

PROXIMAL TIBIAL AND DISTAL FEMORAL OSTEOTOMY

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INTRODUCTION

Osteotomy procedures around the knee can alter the biomechanical axis of the knee, thereby shifting the load from one compartment to another. This can be used to unload an arthritic painful compartment or to decrease the weight experienced by a cartilage restoration procedure. Recent clinical and biomechanical studies have emphasized the importance of correcting the weight bearing axis in a cartilage restoration procedure and to avoid rapid progression of osteoarthritis.^{1,2}

PREOPERATIVE EVALUATION

HISTORY AND PHYSICAL EXAMINATION

A detailed history and physical examination must be performed before a patient is considered for an osteotomy. The history should include the patient's occupation and activity level, all previous surgical and nonsurgical interventions performed on the knee, and where and when he or she experiences pain. All previous arthroscopic and radiographic images should be reviewed with the patient. In addition to a standard physical examination, one should carefully assess the patient's body habitus, overall alignment, and any coronal, sagittal, or rotational instability. Other sources of pain, such as the lower back or hip, must be examined as well. The use of a lateral offset short leg walking cast popularized by Cole et al³ or unloader brace can be used to predict the potential success of a high tibial osteotomy.

IMAGING

Radiographs include four views (ie, standing anteroposterior [AP], lateral, Merchant, and 45-degree flexion posteroanterior [PA]). The PA view allows better analysis of the weight bearing portion of the articular surface. In addition, bilateral long leg standing films are taken to measure the mechanical axis and calculate the required degree of correction. Magnetic resonance imaging (MRI) is only useful with suspected cartilage or ligament damage.

Calculating Degree of Correction (Coronal Plane)

For medial compartment arthritis, overcorrection is usually needed to the 62% lateral weight bearing line (roughly two-thirds of the width of the tibia plateau). The point of the desired mechanical axis is marked on the tibial plateau. A line is drawn from the center of the femoral head to the desired point on the plateau. Another line is drawn from the point on the plateau to the center of the tibial plafond. The angle formed by the two lines is the degree of correction needed (Figure 21-1). Generally, 1 mm of opening corresponds to 1 degree of correction; however, this only applies for a tibial width of 56 mm. For unloading cartilage restoration procedures, correction of the mechanical axis to neutral (center of plateau) is sufficient.

Calculating Degree of Correction (Sagittal Plane)

Increasing the tibial slope will worsen symptoms with anterior cruciate ligament (ACL) instability and improve symptoms with posterior cruciate ligament (PCL) instability. Conversely, decreasing the tibial slope will improve symptoms with ACL instability and worsen symptoms with PCL instability.



Figure 21-1. Calculating degree of correction.

INDICATIONS AND CONTRAINDICATIONS

Osteotomy is indicated for younger patients, generally younger than 50 years of age, with symptomatic medial or lateral compartment arthritis in whom a unicompartmental arthroplasty is contraindicated, either due to young age or high demand (eg, in heavy physical laborers). In patients with ligamentous instability, osteotomy can be performed as long as sagittal plane correction is performed at the same time. Patients with cartilage defects and associated malalignment undergoing cartilage repair can benefit from normalization of their mechanical axis to improve the success rates of cartilage repair.

Osteotomies are contraindicated in patients with:

- Tricompartmental arthritis
- Deformity over 15 degrees
- Flexion contracture over 15 degrees
- Knee flexion under 90 degrees
- Medial/lateral tibial subluxation over 1 cm
- Excessive bone loss (over 3 mm)
- Inflammatory arthritis

- Patella Baja
- Morbid obesity
- Smokers
- Any medical comorbidities that may interfere with bony healing

Relative contraindications apply to patients older than age of 60 or those who have patellofemoral arthritis in addition to the isolated medial or lateral compartment arthritis.

