



## Clinical results of lateral closing wedge high tibial osteotomy for osteoarthritis of the knee (The technique of oblique osteotomy and tension band fixation)

### *Diz osteoartritinde lateral kapalı kama yüksek tibial osteotominin klinik sonuçları (Oblik osteotomi ve gergi bandı tespit tekniği)*

Hüseyin S. YERCAN, <sup>1</sup> Güvenir OKCU, <sup>1</sup> Semih AYDOĞDU, <sup>2</sup> Uğur ÖZİÇ <sup>1</sup>

<sup>1</sup>Celal Bayar University, Medical Faculty, Department of Orthopedics and Traumatology, Manisa, TURKEY  
<sup>2</sup>Ege University Medical Faculty, Department of Orthopedics and Traumatology, İzmir, TURKEY

**Amaç:** Diz medial kompartman osteoartritinde uyguladığımız oblik ve lateral kapalı kama yüksek tibial osteotominin (OKK-YTO) erken dönem klinik sonuçları değerlendirildi.

**Çalışma planı:** Otuz dokuz hastanın (29 kadın, 10 erkek; ort. yaş 53; dağılım 34-64) dizinde medial kompartman osteoartritinde OKK-YTO ve gergi bandı prensibi ile tespit uygulandı. Ahlback sınıflamasına göre hastaların yedisinde evre II, 27'sinde evre III, beşinde evre IV osteoartrit vardı. Tespit için kama plak ve iki adet kortikal vida kullanıldı. Sonuçlar Amerikan Diz Derneği skoru kullanılarak değerlendirildi. Ortalama izlem süresi 23 ay (dağılım 12-41 ay) idi.

**Sonuçlar:** Ortalama diz skoru 43 puandan (dağılım 18-72) 80 puana (20-90), fonksiyonel skor ise 57 puandan (45-90) 72 puana (35-90) yükseldi ( $p<0.05$ ). Hastaların ameliyat öncesi ortalama 8.9 derece ( $3-15^\circ$ ) olan varus dizilimini düzeltmek amacıyla ortalama 11.6 derece ( $7-18^\circ$ ) valgizasyon uygulandı. Son kontrolde elde edilen femorotibial açı değeri ortalaması 171 derece ( $162-183^\circ$ ) bulundu. Ameliyat sonrası dönemde 11 hastada aşırı düzeltme, tespit yetersizliği, geçici sinir felci ve fibula osteotomi bölgesinde duyarlılık gibi farklı komplikasyonlar saptandı.

**Çıkanmlar:** Oblik yüksek tibial osteotomi ve gergi bandı tespit tekniği, sağladığı rijid tespit sayesinde erken aktif harekete izin veren etkili bir yöntemdir. Ancak, öğrenme sürecinde yüksek oranda komplikasyon ile karşılaşılabilir. Komplikasyon ameliyat başarısını olumsuz etkiler.

**Anahtar sözcükler:** Femur/cerrahi; diz eklemi/anormallik/cerrahi; osteoartrit, diz/cerrahi; osteotomi/yöntem; hareket açıklığı, artiküler; tibia/cerrahi.

**Objectives:** We evaluated the preliminary results of oblique and lateral closing-wedge high tibial osteotomy for medial compartment osteoarthritis of the knee.

**Methods:** Thirty-nine patients (29 women, 10 men; mean age 53 years; range 34 to 64 years) underwent oblique and lateral closing-wedge high tibial osteotomy followed by tension band plate fixation. According to the Ahlback system, seven patients had grade II, 27 patients had grade III, and five patients had grade IV osteoarthritis. Fixation was completed with a blade plate and two cortical screws. The results were evaluated using the Knee Society Score at the end of a mean follow-up of 23 months (range 12 to 41 months).

