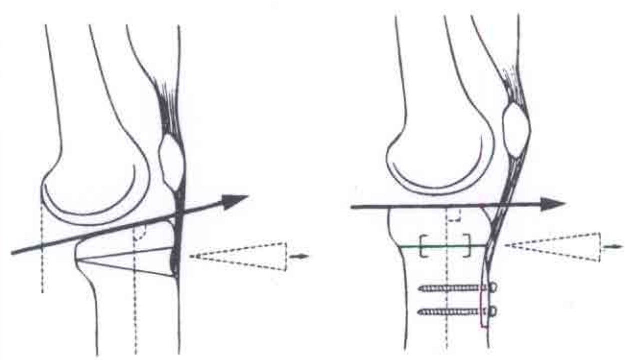

Fig. 4 If the candidate for a lateral closing wedge valgus tibial osteotomy has a posteriorly sloping tibia and anterior instability, a biplanar correction can be performed. The decrease in the posterior slope can decrease the horizontal shear forces. Staged ligament reconstruction can then be performed later if it is still necessary. This same theory applies to posterior instability. (Reproduced with permission from Dejour H, Neyret P: Der Einbeinstand bei chronischer Knieinstabilität, in Jakob RP, Stäubli HU (eds): *Kniegelenk und Kreuzbänder.* New York, Springer Verlag, 1991, pp 579–587.)

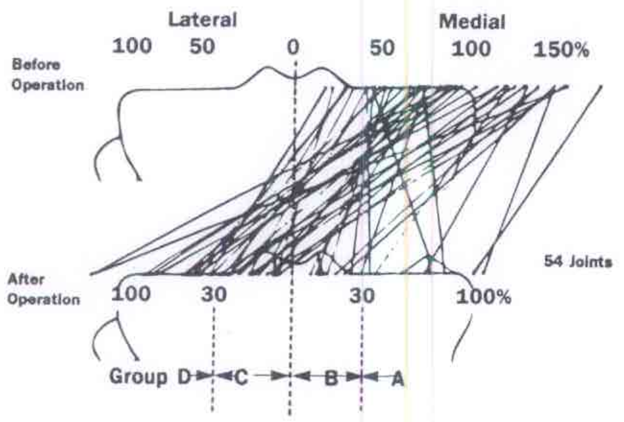

Fig. 5 Their best clinical results correlated with a postoperative mechanical axis that passes through the lateral compartment about one third of the way toward the periphery of the lateral tibial plateau. For this reason our preoperative plan is based on achieving a mechanical axis that passes through this region of the knee. (Reproduced with permission from Fujisawa Y, Masuhara K, Shiomi S: The effect of high tibial osteotomy on osteoarthritis of the knee: An arthroscopic study of 54 knee joints. *Orthop Clin North Am* 1979;10:585–608.)

bone. Osteonecrosis complicates prosthetic replacement because of bone-stock deficiency.

Osteotomy below the tibial tubercle produces a secondary deformity because of its long distance from the joint. This level is generally reserved for patients with open growth plates. The technique described in the following paragraphs—an oblique lateral closing wedge valgus tibial osteotomy behind the tibial tubercle—seeks to minimize the disadvantages of the other two operations while preserving their advantages. This technique allows for unlimited angular correction, stable fixation more than 1 cm from the joint, and does not create a secondary deformity.

Selection of Mechanical Axis

The ideal mechanical alignment following valgus osteotomy is not known. Studies that showed a femoral tibial valgus of five degrees to 13 degrees to be ideal were not based on full-length films and are, therefore, of limited validity.[1,3,10,20] Fujisawa and associates[6] have shown that good clinical results are correlated with the postoperative mechanical axis that passes through the lateral compartment about one third toward the periphery of the lateral tibia plateau (Fig. 5).[21]

Based on this information, as shown in Figure 6, a postoperative mechanical axis is drawn on the full-length anteroposterior radiograph from the center of the hip through a point one third of the way into the lateral compartment (line 1). Next, a second line is drawn from the medial hinge of the osteotomy through the center of the ankle (line 2). Finally, a third line is