SURGICAL TECHNIQUE

SPECIAL INSTRUMENTATION

The surgeon can use any periarticular plate system to stabilize the osteotomy. A number of companies (Synthes, Stryker, DePuy, etc) have such plates available in their trauma line. Our preferred alternative is to use the opening wedge osteotomy system (Arthrex Inc, Naples, FL) for fixation. This chapter will describe this system. In addition, a power drill and saw with a large saw blade are needed to perform the osteotomy. Fluoroscopy is used in every case to measure the degree of correction and to ensure that the screws are appropriately placed.

For grafting of the osteotomy site, commercial allograft cortical wedges and demineralized bone matrix should be available. Alternatively, iliac crest cancellous autograft can be used.

POSITIONING

The patient is placed supine on the operating table. A radiolucent extension is applied to enable fluoroscopic examination. Alternatively, the patient can be placed on the ipsilateral edge of the table to enable fluoroscopic access by abducting the leg or a radiolucent fracture table can be utilized instead. A tourniquet is applied and is used as needed. It is usually deflated prior to closure to ensure adequate hemostasis. If a large correction is anticipated, the ipsilateral iliac crest is draped for potential graft harvest and a rolled blanket or a gel pad is placed under the same buttock.

SURGICAL ANATOMY

The bony landmarks should be palpated and marked prior to incision, including the femoral condyles, tibial plateau, and patella. Structures at risk include the neurovascular bundle in the popliteal fossa; great care should be taken to meticulously dissect the posterior aspect of the proximal tibia and place a retractor and sponges between bone and soft tissue for protection. A preoperative MRI can be useful to rule out an aberrant take-off of the anterior tibial artery, which courses anteriorly, rather than posteriorly, to the popliteus muscle in 2% of patients.

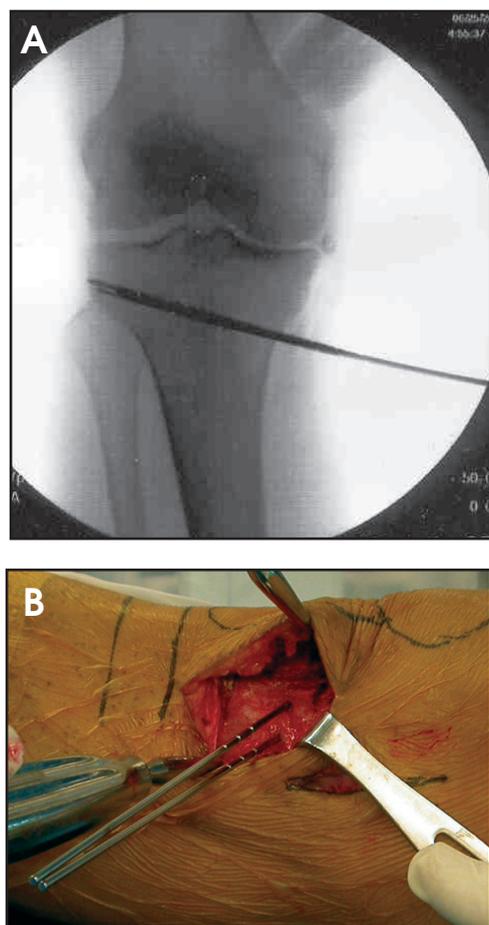


Figure 21-2. Proximal tibial guide pin insertion.

ARTHROSCOPY AND CARTILAGE RESTORATION PROCEDURES

A diagnostic arthroscopy is routinely performed to verify the status of the articular cartilage and menisci. Other reparative or restorative procedures can be performed at this stage.

TECHNICAL STEPS

Opening Wedge High Tibial Osteotomy

A marking pen is used to mark the tibial tubercle, the patellar tendon, and the pes anserine. The high tibial osteotomy (HTO) incision can be planned by drawing a line from the distal aspect of the anteromedial arthroscopic portal distally to the level of pes on the medial side of the tibial tubercle. The portion below the joint line can be used to perform the actual incision. The incision roughly falls between the tibial crest and the posteromedial tibial border. The dissection is carried down to the anteromedial tibia and the sartorius fascia. The hamstring tendons are palpated, and an electrocautery device is used to make a transverse cut along their superior aspect extending from the posteromedial tibia to the level of the patellar tendon. The cut



Figure 21-3. Completing osteotomy cut.

is curved inferiorly to follow along the medial side of the patellar tendon. A sleeve including the pes is raised subperiosteally to the posteromedial tibia and reflected distally and posteriorly. The dissection is continued around the posterior tibia until the proximal tib-fib joint can be palpated. A large blunt retractor is placed behind the tibia to protect the neurovascular structures. Another retractor is placed above the tibial tuberosity to protect the patellar tendon.

