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Sporting Activity After High Tibial Osteotomy for the Treatment of Medial Compartment Knee Osteoarthritis

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Background: Isolated varus osteoarthritis of the knee is a common problem in patients engaged in sports and recreational activities.

Hypothesis: Patients will be able to resume sporting activity after high tibial osteotomy.

Study Design: Case series; Level of evidence, 4.

Methods: A total of 65 patients were surveyed by postal questionnaires to determine their sporting and recreational activities at an average of 36 ± 8.1 months (range, 14-84) after high tibial osteotomy for the treatment of medial compartment knee osteoarthritis. The clinical evaluation included the Lysholm score, the Tegner activity scale, the Activity Rating Scale, and a visual analog scale for pain.

Results: At the time of survey, 90.9% of patients were engaged in sports and recreational activities, compared with 87.9% before surgery ($P = .182$). The number of different sporting activities declined from 3.5 preoperatively to 3.0 after surgery ($P = .178$). The sports frequency per week (2.1 sessions) and the activity duration per week (4.1 hours) did not significantly change from preoperative to postoperative (2.3, $P = .211$; and 4.2 hours, $P = .709$, respectively). The Lysholm score (42.4) and the visual analog scale (6.9) illustrated significant improvements (69.6, $P = .001$; and 2.9, $P < .001$, respectively). No patient returned to competitive sports after surgery, and declines were noted in the Tegner (4.9 ± 2.3 to 4.3 ± 1.5, $P < .05$) and Activity Rating Scale (5.7 ± 5.2 to 3.3 ± 4.6, $P = .001$) scores. After surgery, many patients continued to engage in high-level activities such as downhill skiing or mountain biking.

Conclusion: High tibial osteotomy for the treatment of medial compartment knee osteoarthritis in the active patient demonstrated favorable clinical results and allowed patients to return to sports and recreational activities similar to the preoperative level.

Keywords: high tibial osteotomy; knee osteoarthritis; sports activity; recreational activity

Tibial osteotomy is the treatment of choice for early medial compartment osteoarthritis (OA) of the knee in young and active patients for whom unicompartmental knee arthroplasty (UKA) may not provide sufficient longevity due to polyethylene wear, progression of arthritis, or component loosening.[2,20] The clinical outcome after proximal tibial osteotomy is satisfying, even though long-term results have been shown to deteriorate over time.[9,19,34,35] The high tibial medial open-wedge valgus osteotomy for correction of distal malalignment in the varus knee using a medial plate-fixator represents a popular surgical technique. It avoids detachment of the tibialis anterior muscle, the risk of peroneal nerve damage, leg shortening, and loss of correction when compared with the lateral closing-wedge osteotomy.[21] When successful, high tibial osteotomy (HTO) can improve clinical symptoms, prevent disease progression, and postpone total joint replacement of the knee.[1,3] The indications for surgery have been broadened to treat younger and more active patients with milder osteoarthrosis, allowing for decreased pain with sporting and recreational activities.[29] There is a plethora of literature that describes the return to sports and recreational activities after other surgical procedures, including knee arthroscopy,

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cartilaginous procedures, anterior cruciate ligament replacement, and joint arthroplasty.[4-6,15,18,23,27,30,31] But to our knowledge, there is only 1 study, involving 27 patients, that reported clinical results after HTO that included return to sports and heavy work.[32] Even though HTO is recommended for the active patient, there is little detailed information available describing sports and recreational activities after HTO. The present study was conducted to examine the preoperative and postoperative sporting and recreational activities and the clinical outcome of patients after HTO for the treatment of early medial compartment OA.