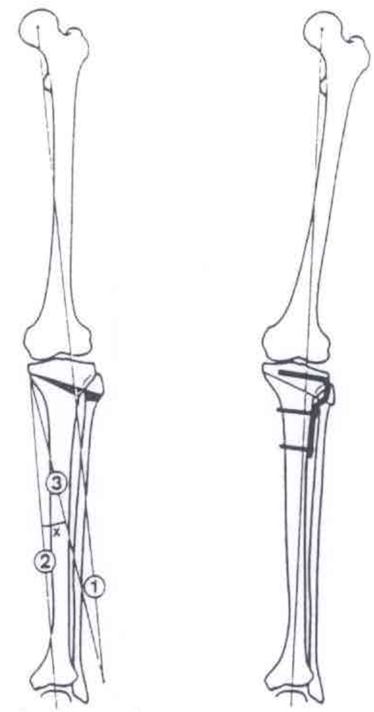

Fig. 6 After wedge removal, the osteotomy is fixed with an adolescent hip plate—(AO) 50 mm blade length, 15 mm displacement. This plate may have to be bent slightly to fit the bone and to achieve the desired angular correction. Small changes in angular correction can be achieved by placing washers under the proximal or distal part of the plate. (Reproduced with permission from Miniaci A, Ballmer FT, Ballmer PM, et al: Proximal tibial osteotomy: A new fixation technique. *Clin Orthop* 1989;246:250–259.)

drawn from the osteotomy hinge to intersect the postoperative mechanical axis at the level of the ankle joint (line 3). The angle between the second and third lines is the angle of the osteotomy wedge.

The valgus stress view is then carefully assessed to see if there is an intra-articular angular shift between the long-leg standing view and the valgus stress view as a result of gapping of the lateral compartment on the long-leg view caused by lateral collateral ligament deficiency. If there is an intra-articular shift, this small angle is subtracted from the planned angular correction. This angular shift must be accounted for in the preoperative planning, because the knee will fall into the valgus stress view position postoperatively. Failure to recognize this intra-articular angular shift will result in overcorrection.

Surgical Technique

The patient is positioned supine on a radiolucent table with a roll under the ipsilateral buttock. In general, arthroscopy is performed at the start of the procedure. Resection of medial meniscal tears and chon-

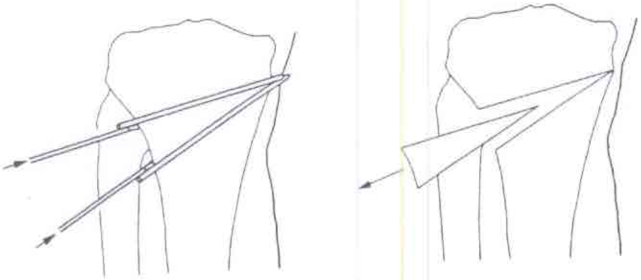

Fig. 7 Wedge resection is performed with the assistance of guide wires.

droplasty of the medial compartment and patellofemoral joint can be performed. The lateral compartment should be examined as well. Because arthroscopic findings do not correlate with results of tibial osteotomy,[22] they should not be used as a factor in the decision to perform an osteotomy. Instead, this decision is based on clinical and radiographic criteria, as previously described. Open arthrotomy should be avoided, if possible, because this complicates the postoperative course.

There are many popular incisions for the lateral closing wedge valgus tibial osteotomy. However, the effect the incision would have on a total knee replacement must always be considered. For this reason, a longitudinal incision is most appropriate. This incision can be in the midline, or just lateral to it, as long as a total knee replacement can be performed through the same incision without the need to raise large flaps.[23,24]

An anterolateral approach to the proximal tibia is performed, and the anterior compartment muscles are elevated to expose the tibia and proximal fibula. Small Kirschner wires (K-wires) are placed under the meniscus in the medial and lateral compartments to mark the position of the joint line. A 2.5-mm K-wire with threaded tip is passed across the tibia more than 1 cm below the joint line and parallel to it. The wire exits the medial tibia and skin and is cut short on both sides so as not to interfere with later steps in the operation. The T-shaped chisel for the adolescent blade plate is then passed just under and along the K-wire. Radiographic information is not required, but may be of assistance during this part of the procedure. A point on the medial tibial cortex that is approximately 2 cm below the joint line is selected. A K-wire is then passed obliquely to meet this point (Fig. 7). Another K-wire is passed more obliquely to also meet this medial osteotomy hinge. The angle between these two K-wires should equal the desired angle of correction. This procedure can be performed with radiographic assistance and without the use of alignment jigs, or, if the alignment jigs are used, it can be performed without radiographic assistance.[25-27]

