

Opening-wedge high tibial osteotomy without bone graft

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Abstract Open wedge high tibial osteotomy has become the trend for correction of varus knee deformities. The drawbacks were the need of autogenous bone graft with its associated morbidity, and later the use of bone substitutes with their cost and delayed healing. In this study, a total of 58 consecutive patients underwent high tibial osteotomy with internal fixation by wedge (toothed) plate and screws without bone graft, from 2004 to 2008. Age of the patients ranged from 24 to 65 years. There were 37 women and 21 men. The osteotomy opening size ranged from 8 to 14 mm. The mean follow-up was 38 months. The osteotomy united in all patients. Average time to union was 12.4 weeks (range 8–16 weeks). Partial loss of correction occurred in one osteotomy. There was significant difference between the healing time and the size of the osteotomy opening. The results at the final follow-up using the HSS score were excellent in 51 knees (88%) and good in seven knees (12%). Despite the routine addition of bone graft as a part of the high tibial osteotomy procedure, this study supports medial opening-wedge high tibial osteotomy up to 14 mm without bone graft or bone substitutes, which shortens the operative time and avoids unnecessary morbidity.

Keywords Opening-wedge · Osteotomy · Varus · Osteoarthritis

Introduction

Medial opening-wedge high tibial osteotomy (OWHTO) has gained popularity in recent years for the treatment of medial compartmental osteoarthritis of the knee [3, 6, 7, 10, 18, 20]. The surgical technique underwent many variations in the fixation technique and augmentation with bone graft or bone substitutes [12–14, 21, 25]. Autogenous iliac graft has been used routinely as a part of the technique [7, 10, 20, 29]. However, the surgical time and possible morbidity including chronic pain, infection, palpable defects, paresthesia and increased blood loss [21, 30] are drawbacks of the procedures. The question of a satisfactory bone union after HTO without bone graft has been raised. This study aims at evaluation of our results with OWHTO up to 14 mm without bone graft or bone substitutes.

Patients and methods

This study included fifty-eight consecutive patients who underwent medial OWHTO between 2004 and 2008. There were 37 women and 21 men. Age of the patients averaged 47.5 years (range 24–65). The median body mass index (BMI) was 28.5. The right knee was operated on in 27 patients and the left knee in 31 patients. In six patients <40 years old, the operation was done for correction of the varus deformity before the development of arthritic changes in the knee.

Pre-operative exclusion criteria included: grade III Ahlbäck [1] medial compartment osteoarthritis, age > 65 years, poor bone quality (pre-diagnosed osteoporosis), varus malalignment >15 degrees, obese patients (BMI > 30), flexion deformity >15 degrees, ROM < 90 degrees, presence of lateral compartment arthritis (by grade I Ahlbäck).

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In the arthritic patients ($n = 52$), 40 patients (77%) had grade I Ahlbäck medial compartment osteoarthritis, and 12 patients (23%) had grade II Ahlbäck medial compartment osteoarthritis. In all arthritic patients, arthroscopy had been performed routinely before HTO. Arthroscopy prior to osteotomy approach is supported by many authors [6, 7, 12, 16, 17, 24]. During arthroscopy, debridement of the degenerate tissues and meniscal tears if present is performed. Microfracture for full-thickness medial articular cartilage defects was performed in nine patients. Arthroscopy also serves to verify the integrity of the lateral compartment articular cartilage. If there is affection of the articular cartilage of the lateral compartment (grade III or more according to Outerbridge grading [19]), the decision to proceed with HTO was cancelled. This was the case in four patients who were enlisted for elective total knee replacement instead of HTO.

The osteotomy opening size ranged from 8 to 14 mm in an attempt to shift the mechanical axis to the Fujisawa point (62% of the tibial plateau located on the lateral side) [8]. In non-arthritic patients ($n = 6$), the correction aimed at shifting the mechanical axis to 50–55% of the tibial plateau).

