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ORIGINAL STUDY

Return to sport and work after medial open wedge high tibial osteotomy : a case series

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Data on return to work and sport following open wedge high tibial osteotomy (HTO) have been underreported. Furthermore, there is no clear consensus in literature about the postoperative alignment goals following HTO. A retrospective case series was performed to evaluate return to sport and work following open wedge HTO.

The University of California, Los Angeles scale, the German classification system according to the Reichsausschuß für Arbeitszeitermittlung, the Tegner score and the Knee injury and Osteoarthritis Outcome Score were used to asses the employment status, sport status and clinical outcome at the time of surgery and at final follow-up, minimum 2 years after surgery. The pre- and postoperative hip knee ankle angle (HKA) were documented. The desired postoperative alignment target was 0°-2° valgus mechanical axis.

30 open wedge HTOs were performed of which 27 patients were retrospectively included in the study. 25 out of 26 patients returned to work and 15 out of 17 patients returned to sport following surgery. Outcome scores were significantly higher after surgery. The mean postoperative HKA was 0,9° of valgus mechanical axis.

This study shows excellent outcome in sport and work activity and clinical outcome after open wedge HTO. We furthermore suggest that these outcomes can be obtained with a postoperative alignment of 0°-2° of valgus mechanical axis.

Keywords : knee surgery ; high tibial osteotomy ; return to sport ; return to work ; osteoarthritis.

INTRODUCTION

High tibial osteotomy (HTO) is recommended for young active patients, who suffer primary degenerative arthritis of the knee joint involving a single compartment in a malaligned limb *(1)*.

Advantages of HTO, in contrast to arthroplasty, are the preservation of the native joint and the absence of activity restriction *(2)*.

2 recent systematic reviews *(2,3)* report excellent outcomes after HTO. Hoorntje et al. reported that 8 out of 10 patients return to work and sport. Although they return to the same or higher workload, they report a return to lower-impact sports *(3)*. Ekhtiari et al reported that the majority of patients return to an equal or greater level of sport and work *(2)*.

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However the current literature presents several limitations as the different techniques in use are not distinguished (closing wedge osteotomy, opening wedge osteotomy or dome osteotomy), indications are poorly reported, surgeries are often combined, and the outcomes measurement scales are not standardized. We report a case series of patients undergoing the same surgical procedure for the same clinical indication, namely varus malalignment and medial osteoarthritis. Additionally, we retrospectively assessed if a postoperative valgus mechanical axis of 0-2 degrees is advisable. Most previous publications report a postoperative alignment of 2° to 8° of valgus mechanical axis following HTO *(4-8)*. To our knowledge only more recently, some authors set the goal for postoperative alignment partially or complete below 2 degrees of valgus mechanical axis *(9-11)*. One of these authors, La Prade et al. set the goal for postoperative alignment to a weight bearing line which crosses at a point of 56 % of the width of the tibia plateau, with 0% the medial border and 100% the lateral border, which is in our experience in the range of 0-2 degrees of valgus *(11)*.

MATERIALS AND METHODS

This retrospective observational case series was approved by the local ethical committee (B670201630636). 30 open wedge high tibial osteotomies were performed in 30 consecutive patients between January 2011 and September 2015 at the department of Orthopedic Surgery and Traumatology of the University Hospital Ghent. All patients were operated by two senior surgeons. Inclusion criteria for the study were age (between 18-60y), symptomatic medial osteoarthritis (Kellgren-Lawrence grade 1 and 2) and varus malalignment of more than 1,5 degrees *(12)*. Exclusion criteria for the study were active knee flexion below 120°, extension deficit exceeding 10°, instability at the time of surgery, concomitant meniscal repair/ meniscal transplantation, concomitant meniscectomy, concomitant ligament repair, concomitant cartilage therapy, inflammatory arthropathy, osteochondritis dissecans and previous tibial plateau fracture.

The primary endpoint of the study was to assess the employment status and participation in sport activities at time of surgery and at final follow-up.

To evaluate the level of sport activity, workload and clinical outcome, different questionnaires were obtained preoperatively and postoperatively at final follow-up. The University of California, Los Angeles scale (UCLA) *(13)* was used to assess the level of physical activity. On a scale of 0-10, the current level of activity is graded, from completely inactive to active at a regularly basis in impact sports. The German classification system according to the Reichsausschuß für Arbeitszeitermittlung (REFA) was used to classify the workload preoperatively and at final follow-up *(14)*. On a scale of 0 to 4, the work intensity is graded, 0 being work without special physical strain and 4 being work with most heavily physical strain. The Tegner score *(15)* interrogates on the following subjects : recreation, competitive sports and work. It is an activity grading scale where work and sport activities are graded numerically from 0 to 10.