Involvement in the development and the clinical testing of the AO-ASIF tibial osteotomy jig has shown that it is possible to cut an osteotomy with an accuracy of 0.5 degrees. This jig works basically with the following technical points (Fig. 8): (1) It is used for doing wedge osteotomies; (2) The location of the apex of the osteotomy is at the level of the medial cortex or 5 to 10 mm inside or outside of it; and (3) The angle can be adjusted by 1-degree increments by moving the two arms of the jig. Three 2.5-mm threaded pins are advanced through the two guide plates. The jig is then removed and the osteotomy cuts are performed along the pins.

The osteotomy of the fibula is performed by removing a segment in the neck of the fibula. The proximal osteotomy is not completely transverse, but is cut in a way so that the posterior cortex remains intact. Following eventual closure of the osteotomy, the distal fibula then rests inside this cortical cage for additional stability. This technique also serves to protect the peroneal nerve.

Before tibial osteotomy, the tibial tubercle is elevated from proximal to distal, taking care to leave the extensor mechanism in bony continuity distally. The medial periosteum is left undisturbed to preserve additional

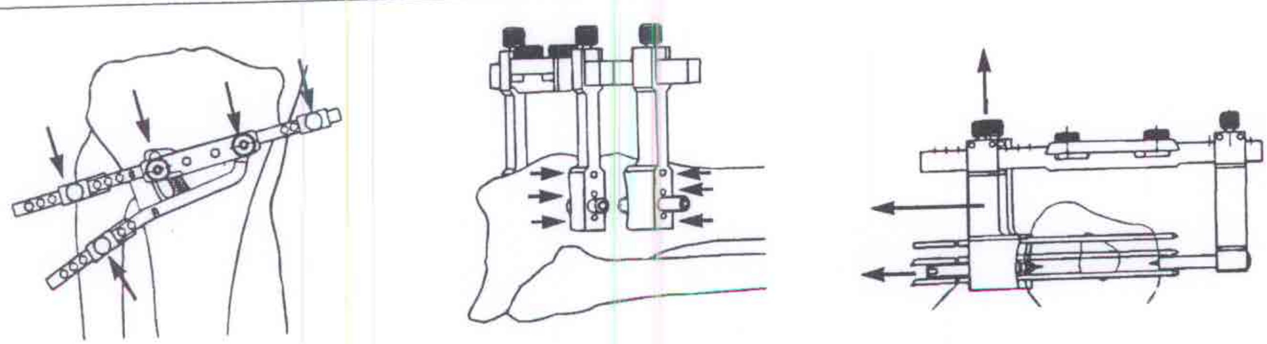

Fig. 8 For greater accuracy, a jig can be used. The AO osteotomy jig works with 2.5 mm wires between which the desired wedge resection can be performed accurately.

