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Return to sport following isolated opening wedge high tibial osteotomy

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ABSTRACT

Background: The purposes of the study are as follows: (1) examine the timeline of return to sport (RTS) following isolated high tibial osteotomy (HTO), (2) evaluate the degree of participation and function upon RTS and (3) identify reasons that patients do not return or discontinue participation in sport activity.
Methods: Patients undergoing isolated HTO were reviewed retrospectively at a minimum of two years post-operatively. Patients completed a subjective sports questionnaire, a visual analog scale for pain, Single Assessment Numerical Evaluation, and a satisfaction questionnaire.
Results: Thirty-eight patients (70.4%) were included at an average of 9.0 ± 3.3 years. Thirty-four patients (average age 42.7 ± 7.2 years, 90.0% with a Kellgren–Lawrence grade of III/IV) participated in sports within three years prior to surgery. Eighteen patients (52.9%) returned to the operating room by the time of final follow-up, including 13 patients (38.2%) who underwent salvage arthroplasty by 6.1 ± 3.6 years following HTO. Thirty patients (88.2%) returned to ≥1 sport at an average of 7.5 ± 5.0 months; however only 41.2% were able to return to preinjury level of participation.
Conclusions: In patients with medial osteoarthritis and varus deformity, isolated high tibial osteotomy provides a high rate (88.2%) of return to sport by 7.5 months postoperatively, yet only a fraction of patients returned to their preinjury level. HTO is not a definitive treatment option as nearly 40% of patients underwent knee arthroplasty by 6.1 years post-operatively. Patient expectations regarding return to sport can be appropriately managed with adequate preoperative patient education.
Level of Evidence: IV.

1. Introduction

Knee osteoarthritis (OA) affects more people than any other joint disease and is the leading cause of disability among patients [1–3]. Initial management is often conservative with pharmacologic or non-pharmacologic interventions aimed at reducing

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symptomology and improving functionality [4,5]. Due to the progressive nature of OA, refractory OA may only be resolved with total knee arthroplasty (TKA). Knee arthroplasty was originally designed for elderly patients with lower levels of activity; however, over time, indications have expanded to include younger and more active patients [6,7]. Younger patients expect to perform better in activities of daily living, work, and leisure — often at higher levels of demand [7]. However, patients younger than 55 years old undergoing TKA have nearly a three-fold higher risk of failure, as assessed by revision surgery [8].

In younger, active patients with medial unicompartmental OA and varus deformity, an opening wedge high tibial osteotomy (HTO) provides a treatment modality that functions by shifting the mechanical axis of the lower extremity laterally [9]. By reducing the contact pressure on the medial tibiofemoral joint, a HTO reduces pain, improves function, and slows knee deterioration, thereby potentially minimizing the need for joint arthroplasty [10].

Following HTO, patients have demonstrated improved functional outcome scores, as measured by the International Knee Documentation Committee (IKDC) and Lysholm scores [11,12]. Patients also exhibit high rates of satisfaction and procedural survivorship [13–15]. However, in young and active patients, adequate functional outcomes, satisfaction, and survivorship may not appropriately recapitulate patient outcomes following HTO. Thus, return to sport (RTS) may be the most important outcome in this cohort of patients. Previous investigations have demonstrated that 91–94% of patients return to sport following opening wedge HTO, with 85.2% of patients returning to the previous level of activity [16,17]. While patients demonstrate a high rate of RTS following HTO, information regarding sport-specific rate of return to play, degree of participation and function upon RTS, and reasons for discontinuing sport activity have yet to be elucidated.

The purposes of this investigation are as follows: (1) examine the timeline of RTS following HTO, (2) evaluate the degree of participation and function upon returning to sport and (3) identify reasons that patients do not return or discontinue participation in sport-related activity.

