

# Is bone graft fundamental in opening wedge high tibial osteotomy? Evaluation of the short-term results of opening wedge high tibial osteotomy without using bone graft

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## Introduction

High tibial osteotomy has been described as an effective procedure for treatment of medial compartmental osteoarthritis of knee. Many techniques have been developed (closing wedge, opening wedge, etc.), but opening (medial) and closing (lateral) wedge osteotomies are the most commonly used. The use of autograft was the gold standard in opening wedge osteotomy for a long time.

## Patients and methods

This is a prospective study carried on 32 knees in 19 patients in a period between January 2011 and January 2013, with a mean follow-up of  $17.4 \pm 2.87$  months. There were 12 males and seven females, with a mean age of  $42.5 \pm 10.68$  years. There were 13 cases with 26 knees with primary osteoarthritis and six were post-traumatic. The preoperative varus angle was measured by the hip–knee–ankle angle on standing scanogram. A single surgical technique was used for knees: medial opening high tibial osteotomy with locked plate fixation but without filling the defect. The preoperative genu varum could not exceed  $15^\circ$ . The following were evaluated: International knee Documentaion committee Scoring (IKDC) functional score and long-leg standing film were performed preoperatively, postoperatively, and at follow-up to evaluate limb alignment and validate the precision of the correction and its stability over time.

## Results

Bone union occurred at 4.3 months on average; two knees required revisions (6.25%). The first was because of delayed union and was revised with an autograft at the seventh month, and another case of nonunion with implant failure was revised at the fourth month by total knee replacement. Before the surgery, the average varus was  $174 \pm 2.18^\circ$  ( $165^\circ$ – $176^\circ$ ); after the surgery, the hip–knee–ankle angle was  $183^\circ \pm 1.88^\circ$  ( $179^\circ$ – $184^\circ$ ) ( $P=0.0001$ ). This correction was maintained at follow-up. Average Knee Score was improved from  $68.0 \pm 20$  preoperatively to  $91.0 \pm 19$  postoperatively. The Visual Analog Scale score was  $76 \pm 23$  and  $38 \pm 19$  at preoperative and postoperative, respectively, with an average reduction of 38 points. Full weight-bearing without assistance was possible after 3 months on an average.

## Conclusion

Union of the arthritic knees was possible without using bone graft (BG). The time to union was comparable to that after using (BG). Meanwhile, It avoids the risks and complications that might be associated with the use BG or Bone substitutes.

## Keywords:

bone graft, high tibial osteotomy, locked plate, opening wedge

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## Introduction

High tibial osteotomy (HTO) has been described as an effective procedure for treatment of medial compartmental osteoarthritis of the knee, especially in young and active individuals [1]. The goal of the surgery is to reduce or even eliminate pain by unloading the medial compartment [2].

Many techniques have been developed (i.e. closing wedge, opening wedge, dome, and chevron osteotomies), but opening (medial) and closing (lateral) wedge osteotomies are the most commonly

used [3]. Medial opening wedge high tibial osteotomy (OW-HTO) was first described in the 1950s [4,5] for the surgical treatment of osteoarthritis of the knee with varus deformity. Since then, many studies have been done for evaluation of this method of treatment with satisfactory results [6–16].

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Lateral closing wedge osteotomy, popularized by Coventry [17] in the Anglo-American literature [17] and by Judet *et al.* [5] in France was the technique of choice for many surgeons. However, although this technique seems easy to perform, it carries many risks and drawbacks such as the need to perform a fibular osteotomy, injury to the common peroneal nerve, the risk of compartment syndrome, malunion of the proximal tibia, and difficulty in revision to total knee arthroplasty (TKA) later on [18].

The opening wedge medial osteotomy, described in France by Debeyre and Artigou [19] avoids the majority of these hazards and complications. However, its popularity was limited for a long time by the need to fill the osteotomy site with bone graft harvested from the iliac crest with its associated morbidity [19].