Pre-operative planning was made as described by previous authors [4, 5, 16]. The pre-operative mechanical axis was measured by the angle between the intersection of the mechanical axis of the femur and that of the tibia. The angle measured from the medial side was used for measurement. The planned correction was calculated by drawing a line from the centre of the hip to the 62% point of the total width of the proximal tibia measured from medial to lateral and the line is continued to the area of the ankle. A transparent paper is fixed on the radiograph, and the shape of the tibia is copied to this template. The tracing is cut through the osteotomy site, and the distal tibia is rotated until the proposed post-correction weight bearing line passes through the centre of the ankle (Fig. 1). The opening of the osteotomy site on the paper directly indicates the necessary correction angle and the opening of the medial cortex of the tibia in millimeters.

Surgical technique

The incision is started just distal to the joint line and ends few centimeters distal to the tibial tuberosity. The superficial medial ligament is subperiosteally elevated and retracted around the posterior edge of the tibia. A guide wire is passed from the medial tibial cortex starting from a point that usually corresponds to a bow in the proximal tibia (the same point used for the tracing in pre-operative planning) aiming at the lateral tibial cortex at the level of tip of the head of the fibula. The osteotomy is always done beneath the guide wire to protect the joint. In knees with

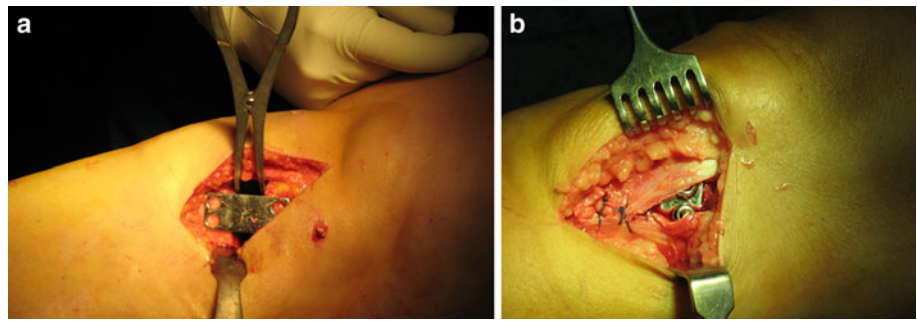


Fig. 1 Post-operative hip-to-ankle AP view made 3 months after OWHTO without graft in a 50-year-old woman. The mechanical axis is overcorrected and passes through the lateral compartment through the planned 62% Fujisawa point

short proximal fragment for fixation (short distance between the joint line and tibial tuberosity); the anterior third of the cut can be modified to be more slanting to pass proximal to the tibial tuberosity. This also has the advantage of increasing the surface area of the osteotomy. Attention was made to careful opening of the osteotomy without force with aid of bone spreader to avoid infraction of the lateral tibial head (Fig. 2a). All osteotomies were done without bone graft or bone substitutes. Internal fixation was done using 4-holes toothed plate (Orthomed-Egypt). This plate is not a self-locking plate and offers osteotomy opening sizes of 8, 10, 12 and 14 mm. Wound closure was done without a suction drain with anatomical closure of the pes anserinus and soft tissues to preserve the fracture haematoma in the osteotomy gap (Fig. 2b).

Patients were kept non-weight bearing with mobilization in bed till removal of stitches to decrease the post-operative oedema and assure good soft tissue healing. Thereafter, partial weight bearing with crutches was allowed as tolerated. Low molecular weight heparin for DVT prophylaxis was given only for high-risk patients. Patients were reviewed monthly for clinical and radiologic assessment till union and then at 6 months for recording the clinical results. Serial radiographs were evaluated for bone union. Union was defined as mature trabecular continuity observed in both the anteroposterior and the lateral radiographs. Clinically, this correlated to absence of pain and

Fig. 2 Important steps in the surgical technique. **a** Opening of the osteotomy without force with a spreader prior to fixation of the plate. **b** Closure of the medial soft tissue sleeve



restoration of function. Statistical analysis for correlating the healing time and the size of the opening of the osteotomy was done using the *t*-test and the one-way analysis of variance (ANOVA) test.

Clinical assessment was evaluated using the Hospital for Special Surgery (HSS) knee-rating score [11]. All patients were reviewed, and results were recorded at 6 months and at the latest follow-up. The mean follow-up was 38 months (range 12–60 months).

