# Anterior Opening Wedge Osteotomy of the Tibia for the Treatment of Genu Recurvatum

*Vincent Villa, MD,* Romain Gaillard,* Jonathan Robin, MD,† Caroline Debette, MD,* Elvire Servien, PhD,* Sebastien Lustig, PhD,* and Philippe Neyret, PhD**

**Summary:** Pathologic genu recurvatum is defined by knee hyperextension in excess of 15 degrees and is usually asymmetric. This is a rare disease that can be related to bony, soft tissue or a combination of both. Patients with genu recurvatum commonly present with anterior knee pain, knee instability, ambulation difficulty on uneven ground, and patellofemoral instability. Anterior opening wedge osteotomy of the tibia is indicated when deformity in the sagittal plane emanates from the tibia (reversed posterior tibial slope) or a combination of tibia and soft tissue. The aim of this study is to present a surgical technique for anterior high tibial osteotomy, with indications, limitations, and review of the literature. We explain the different steps of the surgery with radiologic preoperative planning, skin incision and approach, osteotomy and fluoroscopic control, fixation, and bone grafting. Although this surgery is uncommon and difficult, the overall results in the literature are very positive and lead to increased patient satisfaction and function.

**Key Words:** genu recurvatum—opening wedge—high tibial osteotomy—tibial tubercle osteotomy—staples—bone grafting.

(*Tech Orthop* 2017;32: 66–73)

The most commonly treated deformities in the proximal tibia occur in the coronal plane and valgus or varus producing high tibial osteotomies (HTOs) have been well reported in the literature. Deformities of the tibia in the sagittal plane, however, have not gained as much attention due to their relatively uncommon presentation and necessity for surgical treatment. Genu recurvatum (knee hyperextension) of up to 15 degrees has been found to be physiological in approximately 40% of the population of normal controls and is commonly bilateral and symmetrical in this setting.[1,2] Pathologic genu recurvatum refers to knee hyperextension in excess of 15 degrees and is usually asymmetric.[1] The etiology of pathologic genu recurvatum has been classified as being congenital or acquired, with the latter category subclassified by Dejour et al.[1] In his subclassification, the cause of the recurvatum can be due to:

- Pure osseous deformity usually due to damage and premature growth arrest of the proximal anterior tibial physis. Osseous deformity may also derive from proximal tibial trauma or previous HTO with associated malunion of the posterior tibial slope.
- Soft tissue related, due to either acute traumatic or gradual stretching of the posterior cruciate ligament, posterior capsule, and other posterolateral soft tissues.
- A mixed etiology related to a combination of bony and soft tissue structure abnormalities, usually seen following poliomyelitis. Typically there is a bony deformity first, followed by a gradual stretching of the soft tissues.

A fourth pathologic recurvatum entity was described by Moroni where the etiology is idiopathic. The clinical presentation was bilateral and symmetrical genu recurvatum >15 degrees.[3]

The reverse osseous sagittal plane deformity, with excessive posterior slope is even more rare, and results usually from a malunion of the proximal tibia from trauma, open wedge medial HTO or in exceptional circumstances, congenital deficiency of the anterior cruciate ligament.[4] This results in a block to extension and an ensuing flexion deformity of the knee.[5]

Deformity in the sagittal plane may also emanate from the femur and lead to recurvatum or a fixed flexion deformity at the knee. This is most commonly due to previous trauma and malunion of a distal femoral fracture. Surgery to correct sagittal deformities arising from the femur must be treated by femoral osteotomy, rather than addressing the tibia and possibly creating a second deformity.

Patients with genu recurvatum commonly present with anterior knee pain, knee instability, ambulation difficulty on uneven ground, and patellofemoral instability.[1,6] The exact cause of anterior knee pain is not well understood; however, this may be related to chronic inflammation of the infrapatellar fat pad. Repetitive microtrauma and enlargement of the fat pad on the overlying synovium when the knee is extended, possibly leads to impingement behind the patella and pain.[6] Knee instability usually results from the dysfunction of the lock home mechanism, quadriceps atrophy and dysfunction as well as abolition of the patellofemoral lever arm. Relative patella alta has been reported to be the likely cause of patellofemoral instability.[1] Radiographic analysis of a lateral x-ray in monopodal stance often demonstrates an associated posterior tibial translation with a reduction in posterior tibial slope.

Patients with an exaggerated posterior tibial slope can also present with anterior knee pain, but this is mostly related to the high-pressure contact points in the anterior tibia during knee extension.[5] This deformity is also associated with a fatigue-type rupture of the anterior cruciate ligament.

## INDICATIONS AND CONTRINDICATIONS FOR OSTEOTOMY

The decision to offer operative intervention to a patient with genu recurvatum may be complicated. In fact performing a corrective osteotomy for recurvatum is relatively uncommon. The general indications for surgery include the symptomatic presence of pathologic genu recurvatum with an associated causative correctible deformity whether it be soft tissue, bony or a combination of these.