MATERIALS AND METHODS

Study Design and Outcome Measures

Between January 2003 and January 2006, a total of 80 patients were treated at our department with a high tibial medial open-wedge valgus osteotomy for unicompartmental varus OA of the knee. We contacted all patients an average of 36 ± 8.1 months after surgery by postal questionnaires that included a previously applied sports and activity questionnaire[30,31] for the assessment of lifetime, preoperative, and postoperative engagement in 20 different sports and recreational activities. The questionnaire has been slightly modified by inclusion of the assessment of lifetime sports engagement. The questionnaire also inquired about the patient's overall satisfaction with surgery (very satisfied = 1, satisfied = 2, partially satisfied = 3, not satisfied = 4) and about the use of any pain medication during sports activity (regularly, occasionally, never). The modified Lysholm score[24] and a visual analog scale (VAS) for pain (0 representing "no pain" and 10 representing "maximal imaginable pain") were used to assess clinical outcomes. The Tegner activity scale[38] and the Activity Rating Scale (ARS)[25] were used to determine activity levels. The preoperative American Society of Anesthesiologists (ASA) score[10] was recorded and the Kellgren and Lawrence score[17] with the degree of varus malalignment was assessed at the index knee on preoperative weightbearing and AP hip-knee-ankle radiographs.

Patient Selection

Patients younger than 65 years of age suffering from painful medial unicompartmental varus OA with a tibial deformity were considered for surgery (Figure 1A).[29] The cohort of patients at our department with localized medial OA is predominantly young and active, for which we consider UKA not to be the first choice of treatment. Contraindications included obesity (body mass index [BMI] >35), absence or extensive loss of the lateral meniscus, OA or grade 3 to 4 chondral lesions of the lateral compartment according to the Outerbridge classification,[33] extensive OA (Kellgren and Lawrence[17] grade 3 or 4) of the patellofemoral joint, active knee flexion below 120° or an extension deficiency exceeding 20°, high-grade ligamentous instabilities, active local or systemic infections, and inflammatory arthropathy.

