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IN BRIEF

Complications In Brief

Osteotomy for Lower Extremity Malalignment

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Abstract When performing an osteotomy for lower extremity malalignment, several complications can occur. These can include introducing iatrogenic malalignment, intraoperative fracture or vascular injury, postoperative recurrence of deformity, patella baja, and challenges when performing subsequent total knee replacement in the future. Likewise, a poor functional result can occur secondary to poor preoperative planning and patient selection. In this article, we review the complications that can occur as a result of errors made before, during, and after surgery. This article pertains to opening and closing wedge osteotomies of the distal femur and proximal tibia.

Avoidance of Major Complications

Although several technical, intraoperative errors can occur, appropriate patient selection is paramount to avoid poor functional outcomes (Table 1). For example, it is not advisable to perform a high tibial osteotomy to unload the medial compartment in the setting of significant, lateral and/or patellofemoral arthritis, medial tibial bone loss greater than 2 or 3 mm, ROM less than 90°, flexion contracture greater than 15°, ligamentous instability resulting in worsened instability after bone cuts, and/or inflammatory arthritis.

Intraoperatively, placing a sandbag under the hip of the affected limb allows better access to the lateral aspect of the limb. It is also important to maintain the knee at 90° as the neurovascular bundle is less vulnerable to injury in this position. With regard to technical aspects of the procedure, the cutting jig must be meticulously placed to avoid introducing an anterior or posterior slope to the cut. Carrying the apex of the osteotomy cut to within 10 mm of the far cortex and leaving the proximal fragment at least 15 mm thick can help avoid fracture. Patella baja can be prevented after a lateral closing wedge high tibial osteotomy by using rigid internal fixation and aggressive postoperative mobilization, rather than prolonged casting.

Detection and Treatment of Major Complications

Avoiding preoperative patient selection issues can be addressed with a thorough history and physical examination, radiographic evaluation with full-length standing films, and arthroscopic evaluation, preoperatively and at the time of the planned osteotomy. Intraoperatively, one must monitor for vascular injury by detailed observation of the surgical site (letting down the tourniquet if necessary) as monitoring perfusion of the limb is difficult with the leg obscured by drapes. Similarly, it is advisable to perform these procedures where a vascular surgeon is available in case an injury occurs. Some injuries may be detected postoperatively on neurovascular check (ie, pseudoaneurysm) and some may be managed conservatively, but a vascular surgeon should be notified. Judicious use of fluoroscopy must be used to assess for iatrogenic malalignment or fracture.

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Table 1. Complications related to patient selection