From the *Albert Trillat Center, Croix-Rousse Hospital, Lyon, France; and †Epworth Eastern, Box Hill, Vic., Australia.

The authors declare that they have nothing to disclose.

**For reprint requests, or additional information and guidance on the techniques described in the article, please contact Romain Gaillard, at E-mail: gaillard-romain@orange.fr or by mail at, Albert Trillat Center, Croix-Rousse Hospital 103 Grande Rue de la Croix-Rousse, 69004 Lyon, France. E-mail: gaillard-romain@orange.fr. You may inquire whether the author(s) will agree to phone conferences and/or visits regarding these techniques.**

Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.



Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

**FIGURE 1.** Asymmetric genu recurvatum. full color online

More specifically, Dejour et al[1] have suggested that corrective osteotomy is absolutely indicated when there is a combined bony and soft tissue recurvatum. This can be done either by osteotomy alone or in combination with soft tissue reconstruction. Usually in this setting the aim is to completely correct the recurvatum deformity. However, when there is deformity secondary to poliomyelitis, the recurvatum should not be overcorrected as the passive lock-home mechanism has a stabilizing effect on the lower limb. This effect on stability is important in these patients who frequently lack a functional quadriceps muscle.

Surgery is also indicated when there is a pure bony cause for the recurvatum (reversed posterior tibial slope) and the

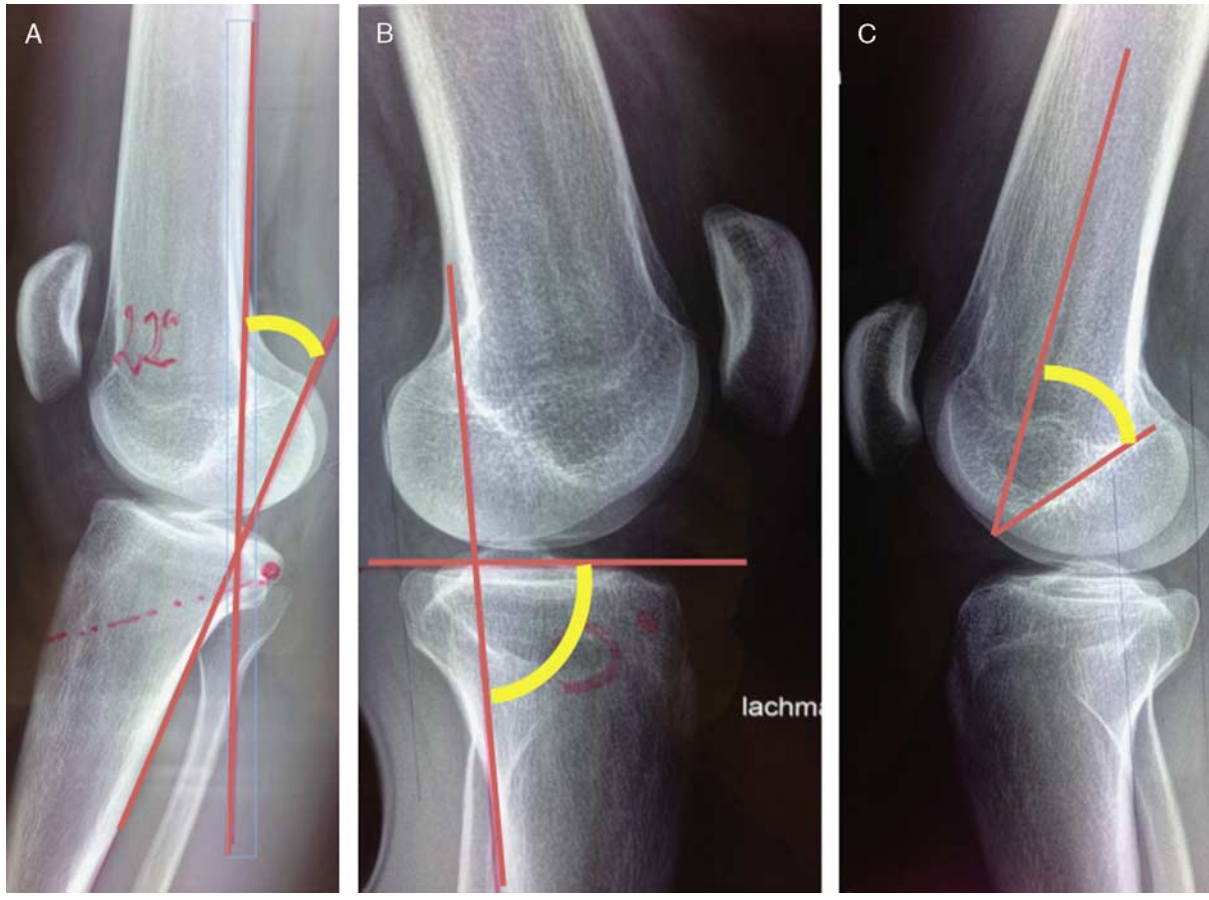


**FIGURE 2.** Radiologic measurements of femoral and tibial recurvatum. A, Global recurvatum (angle between anatomic femoral and tibial axes). B, Tibial slope. C, Epiphyseal femoral angle between the femoral anterior tangent line and the Blumensaat line perpendicular. full color online

Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.


Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

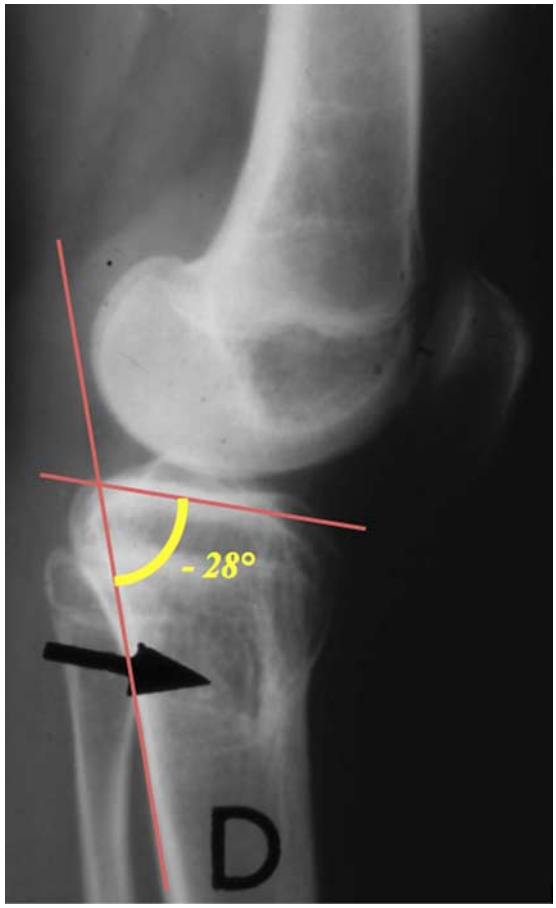


**FIGURE 3.** Negative tibial slope (tibial epiphysiodesis). full color online

patient is symptomatic with pain or instability. This should not be performed until skeletal maturity.

Corrective osteotomy should also be offered where a bony recurvatum exacerbates a previous physiological recurvatum leading to a combined hyperextension of 20 to 25 degrees. These knees are likely to have severe instability and the correction should aim to abolish the total recurvatum deformity.

In the situation of a purely soft tissue recurvatum, there is much less of a role for osteotomy alone and antirecurvatum surgery is contraindicated to manage anterior knee pain in the setting of physiological genu recurvatum.[1]

## PREOPERATIVE PLANNING

To obtain good surgical results a thorough clinical and radiographic workup is required. A detailed history should be obtained including current symptoms especially of pain and instability. The history of a traumatic knee injury is particularly important to recognize especially if it occurred early in childhood leading to a physeal arrest of the proximal tibia, or ligament/capsular injury to the posterior knee. The treatment of the knee injury is also important as plaster cast application and immobilization has been associated with premature anterior proximal tibia physeal closure.[7] Clinical examination must always be carried out with reference to the contralateral limb (Fig. 1). Accurate clinical measurements of the degree of recurvatum are essential, especially when the hyperextension is bilateral. Careful evaluation of ligamentous stability is particularly important in determining its contribution to the overall amount of recurvatum. An assessment of previous surgical scars allows for planning of any subsequent surgery.

Complete radiographic evaluation includes anteroposterior and lateral plain radiographs as well as stress x-rays to determine soft tissue involvement. Sagittal lower limb