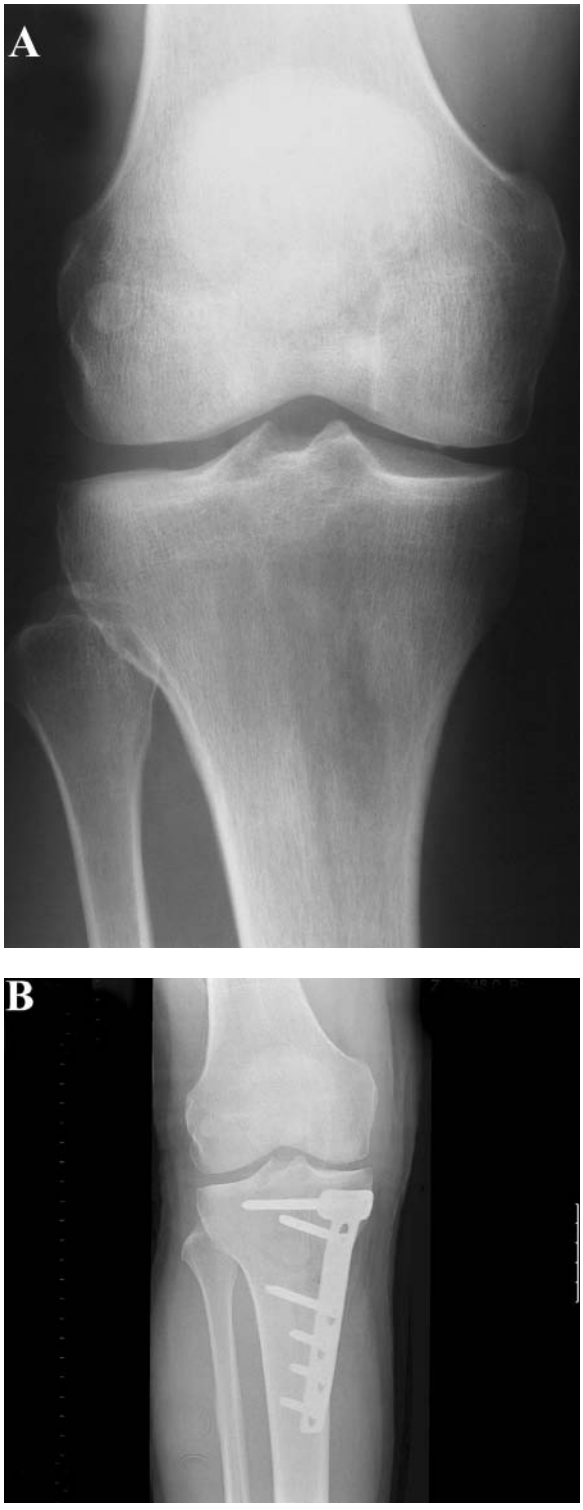

Figure 1. A, preoperative AP radiograph of the right knee in a 31-year-old male patient suffering from mild medial 6° varus gonarthrosis. B, postoperative radiograph shows a medial internal plate used to fix the 7° valgus correction high tibial osteotomy with a 10-mm autologous osteochondral graft at the medial femoral condyle.

Operative Technique

Before the HTO, each knee was arthroscopically evaluated to verify preoperative clinical and radiologic findings, with particular attention paid to the status of the lateral joint compartment. In patients with extensive lateral damage, HTO surgery was abandoned. The procedure was carried out with a medial intraligamentous opening wedge valgus HTO in a biplanar fashion according to the technique published by the AO knee expert group.[21,22] The loading axis was set to the 62% valgus position[12] and the anterior half of the distal fibers of the medial collateral ligament were partially released to decrease the contact pressure within the medial compartment.[1] A standard internal fixator (TomoFix, Synthes, Solothurn, Switzerland) was applied to stabilize the osteotomy, which was not filled with any graft material (Figure 1B). Partial weightbearing (15 kg) was allowed from the first postoperative day until 4 weeks after surgery. Weightbearing was gradually increased from week 4 to week 6 after surgery and full weightbearing was initiated at 6 to 8 weeks after surgery, following radiographic evaluation 6 weeks postoperatively. All patients were routinely followed up at 6 weeks, 3 months, and 12 months postoperatively for clinical and radiographic assessment. Hardware removal was routinely performed about 12 months postoperatively after the osteotomy had healed.

Statistics

Statistical analysis was performed using the software package SPSS (Version 15, SPSS Inc, Chicago, Illinois). All data were tested for normal distribution using the Shapiro-Wilk W test. Afterward, data were compared using *t* tests, or Mann-Whitney *U* and Wilcoxon signed rank tests. Group data were compared using 1-way analysis of variance. Correlations were performed using Spearman's correlation coefficient (*r*). Unless otherwise stated, descriptive results were demonstrated as the mean ± standard deviation. The significance level was defined at $P < .05$ for all tests.

RESULTS

Demographics

A total of 65 questionnaires were available for evaluation (81.3%). The average postoperative follow-up was 36 ± 8.1 months (range, 14-84). The mean age at the time of surgery was 41.2 ± 5.6 years (range, 19-65). The study cohort comprised 51 men (78.5%) and 14 women (21.5%). The mean BMI was 27.1 ± 3.7 kg/m^2 (range, 20-34). The preoperative ASA score averaged 1.4 ± 0.6 (range, 1-3). The mean Kellgren and Lawrence score was 2.3 ± 0.7 (range, 0-4), and the average varus malalignment of the leg axis was 4.8° ± 2.0° (range, 1°-9°) on preoperative plain radiographs. The average surgical correction angle was 6.9° ± 2.3° (range, 3°-12°). Exclusively unilateral osteotomies were performed. Concomitant procedures were performed in 9 cases: 6 partial medial meniscectomies, two 10-mm autologous osteochondral plug transplantations at the medial femoral condyle, and 1 notchplasty.