Error	Clinical effect	Prevention	Detection	Remedy
Performing a HTO on a patient with significant lateral and/or patellofemoral DJD [1]	Decreased chance of success as pain and functional compromise may continue despite addressing medial compartment.	Thorough preoperative evaluation using radiographic, clinical, and possibly arthroscopic information	Radiographs (standing films, stress films), physical examination	Consider more definitive intervention (ie, arthroplasty) or continued conservative management
Performing a HTO on a patient with valgus limb alignment and isolated lateral compartment OA [5]	Correcting valgus angulation on the tibial side has been criticized because it produces obliquity of the joint line, whereas the preferred treatment is a varus-producing distal femoral osteotomy, which does not alter the joint line.	Thorough preoperative evaluation using radiographic, clinical, and possibly arthroscopic information	Radiographs (standing films, stress films), physical examination	DFO for treatment of the much less common entity of isolated lateral compartment OA in patients with valgus limb alignment
Performing a HTO on a patient with medial compartment tibial bone loss greater than 2 or 3 mm [3]	Excessive bone loss from the medial tibial plateau prevents weightbearing on both plateaus after HTO is performed and results in instability of the knee in the coronal plane.	Thorough preoperative radiographic evaluation and intraoperative evaluation (ie, arthroscopy)	Radiographs (standing films, stress films), Arthroscopy (if being performed for another reason like meniscal tear)	Consider more definitive intervention (ie, arthroplasty) or continued conservative management
Performing a DFO on a patient with significant medial and/or patellofemoral DJD [5]	Decreased chance of success as pain and functional compromise may continue despite addressing lateral compartment.	Thorough preoperative evaluation using radiographic, clinical, and possibly arthroscopic information	Radiographs (standing films, stress films), physical examination	Consider more definitive intervention (ie, arthroplasty) or continued conservative management
Performing a HTO on a patient with lateral tibial subluxation greater than 1 cm [6]	Abnormal patellofemoral tracking may be exacerbated if the tibia is brought into further valgus.	Thorough preoperative radiographic and clinical evaluations	Radiographs, physical examination	May consider addressing tibial subluxation surgically
Performing an osteotomy on a patient with knee ROM less than 90° [1]	Poor rehabilitation potential	Thorough preoperative clinical evaluation	Physical examination	Consider more definitive intervention (ie, arthroplasty) or continued conservative management
Performing an osteotomy on a patient with knee flexion contracture greater than 15° [2]	Poor rehabilitation potential	Thorough preoperative clinical evaluation	Physical examination	Consider more definitive intervention (ie, arthroplasty) or continued conservative management
Performing an osteotomy on a patient with greater than 20° correction needed [5]	Poor prognosis with such severe deformity. Also may have residual collateral ligament laxity.	Thorough preoperative radiographic and clinical evaluations	Radiographs (standing films, stress films), physical examination	Consider more definitive intervention (ie, arthroplasty) or continued conservative management
Performing an osteotomy on a patient with ligamentous instability resulting in worsened instability after bone cuts [5]	Deformity may persist because although the bony defect has been addressed, ligamentous laxity and or stiffness may continue to cause symptoms, including instability of the knee	Thorough preoperative clinical evaluation	Physical examination	Consider more definitive intervention (ie, arthroplasty) or continued conservative management

Table 1. continued

Error	Clinical effect	Prevention	Detection	Remedy
Performing HTO on patients with ≥ 30% ideal body weight [4]	Two most predictive causes of failure (recurrent pain/loss of correction) are undercorrection of the angular deformity and relative weight of patient. Coventry et al. [4] reported that patients with ≥ 30% ideal body weight had a significantly greater risk for failure.	Careful patient selection. Preoperative weight loss to maximize possible surgical benefit.	Physical examination, radiographs	Revision osteotomy, total arthroplasty, bracing.
Performing an osteotomy on a patient with inflammatory arthritis	Inflammatory arthritis will likely affect other compartments and inflammation may play a larger role in pain and functional compromise. Osteotomy does not address inflammation directly.	Thorough preoperative radiographic, clinical, and laboratory evaluations	Radiographs, physical examination, rheumatoid factor, C-reactive protein	Antirheumatic drugs, total arthroplasty

HTO = high tibial osteotomy; DJD = degenerative joint disease; OA = osteoarthritis; DFO = distal femoral osteotomy.

Table 2. Preoperative errors

Error	Clinical effect	Prevention	Detection	Remedy
Failure to place sandbag under hip of affected side	Causes difficulty accessing lateral aspect of the lower extremity	Have preoperative routine/checklist	If this step is missed, the surgeon will have difficulty preventing external rotation at the hip	Theoretically could be placed during the operation if sterility is maintained.
Failure to place and inflate tourniquet	This will lead to difficulties with hemostasis.	Have preoperative routine/checklist	Have preoperative routine/checklist, excessive bleeding	Theoretically could be placed during the operation if sterility is maintained.

Alignment can be corrected with additional cuts. A fracture can be treated with additional fixation. Patella baja often is noted during the followup period and can be addressed by a revision procedure or by total knee replacement. When performing a TKA after an osteotomy has been done, one must plan surgery carefully so as to remove hardware, avoid small skin bridges, account for deformity, and consider using special components.

Summary

When performing an osteotomy for lower extremity malalignment, several complications can occur. In this article, we summarize the complications that can arise associated with patient selection (Table 1), preoperatively (Table 2), intraoperatively, (Table 3), and postoperatively (Table 4).