2. Methods

Approval was obtained from the institutional review board prior to the start of this investigation. A retrospective review was performed on a prospectively collected patient database. The registry was queried for patients who underwent opening wedge HTO from 2004 to 2015 by the senior author. Indications for HTO include age less than 65 years old and evidence of isolated medial compartment OA (Kellgren–Lawrence (KL) ≥1). At the time of operative intervention, all patients included in the investigation had at least mild OA. Inclusion criteria for this study were patients who received an isolated opening wedge HTO with a minimum of two years of follow-up. Patients were excluded if they were 18 years or younger at the time of surgery or underwent bilateral HTO within three years of each other. Patients who underwent concomitant osteochondral allograft (OAG), meniscal allograft transplant (MAT), and autologous chondrocyte implantation (ACI) were excluded from this investigation. Patients who underwent prior meniscectomy, microfracture, cartilage procedure (MAT, OAG, or ACI), anterior cruciate ligament (ACL) reconstruction were included in the investigation.

Thirty-eight patients (70.4%) were contacted to complete a follow-up sports questionnaire at a minimum of two years of follow-up. Patients with a functional telephone number or email address were contacted. Those who were not contacted for follow-up had a disconnected phone number or did not respond to attempts to have the questionnaire mailed to their home. This sports questionnaire has been used previously to describe sport-related outcomes following orthopedic procedures [18–25]. Patient-reported activities were stratified into low, medium, and high intensity lower extremity demands (Table 1) [19,20]. In addition to this questionnaire, patients were asked to complete a Single Assessment Numerical Evaluation (SANE), Marx Activity Scale, and Visual Analog Scale (VAS) for pain. Pre-operative diagnosis, demographic information, intra-operative variables, complications, and surgical history were collected from patient records. Additionally, pre-operative X-rays were assessed for the degree of OA by the KL grading system. Operative reports were reviewed for the degree of correction of varus malalignment.

2.1. Surgical technique

A longitudinal incision was made along the anteromedial portion of the proximal tibia and the medial collateral ligament was elevated from the subperiosteal bone. With the aid of fluoroscopy, two osteotomy drill pins were inserted on the medial tibial diaphysis towards the fibular head with the knee flexed to 10° of flexion. The proximal tibia was cut on the anterior, posterior, and medial borders, leaving the lateral cortex intact with the use of an oscillating saw and osteotomes. A HTO wedge plate (Arthrex opening wedge osteotomy system, Arthrex, Inc., Naples, FL) was inserted along the anteroposterior plane. The degree of correction is based on the preoperative long leg alignment films. Each patient had the mechanical axis shifted through the axis of the lateral tibial eminence [26,27]. Two 6.5-mm cancellous screws were inserted proximally and two 4.5-mm cancellous

Table 1
Categorization of sport by intensity.

Demand level	Sport
Low	Golf, swimming, bowling, nature (hunting, shooting) sports, fitness sports, yoga
Medium	Rowing, cycling, cross-country skiing, downhill skiing, softball, baseball
High	Running, basketball, football, tennis, volleyball, soccer

screws were inserted distally. Cancellous bone chips or harvested bone autograft (distal femur, proximal tibia, or iliac crest) was then packed into the osteotomy site.

2.2. Rehabilitation protocol

Patients were limited to heel-touch only and allowed to progress to full weight-bearing after six weeks post-operatively. Patients were advised to use a brace at all times for the first two weeks following surgery. After which, the brace was removed at night until six weeks post-operatively. After six weeks, a brace was discontinued. Patients were allowed range of motion as tolerated, but an emphasis was made on maintaining full extension during the first two weeks by sleeping in a locked brace at 0°.

2.3. Statistical analysis

Statistical analysis was conducted using Microsoft Excel (Microsoft, Seattle, WA) and Rstudio software version 1.0.143 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive analysis of continuous variables included means and standard deviations, whereas frequencies and percentages were used to report discrete variables. A post-hoc power analysis was performed to determine if there was sufficient size to detect a statistical difference with predictive factors of RTS. A binary logistic regression was performed to assess the effect of demographic and surgical variables on patient likelihood of returning to sport as well as undergoing a secondary procedure. All tests for statistical significance were performed using two-tailed hypothesis testing with statistical significance set at $P \leq 0.05$.