Guide Pin Insertion

A 2.4-mm break-away guide pin is inserted into the tibia in an inferomedial to superolateral direction. The starting point is approximately 3 to 4 cm distal to the medial tibial joint line. The guide pin tip should end on the lateral cortex approximately 2 cm distal to the lateral tibial joint line, aiming for the proximal tib-fib joint, whose joint capsule provides additional stability. The position is verified with fluoroscopy. Radiographically, the pin should traverse the superomedial tibial tuberosity at the junction of the patellar tendon insertion and end at the fibular head (Figure 21-2). Insert another pin parallel to the first, taking into account the proximal slope of the tibia. The pins are bent and broken at their break-away point.

Osteotomy Cut

The cutting guide is placed over the two pins. An oscillating saw is used to cut the tibia anteriorly, medially, and posteriorly to within 1 cm of the lateral cortex. Various thin osteotomes are available on the set and can be used to complete the osteotomy anteriorly and posteriorly (Figure 21-3). Avoid the use of thick osteotomes, which can lead to an iatrogenic fracture. Fluoroscopy is used to ensure the osteotome does not violate the lateral cortex. Performing the saw cut and using the osteotomes on the inferior side of the cutting guide and pins can prevent propagation of a fracture into the tibial plateau.

Osteotomy Distraction

Remove the guide pins and insert the calibrated wedges loaded on the handle into the osteotomy on the medial side of the tibia. Gently and slowly advance the wedges to open

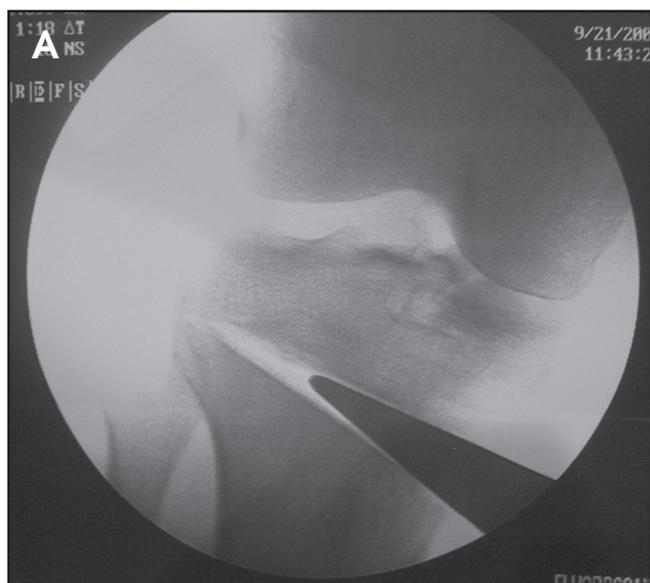


Figure 21-4. Osteotomy distraction.

the osteotomy. If the osteotomy resists opening, the osteotomes should be reinserted to complete the cut around the tibia. The markings on the side of the wedges correspond to the size of medial opening in millimeters (Figure 21-4). Rapid insertion of the wedges can lead to a lateral fracture. The handle is removed, and the wedges are left in place. The cord of an electrocautery device can be used as a fluoroscopic mechanical axis marker over the thigh (hip to ankle) to ensure that an adequate correction has been achieved.