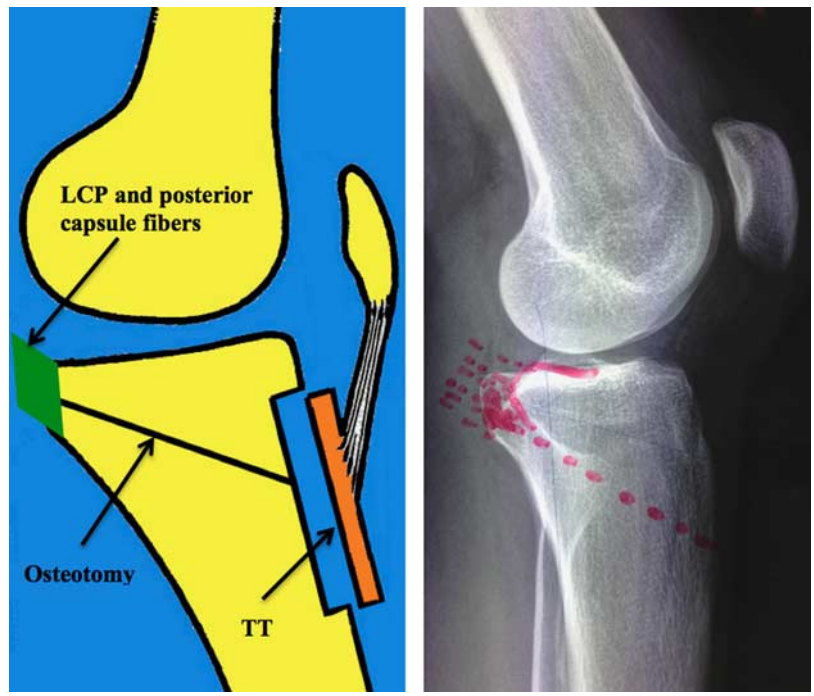


**FIGURE 4.** Surgical technique for anterior opening wedge osteotomy and preoperatory radiologic planification. TT indicates tibial tubercle. full color online


Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.

Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

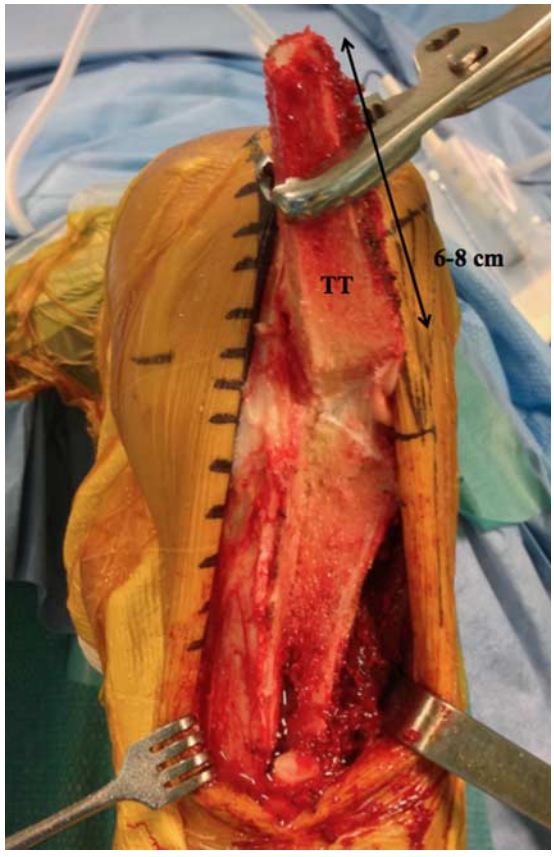


**FIGURE 5.** Tibial tubercle osteotomy. TT indicates tibial tubercle. full color online

**FIGURE 6.** Intraoperative fluoroscopic control of guide pins positioning.

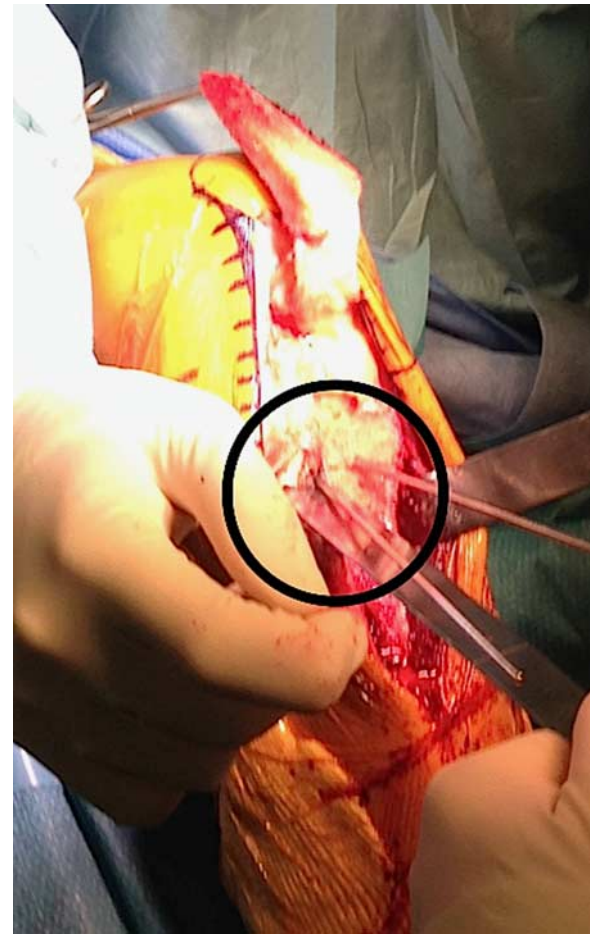

**FIGURE 7.** Tibial osteotomy underneath the guide pins to avoid epiphyseal fracture. full color online

alignment radiographs are performed to quantify the overall recurvatum in both knees and to calculate the amount of recurvatum residing in the femur or/and tibia. Coronal lower limb alignment radiographs are also performed to research an associated alignment disorder in the frontal plan. Lateral radiographs and comparative stress x-rays in full extension are also essential for measuring anterior tibial translation and to decide how much of a correction is necessary in each individual case (Figs. 2, 3). No other radiologic examination (especially computed tomographic scan) is necessary to assist with preoperative planning.