**Results:** The mean pre- and postoperative Knee Society scores were 43 (range 18-72) and 80 (range 20-90), and the mean Knee Function scores were 57 (range 45-90) and 72 (range 35-90), respectively ( $p<0.05$ ). The mean preoperative deviation from the mechanical axis of the leg was 8.9 degrees varus (range 3 to 15 degrees). A mean correction of 11.6 degrees valgus (range 7 to 18 degrees) was afforded in order to obtain a slight valgus alignment. The mean postoperative femorotibial angle was 171 degrees (range 162-183 degrees). Complications were seen in 11 patients, which included severe overcorrection, fixation failure, transient nerve palsy, or pain over the fibular osteotomy site.

**Conclusion:** Oblique high tibial osteotomy combined with tension band fixation is an effective procedure providing secure and durable fixation to allow early motion. It should be recalled that a high complication rate is likely during the learning curve, which adversely influences the clinical results.

**Key words:** Femur/surgery; knee joint/abnormalities/surgery; osteoarthritis, knee/surgery; osteotomy/methods; range of motion, articular; tibia/surgery.

Degenerative arthritis of the knee is an important problem which is usually seen by middle aged to elderly persons. As opposed to the inflammatory arthropathies, gonarthrosis is usually associated with a mechanical problem. Tibial or femoral deformity, intra-articular defects, trauma, osteonecrosis, ligamentous laxity and absence of menisci are playing a role by the developing of knee osteoarthritis. The conservative management including physical therapy, weight loss, assistive device, intra-articular injections and oral medications, constitute of the first step of the treatment. However, it is known that the conservative treatment provides symptomatic relief only but no modality yet exists for the medical treatment of osteoarthritis (1).

High tibial osteotomy (HTO) performed for uni-compartmental osteoarthritis of the knee has been used for a long time successfully. The classical closed wedge osteotomy, has been popularized by Coventry (2). Dome osteotomy, defined by Maquet (3), has followed the closed wedge osteotomy. Recently, some studies about open wedge osteotomy and focal dome osteotomy, described by Paley et al, have been published (4-6).

The goal of the HTO is to correct the mechanical axis deviation of the lower limb and to hold it at desired position. In this way, mechanical load on degenerated joint cartilage is transferred to intact or healthy side; so the pain will be eliminated and the function is restored (7,8). Different fixation methods including plaster, staple, plate and screw, external fixator have been used for various osteotomy types. Each of them has advantages and disadvantages according to other (9).

The aim of this study is to report our early results, complications and their solutions of the oblique closed wedge HTO and tension band fixation technique.

### Patients and methods

Between 1998-2001, Thirty-nine patients (29 women, 10 men; mean age 53 years; range 34 to 64 years) with medial compartment osteoarthritis of the knee underwent oblique and lateral closed wedge HTO followed tension band fixation at two centers. All of the patients have involvement of the single compartment of the knee. Before the operation,

patients were received conservative treatment including physiotherapy, losing weight, brace, intra-articular injections and non steroid antiinflammatory drugs at least six months. The patients who did not respond to conservative treatment, were advised surgical treatment. In these patients, knee motion was noted and detailed physical examination including range of motion of the knee and ligamentous status was performed. The patients with inflammatory arthritis, restricted knee motion (exceed 20° of extension deficit and less than 90° of knee flexion), involvement of medial and lateral compartment of the femorotibial joint, instable knee were excluded in this study. The mild or moderate involvement of the patellofemoral joint was not a contraindication to this procedure. Ahlback radiographic evaluation scale was used to determine the involvement of each tibiofemoral compartment (Table 1) (10).

The radiographs included a standard weight-bearing anteroposterior view, a lateral view with 30° of knee flexion and an axial view with 30° of knee flexion were made preoperatively and postoperatively. Mechanical axis of the lower limb and femorotibial angle were calculated by full-length weight-bearing view which was seen to center of the hip and ankle in same cassette. The correction angle was determined according to mechanical axis deviation.