Plate Fixation

We prefer the titanium locking Puddu plate. Titanium is more MRI compatible and reduces artifact, which is especially important in cartilage repair procedures where follow-up MRI scans are planned. The locking plate construct increases the stability of the osteotomy, especially on the lateral side. An angled plate of the appropriate size is placed in the space between the two wedges with the wider side of the block placed posteriorly to avoid increasing posterior slope. The plate should sit just anterior to the medial collateral ligament (MCL) (Figure 21-5). Two cancellous 6.5-mm screws are used to fix the proximal plate. These screws are unicortical. It is important to use fluoroscopy to make sure the screws do not

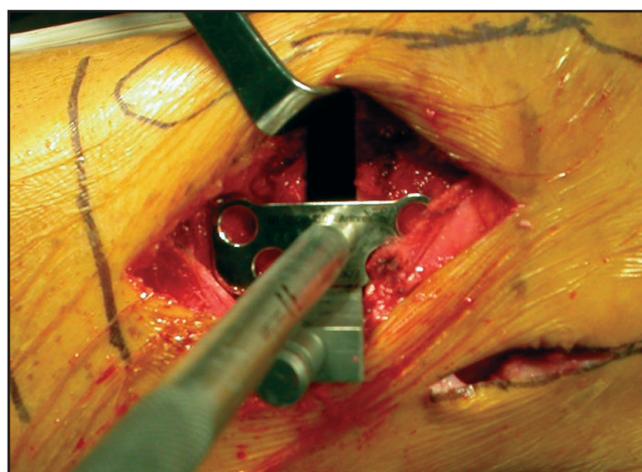


Figure 21-5. Plate placement.



Figure 21-6. Plate fixation.

penetrate the articular surface. The screws should engage and lock into the plate (Figure 21-6), if the locking Puddu plate is chosen. The calibrated wedges are now removed to allow the osteotomy to close down on the plate and obtain bone-to-plate contact. Two 4.5-mm cortical screws are used to secure the plate distally. These screws are bicortical.

Bone Graft

Allograft or autograft bone is inserted in the osteotomy site on both sides of the plate. Graft choices include tricortical wedge allograft, iliac crest autograft, synthetic bone substitutes, or allograft bone chips (Figure 21-7). Local bone graft can be obtained from the distal femur or proximal tibia, utilizing osteochondral allograft technique (OAT) harvesting chisels to remove cylinders of cancellous bone graft.

Incision Closure

The tourniquet is deflated, the incision is irrigated with saline, and hemostasis is achieved. Using #1 Vicryl, the ele-

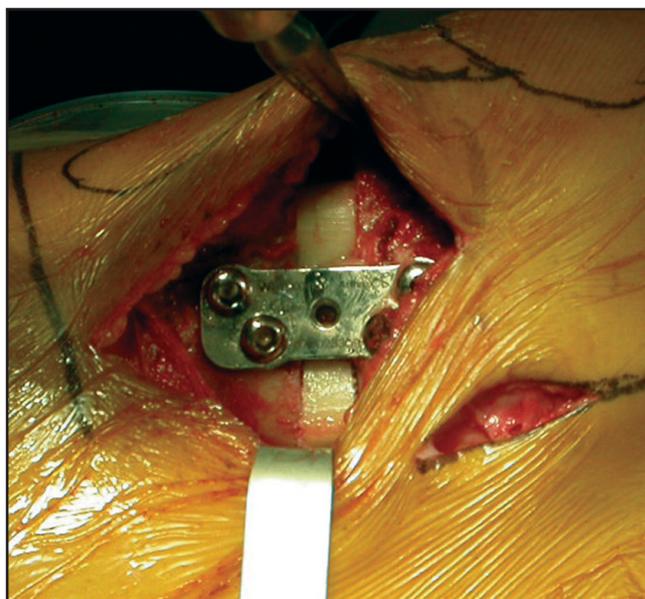


Figure 21-7. Bone grafting the osteotomy site.

vated tissue on the medial side of the tibia is repaired. The remainder of the incision is closed in layers. Sterile dressing and a knee brace locked in extension are applied. A femoral nerve block can be performed after surgery to improve pain control. Anticoagulation is prescribed to the patient using low molecular weight heparin or warfarin for 4 weeks.

