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Open wedge high tibial osteotomy with sliding cancellous bone in distal fragment into the osteotomy gap; 2-year follow-up results

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Abstract

Open wedge high tibial osteotomy (OWHTO) has been performed by orthopedic surgeons without filling the osteotomy gap. However, the osteotomy space dimension and fixation methods suitable for this method are still controversial. We use the metaphyseal cancellous bone of tibia distal fragment; using a special technique to slide the cancellous bone into the osteotomy gap to provide better bone healing. This study was conducted to investigate the benefits of this method in terms of bone union. This was designed as a prospective randomized controlled study. There are 17 patients in each group. Patients with an osteotomy gap of only 12 mm were included in the study in preoperative planning. The Lysholm Knee Scoring Scale was used to assess the functional status of the patients. Hip Knee ankle (HKA) angle and tibial posterior slope angle were measured during preoperative and control visits. Bone healing was assessed by trabecular and cortical continuity on anteroposterior and lateral radiographs. Reduced pain and recovery of functions confirmed the union. The mean union time was 14.3 ± 4.7 (12-22) weeks in the control group and 13.1 ± 3.9 (11-18) weeks in the graft sliding group (P = 0.04). In the control group, the HKA angle was 10.8 ± 2.5 ° Varus preoperatively and 2.1 ± 1.4 ° valgus at second-year control visit. In the graft sliding group, preoperative HKA angel was found 11.3 ± 1.9 ° Varus and 2.7 ± 2.1 ° valgus at second-year control visit (p> 0.05). There was no statistically significant difference between the groups in terms of Lysholm Knee Scale scores at preoperative and postoperative second-year control visits. The sliding cancellous bone of the tibial distal fragment into the osteotomy gap provided earlier bone union than the control group. There was no difference in functional results between the groups in the two-year follow-up results of the patients.

Keywords: Grafting, osteotomy, tibia, cancellous bone, results

Introduction

High tibial osteotomy (HTO) has been preferred to treat medial compartmental osteoarthritis of the knee in especially relatively non-advanced age patients [1-4]. Open wedge high tibial osteotomy (OWHTO) has certain advantages in comparison with closed wedge high tibial osteotomy such as simple surgical exposure and application of deformity correction, preserving bone reserve, avoiding injury to proximal tibiofibular joint and fibular nerve as well as low compartment syndrome occurrence rate [2]. However, it has also been reported that delayed union and correction loss are among the most important disadvantages of OWHTO [5]. For this reason, it is traditionally recommended that surgeons fill the osteotomy gap with bone or bone substitutes [6].

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Orthopedic surgeons use autografts, allografts, synthetic bone void fillers (hydroxyapatite, β-tricalcium phosphate) to fill the osteotomy gap [2, 4, 7]. Despite reports emphasizing the risk that synthetic bone void fillers could disturb the bone healing [2]. Some surgeons prefer to combine allografts or synthetic materials with platelet-rich plasma, growth factor, or stem cell [2, 4, 7]. Although filling the osteotomy gap with autograft from the iliac crest has been accepted as the gold standard [2, 7]. Recent studies reveal that consolidation of osteotomy gap size up to 14 mm is viable without grafting [2, 8, 9]. All in all harvesting the iliac crest graft prolongs operation time and can cause donor site morbidity [9].

Although previous studies report successful outcomes in terms of bone healing without applying bone graft, differences in osteotomy gap sizes and fixation systems hinder a thorough comparison. It was for this reason our priority was fixed on ensuring bone healing. Essentially proximal tibial metaphyseal region is a preferred donor site especially for foot and ankle surgeons for its rich stem cell content and to avoid iliac crest harvesting morbidities [10-12]. It has been reported that efficient remodeling of the tibia proximal metaphyseal donor site was demonstrated via the coronal section computerized tomography [12]. Besides HTO is performed just into this donor site. To benefit from this site we have used tibial metaphyseal cancellous bone distal to the osteotomy line by sliding it into the osteotomy gap. The present study is therefore designed to investigate the benefits of this new technique in connection to bone healing.