The use of autograft was the gold standard in opening wedge osteotomy for a long time to ensure union and stability and prevent recurrence [20–23]. Other methods where a specific osteotomy cut is made do not require the defect to be filled, but the complexity of these procedures makes them less desirable [24,25].

The availability of new internal fixation implants has made the medial opening wedge osteotomy even more reliable, to the point where some have proposed performing this procedure without filling the gap, and a stiff material with locked screws protects the osteotomy [26].

### Objective

This study was performed to evaluate the short-term clinical and the radiographic results of OW-HTO without using bone graft.

### Patients and methods

This is a prospective study carried on 32 knees in 19 patients in a period between January 2011 and January 2013, with a mean follow-up of  $17.4 \pm 2.87$  months (range: 10–28 months). There were 12 males and seven females, with a mean age of  $42.5 \pm 10.68$  years (range: 28–55 years). There were 13 cases with 26 knees with primary osteoarthritis and six were post-traumatic (Table 1). The preoperative varus angle was measured by the hip–knee–ankle (HKA) angle on standing scanogram. Fully informed consent was taken from all patients. The treatment protocol as well as the surgical procedure was approved from the local ethical committee of our institute and followed the international standards.

**Table 1** The summary of demographic data of patients

Details	Data
Sample analyzed	19 patients (32 knees)
Sex (male : female) [n (%)]	12 (63) : 7 (37)
Average age [mean $\pm$ SD (range)] (years)	$42.5 \pm 10.68$ (range: 28–55)
Pathology (primary osteoarthritis : post-traumatic) [n (%)]	26 (81) : 6 (19)
Average follow-up [mean $\pm$ SD (range)] (months)	$17 \pm 2.87$ (range: 10–28)

### Inclusion criteria

The following were the inclusion criteria:

- (1) Medial unicompartmental osteoarthritis without patellofemoral involvement.
- (2) Genu varum with HKA not less than  $165^\circ$  on standing film.

### Exclusion criteria

The following were the exclusion criteria:

- (1) Genu varum less than  $165^\circ$ .
- (2) Patellofemoral involvement.
- (3) Age more than 60 years.
- (4) Limited range of flexion ( $<90^\circ$  flexion).
- (5) Instability.

We performed single oblique osteotomy to create an opening wedge without filling the defect and fixed by locked titanium plate.

### Preoperative planning

The HKA angle was measured on an anteroposterior view of the lower limb (hip, knee, and ankle) with the patient standing and weight-bearing. A line was drawn from the center of the femoral head to the midpoint of the spine of the tibial eminence and another line from this midpoint to the center of the talus surface of the ankle joint. The medial angle between these two lines is the HKA angle (varus  $<180^\circ$ ) [27].

The osteotomy site was determined by connecting a line between three points first, 3 cm below the medial joint line, the second at 30% lateral to center of tibial plateau surface, and the third, just above the fibular head center. Then, a drawing of the tibia distal to osteotomy was made and superimposed on the radiograph and rotated until ankle center lied on normal mechanical axis [28]. The amount of medial opening was measured (Fig. 1).

### Surgical technique

The procedure was done with a tourniquet and under image control. The surgical technique was performed