## OSTEOTOMY OPTIONS

Multiple osteotomy techniques have been described to correct bony recurvatum. Opening wedge osteotomy may be performed proximal to the tibial tuberosity as described by Lexer,[8] Brett,[9] and Bohn,[10] at the level of the tuberosity in association with a tibial tubercle osteotomy (TTO) described by Lecuire et al[2] or distal to the tuberosity in association with a fibular osteotomy as described by Campbell.[11] Closing wedge osteotomy has also been performed proximal to the tibial tuberosity by Bowen et al[7] and distal to the tuberosity in association with a fibular osteotomy by Irwin.[12]

Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.



Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

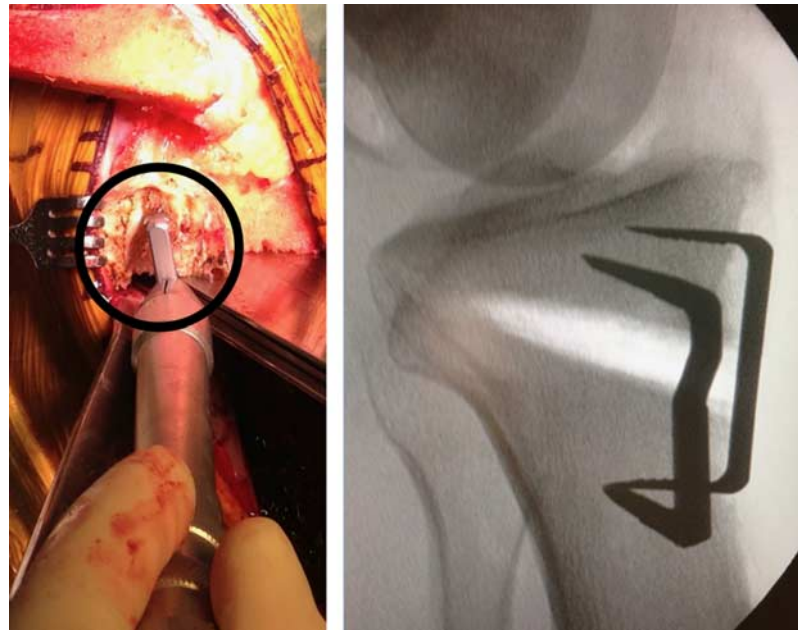

**FIGURE 8.** Fixation by 2 Blount staples. full color online

## ANTERIOR OPENING WEDGE HTO

Our surgical technique follows that of Lecuire et al[2] (Fig. 4). The anterior opening wedge osteotomy is performed at the level of the tibial tubercle (TT) with a posterior hinge. The hinge is situated at a level of the insertion of the fibers of the posterior cruciate ligament and the attachment of posterior knee joint capsule on the tibia. This technique provides a correction close to the deformity, with excellent healing potential in cancellous metaphyseal bone and minimizes the interference with patellofemoral function.

## SURGICAL TECHNIQUE

### Patient Positioning

The patient is positioned supine on the operating table with a tourniquet applied to the proximal thigh. A side support and foot bar is used to keep the knee flexed to 90 degrees. The image intensifier c-arm is present in theater and the leg is prepared and draped in routine manner.

### Incision and Approach

An anteromedial skin incision is made in line with the medial border of the patellar tendon. Dissection is carried out to the TT and the proximal tibia to expose the tubercle, proximal tibia, and patella tendon. Medially, a large periosteal elevator is inserted underneath the fibers of the superficial medial collateral ligament. Laterally the tibialis anterior muscle insertion is partially released. An osteotomy of the TT is performed in routine manner protecting the patella tendon. The tubercle bone block should be 6 to 8 cm long and should reach into the metaphyseal bone (Fig. 5).