The Knee injury and Osteoarthritis Outcome Score (KOOS) *(16)* was used for the clinical assessment preoperatively and at the time of follow-up. The questionnaire has five separately scored items : pain, function in daily living (ADL), function in sport and recreation, other symptoms, and knee-related quality of life (QOL). It consists of 42 questions and each question is assigned a score (0-4). For each subscale a normalized score is calculated (100 indicates no symptoms and 0 indicates extreme symptoms). Subanalysis was done on participants that were involved in work/sports before surgery (REFA and Tegner Adjusted).

Range of motion and tender pain were recorded preoperatively (based on the patients chart) and at the time of follow-up. Stability was assessed postoperatively. Assessing range of motion was performed using a universal goniometer *(17)*. Knee stability was assessed by ligament examination, according the International Knee Document Committee Knee Form. Grades A, B, C or D were applied for the different tests *(18)*.

Pre-and postoperative radiographs included full-weight-bearing long-standing anteroposterior radiographs of the whole lower extremity. The

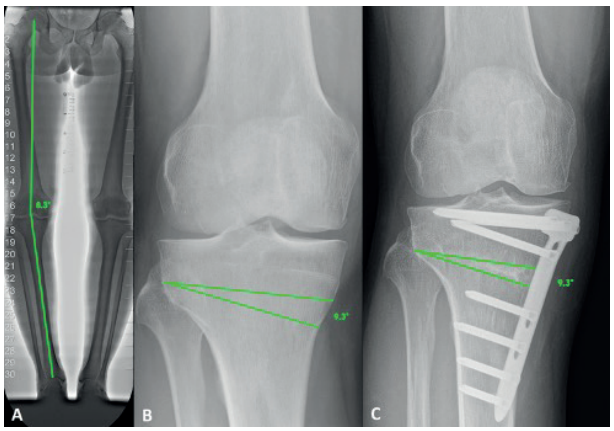

Figure 1. — Data from one of the study participants. 1A : Measurement of the HKA-angle on a full-weight-bearing long-standing AP radiograph of the entire lower extremities. 1B : The correction wedge is drawn on an AP view of the knee with appropriate correct.

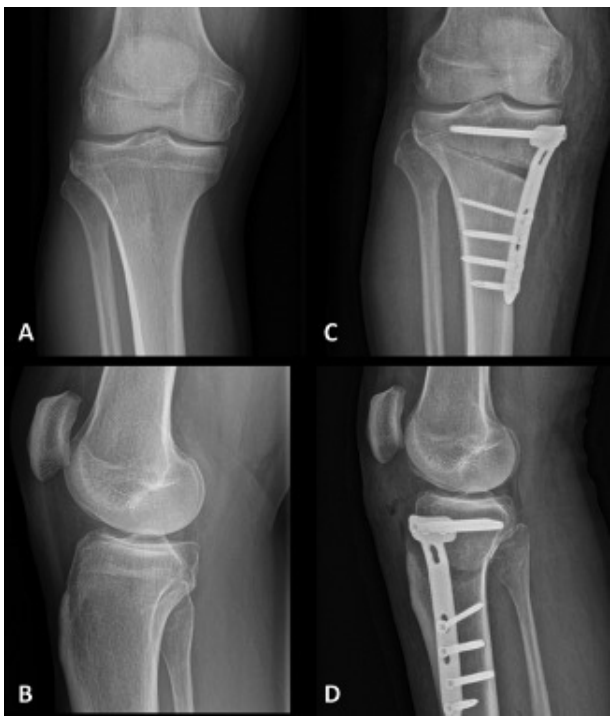

Figure 2. — Data from one of the study participants. 2A : Preoperative AP radiograph. 2B : Preoperative lateral radiograph. 2C : Postoperative AP radiograph. 2D : Postoperative lateral radiograph.

participants were positioned with the tibial tuberosity facing the x-ray beam and with the knee in 0° of flexion.