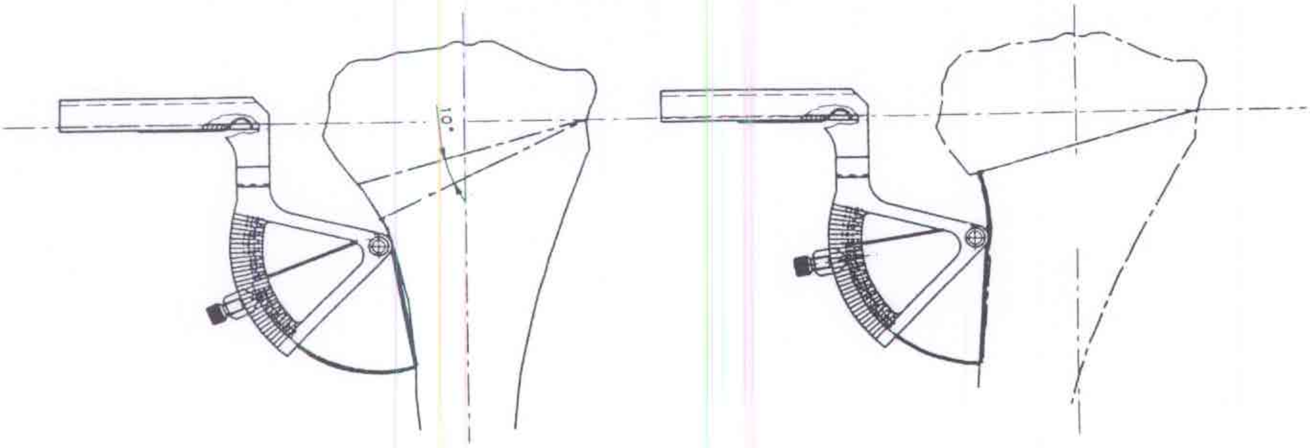

Fig. 9 A special ruler helps to determine the desired angular adaptation of the adolescent osteotomy plate so that the plate fits the bone once the osteotomy is closed.

blood supply to the tubercle. The two limbs of the wedge-shaped osteotomy are then cut with an oscillating saw, which glides along the guide wires. The sagittal plane deformities are corrected by flexing or extending the osteotomy appropriately. After the cut is completed to within a few millimeters of the medial hinge, the wedge is removed. A moderate varus stress is placed across the osteotomy site to check for flexibility. A valgus stress is not placed across the osteotomy site at this stage because the nutcracker effect of the remaining few millimeters of bone can produce enough tension on the medial hinge to break it. If the osteotomy is still rigid, the cut is extended a short distance toward the medial cortex, and the osteotomy flexibility is again checked until it can be closed. Now a special ruler is slid over the seating chisel, and the angle between the lateral cortex of the tibia and the ruler perpendicular to the blade is measured (Fig. 9). For example, if this angle is more or less equal to the desired correction, the adolescent blade plate is bent to the appropriate number of degrees prior to later insertion. If this angle measures 10 degrees and a correction of 10 degrees is desired, the plate has to be bent to 100 degrees to allow the appropriate closure of the osteotomy.

When the osteotomy is flexible, the guide wires are removed, the prebent adolescent blade plate is inserted, and the osteotomy is closed. Following fixation, an anteroposterior radiograph, with a large cassette, is taken. If the leg is slightly undercorrected, a screw washer is placed under the plate in line with the proximal screw to add a few degrees of valgus. If the leg is slightly overcorrected, the screw washer is placed under the plate in line with the distal screw to add a few degrees of varus. With this technique, it is not necessary to remove the plate, which could weaken the fixation. Because the tibial tubercle is intrinsically stable, no fixation is necessary. If there is concern about tibial tubercle integrity, one or more 3.5-mm screws may be used for fixation.

The anterior compartment muscles are gently tacked back into position with a drain underneath. The anterior fascial incision is not closed. Clinical suspicion for compartment syndrome should always remain high, especially in the presence of postoperative epidural anesthesia. Continuous passive motion, if available, and active range- of-motion exercises are started early. Partial weightbearing, begun as soon as the patient can control the leg, is maintained for three months to promote chondroneogenesis.

Discussion

The success of tibial osteotomy in the treatment of varus gonarthrosis correlates directly with proper patient selection, and achievement and maintenance of adequate operative correction.[1,3–6,8,10,12,14,15,20] Patient selection criteria must include age, weight, activity, range of motion, patient expectation, severity of degenerative change, and, in particular, an appropriate interpretation of functional radiographs. Adequate correction depends on precise preoperative planning and intraoperative execution. Maintenance of correction requires adequate bony stability and internal fixation.