### Surgical technique

All patients were placed supine position on radiolucent operation table. Pneumatic tourniquet was used in patients without venous problem of lower extremity. Diagnostic arthroscopy of the knee was performed to all of the patients before osteotomy. Fibular osteotomies were performed to 17 patients at middle-distal 1/3 junction and to 22 patients at neck of the fibula. While a separate lateral skin incision was used for distal fibular osteotomy, fibular neck osteotomy was performed through the same approach with tibial osteotomy.

**Table 1:** Ahlback classification <sup>(10)</sup>

Stage 1: Slightly narrowing of joint space.
Stage 2: Obliteration of joint surface or minor bone attrition
Stage 3: Bone attrition less than 5 mm
Stage 4: Bone attrition less than 10 mm
Stage 5: Bone attrition more than 10 mm associated with subluxation and secondary lateral sclerosis.

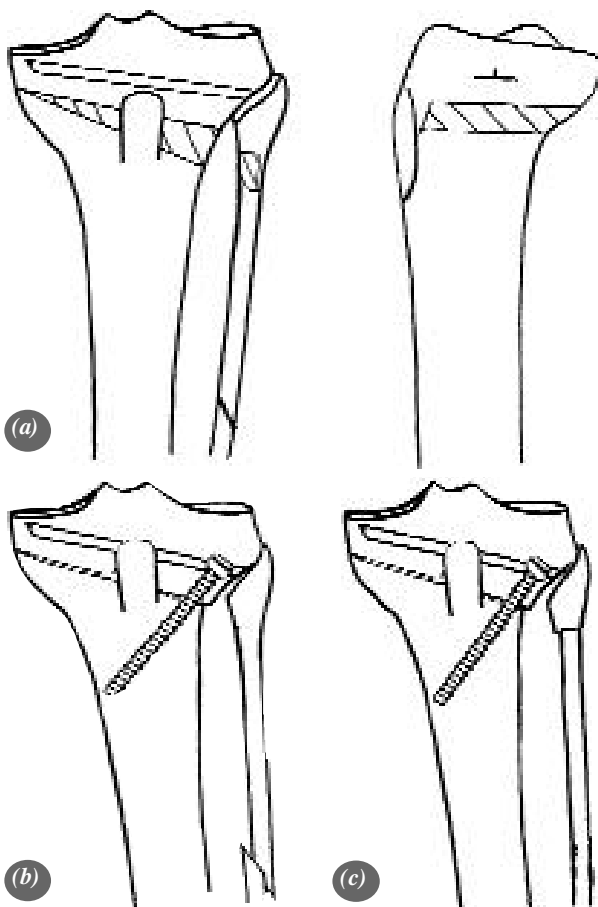
For HTO, skin incision is began just proximally over tibial tubercle, carried to fibular head. The origin of extensor muscles were stripped from upper lateral cortex of the tibia. Under fluoroscopy control, the place of the blade-plate was prepared by chisel, nearly 1 cm under and parallel to joint line. After seated blade-plate, proximal limb of the osteotomy was made oblique to joint level at 1.5 cm distance from plate. The distal limb of the osteotomy was performed at determined wedge distance by goniometer. We paid attention to intersection of the two cuts at 0.5 cm lateral of the medial cortex. Therefore both cuts were carried out with fluoroscopy control. After the bone between the two cutting surface were withdrawn by osteotome, the medial cortex which has been left intact, was perforated and weakened in multiple site by a 4.5 cm drill bit. The osteotomy was gently closed by forceful

manual valgus deviation and fixed by two 4.5 mm cortical screw passing through blade-plate (Figure 1). Care has been taken that the osteotomy surfaces were fitted snugly and translation of them were not permitted. The stability of the fixation was tested by forceful maneuvers. The desired correction angle was decided by cauter cable which was placed from center of the hip to middle of the ankle. The sufficient correction was determined according to the passing place on the knee. It is enough to pass through 1/3 medial of the lateral plateau. The long leg cast was performed to prevent soft tissue edema. At the beginning of first postoperative day, the limbs were removed from the cast intermittently and encourage for passive knee flexion and extension with continuous passive motion machine. All patients have been mobilized with two crutches at second postoperative day. At the end of 10.day, the cast has been removed completely, and elastic bandages were used. When the callus was appeared in radiographs, the patients were permitted partial weight-bearing at 6. Week and full weight-bearing between 8-12 weeks (Figure 2)

