INTRODUCTION

Angular deformities of the knee are a common cause of knee pain. Genu varum and osteoarthritis will increase within the elderly population in most countries along with increases in knee surgeries such as arthroscopy, high tibial osteotomy, and total knee arthroplasty. Jackson first described high tibial osteotomy (HTO) in 1958 and it was further popularized by Coventry. HTO has become a popular treatment option for varus unicompartamental gonarthritis, osteochondral lesions, and joint instability in young and active patients. Although many surgical techniques for HTO have been described, including the dome, Ilizarov, medial opening-wedge, and lateral closing-wedge techniques, medial opening-wedge...
high tibial osteotomy (MOWHTO) has become more popular over the past two decades and has a lower rate of complications. In MOWHTO, different fixation techniques are applied with or without using bone grafts; autografts are usually used to fill the osteotomy defect, although allografts (tricalcium phosphate, dicalcium phosphate granules, acrylic cement, or hydroxyapatite) and xenografts have also been used. Autogenous bone grafts prolong the operating time and increase morbidity, including severe chronic donor site pain, infection, palpable defects, paresthesias, and increased blood loss. Some studies have demonstrated that the bone union rates did not differ significantly with or without a graft in an opening-wedge HTO. However, when grafts or locking plates were not used, a correction deficit and delayed bone union were reported.

Therefore, this study examined differences between patients undergoing MOWHTO with a locking titanium plate with or without autografts by two surgeon’s technique, according to knee score, radiological assessment, deficit correction, patellar height change, bone healing time, weight bearing time, and complication rate. Additionally, we evaluated whether bone grafting is necessary or not for HTO.

MATERIALS AND METHODS

Study Design

This retrospective study evaluated 63 knees of 58 patients who had undergone MOWHTO with an open wedge osteotomy (OWO) titanium locking plate (TST Tibbi Aletler, Istanbul, Turkey) performed at the different medical center by two surgeon’s experience (CI and HS) in patients with isolated varus unicompartmental gonarthrosis between December 2011 and September 2014. Group A consisted of 31 osteotomies were operated by the Surgeon CI in which the osseous tibial defect was filled with autologous iliac crest bone graft. Group B consisted of 32 osteotomies were by the Surgeon CI and HS in which the osseous tibial defect was not filled. Inclusion and exclusion criteria are summarized in Table 1. All patients underwent arthroscopic debridement and assessment before MOWHTO. All patients undergoing HTO were evaluated pre- and postoperatively in terms of range of motion (ROM), Knee Society Score, and Functional Knee Society Score.

Radiological evaluation

Preoperatively, anteroposterior (AP), lateral, and tangential X-rays and magnetic resonance imaging (MRI) of the knee were obtained for patients scheduled to undergo MOWHTO. In pre- and postoperative images, the following measurements were made: the mechanical axis of deviation (MAD), medial proximal tibial angle (MPTA), Insall–Salvati Index (ISI), and Blackburne–Peel Ratio (BPR). The clinical and radiological data were evaluated prospectively at the preoperative consultation and 6, 9, and 12 weeks, and 6 months and 1 year, after the surgery, and then annually. Bone union was evaluated on AP and lateral radiographs. Union at the osteotomy site follows the same process as normal bone healing. Four of the authors (HS, CI, MEI, MU) analyzed the radiological data at every follow-up. In addition, two of the authors (HS, CI) determined when the patients achieved partial and full weight-bearing. The study was approved by the Local Hospital Management Committee. The patients signed the Term of Free and Informed Consent.

Surgical technique

One hour before surgery, 1g cefazolin was administered to all patients intravenously. All patients lay supine under spinal anesthesia. A lower extremity tourniquet was applied in all patients. First, an arthroscopic evaluation was performed and additional intraarticular pathologies were treated using arthroscopic methods. MOWHTO was performed as described elsewhere. The osteotomy incision was made based on the preoperative plan and a titanium locking OWO plate was placed through this osteotomy incision (Figures 2). Under fluoroscopy, the mechanical axis was determined with a metal rod passing through the center of the femoral head and the ankle. The passage of the mechanical axis through the knee was evaluated by arthroscopy. After achieving sufficient correction, the OWO was fixed using a titanium locking plate. In all patients in Group A, an autograft harvested from the contralateral iliac crest was applied on the osteotomy line. All patients underwent prophylactic treatment to protect against deep vein thrombosis for 10 days.