Large angular corrections, which are uncommon, require fracture of the medial hinge. In these cases, and in cases of inadvertent fracture of the medial hinge, the adolescent blade plate is especially useful, because it provides compression and intrinsic varus-valgus, flexion-extension, and axial rotational stability. In contrast, staples only provide a tension band, and a plate with screws provides no intrinsic varus-valgus stability. The use of the adolescent blade plate has solved problems that were occasionally encountered with a semitubular plate-and-screw fixation construct.[28,29] Adequate internal fixation is also particularly important when the osteotomy is combined with chondroplasty. In such cases, early motion is critical. Conversely, chondroplasty alone is never indicated in the treatment of medial compartment arthritis in the presence of mechanical malalignment. Chondroplasty, in these cases, must always be combined with mechanical realignment.[30-32]

The trend toward using the Ilizarov fixator and other external fixation devices instead of internal fixation reflects a reaction to prior problems with accurate surgical correction and fixation. These problems are not solved by abandoning these techniques, however, but by addressing the problems of surgical execution and fixation as previously described. The external fixator allows inexact preoperative planning and imprecise intraoperative execution because of the option of postoperative adjustment. In practice, the patient should never leave the operating room until the appropriate correction has been achieved. The apparatus is not as well tolerated by adults as by children, and it limits knee flexion, particularly in obese patients. The Ilizarov apparatus and other external fixators are best applied clinically in salvage situations where internal fixation has failed.

The tibial osteotomy is not an operation that competes directly with unicompartmental or tricompartmental knee replacement, but, rather, is a complementary procedure. In general, unicompartmental knee replacement is more appropriate for lesser degrees of varus, which are caused primarily by intra-articular erosion.[33,34] These patients are usually older, have more advanced medial compartment arthritis, and may have larger intra-articular angular shift. Patients with a depressed medial compartment and those with severe medial joint wear in the absence of varus deformity are more suitable candidates for hemiprostheses. Although tibia osteotomy, unicompartmental replacement, and total knee replacement have overlapping indications, most patients are clearly better suited to one of these three procedures.[35] In summary, with improved patient selection, preoperative planning, and intraoperative execution and fixation, the results of tibial osteotomy can be maximized.