Opening Wedge Distal Femoral Osteotomy

Valgus deformity in the knee is less common than varus deformity and constitutes approximately 25% of all cases with osteoarthritis. A similar surgical technique can be performed for valgus malalignment by performing an opening wedge distal femoral osteotomy. A similar instrument set with longer plates is available for this procedure. Below are some specific hints to perform a successful opening wedge distal femoral osteotomy.

Surgical Approach

A lateral approach to the thigh is used to perform a distal femoral osteotomy. The posterior edge of the iliotibial band is palpated, and the incision is made 2 cm anteriorly to it. The iliotibial band is split along its fibers, and the vastus lateralis is elevated off the femur and the intermuscular septum to expose the femoral shaft and metaphysis. Perforating vessels are common in this area and should be carefully ligated or cauterized.

Guide Pin Insertion

The guide pin starting point is about 3 to 4 cm proximal to the lateral epicondyle. The pin is placed from proximal-lateral to distal-medial (Figure 21-8). The pin should exit near the medial epicondyle. The superior aspect of the trochlea can be marked under fluoroscopy to make sure the pin is not placed too distally in the femur, violating the patellofemoral articulation.

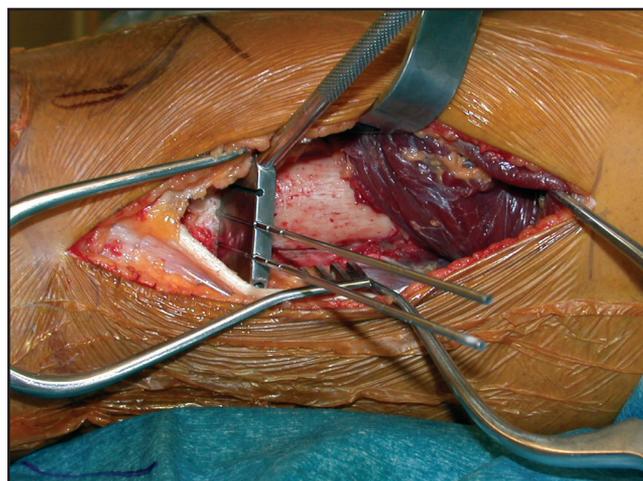


Figure 21-8. Distal femoral guide pin insertion.

Osteotomy Cut

The osteotomy is performed in a similar fashion to a high tibial osteotomy. The cut should be made perpendicular to the femur to prevent flexion or extension of the distal fragment. To this end, the second pin should be placed parallel to the first on the AP view.

Osteotomy Distraction

Under fluoroscopic guidance, a bovie wire can be placed on the thigh from the center of the head to the center of the ankle joint. As the osteotomy is distracted, the mechanical axis can be seen changing on x-ray (Figure 21-9).

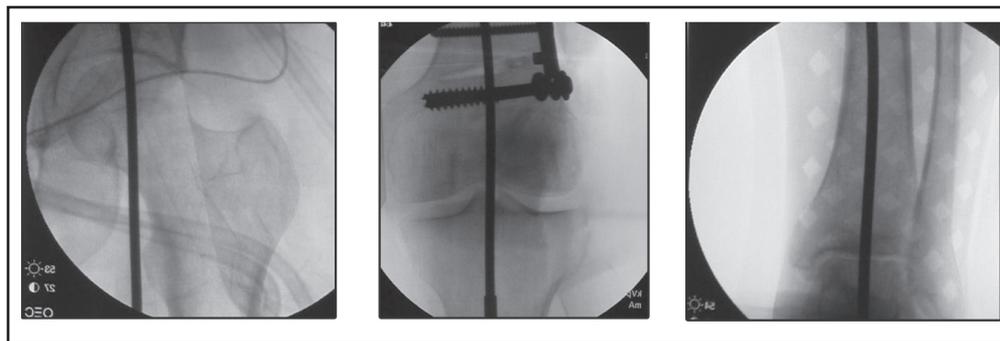
Plate Fixation

Once the appropriate angle of correction is achieved, the plate is fixed distally with unicortical cancellous 6.5-mm screws and proximally with at least three bicortical 4.5-mm screws (Figure 21-10).