The pre-and postoperative hip knee ankle angle (HKA) were documented by one experienced senior surgeon. The point on the tibia plateau where the weight bearing line (WBL) crosses the tibia plateau was documented. The point on the tibia plateau where the WBL crosses the tibia plateau was expressed as percentage of the width of the tibia plateau (%WBL), with 0% the medial border and 100% the lateral border. The HKA and the point on the tibia plateau where the WBL crosses the tibia plateau was used to assess the alignment pre-and postoperatively.

The goal of postoperative alignment was to achieve a postoperative HKA angle of 0°-2° of valgus. To achieve this goal we aimed for a postoperative alignment of 1° of valgus mechanical axis. First, the HKA is measured on a full leg weight-bearing radiograph. This angle plus 1° of overcorrection represents the correction angle of the wedge. Secondly, the correction wedge, with appropriate correction angle, is drawn on a standard AP view of the knee at the desired location (fig. 1).

Patients were treated with open wedge osteotomy mainly according to the surgical technique by Lobenhoffer *(19)*, in which the Tomofix Medial High Tibial Plate system (Tomofix MHT, De Puy Synthes) is applied to stabilize the osteotomy without the use of bone grafts to fill the osteotomy gap *(19)*. Figure 2 shows representative preoperative and postoperative radiographs.

Statistical analysis

IBM SPSS statistics software version 23 (SPSS Inc, Chicago, IL) for windows was used for statistical analysis. The results of the KOOS, Tegner and UCLA scores were compared (preoperatively and postoperatively) with the paired Student's t test, normal distribution and equality of variances was present. Normality of distribution was estimated by Shapiro-Wilk test. Equality of variances was tested by Levene's test. The results of the REFA score, the radiographic findings and the ROM were compared (preoperatively and postoperatively) with the nonparametric Wilcoxon rank test, because of a non-normal distribution. The level of significance was set to $p < 0.05$.

RESULTS

30 open wedge HTOs were performed in 30 consecutive patients. 27 patients were included (fig. 3). One patient was excluded because of instability due to rupture of the ACL and another because of severe tibial plateau fracture in the past history. One patient was lost to follow-up. No patients were converted to a total knee arthroplasty and no patients had revision surgery.

The patient's characteristics are presented in table I. Patients were invited for one follow-up visit with a minimum interval of 2 years after the surgery. Mean follow-up was 32.2 [24.7;39.7] months. Only 1 patient showed obesity. All patients suffered from medial osteoarthrosis with mean malalignment of 6.1° [3.6;8.6] of varus mechanical axis.

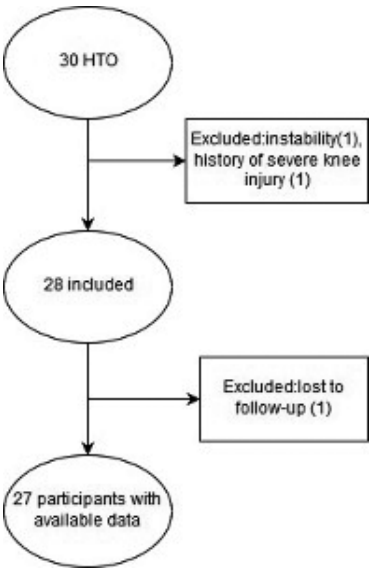

Figure 3. — Flowchart of the study series.

Sport and activity scores

Before surgery 26 (96.3%) patients were employed, compared to 25 (92.6%) at final follow-up. One patient did not return to work, due to knee impairment. Before surgery 17 (63.0%) patients participated in sport activities on a regular basis, compared to 20 (74.1%) patients at final follow-up. Of all patients who participated in sport activities before surgery, only two patients did not return to sport. 10 patients did not participate in sport activities before surgery, 5 of them reinitiated sport activities after surgery. After surgery the

Table I. — Demographic Data of the series

	Data
Number of participants (N)	27
Gender (Male/Female)	M:23; F:4
Side (Left/Right)	L:17; R:10
Age at evaluation in years, mean[95%CI]	41.2 [31.6;50.8]
Follow-up period in months, mean[95%CI]	32.2 [24.7;39.7]
BMI in kg/m², mean[95%CI]	25.4 [22.6;28.2]