Material and Methods

This study was designed as a prospective randomized controlled study. Two groups were formed. No bone graft was used in either of these groups. One of these patient groups was set as the control group while the other consisted of patients operated with tibial metaphyseal cancellous bone sliding technique. (Figure 1 demonstrates the difference between the two techniques) There were seventeen patients in each group. Only those with an osteotomy gap of 12 mm during preoperative planning were included in the study. Preoperative planning was made on long-leg standing roentgenograms. The targeted HKA angle was approximately 3° valgus. The inclusion criteria for this study were as follows: <65 years old; BMI< 30; no patellofemoral or lateral compartmental arthritis; HKA angle < 15° varus; >90° knee flexion; and no requirement for patellofemoral realignment surgery or ligament reconstructions.

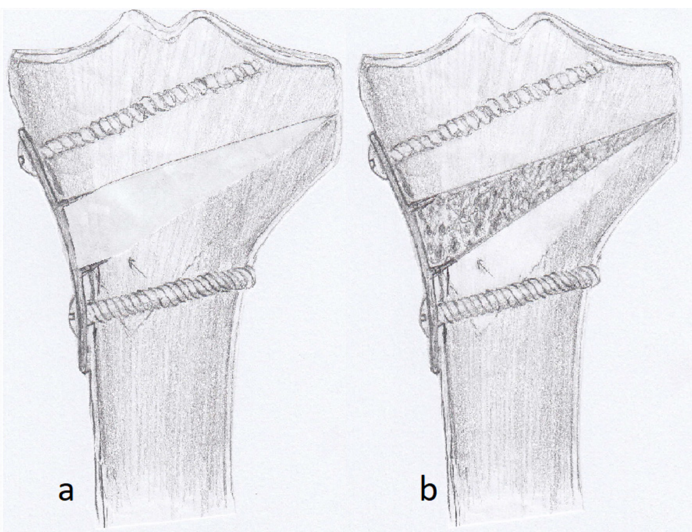

Figure 1. a; osteotomy gap is unfilled in the control group, b; metaphyseal cancellous bone is slid to the osteotomy gap in the graft sliding group.

All surgical procedures started with arthroscopy for evaluating intraarticular structures. Only non-locking two-hole wedged plates were used (hipokrat, Turkey). Cancellous screws were 6.5 mm in diameter. For all patients, we used two plates and four screws. The surgical procedure was performed using tourniquet under fluoroscopy. After the application of arthroscopy, a 3-4 cm incision was made anteromedial on the proximal tibia. One or two K-wires were placed 1 cm distal and parallel to the joint line to preserve the tibial plateau. Two to three K-wires were placed on the medial side distal to the medial joint surface of the proximal tibia laterally towards the target point of 1 cm distal to the lateral joint surface (Figure 2a). The osteotomy was performed with the guidance of these K-wires. In the control group, the osteotomy gap was not filled in. (Figure 2b) Then first a 12 mm plate was placed medially followed by a second plate (9, 10, or 11 mm) was placed anteromedially and with care to evade a potential increase in the tibial posterior slope. In the metaphyseal bone sliding technique, a distal screw of 12 mm plate was placed unicortically as we aimed to allow the distal tibial metaphyseal bone to slide in effortlessly. We used one curved osteotome to separate the metaphyseal cancellous bone from the distal tibial fragment at 40-45° to the horizontal plane (Figure 2c). Next, this cancellous bone was slid into the osteotomy gap by turning it on a lateral pivot point (Figure 2d). Then the second plate placed just as in the same with the control group and unicortical screw was changed with a bicortical one. All patients were applied hemovac drain.