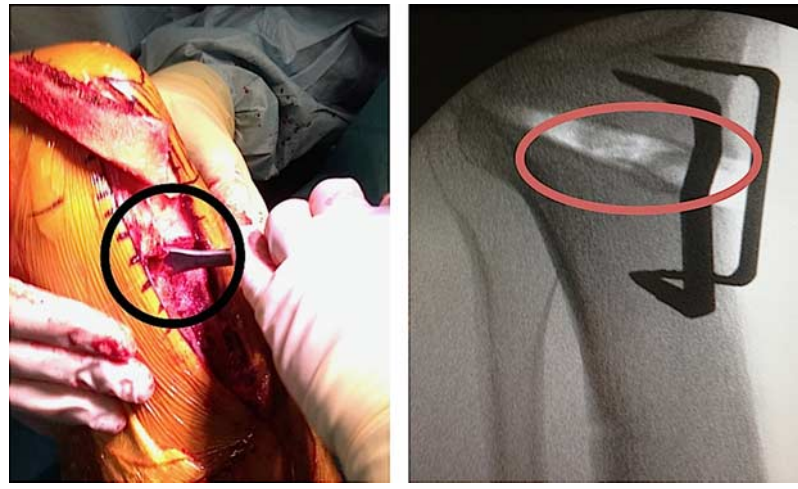

**FIGURE 9.** Bone grafts to fill the osteotomy. full color online


Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.

Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

**FIGURE 10.** Tibial tubercle fixation. full color online

## Opening Wedge Osteotomy

Guide wires are introduced anteriorly, approximately 4 cm below the joint line under radiographic visualization with the c-arm. They are directed and advanced posteriorly toward the level of the insertion of the posterior cruciate ligament and proximal to the insertion of the posterior capsule (Fig. 6). The osteotomy is created with an oscillating saw underneath, but always in contact with the guide wires. The osteotomy should be situated proximal to the tibiofibular joint (Fig. 7). The posterior tibial cortex is weakened with the 3.2 mm drill to allow controlled opening of the osteotomy. The drill is aimed away from the midline to avoid the posterior neurovascular bundle. Opening of the osteotomy is achieved by the sequential introduction of several osteotomes. An anterior tibial osteotomy naturally increases varus in the proximal tibia, therefore, the osteotomes should be introduced from the medial side during opening to minimize this effect. Generally, each osteotome gives 1 mm of opening and achieves a correction of approximately 2 degrees. The final correction should be as planned preoperatively and take into account not only the bony genu recurvatum measured radiologically, but also the clinical genu recurvatum. Overcorrection into a flexion deformity is usually poorly tolerated. It is also important to understand that this type of osteotomy has the natural tendency to create a small amount of tibia vara. It is imperative that the surgeon pays careful attention to the correction in both sagittal and coronal planes.

## Bone Grafting, Fixation, and Closure

The osteotomy is fixed by 2 Blount staples on either side of the TT (Fig. 8). Fixation with a locking plate is also now a valuable alternative. Cortical and cancellous autogenous bone grafts are taken from the iliac crest and are placed to fill the osteotomy gap (Fig. 9). The TT osteotomy is fixed using two 4.5 Arbeitsgemeinschaft für Osteosynthesefragen screws in routine fashion, paying particular attention not to alter the patella height. To achieve this, the TT osteotomy bone block is proximalized by the same amount as the opening wedge

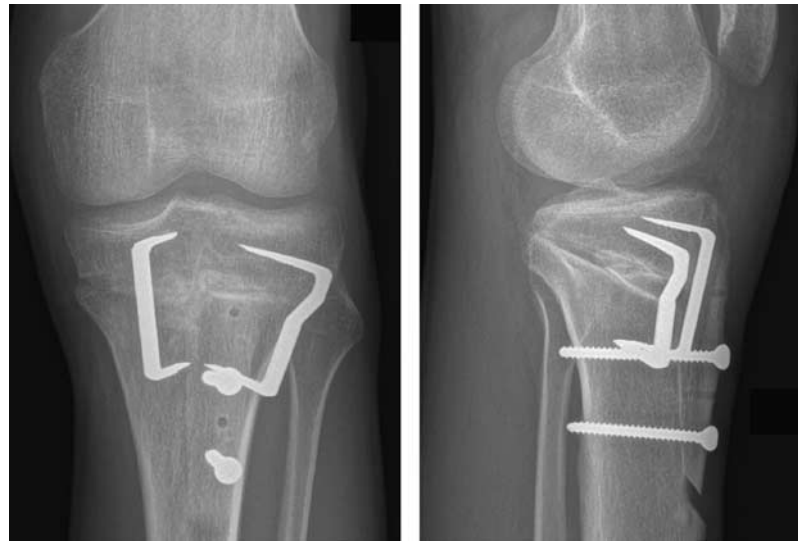

**FIGURE 11.** Postoperative x-rays.

Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.


Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

**TABLE 1.** Different Osteotomies and their Results in Literature

| | Osteotomy Type | TT Displacement | Osteotomy Level | No. Cases | Mean Follow-up | Results |
|---|---|---|---|---|---|---|
| Lecuire et al[2] | Opening wedge | Yes (proximal) | At the level of the TT | 44 | — | Satisfactory, especially in osseous recurvatum |
| Bowen et al[7] | 8 closing wedge + anterior displacement | Yes (anterior) | Proximal or distal to the TT | 17 | 20 mo | Favoring closing wedge + anterior displacement: stability, rapid healing and decreasing retropatellar compression |
| | 6 proximal closing wedge<br>1 distal closing wedge<br>2 proximal opening wedge | No | | | | |
| Vicenzi et al[13] | Opening wedge | Yes (proximal) | At the level of the TT | 23 | — | Excellent results, especially in osseous recurvatum and TT proximal displacement association |
| Moroni et al[3] | 22 proximal opening wedge | 18 proximal TT displacement<br>4 without TT displacement | Proximal or distal to the TT | 27 | 14.5 y | Better results for patients with an osseous recurvatum and a proximal osteotomy level |
| | 5 distal opening wedge | No | | | | |
| Balestro et al[14] | Opening wedge | Yes (proximal) | At the level of the TT | 12 | 69 mo | Best results for patients with an osseous recurvatum |

TT indicates tibial tuberosity.

osteotomy to avoid a patella infera (Figs. 10, 11). The tourniquet is deflated and hemostasis is achieved before a layered closure over a suction drain.

## POSTOPERATIVE GUIDELINES

After opening wedge anterior HTO, the patient is placed in a brace which is maintained at 20 degrees of flexion while at rest to prevent patella baja and early mobilization is encouraged. Operative drains are removed after 24 hours. The patient remains non–weight-bearing on crutches for 2 months (partial weight-bearing if a locking plate is used) with the knee in full extension in the brace. Progressive mobilization of the knee is prescribed, but limited to 90 degrees for 60 days (to ensure union of the TTO). Postoperative radiographs should include a lateral radiograph of the knee to measure the correction that has been obtained.

## COMPLICATIONS

The most common complication following HTO is hemotoma. Because of the subcutaneous position of this osteotomy, there is a higher potential for the hemotoma to become infected, and thus superficial infections must be treated aggressively. Complications specifically relating to this osteotomy include damage to the posterior neurovascular structures and careful attention to the direction of wires, osteotomes and drills is mandatory. Fracture to the posterior bone hinge may occur leading to an added degree of instability. Overcorrection must be avoided at all costs and preoperative planning is recommended to help avoid this. Likewise, undercorrection and persistence of recurvatum is an unwanted outcome. Delayed and nonunion may occur, and are additional risks. Extension lag is uncommon, especially with detachment and subsequent reattachment of the TT to prevent alterations in patella height and keep the lever arm of the extensor mechanism.

## RESULTS

Because of the relatively uncommon presentation and need for surgery in patients with genu recurvatum, there are few recent results reported in the literature, and most document the general results of varying surgical techniques which makes comparison difficult.

The earliest documented results were those of Lecuire et al[2] from Lyon. This group analyzed the results of 44 osteotomies with the main procedure being an opening wedge anterior HTO with detachment and subsequent reattachment of the TT to prevent alterations in patella height. This technique was found to be satisfactory especially in cases of pure bony recurvatum due to premature closure of the anterior proximal tibial physis.

Bowen et al[7] reported on their results using both an opening and closing wedge technique on adolescents who had a bone deformity from premature physeal closure. They favored a closing wedge anterior displacement osteotomy due to its stability, rapid healing, and ability to alleviate retropatellar compression by displacing the TT anteriorly. Their clinical and radiographic results were superior using the closing wedge osteotomy; however, this technique was performed in 14 of the 17 cases, showing a clear bias.

An anterior opening wedge HTO technique was reported by Vicenzi et al[13] to treat osseous, ligamentous, and combined causes of genu recurvatum. Excellent results were recorded when the HTO was performed for a purely osseous deformity, whereas when there was a predominantly capsulo-ligamentous prevalence results were only fair and poor. Excellent results were also reported when the HTO was combined with TTO (as described by Lecuire et al,[2]) whereas poorer results were observed when TTO was not performed or the osteotomy was performed at the infratuberosity level.

Similar results were reported by Moroni et al,[3] who studied anterior opening wedge HTO for genu recurvatum in 25 patients with a mean age of 23 years and were followed up for an average of 14.5 years. Of the 18 knees in which HTO plus TTO and reattachment was performed, 78% had results that were excellent or good. Four knees had a HTO without TTO. The results were excellent in 1 knee, good in 2 knees,


Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.

Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

and fair in 1. Five knees had an osteotomy distal to the tuberosity. There were no excellent results and only one good result. Eighty-six percent of HTOs performed for entirely or predominantly osseous deformity resulted in excellent and good results. None of the 6 knees in which the deformity was predominantly soft tissue in nature had an excellent or good result. Patients in whom the deformity was not predominantly osseous and who had an osteotomy below the level of the TT were much more likely to have a fair or poor result.

