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ORIGINAL STUDY

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Tibial cancellous bone auto-grafting for medial open-wedge high tibial osteotomy: bone void filling with tissue harvested from osteotomized medullary canal

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The aim of the study was to evaluate the clinical and radiological outcomes in a series of patients undergoing open wedge high tibial osteotomy (OWHTO) using tibial cancellous autograft harvested from the osteotomized medullary canal which is not reported in the literature before.

Patients with medial compartment osteoarthritis were treated with OWHTO and tibial cancellous auto-grafting performed from the osteotomized medullary canal and used for bone void filling. Seventy patients (seventy-two knees) treated with OWHTO were analyzed. All patients started partial weight-bearing with crutches the day after surgery and full-weight bearing eight weeks after surgery, according to radiological evaluation. Fifty-seven women and 13 men with a mean age of 54.2±8.1 years were evaluated in this study. The mean correction angle was 8.4±2.5° (range: 5.3°-14.3°). The osteotomy sites of all patients were grafted with tibial cancellous autografts. In all patients bony union was detected after surgery. No implant failures or major complications were encountered. Clinical and radiological findings revealed that bone void filling with the harvested autograft from the osteotomized medullary canal may be a satisfactory and reliable option in OWHTO.

Keywords: Knee medial compartment arthritis; open-wedge high tibial osteotomy; bone graft materials; tibial cancellous autograft.

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Informed consent: Informed consent was obtained from all individual participants included in the study.

INTRODUCTION

Medial open-wedge high tibial osteotomy (OWHTO) is an accepted surgical treatment method for correcting deformities and reducing pain in the treatment of varus knees with osteoarthritis involving the medial compartment in active patients *(1)*. Although OWHTO is a better treatment choice for medial uni-compartmental osteoarthritis, sometimes the osteotomy site requires bone grafting to fill the bone defect after deformity correction *(2)*. Various bone void fillers have been described. Tri-cortical auto-graft from the iliac crest is the "gold standard" graft material and has been used for the gaps and successful results have been reported *(3)*. OWHTO without grafting was practiced previously, but delayed union and also nonunion problems were

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reported *(4)*. However, an important unanswered question remains; if, when and which bone void fillers should be used.

For bone void filling of the osteotomy site, allograft bone and various synthetic bone substitutes have been employed. These substitutes were used either alone or in combination with autograft or allograft, beta tri-calcium phosphate, hydroxyapatite (HA) or acrylic cement *(5,6)*. Cancellous bone graft harvesting from the medullary canal of the proximal and distal tibial fragments may be appropriate for filling the gap in the osteotomy site and would yield more satisfying radiographic and clinical results. However, to date there is no ideal graft material identified for OWHTO. In this research, our aim was to apply autologous cancellous bone graft, without creating any donor site morbidity, in OWHTO patients in order to encourage fast and optimal healing.

MATERIALS AND METHODS

Approval for this study was granted by the local ethics committee (KU GOKAEK 2017/10.2 Project No: 2017/7). Written informed consent of all participants was obtained. Consecutive patients with varus knee with medial uni-compartmental osteoarthritis who had undergone OWHTO using on-site tibial cancellous bone autograft, between June2009 and March 2013, were retrospectively analyzed. Seventy-two knees of 70 patients, of whom 57 (81.4%) were female, were treated with OWHTO using on-site tibial cancellous bone autograft during the study period. The mean±SD age was 54.2±8.1 (range: 36-72) years. The mean duration of follow-up was 36 months (range 32-50).

All the knees had painful, medial, uni-compartmental osteoarthritis. No patient had a history of rheumatoid arthritis or severe trauma involving the knee.

The senior surgeon performed clinical and radiographic evaluation of each patient. Preoperative measurements were obtained from full-length, standing radiographs, giving a correct estimation of axial alignment of the lower extremity. Bone union was considered to have occurred when bone bridging across the osteotomy site and disappearance of osteotomy line on serial radiographic examinations was evident. Non-union was considered in patients when these indicators were absent after six months.

The operation was performed under general or spinal anesthesia. Thromboembolic prophylaxis (Clexane®, 0.4 ml,Sanofi, Istanbul, TURKEY) and intravenous antibiotic (Sefazol® 1gr, Mustafa Nevzat, Istanbul, TURKEY) were used. During the operation, patients were in a supine position in which the leg was draped free, including the iliac crest so we were able to check alignment intra-operatively, since we could see the entire lower extremity from anterior superior iliac spine to the ankle joint. A tourniquet was applied on the thigh. To visualize the knee joint in two planes, a fluoroscope was installed. A knee arthroscopy was first performed on each patient, in order to ensure an intact lateral joint compartment and to treat additional intra-articular lesions. Arthroscopic assessment of the joint status and other co-morbid procedures were performed, such as menisectomy and cartilage regeneration procedures (cartilage debridement or micro-fracture).