Table 3. Intraoperative complications

Error	Clinical effect	Prevention	Detection	Remedy
Introducing anterior or posterior slope to the proximal tibia/tibial plateau during HTO [6]	If unwanted anterior or posterior slope is introduced, it may alter mechanics at the knee, accelerating arthritis, and negatively impacting pain and function. It also may lead to instability if there is cruciate ligament insufficiency. Can improve instability by changing slope to prevent anterior or posterior tibial translation.	Meticulously line up jig with native posterior slope of tibial plateau.	Intraoperative visual inspection, postoperative x-rays	If noted intraoperatively, may recut bone at more appropriate slope, but must avoid cutting too much bone.
Fracture [10]	Propagation of osteotomy through far cortex can destabilize proximal fragment, leading to possible nonunion. Propagation into the articular surface is even more severe because of potential articular incongruity.	Carrying apex of osteotomy cut to within 10 mm of far cortex and leaving the proximal fragment at least 15 mm thick. Gradual closure also permits stress relaxation of intact far cortex. No difference between medial opening wedge and lateral closing wedge in terms of maximal obtainable correction angle without failure of far cortex.	Heightened suspicion, intraoperative visual inspection, postoperative radiographs	Fractures must be appropriately reduced and stabilized
On removing bone wedge, leaving residual bone	May be encountered on compression of distal and proximal segments of the tibia after wedge is removed, if full compression is not achieved.	Meticulous removal of bone wedge and remaining fragments of bone	Compression may take up to 5 minutes for plastic deformation to occur. If compression and osteotomy closure are not achieved, reassess for bone fragments.	Resect remaining bone and remove it
Neurovascular injury on lateral proximal tibial dissection for lateral closing HTO [8]	Peroneal nerve is most at risk with osteotomy of the proximal fibula, where the nerve wraps around the neck of the fibula before dividing into the deep and superficial branches. The peroneal veins and anterior tibial vessels are close to the fibula in the upper half of its shaft.	Use blunt Hohmann retractor to protect neurovascular structures on dissecting the proximal tibiofibular capsule	Postoperative neurovascular check	Vascular repair/ consultation, nerve repair, conservative management.

HTO = high tibial osteotomy.

Table 4. Postoperative complications

Error	Clinical effect	Prevention	Detection	Remedy
Recurrence of deformity [4]	Major complication leading to recurrence of pain. Long-term studies indicate that clinical success deteriorates with time, with continued efficacy in approximately 60% of patients at 10 years followup.	Overcorrection of angular deformity. Coventry et al. showed the risk of failure was increased if alignment was not overcorrected to at least 8° valgus [4]	Careful intraoperative measurements. However, the true alignment under weightbearing conditions will not be known until postoperatively. Standing, full-length radiographs should be performed 6-8 weeks postoperatively.	Revision osteotomy, total arthroplasty, bracing.
DVT/PE	Rate of DVT after osteotomy has been reported to be as much as that of TKA. Fatal pulmonary embolism is rare but has been reported	DVT prophylaxis (ie, early ambulation, compression stockings, chemical prophylaxis)	Heightened postoperative clinical suspicion, close monitoring of vital signs, CT or V/Q scan of chest to rule out pulmonary embolism.	Chemical anticoagulation (ie, heparin, Lovenox®, Coumadin®), IVC filter.
Compartment syndrome	Exact incidence unknown, however elevated anterior compartment pressures are common after HTO. Risk may be increased when concomitant, arthroscopically assisted ligament reconstruction is performed.	Careful surgical technique can avoid possible trauma and vascular injury that may lead to a compartment syndrome. Avoid prolonged postoperative epidural analgesia that potentially could mask compartment syndrome.	Tense compartments, pain with passive stretch, elevated compartment pressures, pain out of proportion, increasing pain medication requirement.	If compartment syndrome is suspected, then a fasciotomy should be performed immediately.
Patella baja [9]	HTO has been associated with a high incidence of patella baja. Can result in anterior knee pain and more difficult conversion to TKA. Lateral closing wedge HTO results in baja because of a contracture of the patellar ligament after prolonged immobilization, whereas a medial opening wedge actually increases the tibiofemoral joint line.	Patellar tendon contracture after a lateral closing wedge HTO can be eliminated by using rigid internal fixation and aggressive postoperative mobilization, rather than prolonged casting.	Physical examination, radiographs	Revision, total arthroplasty
Osteonecrosis of the proximal fragment	Osteonecrosis of the proximal tibial fragment can result if the bone segment is cut too thin, or if a fracture propagates from the osteotomy site creating a detached bony island. Both can compromise blood supply to the proximal fragment.	Must leave a proximal fragment of at least 15 mm thickness and minimize the risk of intraarticular and far cortex fractures. Carry the apex of the osteotomy cut to within 10 mm of the far cortex, and the addition of a drill hole at the apex of the osteotomy site can increase the amount of correction obtained before cortical fracture.	Postoperative pain, physical examination, radiographs (sclerosis, deformity, collapse)	Bone grafting, revision osteotomy, total arthroplasty