Knee Society score was used to evaluate preoperative and last follow-up status of the patients (11). The differences of ROM and knee score were determined by paired t-test and a p value of 0.05 was considered significant. The pain at the site of the fibular osteotomy during weight-bearing has evaluated with visual analog scale (0: no pain, 10: intolerable pain). At the last follow-up, the femorotibial angle and mechanical axis of the lower limb were calculated by standard and full length of the lower extremity weight-bearing A-P radiographs. The mean follow-up period is 23 months.

## Results

According to Ahlback classification, the severity of the osteoarthritis has been determined on seven patients as Grade II, 27 patients as Grade III, five patients as Grade IV preoperatively. The etiologies of the gonarthrosis were found in 28 patients as primary, in 11 patients as secondary osteoarthritis (Postmenisectomy in 8 cases, osteonecrosis in 3 cases). During diagnostic arthroscopy before HTO, degenerative tears of the medial meniscus were found in 24 cases. Although there was an evidence of cartilage degeneration in medial compartment, the cartilage in lateral compartment was intact. The



**Figure 1:** a) Appearance of HTO and tension band fixation, b) Appearance of fibular diaphysis osteotomy, c) Appearance of fibular neck osteotomy.

cartilage degeneration of patella was found different severity in 12 knees. No patients had lateral meniscus lesion. The diagnostic arthroscopy did not change the indication of HTO. The average preoperative knee score was improved from 43 points (range, 18-72) to 80 points (range, 20-90) at last follow-up. The functional score was increased from 57 points (range, 45-90) to 72 points (range, 35-90) at last follow-up. The differences of the both scores were found significant ( $p < 0.05$ ). According to knee score, the outcome was poor in five patients, moderate in four, good in 14 and excellent in 15 patients (77% excellent-good result). According to functional score, the outcome was excellent in 12 patients, good in 15, moderate in 7 and poor in 5 patients (70% excellent-good result). The varus angle of the mechanical axis which was measured on full length weight-bearing view was found an average of  $8.9^\circ$  (range, 3-15) preoperatively. A mean of  $11.6^\circ$  valgus osteotomy was obtained (range, 7-18).

The femorotibial angle was found for an average of  $171^\circ$  (range, 162-183) and mechanical axis detected an average of  $3^\circ$  valgus alignment (range from  $20^\circ$  valgus to  $8^\circ$  varus) at last follow-up. The outcome was poor in two patients who had excessive valgus alignment and in three who had the recurrence of varus deformity. The knees had an average of  $4.4^\circ$  of extension deficit (range, 0-10) and  $125^\circ$  of flexion (range, 110-135) preoperatively, extension deficit was  $2.5^\circ$  (range, 0-5) and knee flexion was  $125^\circ$  (range, 110-135) at last follow-up. There was no significant difference in arc of motion between

preoperative and last follow-up period ( $p > 0.05$ ).

The lateral cortex was perforated with blade-plate during fixation of the osteotomy in one patient. It was removed and changed by AO T plate. In two patients, the blade-plate failed to fix the osteotomy securely and two staples were added in order to improve the fixation. In two patients, instability of the osteotomy was treated by cylindrical cast for six weeks. In three of five patients who had fixation problems of osteotomy site, loss of the correction occurred during the following 10 weeks. In two patients, excessive valgus alignment was detected (mechanical axis  $< 13^\circ$  of valgus). The fibular osteotomy area affects the patients satisfaction. In one patient who had fibular neck osteotomy, the peroneal palsy was occurred during the first day and it was completely recovered without any intervention during postop. 7 week. In three patients, persistent pain was detected at the osteotomy area in distal-middle 1/3 of the fibula. The pain was increased with weight-bearing at osteotomy area for six months in two patients and for one year in one patient. The intensity of pain in these patients was evaluated according to the visual analog scale and it was found mean 6.3 points (range, 6-7). In eleven patients (28% of all), perioperative and postoperative problems were observed. The outcome was poor in five, moderate in two and good in four patients (Table 2). No patient necessitated total knee arthroplasty secondary to failed HTO during follow-up. Infection and deep venous thrombosis were not observed in any patient.