Sports and Recreational Activities

During their lifetimes, 95.5% of the patients were engaged in an average of 6.8 ± 4.1 (range, 0-17) different sport and recreational disciplines. A total of 15.2% of patients were engaged in competitive sports during their lifetimes. Throughout the year before surgery, 87.9% of the patients were engaged in an average of 3.5 ± 3.1 (range, 0-17) different disciplines, illustrating a significant decline ($P < .01$) when compared with the number of lifetime sporting activities. The frequency of sporting activity (sessions per week) during the year before surgery was 2.1 ± 1.8 (range, 0-7), with a mean duration of 4.1 ± 3.9 (range, 0-20) hours per week. At the time of survey, 90.9% of the patients were active in sports ($P = .182$). The number of reported sports activities declined to an average of 3.0 ± 2.1 (range, 0-9), without reaching statistical significance ($P = .178$). The sports frequency and the duration of activities did not significantly change after surgery: 2.3 ± 1.8 (range, 0-7; $P = .211$) and 4.2 ± 3.5 (range, 0-20; $P = .709$) hours, respectively. A total of 4.6% of the patients stated that they had performed competitive sports during the year before surgery, while no patient was involved in competitive sports after HTO. Distribution patterns among the top 10 cited sports activities did not change for the lifetime, preoperative, and postoperative periods, with the exception of soccer, jogging, and nordic walking (Table 1). Although 47% of patients played soccer during their lifetime, 9.2% ($P < .001$) did so during the year before surgery and only 4.6% ($P < .001$) did so after surgery. The proportion of patients actively jogging decreased from 45.5% during lifetime to 13.6% ($P < .001$) preoperatively and 7.6% ($P < .001$) after HTO. There was no difference between the preoperative and postoperative participation for soccer, jogging, and nordic walking. Activity levels according to the Tegner scale dropped significantly from 4.9 ± 2.3 (range, 1-10) preoperatively to 4.3 ± 1.5 (range, 2-9) ($P = .027$) after surgery. Scores of the ARS decreased significantly, from 5.7 ± 5.2 (range, 0-16) before HTO to 3.3 ± 4.6 (range, 0-16) postoperatively ($P = .001$).

Clinical Outcome

The overall satisfaction with surgery averaged 1.9 ± 0.8 points (range, 1-4); 35% of patients were very satisfied, 42% were satisfied, 18% were partially satisfied, and 5% were not satisfied with the procedure. Overall, 75% of patients required no pain medication to perform sports or recreational activities, 22% of the patients required occasional pain medication, and 3% of the patients required regular pain medication. The VAS for pain decreased significantly, from 6.9 ± 2.4 (range, 0-10) preoperatively to 2.9 ± 2.2 (range, 0-8) postoperatively ($P < .001$). The Lysholm score improved significantly, from 42.4 ± 20.6 (range, 7-90) preoperatively to 69.6 ± 17.4 (range, 22-95) after surgery ($P < .001$). The BMI, ASA, Kellgren-Lawrence score, satisfaction, pain medication, varus malalignment, or correction angle were not significantly correlated with activity levels, sports participation, or clinical outcome. There was no significant difference in the measured outcome between genders or in patients who underwent concomitant procedures.

TABLE 1
Top 10 Activities by Percentage in Which Patients (N = 65) Participated During Lifetime, Before, and After High Tibial Osteotomy[a]

Activity	Lifetime	Preoperative	Postoperative
Cycling	72.7	66.7	71.2
Downhill skiing	54.5	27.3	27.7
Swimming	50	65.2	45.5
Hiking	43.9	25.8	30.3
Fitness	40.9	19.7	25.8
Mountain biking	29.8	19.7	21.2
Cross-country skiing	28.8	10.6	7.6
Tennis singles	24.2	4.5	3.0
Volleyball	22.7	4.5	4.5
Inline skating	22.7	12.1	9.1

[a]Soccer was among the top 10 only during lifetime (47%). Jogging was among the top 10 during lifetime (45.5%) and before surgery (13.6%), but dropped out of the top 10 after surgery. Nordic walking was not among the top 10 before surgery, but 10.6% of patients were involved in that activity postoperatively.

There were two patients with delayed healing of the osteotomy with consequent delayed plate removal. There were no significant differences in the measured outcome when compared with the remaining patient cohort or the matched age group. No postoperative loss of correction occurred among all patients.