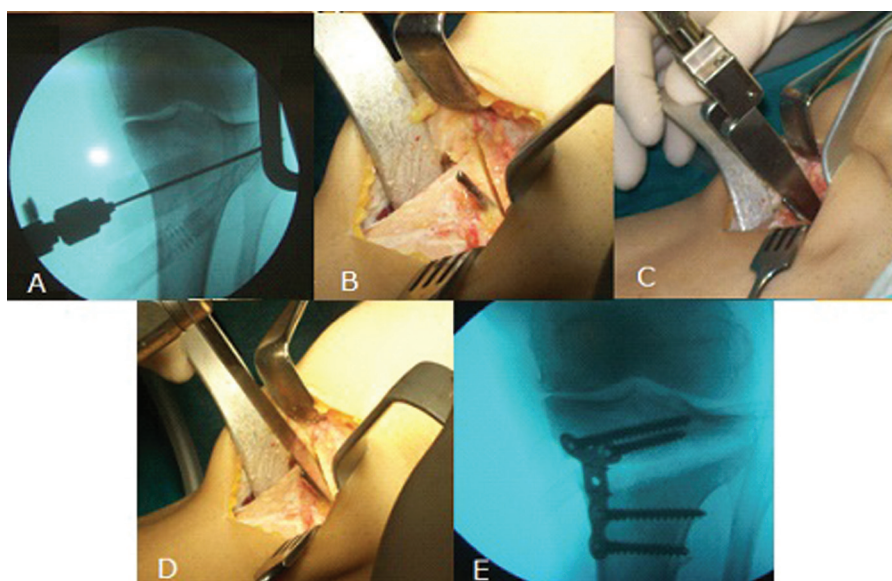
through medial longitudinal incision; the medial collateral ligament was removed from the posteromedial tibial cortex. Kirschner-wire was inserted as a guide for osteotomy plan. It was placed from the medial tibial metaphysis curvature directed upward and laterally toward the upper tibiofibular joint.

**Figure 1**



Preoperative standing scanogram for measurement of hip-knee-ankle.

**Figure 2**



Surgical technique. (a) A guide pin was placed from the superomedial portion of the tibial tuberosity to the fibular head ~1 cm below the lateral articular margin of the tibia. (b) Osteotomy was advanced with an osteotome to 5 mm medial to the lateral cortex. (c, d) Opening the osteotomy site. (e) Application of the plate on medial site.

Lateral radiograph was taken to locate the osteotomy plane parallel to the joint surface. The osteotomy was performed along a Kirschner-wire guide initially by an oscillating saw, and then with an osteotome, which stopped at ~5 mm from lateral cortex, under radiographic control. Opening was performed with introduction of another osteotome with larger thickness.

Diathermy cable was placed along the line connecting hip and ankle centers under radiographic control to confirm the restoration of the mechanical axis and absence of lateral translation of distal fragment. Osteotomy fixation was performed by the plate which was placed below the medial collateral ligament. The tourniquet was then released and homeostasis was done. No cast was needed, and only bandage was used (Fig. 2).

#### Postoperative

The knee was mobilized 1 day after operation. Six weeks of non-weight-bearing and another 6 weeks of partial weight-bearing walking were advised. Assessment was done clinically and radiologically at 6 weeks, 3, 6 months, and later on every 6 months. Clinically, reduction in pain and improvement of joint function postoperatively were compared with the preoperative period.

The following parameters were used for patient assessment:

- (1) Visual Analog Scale (VAS) [29]: for subjective perception of pain.

- (2) Knee Scores (modified by Insall *et al.* [30]) for functional assessment of joint.

Radiological evaluation: immediate postoperative scanogram was done for measurement of postoperative mechanical axis and follow-up plain film anteroposterior and lateral views at 6 weeks, 3, and 6 months for assessment of union at osteotomy site. Another scanogram was done at the end of follow-up to measure any loss of correction. A loss of correction was defined as displacement of the osteotomy before union or if the HKA angle decreased by  $3^\circ$  or more on standing leg radiographs.

Clinical union was determined according to the absence of pain and tenderness at the osteotomy site, and the radiographic union was determined if the ossified lines were visible in the middle of the gap.

#### Statistical analysis

Statistical evaluation was performed to determine if significant differences exist between the preoperative and postoperative clinical evaluation of the patient at the follow-up. The following tests were used:

- (1) The nonparametric Wilcoxon test was used to compare the average of the subjective pain difference (difference between preoperative and postoperative follow-up as determined by the VAS score) and the joint function (as measured by the Knee Score comparing preoperative function with that at follow-up).