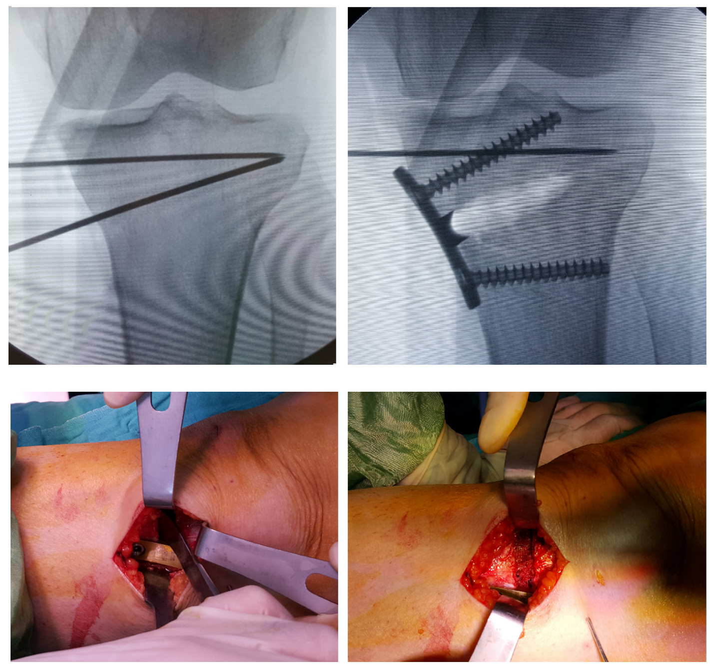

Figure 2. a; osteotomy is performed with the guidance of these K-wires, b; osteotomy gap is left unfilled in the control group, c; one curved osteotome is used for separation of the metaphyseal cancellous bone from the distal tibial fragment at 40-45° to the horizontal plane, d; cancellous bone is slid into the osteotomy gap in graft sliding group

Infection prophylaxis was performed using 1gr cefazolin for one hour before the operation. For thromboembolism prophylaxis, 40 mg/0.4 ml enoxaparin sodium (Clexane®4000 anti-Xa/ 0.4ml pre-filled syringes, Sanofi Aventis) was administered subcutaneously 12 hours after the operation and this was further applied once a day for 3 weeks. Partial weight-bearing was allowed in the control visit in the sixth week. Full weight-bearing was planned at the end of the third month.

The functional status of the patients was evaluated before the surgical procedure and during the first year control visit by using the Lysholm Knee Scoring Scale. Magnetic resonance imaging of the knee and long-leg standing roentgenograms were conducted preoperatively. Patients were called in on the postoperatively 45th day, in the third and sixth months, and 1 year after the operation for a control visit. HKA angle and tibial posterior slope angle were estimated preoperatively and during these visits. Bone healing was evaluated through trabecular continuity at anteroposterior and lateral radiographs and was ensured by decreasing pain and regaining of functions. (Figure 3 and Figure 4 demonstrate the postoperative follow up radiographs of the patients treated by the two techniques)

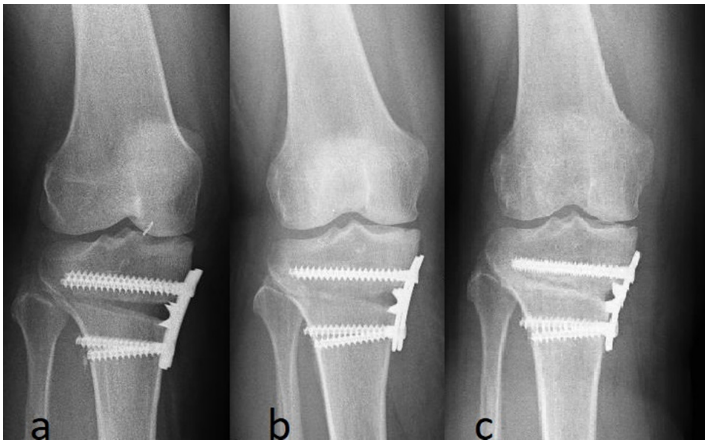

Figure 3. anteroposterior right knee roentgenograms of 46 years old women in the control group, a; immediate postoperative, b; postoperative third month, c; postoperative first year.