Age-Specific Results

The number of disciplines, the VAS, the Tegner scale, and the ARS declined in all groups (Table 2). Frequency and duration of sports and the Lysholm score increased among all groups except for the decreased duration noted in patients aged 31 to 40 years and the increased Tegner scale and ARS in patients aged 51 to 60 years. Preoperative and postoperative changes between different age classes were not significantly different. Higher age at the time of the operation was significantly correlated to a greater increase between the preoperative and postoperative Lysholm score ($r = .277$; $P = .025$).

DISCUSSION

High tibial osteotomy to correct malalignment in the early osteoarthritic knee has proved to be a successful operative procedure, illustrated by improvements in knee function and decreased pain levels. Our clinical results after HTO are comparable with those previously reported.[9,19,34,35,37] The significant increase in Lysholm scores and the decrease in VAS levels reflect the ability of HTO to relieve clinical symptoms of medial compartment OA. Our study also presents a unique focus on HTO in a very active population. Overall, the high proportion of patients engaged in sporting activities increased slightly as more than 90% of the patients were engaged in sports after surgery. Our patients continued to participate in sporting activities with the same weekly frequency and hourly duration after surgery, indicating the ability to maintain an active sporting lifestyle after HTO. Interestingly, there were no major differences in the number of patients participating in the top 10 most popular sports. In particular, the percentage of patients who participated in demanding sports such as downhill skiing or mountain biking did not change significantly from preoperative to postoperative.

Previous investigations on other types of surgical procedures (anterior cruciate ligament reconstruction, cartilage restoration, joint arthroplasty) reported that preoperative levels of sports participation and patient age generally affected postoperative activity levels.[‖] High-level athletes could usually resume sports activity at the same level, whereas the activity level of recreational athletes has been noted to decline after surgical procedures.[5,18,26-28] For the most elite, active patients, surgery seemed to lead to limitations postoperatively. When separating out those patients who preoperatively described themselves as competitive athletes (4.5%), none of them returned to competitive sports. Competitive athletes may consider the valgus-producing osteotomy as an end point to their active career that resulted in the herein-reported lack of competitors after the operation.

Thus, our results with HTO are similar to those reported for other surgical procedures in this regard. More detailed activity-specific surveys indicated that there were significant changes on these scoring scales as represented by major differences noted on the pre- and postoperative Tegner and ARS scores. Reasons for the observed activity decrease may be that patients are indeed advised to be physically active in general,[14] while excessive participation in impact sports like soccer or tennis is not recommended. Furthermore, sport is believed to increase the risk of developing OA, depending on the amount, type, and intensity of sports activity.[7] This may be particularly true for patients already suffering from symptomatic knee OA who are still active in sports. Even though function and pain levels improved, patients may be concerned about the intensity of

[‖]References 4-6, 8, 11, 13-16, 18, 23, 27, 28, 30, 31, 36.

TABLE 2
Preoperative/Postoperative Difference in Sports Participation and Clinical Outcome Among Different Age Groups[a]

	Preoperative	Postoperative	Difference
All patients (N = 65)			
Disciplines	3.5	3.0	–0.5
Frequency	2.1	2.3	+0.2
Duration	4.1	4.2	+0.1
VAS	6.9	2.9	–4.0[b]
Lysholm	42.4	69.6	+27.2[b]
Tegner	4.9	4.3	–0.6[b]
ARS	5.7	3.3	–2.4[b]
≤30 years (n = 12)			
Disciplines	3.8	2.7	–1.1
Frequency	2.3	2.8	+0.5
Duration	4.0	4.3	+0.3
VAS	5.8	3.0	–2.8[b]
Lysholm	42.1	63.2	+21.1[b]
Tegner	5.0	4.5	–0.5
ARS	5.3	4.0	–1.3
31-40 years (n = 17)			
Disciplines	3.8	3.6	–0.2
Frequency	2.1	2.4	+0.3
Duration	4.5	4.1	–0.4
VAS	6.2	2.4	–2.8[b]
Lysholm	53.0	76.6	+23.6[b]
Tegner	5.6	4.2	–1.4[b]
ARS	7.4	2.7	–4.7[b]
41-50 years (n = 24)			
Disciplines	3.6	3.1	–0.5
Frequency	1.8	2.1	+0.3
Duration	3.5	3.9	+0.4
VAS	7.7	3.1	–4.6[b]
Lysholm	38.4	64.5	+26.1[b]
Tegner	5.1	4.6	–0.5
ARS	6.2	3.5	–2.7[b]
51-60 years (n = 10)			
Disciplines	2.8	2.6	–0.2
Frequency	2.0	2.7	+0.7
Duration	4.0	5.1	+1.1
VAS	7.4	3.0	–4.4[b]
Lysholm	36.1	75.0	+38.9[b]
Tegner	3.5	3.9	+0.4
ARS	2.8	3.3	+0.5