3. Results

One hundred twenty-one patients who underwent a HTO were screened from 2004 to 2015. Of which, 54 patients (44.6%) underwent isolated HTO without concomitant procedures. Sixteen patients were lost to follow-up; thus, 38 patients (70.4%) were available for follow-up at an average of 9.0 ± 3.3 years. Thirty-four patients (89.5%) participated in sports within three years of surgery, leaving 34 patients for final analysis. The average age at the time of surgery was 42.7 ± 7.2 years (range: 28–62 years). There was a male predominance in this group of patients (n = 29; 85.3%). The average body mass index (BMI) was 27.1 ± 3.5 kg/m^2. The average degree of correction was 9.8° ± 2.5° of varus malalignment to the tibial eminence. Nineteen patients (55.9%) had their dominant leg operated on, and 30 patients (88.2%) previously underwent at least one operation on the ipsilateral leg prior to their HTO. Previous ipsilateral surgical procedures included medial meniscectomy (n = 20, 58.8%), ACL reconstruction (n = 10, 29.4%), and osteochondral allograft transplant (n = 2, 5.9%). Fourteen patients (41.2%) previously had surgery performed on their contralateral leg. KL grade III or IV OA were present in 31 knees (91.2%). The most commonly patient-reported reasons to pursue a HTO was to achieve pain relief (28 patients, 82.4%), a desire to stay active (24 patients, 70.6%), and to improve motion (14 patients, 41.2%).

At the time of final follow-up, 18 patients (52.9%) returned to the operating room for further treatment after HTO. Four patients (11.8%) underwent hardware removal due to prominent hardware, whereas 13 patients (38.2%) underwent subsequent knee arthroplasty (nine TKA, four unicompartmental knee arthroplasty) by 6.1 ± 3.6 years following their HTO. The average age of patients undergoing subsequent arthroplasty at the time of surgery was 43.2 ± 7.1 years. A single patient (2.5%) underwent a revision HTO due to non-union. There were no cases of infection, deep vein thrombosis, or neurovascular injury in this patient cohort.

3.1. Outcome scores

The average post-operative SANE score was 66.7 ± 22.8, the average VAS pain score was 2.9 ± 2.4, and the average post-operative Marx Activity Scale was 3.1 ± 4.4 (range, 0–16). Twenty-three patients (67.6%) stated that in retrospect, they would have undergone this operation again, while 22 patients (64.7%) reported being at least somewhat satisfied with the outcomes of the procedure. Thirty patients (88.2%) reported at least one problem with their knee post-operatively, which included stiffness (44.1%), frequent swelling (23.5%), instability (14.7%), and catching/locking (8.8%). Notably, 88.2% of patients reported postoperative pain (50.0%: occasional pain, 38.2%: chronic pain).

3.2. Sport-related outcomes

Of the 34 patients who participated in sports within three years prior to surgery, 30 patients (88.2%) resumed playing at least one sport post-operatively at an average time of 7.5 ± 5.0 months (range: two to 24 months). The patient who returned to sport after two months was able to participate in cycling and martial arts; however, he was only able to do so in a reduced capacity. Twenty-four patients (70.6%) stopped playing at least one sport that they had previously participated in prior to their HTO. The average number of sports participated in preoperatively was 4.4 ± 1.9 (range: one to nine), which decreased to 3.0 ± 2.0 (range: one to eight) postoperatively ($P = 0.004$). Prior to surgery, patients participated in an athletic activity 3.8 ± 2.1 days per week, which decreased to 2.8 ± 2.2 days per week following their HTO ($P = 0.07$). Nineteen patients (55.9%) described their level of physical fitness after surgery as the same or better than their level of pre-operative fitness. With respect to level of play, one (2.9%) competed professionally, five

patients (14.7%) competed competitively and 28 patients (82.4%) competed recreationally. Postoperatively, one patient (2.9%) competed professionally, and 33 patients (97.1%) competed at a recreational level.

Twenty patients (58.8%) reported returning to a lower level of sport after surgery, nine patients (26.5%) returned at the same level, and five patients returned at a higher level (14.7%). Twenty patients (58.8%) reported being at least somewhat satisfied with their ability to RTS following their HTO. Of these 20 patients, five had returned to a lower level of sports participation (25.0%). The patient who received a revision HTO has since returned to golf, cycling, and swimming; however, he was unable to participate in football, basketball, softball, or tennis. Furthermore, he was only able to participate at a lower level of intensity than he did pre-operatively, and his level of fitness was lower than his pre-operative fitness level. Despite the patient's ability to RTS, he was dissatisfied with his ability to play sports.