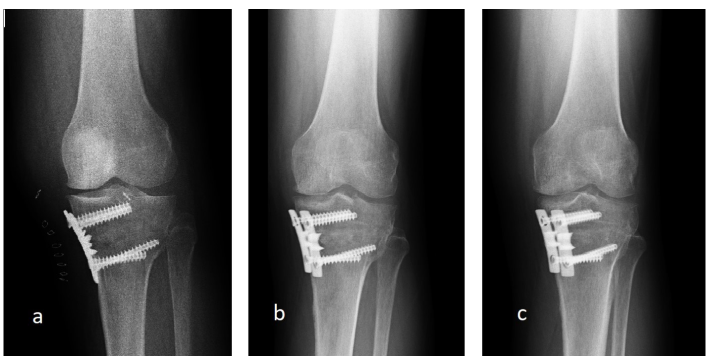

Figure 4. anteroposterior left knee roentgenograms of 53 years old women in graft sliding group, a; immediate postoperative, b; postoperative third month, c; postoperative first year.

Statistical analysis

Statistical analysis was performed using SPSS for Windows 20 (SPSS, Inc.). The Shapiro-Wilk test was used to test the reliability of the distribution of data. If the data were normally distributed, differences between the two groups were evaluated using the t-test. In the case of non-normally distributed data, the Mann-Whitney U test was brought forward to evaluate the differences. When it was supposed that α equaled 0.05 and 1-β (power) equaled 0.80 for the power analyses with regards to bone healing time, fifteen patients were considered adequate for each group. A p-value of <0.05 was considered statistically significant.

Results

One of the patients in the control group was hospitalized in the intensive care unit on the 20th postoperative day. Although this patient recovered, she refused to further participate in the study during the rehabilitation period. Also, having moved to a province with a considerable distance to the center where the study was carried on, another patient in the control group dropped off reducing the number of patients in the control group to fifteen. All seventeen patients in the graft sliding group were followed at least for one year. The demographic features of the study groups are demonstrated in Table 1. The average time to union was 14.3±4.7 (12-22) weeks in the control group; this was 13.1±3.9 (11-18) weeks in the graft sliding group. (p=0.04) HKA angle in the control group was 10.8±2.5° varus preoperatively; 3.6±1.2° valgus on the postoperative 45th day; and 2.9±1.7° in the first postoperative year. In the graft sliding group this was 11.3 ±1.9° varus preoperatively; 3.8±1.6° valgus on the postoperative 45th day; and 3.2±1.9 during the control visit after one postoperative year. There was no difference between the groups in terms of preoperative and postoperative HKA angles. The tibial posterior slope angle in the control group was 10.1±3.2° preoperatively and 11±2.8° in the postoperative year one. In the graft sliding group, this was 9.8±2.5° preoperatively and 11.2 ±3.7° postoperatively after a year. Also, there was no difference between the groups in terms of preoperative and postoperative tibial posterior slope angles.

Table 1. Demographic features of the groups

	Graft sliding group	**Control group**
Age	52.5±8.3 (39-62)	50.9±6.4 (41-60)
Gender	13 female 4 male	14 female 1 male
BMI	29.4±3.9	30.7±2,5

The average preoperative Lysholm Knee Scoring scale score was 39.5±9.6 (30-64) in the control group and 42.8±11.4(34-70) in the graft sliding group. One year into the operation, this was 73.6±14.5 (55-90) in the control group and 76.1±12.4 (50-92) in the graft sliding group. There was no statistically significant difference between the two groups in terms of preoperative and postoperative Lysholm Knee Scoring scale scores.

One patient in the control group experienced complications with lateral hinge fracture during the osteotomy procedure but the patient did not need to undergo any additional surgery procedures. We did not require postoperative blood transfusion for either of the groups. Superficial infections occurred in two patients in the control group and one of the patients in the graft sliding group. We did not experience nonunion or delayed union in either of the groups. In the control group, bone union was completed in the 18th week in four patients, in the 20th week in two patients, and in the 22nd week in one; in the graft sliding group, the union was completed in the 18th week in three patients.