- (2) The Kruskal–Wallis test was used to study the difference for the subjective pain and Knee Score parameters based on the length of follow-up (Fig. 3).

## Results

### Postoperative complications

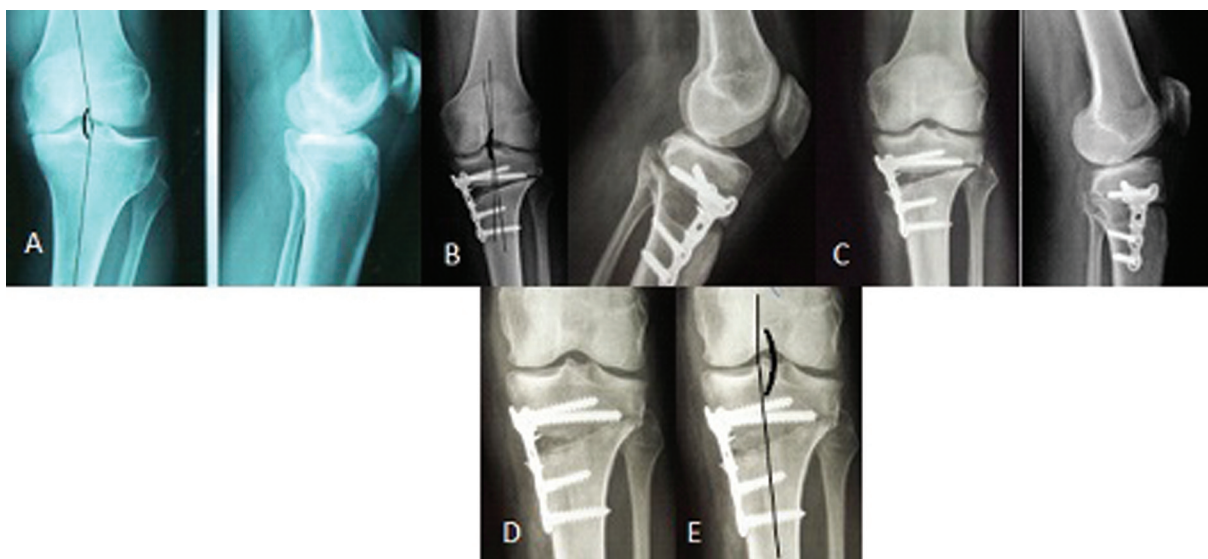
We observed three minor complications that did not require any additional procedure: two cases of superficial infection, and one case of deep venous thrombosis. Two (6.25%) knees required a surgical revision. The first because of delayed union, and it was revised by the use of bone graft only without changing the fixation plates. The surgical revision was done at the seventh month after the first intervention, and the patients showed bone union in less than 10 weeks with no more pain. Regarding the second case, the revision was because of nonunion and implant failure. This failure can be attributed to poor bone quality with early weight-bearing. Revision was done 4 months postoperatively and done by total knee replacement owing to inadequate bone stock for osteosynthesis and advancement of arthritic changes (Fig. 4).