The binomial logistic regression demonstrated that there was no correlation between age at the time of surgery ($P = 0.1$), BMI ($P = 0.4$), gender ($P = 0.6$), surgery on the dominant extremity ($P = 0.1$), KL Grade III or IV ($P = 0.2$), patient satisfaction ($P = 0.7$), degree of correction ($P = 0.2$), and a patient's ability to RTS following HTO.

The direct rate of return to the most commonly reported sports was 94.7% for cycling (18/19), 81.3% for golf (13/16), 80.0% for swimming (8/10), 52.2% for weightlifting (12/23), 36.4% for softball (4/11), 32.5% for crossfit (3/8), 14.3% for running (2/14), 12.5% for basketball (1/8), 0% for tennis (0/7), and 0% for soccer (0/2, Figure 1). In terms of RTS when stratified by the highest pre-operative intensity level, the return rate for medium intensity sports was 85.7% (12/14) and 40.0% (8/20) for high intensity sports. There were no patients who participated solely in low-intensity activities pre-operatively.

For the patients that stopped playing at least one sport, 52.9% (18/34) cited persistent pain, 47.1% (16/34) cited a desire to prevent further damage to the knee, 26.5% (9/34) did not return to at least one sport due to persistent swelling, 11.8% (4/34) cited the surgery itself, and 5.7% (2/34) cited no interest in continuing to play sports.

4. Discussion

In this investigation, we demonstrated that 88.2% of patients resumed playing at least one sport at an average of 7.5 ± 5.0 months following isolated HTO. However, upon returning to sport, the patient's level of fitness and level of activity intensity decreased. This study also reports sport-specific rates of return for patients undergoing isolated HTO for medial compartment OA