**Figure 2:** a) The medial compartment osteoarthritis of the left knee of the Fifty-six years old-male patient.  
b) Control radiographs of the patients in postoperative 6. months.

**Table 2:** List of complications

Complication	Patient number	Treatment	Result
Temporary peroneal palsy	1		good
Insufficient fixation	1	Changing of plate	poor
	2	Additional staples	poor
	2	Cylindrical cast	moderate
Excessive valgus alignment	2		poor
Persistent pain in distal-middle 1/3 of the fibula	3		good

## Discussion

Satisfactory results are obtained by HTO in pain relief related to gonarthrosis. The classic closed lateral wedge osteotomy popularized by Coventry (2), is still used frequently. In transverse closed wedge osteotomy, inequality limbs of the osteotomy result to a step on lateral cortical wall following fixation. The postoperative deformation of the proximal tibia may be a problem for later total knee arthroplasty, especially placing tibial component with straight stem. To prevent step on cortical wall, lateral displacement of the distal fragment will disturb the continuity of the medial cortex. This procedure is harmful for stability of osteotomy and it can lead to recurrence of varus deformation in early period. The oblique closing wedge osteotomy which consists of equal limbs creates no step and preserves the shape of proximal tibia. In this way, the possibility of error in placement of the tibial component is decreased (12).

HTO is an efficient and successful technique in suitable patients. The success rate during first 10 years was reported as 63-94% (13-15). But, it has also been emphasized that the results were deteriorated by the time (16-20). Various factors adverse the outcomes in the early and late periods. The presence of complication, amount of correction, loss of the correction, age and weight of the patient, the severity of osteoarthritis, the degrees of the varus deformation, status of the soft tissue and the previous knee operation history can affect the result (13,20). A lot of complications have been reported about the closed wedge osteotomy technique. Delayed union, nonunion, intra-articular fracture, deep venous thrombosis, peroneal palsy, vascular injuries and compartment syndrome can be account among them. The complication rates differing between 5-20%

have been reported in the literature (9,13,15,21-23). Aynacı et al, have performed a similar wedge osteotomy in 20 knees. They have used blade-plate for fixation similar to us and have determined nonunion in two knees (23). Insall et al (24), have reported that all patients with complication resulted from technical error had poor results. In the current study, complications developed in 28% of the patients and this was the main reason of the poor results. In two patients with excessive valgus alignment, we obtained poor results. We think that esthetic problem resulted from excessive valgus alignment contributed to poor results. This problem originated from a mistake of the calculation of the wedge size. Coventry's suggestion for removing 1 mm wedge for each 1° correction is not suitable for all knees (7); this rule is only valid if the wide of the tibia on the osteotomy level is 56-60mm. According to this calculation, for the wide tibia, the correction will be less; for the narrow tibia, it will be more than necessity (7). The reason of this complication in two patients was that the wideness of the osteotomy area was more narrow than we thought. Therefore, we suggest fluoroscopic control during the operation to prevent overcorrection. We think that the fracture of lateral cortex during plate fixation was caused from osteoporosis. To avoid this complication, we recommend to leave 1.5 cm bone bridge between the blade-plate and osteotomy. Müller advised to perform corticotomy to medial cortex before fixation with plate or applied compression device. Otherwise, in osteoporotic bone, blade plate will probably fall to osteotomy area (12). In the stability of closed wedge osteotomy, two factors play most important role. First, medial side of the osteotomy including cortex, periosteum and soft tissue is preserved in order to provide function as a hinge. Therefore, the medial cortex should not be cut with oscillating saw.