### Clinical results

#### Assessment of subjective pain (Visual Analog Scale)

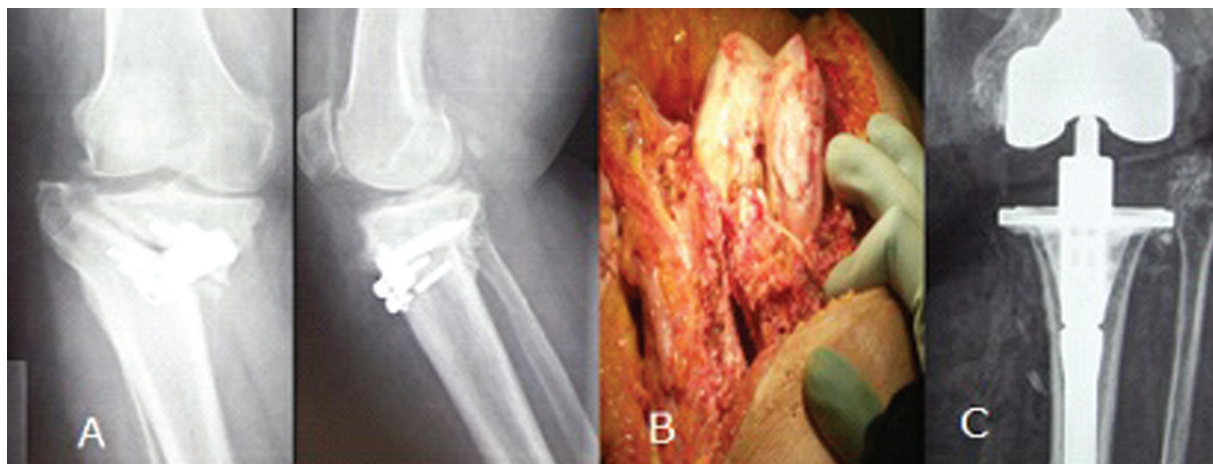
The VAS was analyzed before surgery (preoperative) and subsequently at the follow-up visit (postoperative). The average value and SD from the average (mean  $\pm$  SD) were then calculated. The average values were  $76 \pm 23$  and  $38 \pm 19$  at preoperatively and postoperatively,

Figure 3



(a) The preoperative standing anteroposterior (AP) and lateral radiograph with hip–knee–ankle angle  $174^\circ$ . (b) Immediate postoperative AP and lateral view after open-wedge high tibial osteotomy with hip–knee–ankle angle  $183^\circ$ . (c) The AP and lateral radiograph obtained 6 weeks postoperatively, (d) 12 weeks postoperatively, and (e) 3 months postoperatively showed union at osteotomy site and maintenance of corrected angle.

Figure 4



(a, b) Nonunion osteotomy with failure of the implant. (c) Revision with total knee replacement.

respectively, with an average reduction of 38 points. The difference found between preoperatively and postoperatively was statistically significantly ( $P < 0.0001$ ) (Fig. 5).

#### Assessment of joint function (Knee Scores – Insall modification, 1993) [30]

The Knee Score was analyzed before surgery (preoperatively) and subsequently at the follow-up visit (postoperatively). The mean value and SD from the mean (mean $\pm$ SD) were then calculated. Clinical average Knee Score was improved from  $68.0 \pm 20$  preoperatively to  $91.0 \pm 19$  postoperatively. The comparison between average scores showed statistical significant difference ( $P < 0.0001$ ).

#### Effect of follow-up on Knee Scores

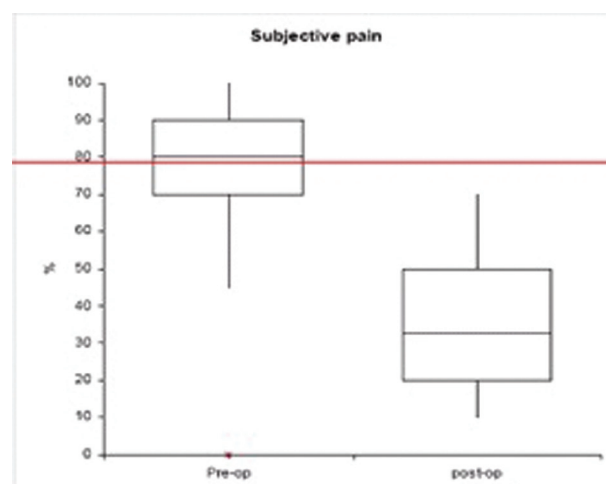
A slight improvement in the mean values of Knee Scores with increasing follow-up was seen; nonetheless, these values do not show statistically significant differences ( $P = 0.55$ ). Partial weight-bearing was allowed after 6 weeks but full weight-bearing without assistance was possible after 3 months on average.