Finally, the most recent report by Balestro et al[14] studied the effectiveness of anterior opening wedge HTO plus TTO (as per Lecuire et al[2]) and its effect on preserving patella height. Twelve patients with a mean age of 34 years were followed up for an average of 69 months with clinical and radiographic methods. Six patients had a predominantly osseous recurvatum and the other 6 had a predominantly soft tissue cause. Overall, hyperextension was reduced by 11 degrees, with 11 of 12 patients being satisfied or very satisfied. Average postoperative functional International Knee Society were 74 and radiographic analysis showed a correction of tibial slope by 10 degrees with well preserved patella height. Consistent with the other reported studies, results were best where the deformity was predominantly osseous in nature (Table 1).

Different series essentially show results of differents series of tibial antirecurvatum osteotomy with varying surgical techniques, demonstrating the benefit in most cases for the patients with a genu recurvatum especially osseous. But any specifically explain in detail their surgical techniques with progressive stages and major tips. Our paper focuses on the surgical technique and details step-by-step how to achieve an anterior opening wedge HTO plus TTO, as described initially by Lecuire et al.[2]

## CONCLUSIONS

Pathologic genu recurvatum is an uncommon but nevertheless problematic orthopedic condition. It may be caused by a combination of bony and soft tissue deformities, most commonly due to growth arrest of the anterior proximal tibial physis leading to a reversal in posterior tibial slope. This manifests with knee pain, instability, ambulation disturbance and patellofemoral dysfunction. Surgical treatment is indicated to correct symptomatic bony and soft tissue deformities. Our technique for anterior opening wedge HTO is described. Closing wedge osteotomy can also be performed, but due to the nature of the osteotomy a TTO is not required in the latter. There are few case series of antirecurvatum osteotomies in the literature; however, the overall results are very positive and lead to increased patient satisfaction and function, especially where the cause is predominantly osseous in nature.

## REFERENCES


1. Dejour D, Bonin N, Locatelli E. Tibial antirecurvatum osteotomies. *Oper Tech Sports Med*. 2000;8:67–70.
2. Lecuire F, Lerat JL, Bousquet G, et al. The treatment of genu recurvatum (author's transl). *Rev Chir Orthopédique Réparatrice Appar Mot*. 1980;66:95–103.
3. Moroni A, Pezzuto V, Pompili M, et al. Proximal osteotomy of the tibia for the treatment of genu recurvatum in adults. *J Bone Joint Surg Am*. 1992;74:577–586.
4. Dejour H, Neyret P, Eberhard P, et al. Bilateral congenital absence of the anterior cruciate ligament and the internal menisci of the knee. A case report. *Rev Chir Orthopédique Réparatrice Appar Mot*. 1990;76:329–332.
5. Kimura Y, Ishibashi Y, Tsuda E, et al. Sagittal realignment osteotomy for increased posterior tibial slope after opening-wedge high tibial osteotomy: a case report. *Sports Med Arthrosc Rehabil Ther Technol*. 2009;1:26. Doi:10.1186/1758-2555-1-26.
6. Van Raaij TM, de Waal Malefijt J. Anterior opening wedge osteotomy of the proximal tibia for anterior knee pain in idiopathic hyperextension knees. *Int Orthop*. 2006;30:248–252.
7. Bowen JR, Morley DC, McInerny V, et al. Treatment of genu recurvatum by proximal tibial closing-wedge/anterior displacement osteotomy. *Clin Orthop*. 1983;179:194–199.
8. Lexer E. *Die Gesamte Wiederherstellungschirurgie*, 2nd ed. Leipzig: Johann Ambrosius Barth; 1931.
9. Brett AL. Operative correction of genu recurvatum. *J Bone Jt Surg*. 1935;17:984–989.
10. Bohn CL. The treatment of traumatic genu recurvatum by corrective, subarticular osteotomy on the tibia and by bone transplantation. *Acta Orthop Scand*. 1956;25:310–317.
11. Campbell WC. An operation for the correction and prevention of paralytic genu recurvatum. *JAMA J Am Med Assoc*. 1918;71:967. Doi:10.1001/jama.1918.26020380003002b.
12. Irwin CE. Genu recurvatum following poliomyelitis: a controlled method of operative correction. *J Am Med Assoc*. 1942;120:277. Doi:10.1001/jama.1942.02830390027008.
13. Vicenzi G, Moroni A, Ceccarelli F, et al. Tibial osteotomy in the treatment of genu recurvatum in the adult. *Ital J Orthop Traumatol*. 1986;12:427–432.
14. Balestro J, Lustig S, Servien E. Anterior opening wedge osteotomy of the tibia assessment for the treatment of genu recurvatum, Société Française de Chirurgie Orthopédique et Traumatologique, 2008.


Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.


Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.