Results

Radiological results

Thirty-eight knees (66%) had osteotomy openings ≤ 10 mm, and 20 knees (34%) had >10 mm osteotomy openings. The osteotomy united in all patients. Average time to union was 12.4 weeks (range 8–16 weeks). By the end of the third month (12 weeks), 71% of osteotomies have healed. Correlating the healing time with the osteotomy opening size using the one-way ANOVA showed that the difference was statistically significant ($P = 0.0003$). A higher correlation between the healing time of osteotomy openings of 8 and 14 mm was found using the *t*-test ($P < 0.0001$). However, when the healing time of osteotomy openings of 10 and 12 mm was compared with 14 mm, the difference was not found significant (Table 1).

Measurements for correction of the deformity revealed that the mechanical femorotibial angle was corrected from 173.2 ± 2.1 degrees (mean \pm SD) pre-operative to

183.9 ± 1.6 degrees post-operative and was maintained at the latest follow-up at 183.5 ± 1.7 degrees. The mechanical axis was corrected to the planned point on the lateral tibial plateau $\pm 2.5\%$ (62% in arthritic knees and 52.5% in non-arthritic knees) in all knees.

Clinical results

According to HSS score recorded at the latest follow-up, the average pre-operative score in the arthritic group ($n = 52$) was 62 (range, 51–73), and the average post-operative score improved to 92 (range 71–100). In the non-arthritic group ($n = 6$), the average pre-operative score was 84 and improved to 97 post-operative. Overall, the results in all 58 knees were excellent in 51 knees (88%), good in seven knees (12%) and without fair and poor results. Full weight bearing was achieved at a mean of 10 weeks (8–16 weeks) post-operatively.

We had two cases of fracture of the lateral cortex, one was observed intraoperative after opening a wedge of 12 mm. This was managed by a lag screw fixation compressing the lateral tibial fragments. The second was observed in the follow-up radiograph after 6 weeks during healing of the osteotomy, and full weight bearing was delayed till complete union. Both osteotomies healed after 12 weeks. Partial loss of correction occurred in one osteotomy after 6 weeks. This was attributed to early weight bearing before solid union (Fig. 3). Wound complications included two superficial wound infections managed with antibiotics. There were no deep wound infections or clinically detected DVT.

Table 1 The correlation between osteotomy opening size and healing time after 12 weeks of post-operative follow-up

Osteotomy opening size in millimeters	Number of patients	Number of osteotomies united at 12 weeks	<i>P</i> value (comparing healing time of each with that of 14 mm)
8	15 (26%)	15 (100%)	<0.0001
10	23 (39.5%)	17 (73%)	NS
12	11 (19%)	6 (54%)	NS
14	9 (15.5%)	3 (33%)	–
Total number	58	41 (71%)	



Fig. 3 Six weeks post-operative AP radiograph after OWHTO and plate fixation (14 mm). The upper tooth of the plate appears tilted into the medial tibial cortex. The patient was walking prior to union. Despite this, solid union was achieved at 16 weeks and the patient had a good result. The mechanical femorotibial angle measured 185 degrees post-operative and partial loss of correction (4 degrees) occurred with the final post-operative angle of 181 degrees

Discussion

The rationale of performing OWHTO without bone graft involves mechanical and biological considerations. The mechanical factors are related to the stability of the osteotomy depending on the osteotomy size, intact lateral cortex and rigid internal fixation. There is general agreement that deformity correction offered by OWHTO should be limited to about 15 degrees of correction [6, 9, 15, 23, 25].

In higher varus angles, the stability is dependent largely on an intact lateral hinge which if lost, would lead to loss of resistance to axial compression forces and loss of correction.

Infraction of the lateral tibial head has been observed in one patient during surgery and managed by internal fixation with a lateral lag screw, and in one patient in the post-operative period. If it happens in opening of large wedges; the stability achieved by the plate and rapid healing can protect the implant. In cases done earlier in this study, the opening of the osteotomy was limited to 10 mm. This was extended to 14 mm with sound healing of the osteotomy. If there is a lateral cortex fracture there is an unstable situation and, non-angular stable wedge plates provide insufficient primary stability [28]. Also, this stability is not

improved by additional bi- or tri-cortical iliac crest autograft [25].