Table II. — Overview of the reported outcomes

	pre-operative [95%CI]	post-operative[95%CI]	p-value
UCLA	4.7 [2.7;6.7]	7.2 [5.3;9.1]	<0.001
REFA	1.8 [0.9;2.7]	1.8 [0.9;2.7]	0.317
REFA adjusted	2.2 [1.4;3.0]	2.2 [1.4;3.0]	0.317
Tegner	3.0 [1.5;4.5]	3.9 [1.9;5.9]	<0.001
Tegner adjusted	4.2 [3.2;5.2]	5.3 [3.6;7.0]	0.014
ROM	0.5° [-0.8;1.8]– 126.8° [118.3;135.3]	0.40° [-1.0;1.8] – 134.8° [131.4;138.2]	0.010
Koos Sport and Rec	39.7 [26.5;52.9]	66.0 [38.2;93.8]	<0.001
Koos QoL	40.1 [22.7;57.5]	66.1 [45.6;86.6]	<0.001
%WBL	22.1 [13.2;31.0]	53.4 [43.4;63.4]	<0.001
HKA	6.1° [3.6;8.6]	- 0.9° [-3.0;1.2]	<0.001

UCLA and Tegner scores increased significantly compared to pre-operative measures ($p<0.001$). The postoperative REFA score did not increase significantly ($p=0.317$). Results of all outcome measures are summarized in Table II. After surgery the preoperative subscales Sport/rec and QoL scores increased significantly ($p\leq0.001$).

Clinical outcomes

A significant change in flexion postoperatively 134,8° [131.4;138.2] compared to preoperatively 126,8° [118.3;135.3] was observed (p=0,025). Preoperative joint effusion was present in 12 (44.4%) patients. At final follow-up 4 (15.0 %) patients showed joint effusion, in all these cases the effusion was slight. 21 (77.8%) patients showed tender pain preoperatively compared to only 5 (18.5%) at final follow-up. All patients showed a stable knee joint at final follow-up.

Radiographic outcomes

Preoperatively the mean HKA-angle was 6.1° [3.6;8.6] of varus mechanical axis, postoperatively the mean HKA-angle was 0.9° [-1.2;3.0] of valgus mechanical axis. This change was significant ($p\leq0.001$). Preoperatively the mean WBL crossed at the tibia plateau at 22,1% [13.2;31.0] of the width of the tibia plateau, at final follow-up the mean WBL crossed at the tibia plateau at 53,4% [43.4;63.4] of the width of the tibia plateau. This increase was significant with $p\leq0.001$.

Complications and plate removal

4 out of 27 (14.8%) participants presented a complication ; there were two cases of cellulitis that were treated with oral antibiotics, one case of wound dehiscence that resolved with aseptic wound care and one case of postoperative hematoma. In 13 (48.1%) patients hardware was removed because of hardware irritation,. 2 patients had an additional intervention : a resection of the proximal tibiofibular joint and an arthroscopic debridement of the medial compartment because of locking due to unstable osteochondral fragment.

DISCUSSION

This study shows that the majority of patients with medial osteoarthritis and varus malalignment return to work and sport activities following open wedge HTO. The mean level of sport activity was higher and the mean level of workload was equal after surgery compared to before surgery.

These results are in line with previous reports. Saragaglia et al.[20]reported a return to sport of 85,5% in a consecutive series of 83 open wedge osteotomies and Salzmann et al. *(21)* published a similar series of 65 open wedge osteotomies and reported that at the time of survey 90.9% of the patients were active in sport, compared to 87.9% before surgery. Both studies however had less restrictive inclusion criteria and showed less uniformity in the evaluation strategies, possibly explaining the somewhat lower outcomes.

In a prospective follow-up study of 64 patients with follow-up of 24 months Saier et al. *(22)* reported a return to work rate of 90% following open wedge HTO without any limitations. Only the medial open wedge technique was used. This return to work rate is very comparable to the return to work rate we reported, being 96.2%. In a recent single-center, retrospective study of 30 patients who underwent medial open wedge HTO for medial osteoarthritis Bastard et al. showed a return to sports rate of 100%, 73,3% of the patients at the same level, 23,3% at a higher level and 3,4% at a lower level *(23)*. In our study 88.2% of patients who participated in sport activities before surgery continued to do so. In the study published by Bastard et al. the postoperative Tegner score did not increase compared to the pre-operative values, in contrast to our study results showing a significant increase in the mean level of sport activities. Important to mention is the short follow-up period of only 1,3 years in the study of Bastard et al, the mean follow up in our study was 2,7 years with a minimum follow up period of 2 years.