Secondly, bone contact should be preserved as much as possible (12,15). Three patients had developed recurrence of the varus deformity (in early period) due to fixation problem. Especially, in one patient who had inadequate fixation was detected to have compound fracture of medial cortex. This community prevented tension band fixation by plate and resulted to inadequate fixation. This mistake resulted from technical error during learning curve. Different methods including cast, staple, plate-screw, blade-plate and external fixator can be used for fixation of HTO. The fixation with cast is not current method because it needs frequent observation and does not permit early motion (1,9). Although the stepped staples are still widespread used for fixation, the medial continuity should be preserved. Moreover it has a disadvantage that needs to help a supporting device for secure fixation. The plate-screw fixation system such as AO T, L plate or angle plate is often used. They provide stable fixation to permit early motion and can be a more durable fixation than staple (26). However, it is necessary to do a wide surgical dissection to seat as well as to apply compression device. Coventry emphasized that the plate fixation will necessitates more soft tissue dissection which will increase the complication rates (27). In our study, surgical incision and dissection which has been needed to seat the blade-plate is equal that was used for staple. In this way, surgical morbidity was restricted by our system more than other plate-screw system. Currently, external fixation is used for dome osteotomy and open wedge osteotomy associated with hemicallotasis (3-6,23). The most important advantage of external fixator is to permit early motion as well as weight-bearing immediately. But, its disadvantage is the increased cost. Moreover, it has been reported that pin tract infection and increased nerve palsy have been continued to be a problem (1,6).

Various complication rates have been reported concerning to fibular osteotomy (12,13). Nowadays, fibular osteotomy which is performed the fibular neck or distal-middle 1/3 junction is accepted as more secure (1,28). Müller has reported that the incidence of problems related to fibular osteotomy was 0.5%; moreover he has seen problems such as permanent or temporary peroneal palsy, pseudoarthrosis (12). In our study, temporary peroneal palsy has

occurred in one patient who had been performed fibular neck osteotomy. There is only possibility of superficial peroneal nerve injury during fibular osteotomy performed in distal-middle 1/3 (28). Although we have not seen a problem like this, but in three patients, persistent pain over osteotomy area which affects life quality has occurred in postoperative period. In two patients, the pain decreased in six month and other one in one year. The reasons of the pain were delayed union in one patient and impression of the excessive callus to local tissues in other patient.

Rinanopoli et al (19), and Insall et al (21), reported that lower limb alignment was not affected to the results. In the literature, the overcorrection has been recommended and the different values have been proposed for this subject. Yasuda et al (18), reported that optimum femorotibial angle was to be between 164°-168°. Whereas these values result to excessive valgus alignment of the knee. Different authors reported that it should be between 167°-173° (14,16). We recommend 3° overcorrection of the deformity like Maquet. In this situation the femorotibial angle should be average of 170°.

There is controversial about performing diagnostic arthroscopy before HTO. It can be defended that the arthroscopy can be provided diagnosis and treatment of the additional internal derangement pathology into joint. The medial meniscus lesion usually accompanies to medial compartment osteoarthritis (29). In our study, the incidence of meniscal tear was found as 61.5% and we did not perform any surgery for it. The reason of becoming asymptomatic of meniscal tear without surgery may be relieving stress on it. We conclude that it is a time consuming procedure and is not necessary for HTO indication and routine usage. The reason for the using arthroscopy is propose to continue of our prospective studies including the knee osteoarthritis and arthroscopy.

In conclusion, oblique closed wedge HTO and tension band fixation is a current treatment modality. It provides a secure fixation, allows early active motion and also obliterates the need for the supporting device.

This method which is less affected upper tibial geometry, not produces a problem for later TKA. Its disadvantage is the need of a long term learning

curve and during this period to be confronted with high rate complication. In early period, the main factor determining success is presence of complications perioperative and postoperative period.

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