Table 4. continued

Error	Clinical effect	Prevention	Detection	Remedy
Infections	Most common with medial opening wedge techniques that involve use of external fixator. Although external fixators allow for more precise angular correction, superficial pin tract infections are common (25%-50%). More serious infections, although rare, include septic arthritis and chronic osteomyelitis, which may jeopardize subsequent salvage with TKA.	Strict adherence to sterile operative technique, with the use of prophylactic perioperative antibiotics. Diligent postoperative pin care. Avoidance of external fixators for medial opening wedge HTO, in favor of a medial distraction plate.	ESR, CRP, WBC, fevers, erythema, warmth, swelling, positive cultures	Pin tract infections typically remain superficial and respond favorably to pin care and oral antibiotics. Deeper infections may require thorough washout and débridement.
Delayed union and nonunion	Rare occurrence that is associated with motion between the osteotomy fragments. Less common after lateral closing wedge HTO because of excellent healing potential of two metaphyseal cancellous surfaces that are in direct apposition. Medial opening wedge techniques, however, must traverse segment of the autograft or allograft.	Rigid fixation of osteotomy fragments in a biologically healthy environment will decrease the chance of nonunion. Large angular corrections are relative contraindications to medial distraction plate technique because of risk of nonunion. Avoid patient risk factors, such as tobacco use and diabetes mellitus.	Physical examination, radiographs	Resection of the pseudarthrosis, bone grafting, and rigid fixation
Peroneal nerve palsy [7]	Most often related to fibular osteotomy in conjunction with lateral closing wedge HTO. Incidence has been reported as much as 20%. Postoperative peroneal deficits also may be related to increased pressure in the anterior compartment.	Care must be taken when dissecting and retracting in the vicinity of the fibular head. Use blunt retractor to protect the neurovascular structures when dissecting around the tibiofibular capsule.	Careful postoperative neurologic examination, close monitoring for potential compartment syndrome.	Conservative management, bracing
TKA after osteotomy [10]	After 10 years, 40% of patients require conversion to TKA. More technically demanding procedure with slightly lower rates of excellent results. Contracture of the patellar tendon (patella baja), prior skin incisions, retained hardware, large angular corrections, and diminished tibial bone stock all can complicate subsequent TKA.	Careful attention to preserving tibial bone stock, early mobilization to prevent patellar tendon contracture, and use of a standard midline longitudinal incision can make conversion to an eventual TKA easier.	Physical examination, radiographs	Avoidance of thin skin bridges (< 7 cm), removal of retained hardware, careful consideration of proximal tibial deformation in preoperative TKA planning, and possible modified/revision of components for large angular corrections

HTO = high tibial osteotomy; IVC = inferior vena cava; V/Q = ventilation/perfusion; ESR = erythrocyte sedimentation rate; CRP = C-reactive protein; WBC = white blood cell; Lovenox®, Sanofi US, Bridgewater, NJ, USA; Coumadin®, Bristol-Myers Squibb, Bridgewater, NJ, USA.

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