[a]There were 2 patients above the age of 60 years, who are not presented in the age-group data. VAS, visual analog scale; ARS, Activity Rating Scale.
[b]Significant ($P < .05$).

performing demanding sports and recreational activities or the increased risk of sports-related injuries, which might both lead to an unintentional disease progression or conversion to joint arthroplasty.[36] The percentage decrease of patients who previously were engaged in impact sports like tennis or volleyball supports the idea that patients are willing to prevent further degeneration in relation to impact or trauma.

There is little published literature that specifically tracks return to sporting activites after HTO. In a study by Odenbring et al,[32] 9 of 27 patients (33.3%) below the age of 50 years were able to return to high-activity sports or heavy work after an HTO. Our study results compare favorably. Twenty-three of 65 patients (35.4%) had postoperative Tegner scores ≥5, which would correspond to high activity levels of sports or heavy work. For some patients, UKA is considered as an alternative to HTO. At least 1 study by Naal et al[30] described a good clinical outcome with a high return-to-sports rate for patients (average age, 65 years) after UKA. They nevertheless observed a decline in the amount of activities and a shift away from high-impact activities after surgery. On the contrary, our results did not show a decline in either frequency or duration of sporting activities after HTO. In reviewing the most popular activities, we did not observe a major shift to participation in lower-impact activities. Direct comparison of the results for

UKA and HTO remains difficult because our patient population was significantly younger (average age, 41 years).

Within our collective of patients, age was not significantly linked to the return to postoperative sporting activities. Other studies have noted that older patients tended to have a greater increase in activity levels after a surgical procedure compared with younger patients.[31] Our older patient group (>51 years) had clinical and activity results that paralleled the patient population as a whole. In fact, this age group was the second most active patient group considering the weekly frequency and the duration of activities, which may be related to social issues and more time to spend in sports due to retirement. Furthermore, they showed the only postoperative increases in the Tegner and ARS scores. Thus active patients over 50 years of age can specifically realize the benefits of HTO and should not suffer any decrease in sporting activity postoperatively when compared with younger patients.

There were a total of 9 concomitant surgical procedures performed within the same operative setting as the HTO. However, we found no significant differences between patients with isolated HTO and those who underwent concomitant procedures. Additional surgical procedures did not seem to affect outcomes, allowing surgeons to address other articular/cartilage pathologic changes at the time of HTO without fear of affecting results.

The main limitations of the present study are to be found in the retrospective design. Patients were asked for activities and clinical information that, in some cases, dated back several years. Also, 15 of 80 patients in the present study did not respond to our survey, raising the possibility of some selection bias. The short-term nature of the study did not allow drawing conclusions concerning arthroplasty avoidance, the continuation of sporting activities, or the relationship between continued sporting activities and the progression of knee OA. These issues should be investigated in future studies.

In summary, we demonstrated that after HTO, all patients returned to sports and recreational activities. They were engaged in sports at an equal frequency and duration when compared with preoperative levels. There was some activity modification as noted on the activity-specific evaluation instruments, which might be related to concerns of the patients regarding disease progression or sports-related injuries. The clinical outcome as demonstrated by Lysholm scores, pain levels, and patient satisfaction was favorable. High tibial osteotomy can therefore be considered a clinically successful procedure that allows the active patient with beginning OA of the knee to return to regular and sustained sporting activities.

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