All these previous data—in addition to our results—support the use of short wedge plates in the stable situation of intact lateral hinge in selected patients who are not obese and with good bone quality. The use of longer locking compression plate systems as Tomofix [3, 15, 16, 24] can provide an obvious advantage in patients who are obese, with questionable bone quality, in large corrections and in the unstable situation following fracture of the lateral tibial cortex [15, 16, 25].

Biologic considerations vary according to the choice of using either autograft, bone substitutes or no graft at all. Autogenous iliac graft was considered the gold standard as it was used routinely by most surgeons [7, 10, 20, 29]. The recent trend of leaving the osteotomy with no graft is supported by some authors [3, 15, 16, 25]. Iliac graft could be used only in the high-risk patients (obese, smoker, opening angle bigger than 10) [2].

Synthetic bone augmentation does not add much in primary stability and is not intended for load bearing. Furthermore, it must be used in a mechanically stable environment otherwise it cannot remodel into bone and shows slower incorporation into bone [27]. Another disadvantage of using bone substitutes is the possibility of soft tissue irritation and deep infection [22].

Recent studies histologically and radiologically demonstrate the complete rebuilding of lamelliform bone in gaps created after osteotomy [2, 15]. The haematoma in the gap is replaced by connective tissue, which provides a scaffold for further callus formation. That is why we do wound closure without a suction drain. On plain radiographs, healing occurs from lateral to medial, starting at the laterally based hinge point (Fig. 4). There is a significantly higher risk for failure of high tibial osteotomies in patients of 65 years or more compared to younger patients [26]. Therefore, patient selection is essential for success of the technique. Our results also show that the healing time in small osteotomy gaps of 8 mm is significantly shorter than that of wider 14-mm gaps ($P < 0.0001$).

According to 21 surgeons' results from 182 completed cases of OWHTO [29], the most commonly approved disadvantage of OWHTO was bone graft harvest morbidity. The second commonly approved disadvantage was delayed or non-union, and the third was the time of non-weight bearing. Perhaps, if all these disadvantages are avoided in an OWHTO that heals without a bone graft and with a rigid fixation that allows early weight bearing; this procedure will provide the safest successful way for management of the varus deformed knee.

This study supports that open wedge osteotomy gaps up to 14 mm can fill with callus, and healing could be verified

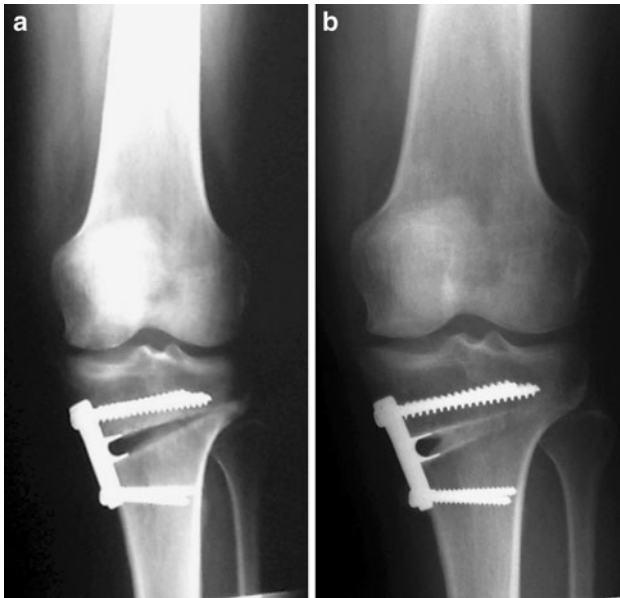


Fig. 4 Bone healing in an OWHTO without graft of the left knee in a 47-year-old man. **a** Post-operative radiograph after OWHTO with 10-mm osteotomy gap. **b** Progressive healing from lateral to medial is shown after 8 weeks

in this study by radiographs at an average time of 3 months (12.4 weeks).

We have applied this technique for a selected group of patients, and the results can be biased by patient selection; however, further comparative controlled studies are required to validate the current findings. Future research can include patients who are obese, patients who have advanced medial compartment osteoarthritis or more severe deformity.

Conclusion

Despite the routine addition of bone graft as a part of the OWHTO procedure, this study supports OWHTO up to 14 mm without bone graft, which shortens the operative time and avoids unnecessary morbidity.

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