The survival rate in terms of TKP or UKP was 100% with a minimum follow-up of 2 years. Further follow-up is necessary to see if these results are sustainable as other studies have shown an expected decrease in survival rate over time related

to progressive osteoarthritis disease and aging *(24)*. It has been shown that a higher BMI is related to a lower survival rate, one patient in our study showed obesity which might affect survival rate in the future *(25)*.

Besides the clinical outcome, we took advantage of this study to address the disparate data related to the postoperative alignment goals. The degree of correction is variable and controversial and there is no clear consensus about the desired postoperative alignment in patients with medial osteoarthritis of the knee (Kellgren-Lawrence grade 1 and 2) and varus malalignment. Different targets have been set for postoperative alignment. Most authors seem to believe in overcorrection of 2° to 8° of valgus mechanical axis. Although these publications date from the eighties-nineties, they are still com-monly referred to and applied in more recent reports *(4-8)*. Only more recently, some authors aim for a postoperative mechanical axis completely or partially below 2 degrees of valgus mechanical axis *(9-11,26)*. Although the shift in literature suggests that there is a return from overcorrection when comparing older and more recent studies, there is little evidence supporting the clinical benefits of a slight postoperative mechanical valgus compared to more conservative correction aims. Feucht et al. *(9)*, McNamara et al. *(10)* and La Prade et al. *(11)* all reported good clinical outcome but only La Prade et al. quantified the outcome with a modified Cincinnati Knee Scores which improved significantly from 42.9 preoperatively to 65.1 at a mean of 3.6 years of follow-up.

The target in the present study was 0°-2° of valgus. To achieve this we aimed for a post-operative HKA of 1° of valgus. We aimed for a slight less postoperative valgus mechanical axis in order to mechanically realign the leg and unload the medial compartment without the risk of overloading the lateral compartment, gradual medial collateral ligament failure, progressive valgus deformity or creating a cosmetically un-appealing valgus. Dugdale et al. shared some of these concerns of overcorrection[7] and in a study of Hernigou et al. *(5)* all knees with a postoperative HKA of more than 6° of valgus mechanical axis showed progressive degenerative changes in the lateral compartment. Overall, literature addressing the subject of overcorrection is sparse and outdated. Biomechanical studies support that the medial compartment is unloaded even in neutral or slight valgus mechanical alignment. Agneskircher et al. and Riegger Kruch et al. conclude in two in vitro biomechanical studies that even neutral mechanical alignment leads to decreased loading of the medial compartment and suggest that markedly overcorrection might not be necessary *(27,28)*. Mina et al. found in a laboratory study that contact pressure is approximately equally distributed between the medial and lateral compartments for alignments of 0°-4° of anatomical valgus *(29)*. Furthermore, we believe as described by Saragaglia et al. that a varus knee or a knee with a neutral axis is the best for participating in running sports *(20)*. When the knee is too much overcorrected, the athlete may struggle to regain their proprioception and ground support which will impair return to sport to the previous level, even though a residual varus might imply a higher risk of residual pain when participating in running sport.

In our study only patients with medial osteoarthritis (Kellgren-Lawrence grades 1 and 2) were selected, and we found excellent clinical and radiographical results with a postoperative alignment goal of 0-2° of valgus mechanical axis after a minimum of 2 years follow-up. Unfortunately, we can only suggest but not correlate the excellent clinical outcomes with the correction angle, as the study design does not allow us to draw such conclusions.

As discussed above there are several limitations to our study. We present data from a small case series of 27 patients. The study is observational and retrospective which due to its design is vulnerable to selection bias. As the study lacks a comparator group it is difficult to validate this data and show a cause-effect. Furthermore, the follow-up period is too short to inform on long-term outcome.

CONCLUSION

This study confirms that the majority of patients with medial osteoarthritis of the knee (Kellgren-Lawrence grades 1-2) and varus malalignment return to sport and work after open wedge HTO and

that the mean level of sport activity is higher after surgery than before. Furthermore, we observed these excellent clinical results with a mean postoperative valgus mechanical axis of 0,9°. We acknowledge that longer follow-up is needed to make any long-term conclusion concerning outcome and that our study design does not allow conclusions on posoperative alignment. Larger cohorts with pre-defined alignment goals and blinded controls are needed to further enlight on these findings.

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