#### Radiological results

The tibial slope did not significantly change:  $5.1 \pm 3.27^\circ$  before the surgery and  $5.6 \pm 3.87^\circ$  after the surgery and at the last follow-up. Before the surgery, the average varus was  $174 \pm 2.18^\circ$  ( $165^\circ$ – $176^\circ$ ), and after the surgery, the HKA angle was  $183 \pm 1.88^\circ$  ( $179^\circ$ – $184^\circ$ ) ( $P = 0.0001$ ). This correction was maintained at follow-up.

Radiological union occurred on an average after 4.3 months, with a minimum of 2.5 months and a

Figure 5



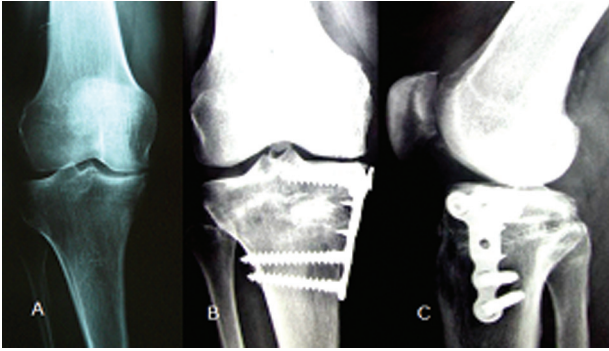
Assessment of subjective pain.

maximum of 5.5. No significant difference was found between the time of union needed and degree of correction (Figs. 6 and 7).

#### Discussion

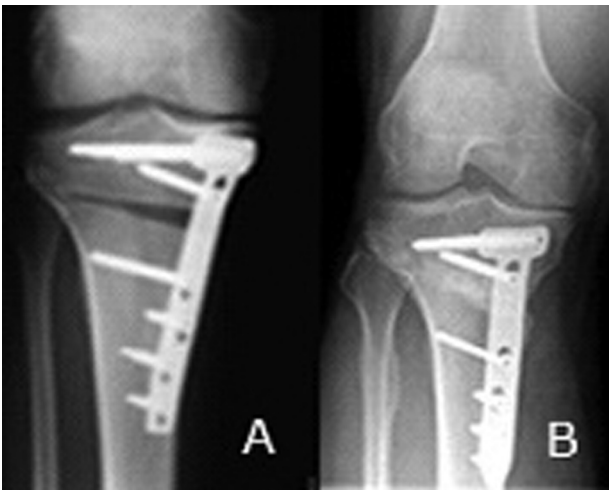
HTO in knees with medial unicompartmental degenerative arthritis is an effective procedure for relieving symptoms. It can eliminate pain by transferring the weight-bearing axis from the damaged medial compartment to the lateral side of the joint and delaying the need for a TKA [31]. The average longevity of a HTO has been estimated to be ~6–7 years, with 20% of patients converted to TKA after 5 years, 40% after 10 years, and 60% after 15 years [32]. Medial OW-HTO represents the gold standard treatment for medial compartment osteoarthritis of the knee in a young person. The alternative is arthroplasty,

Figure 6



(a) The preoperative radiograph and (b, c) the follow-up radiographs after 12 months.

Figure 7



(a) The immediate postoperative radiograph and (b) the follow-up radiographs after 24 months.

most notably unicompartmental knee arthroplasty [7–9]. Regarding factors likely to influence the longevity of the osteotomy, it is advised to do an overcorrection rather than undercorrection [16]. Patients who underwent revision were statistically significantly more likely to have a HKA angle less than  $182^\circ$  than those not revised ( $P < 0.001$ ). There is a great debate about the importance of usage bone graft in the osteotomy site [13,33]. Our study found that an OW-HTO can be performed without grafting and without an elevated risk of nonunion or loss of correction.

#### Clinical evaluation

This study assessed the short-term results of medial opening wedge osteotomy fixed with locked plate without filling the defect.