POSTOPERATIVE ISSUES

REHABILITATION PROTOCOL

- Phase I (0 to 4 weeks): Touch-down weight bearing is allowed with crutches for at least 6 weeks. The brace is worn at all times except for continuous passive motion machine (CPM) use. The CPM is used for 4 hours a day, attempting to achieve 90 degrees of flexion in the first 3 weeks. Physical therapy includes quadriceps sets, ankle pumps, straight leg raises with the brace locked in extension, and nonweight bearing calf/hamstring stretches.
- Phase II (4 to 6 weeks): Weight bearing is advanced without crutches as long as an x-ray taken at 4 weeks shows adequate healing. The brace is unlocked for ambulation. CPM is discontinued when knee flexion

Figure 21-9. Measuring mechanical axis.

reaches 90 degrees. Physical therapy continues with gentle stationary bike and straight leg raises without the brace.

- Phase III (6 weeks to 3 months): Brace is discontinued if the patient is pain free. Start mini-squats (0 to 45 degrees), leg-press (0 to 60 degrees), closed-chain terminal knee extension, balance activities, and toe raises.
- Phase IV (3 to 9 months): Progress closed-chain exercises as tolerated. Begin treadmill walking, and progress as tolerated. Return to full activities typically occurs by the end of phase IV.

COMPLICATIONS

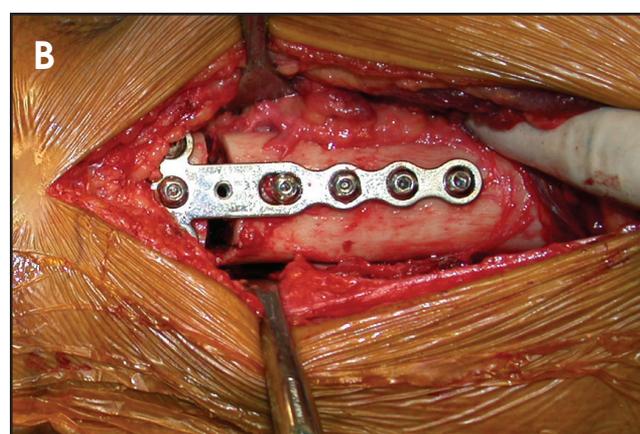
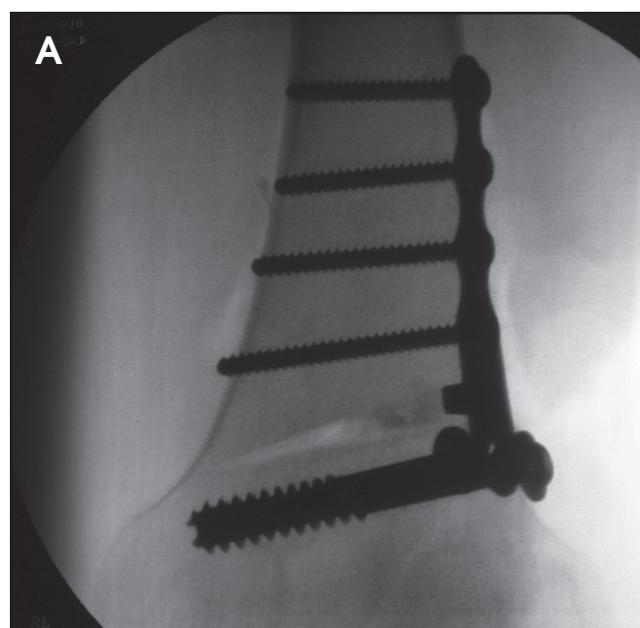
In addition to the usual complications encountered in knee surgeries, complications of osteotomy procedures include iatrogenic tibia fractures (<2%), deep vein thrombosis (15%), and nonunion (1%).