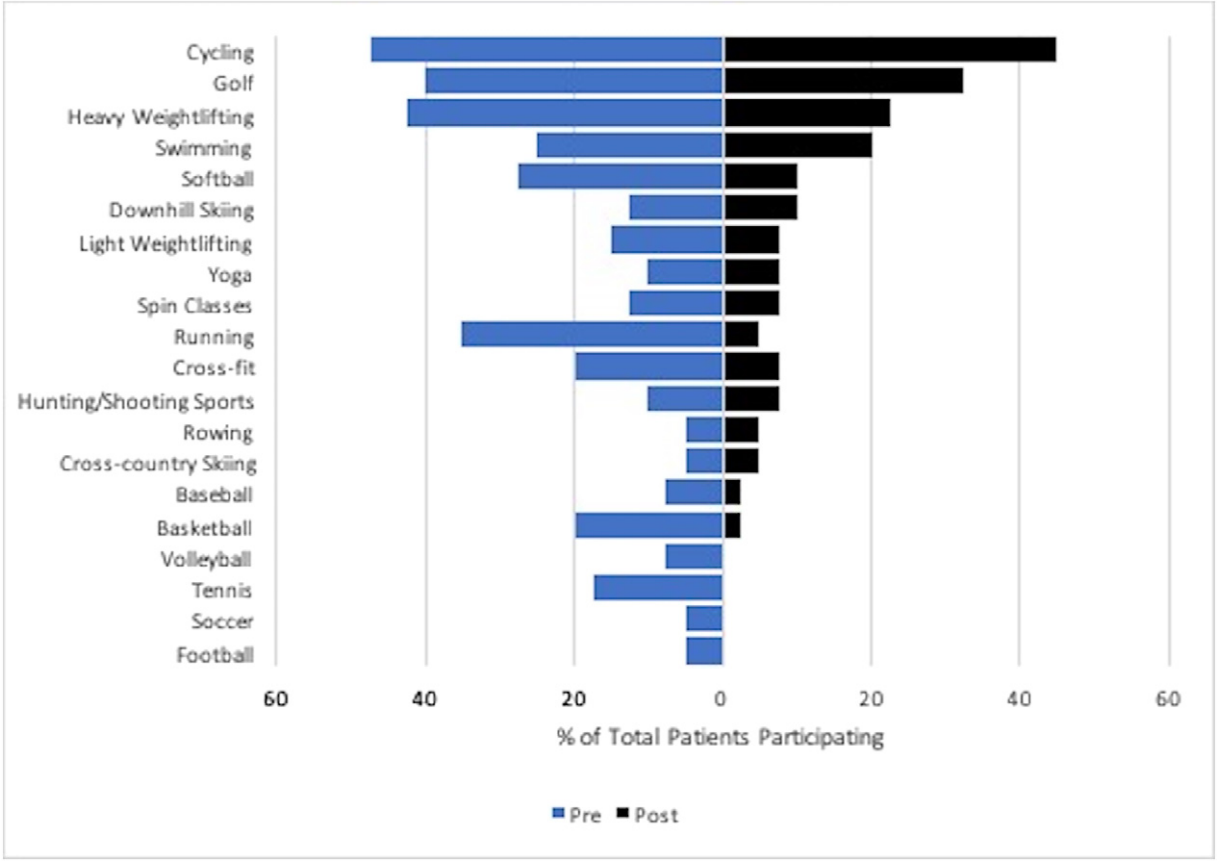

Figure 1. Direct return to sport rates following isolated high tibial osteotomy.

and varus malalignment. The results of this investigation are critical for counseling patients and managing post-operative expectations.

The rate of RTS in this investigation is comparable to what has previously been reported (88% vs. 91–94%) [16,17]. The patient population in these meta-analyses is similar in age and gender distribution to that of our cohort. Despite these similarities in demographics, patients in our cohort predominantly had grade III–IV OA at the time of surgery, while many patients included in previous reviews had lower levels of pre-operative OA. Differences in pre-operative OA may contribute to variations in the rate and duration of RTS as lower levels of pre-operative OA may result in improved outcomes and higher rates of RTS. Furthermore, previous meta-analyses contained patients undergoing HTO due to varying indications, different techniques, additional joint-preserving procedures, as well as closing wedge HTO [16,17]. Therefore, comparing the rate of RTS to previous reviews is inherently flawed as the inclusion of heterogonous patient populations limits the interpretation and clinical applicability of the results.

Reporting overall RTS may be misleading as patients may be able to participate in athletic activity post-operatively; however, they may only be able to do so at a lower capacity. In the present investigation, 41.2% of patients were able to return to an equal or greater level of sport following isolated HTO. Similarly, Niemeyer et al. demonstrated that 67.5% of patients reached their pre-disease activity level by 24 months post-operatively [28]. This finding suggests that although a high proportion of patients are able to RTS, they may be unable to return to their previous level of function. Patients exhibit a statistically significant improvement in patient-reported outcome measures (PROMs) by six months post-operatively [29]; however, only 59.0% of patients in this investigation were at least somewhat satisfied with their ability to return to their previous level of activity. Thus, it is important to note that PROMs have a ceiling effect and that statistically significant differences in PROMs may not be clinically relevant [30,31]. Therefore, evaluating RTS at the same level of activity provides a more precise evaluation of patient outcomes.

Similar to what has been previously reported, high intensity activities such as running, basketball, and tennis, had lower rates of RTS in comparison to lower intensity activities [32–34]. It is imperative that the results of this investigation also be evaluated in the context of other treatment options for isolated medial compartment disease. The overall rate of RTS in patients undergoing HTO is lower than those with medial unicompartmental knee arthroplasty and the direct rate of RTS for medium/high intensity activities, such as swimming, soccer, and tennis was lower than those undergoing medial unicompartmental knee arthroplasty [35]. However, young patients who are motivated may be more likely to resume strenuous activities following HTO [36]. Pre-operative patient education is imperative in managing post-operative expectations, which has been shown to impact subjective clinical outcomes [37,38]. The results of the investigation allow clinicians to counsel patients that although many patients return to sport following isolated HTO, a low proportion of patients return to high intensity activities.