Under fluoroscopic control, the direction of the joint line was marked parallel with a 2.0mm K wire (Figure 1). The direction of the osteotomy in the frontal plane was marked with a 2.5mm K wire. The osteotomy started at the upper margin of the pes anserinus and ended 1 cm from the lateral cortex and 20-25 mm away from the proximal articular surface of the tibia. The osteotomy site was opened slowly and inferiorlyusing a spreading clamp, and the distal fragment elevated evenly in both the front and the back and with great care taken not to break through the lateral cortex. With acurette, the cancellous bone from the two adjacent cut surfaces was taken. This cancellous bone, harvested from the tibial metaphyseal area and medullary canal, was morselized and used to fill the osteotomy site under the plate (Fig. 2a and 2b). A block plate and screws, the high tibial open wedge osteotomy plate (Deva Orthopaedic Implants, Istanbul, Turkey) were used to fixthe osteotomy site. The block was placed into the osteotomy site just in front of the posterior tibial cortex. Then the harvested cancellous grafts were inserted up to the osteotomy site, just to the anterior

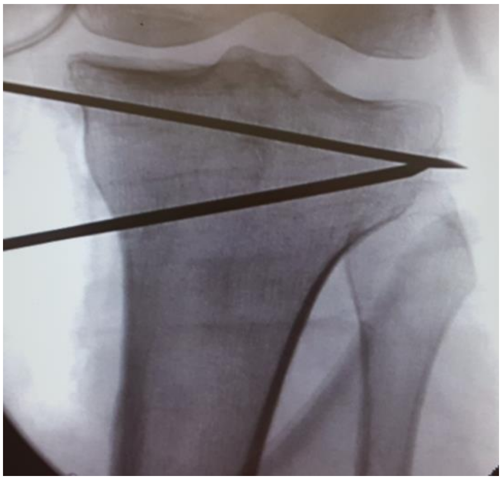

Figure 1. — The direction of the joint line was marked by a parallel, 2.0mm diameter, K wire. The direction of the osteotomy in the frontal plane was marked with a 2.5mm K wire (oblique oriented K-wire).

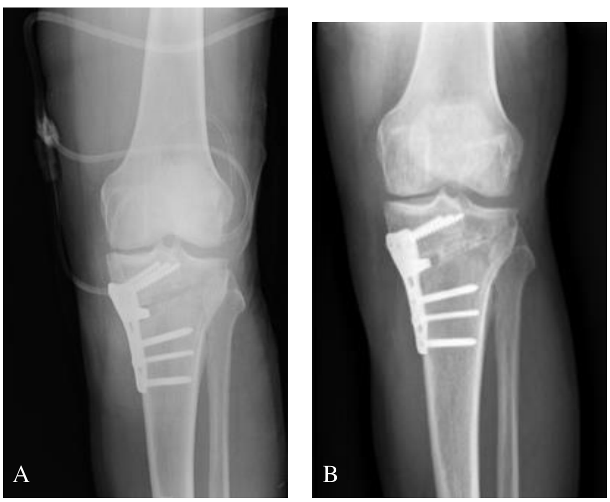

Figure 2. — The osteo-integration of the cancellous bone can be seen by six months postoperatively: A) early postoperative AP view; B) six months AP view.

and posterior gap, and compressed between bony cortex and periosteum.

On the first day after surgery, quadriceps and range of motion (ROM) exercises were started. No braces or casts were used. Partially weight bearing (max.15-20 kg) was started the day after surgery. Full-weight bearing was started approximately eight weeks after surgery, depending on radiological evaluation. Follow-up was done everytwo months from the operation time to evaluate the radiographic and clinical improvement.

All statistical analyses were performed using IBM SPSS for Windows version 20.0 (SPSS, Chicago, IL, USA). Kolmogorov-Smirnov tests were used to test the normality of data distribution. Continuous variables were expressed as mean ± standard deviation (SD), median ($25^{th}$to 75^{th}percentile, IQR). Comparisons of continuous variables between the groups were performed using the Student's t test and Mann Whitney U Test as appropriate. A two-sided $p<0.05$ was considered statistically significant.

RESULTS

In the early post-operative radiograph, the femoro-tibial axis was in valgus (post-operative mean femoro-tibial angle was 6.4±2.2° valgus) that decreased gradually during follow-up. The mean correction was 8.4±2.5° (range 5.3° to 14.3°). The grafted osteotomy sites were observed radiographically during follow-up and no collapse was found. Bony union was noted at the osteotomy siteat approximately eight weeks, with trabecular continuity observed on AP view. In all cases mature trabecular continuity was observed at twelve to eighteen weeks after the osteotomy (Fig. 2a, 2b).