We evaluate the clinical improvement by assessment of subjective pain using VAS score and joint function by

IKS. Throughout the literature, pain relief has been uniformly reported as satisfactory. Aglietti *et al.* [34] followed 61 patients clinically up to 21 years after surgery and reported that 79% had no pain to only mild knee pain [34]. This is comparable with our results for evaluation of pain, and there was an improvement in VAS from  $76 \pm 23$  to  $38 \pm 19$  postoperatively and so for IKS, which improved from  $68.0 \pm 20$  to  $91 \pm 19$ . The results of this study are comparable to published data in terms of functional results [20–23,35–38]. Overcorrection of coronal valgus alignment was important to obtain satisfactory result after HTO [6,10]. Hernigou *et al.* [10] reported that the best results were obtained in 20 cases of OW-HTO that had mechanical HKA angle of  $183^\circ$ – $186^\circ$ . An anatomical valgus alignment at consolidation between  $8^\circ$  and  $15^\circ$  was significantly correlated with the best result [10]. In the current study, the former recommendation was followed, with postcorrection mechanical hip–knee angle of  $183 \pm 1.88^\circ$  ( $179^\circ$ – $184^\circ$ ) ( $P = 0.0001$ ). To achieve the target alignment, a few points were important, including accurate preoperative planning and careful prevention of lateral tibial translation on opening up the osteotomy. The knee range of motion was not altered significantly after HTO, whereas the function and Knee Scores were significantly improved. Our goal was a correction of  $3^\circ$  valgus to be consistent with published data [39,40] and a study of ranges by Thomine *et al.* [41].

#### Bone union

Bone union occurred in an average time of 4.3 months, similar to results reported by Brinkman *et al.* [42] Bonneville *et al.* [20] who used a tricalcium phosphate macroporous substitute to fill this opening, with the average time of union of 3.7 months [20]. A study done by Koshino *et al.* [22] found the osteotomy site was united after 4 months using porous hydroxyapatite as a filler (nonresorbable ceramic substitute) after a medial opening wedge osteotomy [22]. Bove [43] used a porous inert alumina ceramic spacer to achieve union in an average of 3 months; a plate was used for fixation, and there was no loss of correction in the 50 cases. However, a radiolucent margin was observed around this inert, and nonresorbable spacer was found in one-quarter of the cases [43]. Staubli *et al.* [26] did not use grafts or bone substitutes to fill the gap and reported that full remodeling of the medial cortex can take up to 1 year. They reported one case of nonunion in 92 patients [26]. It can be concluded that bone healing occurs with or without filling of the gap. Furthermore, bone healing times

do not vary. It can therefore be debated whether the gap should be filled at all. The results of our technique without using bone graft or introducing an additional foreign body for union and filling of the osteotomy site are comparable with the previous studies.

#### Maintenance of correction

No loss of correction was found between the postoperative evaluation and the follow-up even in the case of delayed union. We allow partial weight-bearing after 6 weeks, while full weight-bearing after 12 weeks. Asik *et al.* [44] reported that full weight-bearing was possible after 3 months. Staubli *et al.* [26] using Tomofix for fixation in OW-HTO without filling the gap and without using a brace or cast, found that full weight-bearing was possible at 10 weeks [26].

This study has some limitation: the number of cases is limited, short duration of follow-up but since the initial hypothesis was that the osteotomy site can be united without using the graft and correction can be maintained with plate till union occurred. From thus only short-term follow-up was enough to study these elements and to reach the goal of the study, and finally we did not record any data about body weight and BMI. However, we did not have any cases with marked obesity.

#### Conclusion

Medial OW-HTO is an effective procedure for isolated medial unicompartmental osteoarthritis. Union of the osteotomy without using bone graft occurred in a period comparable to its use without problems. In addition it gets away from the risks related to filling the osteotomy site with bone or an inert substitute.

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Nil.

#### Conflicts of interest

There are no conflicts of interest.

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