Discussion

It has been reported that harvesting iliac crest autograft can cause minor complications such as superficial infection, seroma, or hematoma. Especially after a massive graft harvesting, major complications can occur such as herniation of abdominal content, vascular damage, neurologic damage, deep infections, deep hematomas, and iliac wing fractures [13]. Besides allografts reportedly have low-grade osteoinductive features and disease transmission risks while synthetic bone void fillers have a low resistance to compressive loads and unclear degradation features in the tissue [14]. For these reasons, many orthopedic surgeons have performed OWHTO without bone graft [2, 4, 13, 15, 16]. Staubli et al. [15] report delayed union in only two of 92 patients in a prospective study that did not implement bone graft. On a similar note, A.R. Zorzi et al. [16] report that there was no difference in terms of bone union and complications between patients whose osteotomy gaps were filled with iliac bone autograft and those whose osteotomy gaps remained unfilled. El-Assal MA et al. [9] relate that 8 mm osteotomy gap size healed faster than 14 mm gap size in their series and recommend that osteotomy gap size >14mm should be filled with graft. More to the point, it has been reported in previous studies that different osteotomy gap sizes ranging from 12 to 15 should be filled in [17-19]. However, these studies do not compare standard osteotomy gap sizes in terms of bone healing. The present study focuses on whether gentle sliding of a local cancellous bone skeleton into the osteotomy gap has any positive effect on bone healing rather than the requisite for filling the osteotomy gap. Also, for a comparison between the two groups, only the patients with a gap size of 12mm were included in the study. It is difficult to come up with favorable comparisons between previous studies so far as the duration of bone healing is concerned due to the marked differences between the studies with regards to fixation techniques, osteotomy gap sizes, and weight-bearing status. El Assal et al. [9] report average time to the bone union as 12.4 [8-16] using non-locking wedged-plate without bone graft. In a study by T.Brosset et al. this is reported as 4.5 months [1.5-8] using a locking plate (Tomofix) without bone graft. The average time to union in the present study was 14.3±4.7 [12-22] weeks in the control group and 13.1±3.9 [11-18] weeks in the graft sliding group (p=0.04). It has further been reported that the nonunion rate was %0.4 (0-2) in previous studies [2]. There was no delay or nonunion observed in the current study in either of the groups.

The basic principle of HTO is based on removing tibia-femoral contact stress on the effected articular region [20]. Many surgeons use the Fujisawa point during the correction process [21]. Henrique et al. [6], for instance, report that >6° valgus correction can cause progressive medial and lateral compartmental damage. The average valgus angles in the first year were approximately 3° in each group in our study. As part of this application, it should be kept in mind that the posterior slope of the tibia should be preserved to prevent anterior cruciate ligament insufficiency [20]. In our study, we preserved the posterior slope of the tibia by using different wedge size plates on medial and anteromedial sides of the tibia.

Reports show that %90 of previous studies on OWHTO applications without bone graft have been performed using locking plates [2]. However, fixation loss and nonunion rates of the remaining studies without bone graft were very low as well [7, 16]. The plate systems used in this study was preferred as it is atraumatic and suitable for minimally invasive surgery while it also offers high stability features and safeguards the tibial posterior slope.

There was no difference between the groups in terms of the lysholm knee scoring scales preoperatively or postoperatively within the first year in our study. Preoperative and postoperative first-year clinical scores in each group were compatible with other studies using the lysholm knee scoring scale [7]. It has been reported that the rate of lateral hinge fracture in earlier studies is %0-27 [16, 22-24]. Throughout our study, only one patient in the control group developed a lateral hinge fracture. Previous studies also report infection incidence that required revision at a rate of %0-9 [16, 22-24]. In our study, we did not observe infection calling for a revision in any of our patients.

The crucial element we took into consideration in our study was the duration of time elapsed for bone healing. In this respect, it is safe to say that our study demonstrates a statistically significant shortening of bone healing time. However, indeed, there is still a need for extensive studies to have a better insight into the efficacy of this technique on delayed union or nonunion.

Conclusions

In the light of the results of this prospective randomized controlled study, open wedge high tibial osteotomy performed via the cancellous bone sliding of the tibial distal fragment into the osteotomy gap promotes cogent healing since it provided earlier bone union compared to the patients in the control group.

Conflict of interests
The authors have no conflicts of interest to declare.

Financial Disclosure
All authors declare no financial support.

Ethical approval
Ethics committee approval was received from Inonu University Faculty of Medicine by Ethics Committe for the study, ethic number 2015/209

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