HELPFUL HINTS

- The most important part of the case is proper placement of the guide pins.
- If the osteotomy extends to the opposite cortex, it can be fixed by making a small incision over that cortex and placing two bone staples.
- If the osteotomy extends proximally to the tibial plateau, it can be fixed using two cannulated, partially threaded AO screws from lateral to medial or using a formal periarticular plate with additional screws placed directly underneath the tibial plateau.

RESULTS

Long-term results indicate that osteotomies have the potential to prolong the life of a native knee at least 10 years in the right patient.⁴⁻⁶ Naturally, the clinical efficacy declines with time. In appropriately selected patients with high-demand jobs and sports, a knee osteotomy is superior to a traditional total knee arthroplasty for allowing patients to resume their preosteotomy activities (Table 21-1).

**Figure 21-10.** Plate fixation.

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TABLE 21-1

REVIEW OF PUBLISHED RESULTS

<i>Study</i>	<i>Results</i>
Cole et al. ³	The authors evaluated the effect of a lateral offset walking cast on patients with varus medial arthritis indicated for HTO. Nineteen patients were placed in a cast for 3 days and pre- and post-cast gait analysis was performed. The cast led to 53% reduction of pain, and 36% reduction in adduction moment in 17 of 19 patients who tolerated the cast. There was a correlation between the reduction of pain and adduction moment ($r=0.63$).
Esenkaya & Elmali ⁷	The authors performed 58 opening wedge high tibial osteotomies in patients with medial compartment arthrosis. The ages ranged between 36 and 66, and the average follow-up was 21 months. The HSS score improved from 58 to 89. Lateral tibia plateau fractures were seen in 8.6% of patients, and lateral cortex fractures were noted in 25.8% of patients. Delayed union was seen in 1.7% of patients.
Finkelstein et al ⁸	Twenty-one patients were treated with closing wedge distal femoral osteotomy for a valgus deformity. The patients were followed for an average of 133 months. The 10-year survival rate was 64%.
Franco et al ⁹	Thirty patients were treated with opening wedge HTO and were followed for 36 to 48 months. The average age was 49 years. The authors used International Knee Committee and HSS scoring systems for evaluation. Preoperatively, 11 patients were in the C group, and 19 were in the D group according the International Knee Committee scales. At the latest follow-up, 17 patients were in the B group, and 13 were in the C group. All patients improved at least one category.
Gaasbeek et al ¹⁰	The authors analyzed the differences in angle accuracy and initial stability between closing and opening wedge high tibial osteotomy using cadaveric specimens. There was a tendency to over-correction with the closing wedge samples, but this was not statistically significant. There was no difference in the initial stability between the two techniques.
Hernigou et al ¹¹	Using an opening wedge technique, the authors treated 93 knees. At a 5-year follow-up, 90% of the knees had good or excellent results. The results deteriorated over time, and after 10 years, 45% of the patients had excellent or good results.
Koshino et al ¹²	The authors studied the outcomes of 21 knees that underwent opening wedge high tibial osteotomy. The mean age was 66.6 years, and the patients were followed for an average of 78.6 months. Two hydroxyapatite wedges were placed in each osteotomy site. The mean knee and functional scores of the American Knee Society improved from 60.2 and 48.1 to 94.3 and 93.1, respectively. No recurrence of varus deformity was noted in any patient.
Naudie et al ¹³	Seventeen knees with instability rather than osteoarthritis were treated with an opening wedge high tibial osteotomy. Functional results were evaluated based on the scoring systems by Lysholm and Tegner and using a 5-point analog scale to assess knee stability and satisfaction. Patients were followed for 56 months. All patients had an increase in their activity level. All but one were satisfied with their outcome. Radiographic results showed a correction of the mechanical axis to about 46% toward the lateral side.
Yacobucci & Cocking ¹⁴	This case series reviewed 50 patients who underwent medial opening wedge high tibial osteotomy and were grafted with corticocancellous wedge allograft. The average time to union was 12.1 weeks. Overall, 4% had a nonunion, and 2% had loss of correction.

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