In this investigation, 52.9% of patients returned to the operating room following the index HTO, and 88.2% of patients reported at least one problem with their knee post-operatively. The most common complaints were pain, stiffness, and swelling. These complaints may be due to progression of OA, which was initially managed non-operatively with activity modification, physical therapy, or pain management; however, many of these cases (38.2%) progressed to eventual knee arthroplasty by 6.1 $\pm$ 3.6 years following the index HTO due to medial compartment disease progression, continued symptomology, or an unknown reason. It has previously been shown that the survivorship of HTO ranges from 73%–92% by seven to 10 years following the index procedure [15,39–41]. The patients in this investigation were younger and had higher grade of preoperative OA than those in previous investigations [15,39,42]. Younger patients with higher-grade preoperative OA may be at higher risk of early conversion to knee arthroplasty due to higher expectations or motivation. This may result in participation in more strenuous activities that can lead to further disease progression. The proportion of patients younger than 55 years of age receiving a TKA has significantly increased [43]. Since the outcomes for TKA are dependent on the degree of OA, knee arthroplasty may be discussed earlier in patients who have continued symptomatology or disease progression following HTO [44,45]. Therefore, isolated HTO may only be a temporizing solution to medial compartment disease.

The analysis of this investigation must be interpreted within the context of the study's limitations. This investigation is subject to nonresponse bias as 29.6% of patients were lost to follow-up. The retrospective survey implemented in this investigation may also result in significant recall bias that can influence the results of RTS or patient satisfaction. However, the design of this investigation is similar to previous studies that examined RTS and patient satisfaction following orthopedic procedures [18,19,21,24]. The patient population that was lost to follow-up may represent a fundamentally different patient population. Patients who were more active and mobile may have been able to move elsewhere. Those with less successful outcomes may have been unable to move and may have been disproportionately available for this investigation. However, there was no difference in the degree of KL grade III or IV OA in patients who were contacted for follow-up and those who were lost to follow-up (91.2% vs. 87.5%; $P = 0.7$). Although RTS information was unable to be discerned from patients who were lost to follow-up, no patients in this cohort underwent revision HTO. However, one patient (6.3%) underwent open reduction internal fixation due to non-union, one patient (6.3%) had a lateral hinge fracture, and a single patient (6.3%) underwent conversion to TKA by 1.6 years post-operatively. Comparisons of complications were not made to the study cohort since the duration to follow-up was significantly shorter in those who were lost to follow-up. The authors also acknowledge that the included patient population may be heterogeneous as evidenced by the wide age range. There was also a male pre-dominance in this group, which may not be applicable to patient populations that are female pre-dominant. However, we attempted to minimize heterogeneity by performing multivariate statistical analyses that can account for confounding variables. A post-hoc power analysis demonstrated that this investigation was underpowered to perform multivariate binomial logistic regression analysis. Therefore, the results of the regression analysis must be interpreted with caution. Furthermore, radiographic evaluation was not performed at final follow-up to evaluate if continued sports activity may have led to progression of OA. Additional clinical assessments, such as range of motion and strength, were not performed due to logistical challenges associated with patients

returning to the senior authors' clinic to undergo further clinical evaluation. Other standardized outcome metrics, such as Knee Injury and Osteoarthritis Outcome Score (KOOS), IKDC, Western Ontario and McMaster Universities Arthritis Index (WOMAC), and Lysholm scale were not administered at final follow-up. Shorter outcome scores, such as the VAS-Pain, SANE, and Marx Activity Scale, were used to avoid respondent fatigue and improve compliance. Lastly, preoperative PROMs were unable to be collected which limits the interpretation of the postoperative scores.

5. Conclusion

In a young and active population with medial OA and varus deformity, HTO provides a high rate (88.2%) of RTS by 7.5 months postoperatively; however, only 41.2% of patients could return to preinjury level or better. Despite the ability to RTS, HTO is not a definitive treatment option in patients with high-grade medial compartment OA as nearly 40% of patients underwent knee arthroplasty by 6.1 years post-operatively. Patient expectations regarding RTS can be appropriately managed with adequate preoperative patient education.

Declaration of competing interest

The authors have no conflicts of interest that are directly related to the production of this manuscript.

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