Postoperative Rehabilitation

No external immobilizer was applied in any patient. Patient-controlled anesthesia (PCA) was used to manage the postoperative pain and facilitate the rehabilitation process. On postoperative day 1, active knee ROM exercises were initiated up to 90° as tolerated by the patient. After the second week, rehabilitation exercises were continued freely after ROM of 90° was achieved. One day after surgery, the patients were mobilized, and walking with the aid of a pair of crutches was permitted. For the first 2 weeks, walking with the heels contacting the ground was permitted. Then, partial weight-bearing was allowed as tolerated by the patient. After 6 weeks, full-weight bearing on a crutch while walking was permitted. Three months postoperatively, the patients walked without support.

Table 1. Inclusion and exclusion criteria.

| Inclusion criteria | Exclusion criteria |
|--------------------|-------------------|
| Patients aged <65  | Patients aged >65 |
| Isolated medial compartment arthritis (Ahlbäck grade 1 or 2) | Ahlbäck grade 3 arthritis and excessive patelofemoral arthritis |
| Good patient motivation to comply with postoperative rehabilitation | Poorly patient mentally to comply with postoperative rehabilitation |
| Range of motion >100° | Range of motion <100° |
| Absence of knee contractures | Flexion contracture of >10° |
| Moderate to severe varus malalignment (5-15°) | Varus gonoarthrosis requiring >20° correction |
| Stable knees | Laxity of collateral ligament, Anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) insufficiency |
| BMI< 30 kg/m2 | Previous ACL and/or PCL reconstruction |
| | Joint infection and rheumatoid arthritis |

Figure 1. A) Open Wedge Osteotomy titanium locking plate AP. B) Open Wedge Osteotomy titanium locking plate LAT.
Figure 2. A) Placement of Guide K wires. B) Determination of the size of the Puddu plate to be placed on the osteotomy incision line. C) AP radiogram following perioperative implantation of a plate. D) LAT radiogram following perioperative implantation of a plate.

Statistical Analysis

The data analysis was performed using the Statistical Package for the Social Sciences software, version 20 for Windows (SPSS Inc., Chicago, IL). The data are shown as mean ± standard deviation for continuous variables, medians (minimum–maximum) for ordinal variables, and frequencies with per cent for categorical variables. Comparisons between groups were performed using one-way ANOVA with post hoc analysis by Tukey’s HSD or independent samples t-test and the Kruskal-Wallis tests or Mann-Whitney U test for normally and abnormally distributed data, respectively. The categorical variables between groups were analyzed using the chi-square test. A p value of <0.05 was considered statistically significant.

RESULTS

Clinical results

This study included 58 patients (4 men, 54 women; mean age, 52 years; range: 46–59 years) who were operated on using the MOWHTO method. The patients were followed for at least 1 year. The mean duration of the follow-up was 19.3 months (range: 12–25 months). No significant difference was detected between the groups in the demographic characteristics or size of implants used (Table 2). No significant (p>0.05) difference was found between the pre- and post-operative ROM in the patients. The postoperative Knee Society and Functional Knee Society Scores were significantly (p<0.05) different when compared with the preoperative scores in both groups (Table 3).

Radiological results

In Groups A and B, full union of the osteotomy line required 11.85 and 12.15 weeks, respectively; the difference was not significant (p=0.117). After an average of 6 months, radiological bone union was seen. There was no significant (p>0.05) difference in the degree of correction at the first postoperative year between the groups. The X-ray results are summarized in Table 4.

Table 4. The evaluation of X-ray results.

| Group | A (N=31) | B (N=32) | p   |
|-------|----------|----------|-----|
| Preop MAD | 29.6 mm medial  | 29.3 mm medial  | 0.885 |
| Early Postop MAD | 5.06 mm lateral | 5.3 mm lateral | 0.388 |
| Postop 1 year MAD | 4.9 mm lateral | 5.1 mm lateral | 0.402 |
| Preop aMPTA | 81.3° (77°–86°) | 81.8° (76°–87°) | 0.459 |
| Early Postop aMPTA | 91.1° (87°–97°) | 91.4° (86°–97°) | 0.757 |
| Postop 1 Year aMPTA | 90.3° (86°–97°) | 91° (85°–97°) | 0.571 |
| Correction degrees of post-operation | 10.39° | 10.31° | 0.817 |
| Correction degrees of post-operation at 12 months | 9.97° | 9.94° | 0.918 |
| Difference of correction degrees | 0.42° | 0.39° | 0.910 |
| Preop ISI | 1.05 (0.79-1.22) | 1.01 (0.79-1.25) | 0.260 |
| Postop ISI | 1.12 (0.8-1.35) | 1.09 (0.81-1.35) | 0.534 |
| Postop ISI at 12 months | 1.14 (0.82-1.36) | 1.13 (0.84-1.36) | 0.854 |
| Preop BPR | 0.98 (0.77-1.12) | 0.94 (0.75-1.14) | 0.094 |
| Postop BPR | 0.94 (0.77-1.06) | 0.90 (0.75-1.05) | 0.099 |
| Postop BPR at 12 months | 0.92 (0.76-1) | 0.88 (0.75-1) | 0.100 |