At the first follow-up examinations, hyposensitivity in the area of the cutaneous branch of the saphenous nerve was observed in nine (12.9%) patients. No other neurological complications were seen.

Deep surgical site infection was not observed, but two local superficial infections without joint involvement occurred and were successfully treated with oral antibiotics. During the follow-up no implants were removed after operation.

DISCUSSION

OWHTO in varus knees with medial compartmental degenerative arthritis is a method used for reducing symptoms by transferring the weight-bearing axis from the damaged medial compartment to the midline axis of the joint and delays the need for a total knee arthroplasty *(1,7-11)*. The disadvantages of this techniqueis the gap after osteotomy, and need for bone void filling.Variable grafts were used in order to fill this gap *(12,13)*.

Autogenic bone grafts harvested from the iliac crest is considered the goldstandard graft material in high tibial osteotomy with satisfying results *(3)*. The major advantages of iliac crest bone graft includeosteo-conduction, osteo-induction and osteo-genesis *(14)*. However, the disadvantages are numerous and include extended surgical time for graft harvesting, donor site pain, the risk of in-flammation,incision scar and risk of donor area infection, hematoma, discomfort, altered bone contour, delayed healing, herniation of abdominal contents, altered gait with discomfort, excessive blood loss, and fracture at the donor site *(15-19)*.

The technique of autogenic graft harvesting from the osteotomy site of both proximal and distal fragments precludes the development donor area morbidity. In this simple technique, the cancellous bone can be harvested from the osteotomy site with just a curette, and metaphyseal cancellous bone with its healing potential was mobilized towards the osteotomy site.

Allogenic bone grafts have been traditionally suggested as an alternative in most studies *(12,20)*. They have no osteo-inductive and osteogenic properties. Their benefits over autogenic bone grafts include no concern for donor site pain, a theoretical limitless supply and shortened surgical time. However, the disadvantages of these can be low bone formation rate, longer graft incorporation, the risk of infection transmission, and increased cost of surgery. In a study of Kuremsky et al., although it was reported that allogenic grafts provided comparable results to autogenic grafts in terms of the clinical and radiographic results with bone union period, the failure rate of OWHTO using a Puddu plate was six times higher in the allogenic graft group than in the autogenic graft group. A medial cortical gap of more than 11 mm because of the large wedge size was suggested as leading to the failure *(12)*. Our method, using tibial cancellous autograft harvesting from the osteotomy site, has no risk of disease transmission, low cost, and short union periods compared with allografts.

Synthetic grafts are used as an alternate substitute to auto- and allografts for OWHTO, and results are successful *(6)*. Graft substitutes, such as tricalcium phosphate (TCP), bi-calcium phosphate granules, acrylic bone cement, and hydroxyapatitehave been reported to cause late bone union in the osteotomy site and allergic reactions *(21)*. Goutallier et al. compared the effectiveness of a ceramic wedge (hydroxyapatite + ß-TCP) and an autogenic tri-cortical graft from iliac crest in OWHTO. These authors reported that surgical site pain up to the sixth postoperative month was greater in the ceramic wedge group and the frequency of loss of correction was greater in the ceramic group than in the autogenic graft group. Pain was greater at the graft harvest site than the osteotomy site in most patients, but it improved by the second postoperative week, showing no significant difference *(22)*.

If the osteotomy site requires grafting then the risk of non-union depends on the type of the implant and graft material used *(23)*. In contrast, El-Assal et al. reported satisfying results of medial OWHTO up to 14 mm without bone grafting, but this study did not include patients with obesity or poor bone quality *(4)*.

Limitations of our study include the small number of patients, its retrospective nature and the lack of a control group. The small number of patients precluded statistical analysis to identify risk factors that predicted failure of the treatment.

CONCLUSION

The grafting technique described wasnotable for providing what we believe to be a “gold standard” equivalent autograft that promotes excellent bone healing and high patient satisfaction. There was no necessity for multiple incisions and in our cohort there was no risk of disease transmission or allergic reaction and no donor site morbidity. Therefore, due to the reduction in surgical complexity and rapid recovery, we believe that this technique will also be associated with lower health-care costs.

With this simple technique, the sawn and flat osteotomy surfaces are eliminated, thus promoting strong and rapid bone healing. The results of this study suggest that metaphyseal curreting of cancellous autograft from the osteotomy site and debris from the medullary canal is an excellent alternative to iliac crest bone for speeding the healing process in patients undergoing OWHTO.

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