References

1. Aglietti P, Rinonapoli E, Stringa G, et al: Tibial osteotomy for the varus osteoarthritic knee. *Clin Orthop* 1983;176:239–251.
2. Arnoldi CC, Lempberg RK, Linderholm H: Intraosseous hypertension and pain in the knee. *J Bone Joint Surg* 1975;57B:360–363.
3. Coventry MB: Osteotomy about the knee for degenerative and rheumatoid arthritis: Indications, operative techniques, and results. *J Bone Joint Surg* 1973;55A:23–48.
4. Coventry MB: Upper tibial osteotomy for gonarthrosis: The evolution of the operation in the last 18 years and long term results. *Orthop Clin North Am* 1979;10:191–210.
5. Engel GM, Lippert FG III: Valgus tibial osteotomy: Avoiding the pitfalls. *Clin Orthop* 1981;160:137–143.
6. Fujisawa Y, Masuhara K, Shiomi S: The effect of high tibial osteotomy on osteoarthritis of the knee: An arthroscopic study of 54 knee joints. *Orthop Clin North Am* 1979;10:585–608.
7. Insall JN, Joseph DM, Msika C: High tibial osteotomy for varus gonarthrosis: A long-term follow-up study. *J Bone Joint Surg* 1984;66A:1040–1048.
8. Insall JN, Shoji H, Mayer V: High tibial osteotomy: A five year evaluation. *J Bone Joint Surg* 1974;56A:1397–1405.
9. Jackson JP: Osteotomy for osteoarthritis of the knee. *J Bone Joint Surg* 1958;40B:826.
10. Kettelkamp DB, Wenger DR, Chao EYS, et al: Results of proximal tibial osteotomy: The effects of tibiofemoral angle, stance-phase flexion-extension, and medial-plateau force. *J Bone Joint Surg* 1976;58A:952–960.
11. Salter RB, Simmonds F, Malcom BW, et al: The biological effect of continuous passive motion on the healing of full-thickness defects in articular cartilage: An experimental investigation in the rabbit. *J Bone Joint Surg* 1980;62A:1232–1251.
12. Shoji H, Insall JN: High tibial osteotomy for osteoarthritis of the knee. *Int Surg* 1976;61:11–14.
13. Tjörnstrand BAE, Egund N, Hagstedt BV: High tibial osteotomy: A seven-year clinical and radiographic follow-up. *Clin Orthop* 1981;160:124–136.
14. Scott RD, Santore RF: Unicondylar unicompartmental replacement for osteoarthritis of the knee. *J Bone Joint Surg* 1981;63A:536–544.
15. Ziller R, Seyfarth H: Loss of correction following high tibial osteotomy. *Beitr Orthop Traumatol* 1974;21:358–363.
16. Maquet PGJ: *Bioméchanique du Genou*. New York, Springer Verlag, 1977, p 135.
17. Maquet PGJ: *Bioméchanique du Genou*. New York, Springer Verlag, 1977, p 194.
18. Cartier P: Stellenwert der unikompartimentären Prothese bei der Femorotibialarthrose mit insuffizientem Zentralpfeiler, in Jakob RP, Stäubli HU (eds): *Kniegelenk und Kreuzbänder*. New York, Springer Verlag, 1991, pp 588–600.
19. Dejour H, Neyret P: Der Einbeinstand bei chronischer Knieinstabilität, in Jakob RP, Stäubli HU (eds): *Kniegelenk und Kreuzbänder*. New York, Springer Verlag, 1991, pp 579–587.
20. Hernigou PH, Medevielle D, Debeyre J, et al: Proximal tibial osteotomy for osteoarthritis with varus deformity: A ten to thirteen-year follow-up study. *J Bone Joint Surg* 1987;69A:332–354.
21. Jakob RP: Instabilitätsbedingte Gonarthrose—spezielle Indikationen für Osteotomien bei der Behandlung des instabilen Kniegelenkes, in Jakob RP, Stäubli HU (eds): *Kniegelenk und Kreuzbänder*. New York, Springer Verlag, 1991, pp 555–578.
22. Keene JS, Dyreby JR Jr: High tibial osteotomy in the treatment of osteoarthritis of the knee: The role of preoperative arthroscopy. *J Bone Joint Surg* 1983;65A:36–42.
23. Katz MM, Hungerford DS, Krackow KA, et al: Results of total knee arthroplasty after failed proximal tibial osteotomy for osteoarthritis. *J Bone Joint Surg* 1976;69A:225–233.
24. Staheli JW, Cass JR, Morrey BF: Condylar total knee arthroplasty after failed proximal tibial osteotomy. *J Bone Joint Surg* 1987;69A:28–31.
25. Jiang C-C, Hang Y-S, Liu T-K: A new jig for proximal tibial osteotomy. *Clin Orthop* 1988;226:118–123.
26. Myrnerts R: Clinical results with the Saab jig in high tibial osteotomy for medial gonarthrosis. *Acta Orthop Scand* 1980;51:565–567.
27. Myrnerts R: Failure of the correction of varus deformity obtained by high tibial osteotomy. *Acta Orthop Scand* 1980;51:569–573.
28. Miniaci A, Ballmer FT, Ballmer PM, et al: Proximal tibial osteotomy: A new fixation technique. *Clin Orthop* 1989;246:250–259.
29. Weber BG, Brunner CF: *Special Techniques in Internal Fixation*. New York, Springer-Verlag, 1982.

30. Dandy DJ: Abrasion chondroplasty. *Arthroscopy* 1986;2:51–53.
31. Friedman MJ, Berasi CC, Fox JM, et al: Preliminary results with abrasion arthroplasty in the osteoarthritic knee. *Clin Orthop* 1984;182:200–205.
32. Johnson LL: Arthroscopic abrasion arthroplasty historical and pathologic perspective: Present status. *Arthroscopy* 1986;2:54–69.
33. Jackson RW, Burdick W: Unicompartmental knee arthroplasty. *Clin Orthop* 1984;190:182–185.
34. MacIntosh DL, Welsh RP: Joint debridement: A complement to high tibial osteotomy in the treatment of degenerative arthritis of the knee. *J Bone Joint Surg* 1977;59A:1094–1097.
35. Insall JN, Hood RW, Flawn LB, et al: The total condylar knee prosthesis in gonarthrosis: A five to nine-year follow up of the first one hundred consecutive replacements. *J Bone Joint Surg* 1983;65A:619–628.