Complications

None of the patients developed a neurovascular injury, serious infection, or patellar dislocation. Twelve (19%) patients developed various complications: four patients had lateral cortex fractures during the osteotomy procedure (a short-thread cancellous screw was placed through the hole of the plate crosswise at the osteotomy line and the other screws placed in the plate were locking screws; see (Figure 3); three developed deep hematomas in the muscle; three Group A patients had chronic tenderness at the iliac graft harvesting site; and two patients developed lateral plateau fractures while expanding the osteotomy line (after fixing the plate with two spongy screws, the osteotomy line was opened until required correction was achieved (Figure 4); the time to bone union was not different in these patients and no correction deficit developed.

DISCUSSION

MOWHTO, which is a treatment alternative for young and active patients with medial gonarthrosis of the knee, has improved mid- and long-term outcomes with appropriate patient selection and attentive surgery.\(^1\)\(^-\)\(^4\) With MOWHTO technique, no implant is applied at the joint surface, no septic or aseptic loosening is detected (as seen in arthroplasty) and, most importantly, total knee arthroplasty is postponed by preserving the integrity of the patient’s own anatomy.\(^6\)\(^-\)\(^8\)\(^,\)\(^10\)
MOWHTO is associated with stability of the osteotomy in accordance with osteotomy size, an intact lateral cortex, and rigid fixation. Even if these criteria are met, with MOWHTO it is not always possible to achieve the desired state of wellbeing. Serious problems include problematic union of the osteotomy line, unwanted fractures, and under- and overcorrection. Grafting of the osteotomy line is directed at preventing problematic bone union. When a fracture occurs, union can be problematic and a correction deficit can occur despite rigid fixation. During surgery, the correction should be at least 80° valgus with a tendency towards rigid fixation.  

With MOWHTO, although the use of autografts is frequently preferred, this increases the operating time, pain at the donor site, and the risks of iliac wing fracture and inflammation. The disadvantages of allografts, which are being used increasingly, include lower bone formation rates, contagious diseases, and higher costs. To prevent correction deficits and accelerate bone healing, Spahn recommends the use of grafts for osteotomy defects > 12°, and tibial size effects on wedge height. In our series, three Group A patients developed chronic pain at the donor site, which was consistent with the literature. We did not observe any significant differences between the groups with and without grafts in terms of union of the osteotomy line or correction deficit. Additionally, the tibial wedge heights of our groups were similar, and was not observed any significant differences between the groups with and without grafts in terms of union of the osteotomy line or correction deficit. Therefore, it is not necessary to risk additional morbidity and potential complications by using grafting in patients who are undergoing MOWHTO with rigid fixation. However, correction degrees of post-operation at 12 months were approximately 10 degrees. It was not than 12 degrees.

Many studies have demonstrated consolidation in patients who underwent MOWHTO with rigid locking plates without using grafts. Correction deficits were reported in cases with lateral cortex fractures when adequate stabilization could not be achieved using conventional Puddu stainless steel plates. We think that the use of an OWO titanium locking plate and a 6.5 mm short-thread cancellous screw inserted through the screw holes in the plate provided additional stabilization of the fracture line.

El-Azab et al. demonstrated that closing-wedge HTO and open-wedge HTO increased the incidences of patella alta and patella baja, respectively. In our series, the development of patella baja was seen in patients with MOWHTO. However, there were no significant differences between the pre- and postoperative measurements of the length of the patellar tendon, ISI, and IBR. Study limitations included its retrospective nature, the performance of the surgeries by different surgeons in the groups with and without graft implantation, the inability to assess the smoking status or number of pack-years of the participants, the wide age range, and the small sample size.

CONCLUSION

In patients undergoing MOWHTO using an OWO titanium locking plate, the use of a graft does not make an additional contribution to the time to bone union or preservation of the correction achieved, while not using a graft avoids the development of additional co-morbidities that might occur with an allograft or autograft. We also believe that not using a graft decreases the operating time and costs.

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