Return to Sport and Work After High Tibial Osteotomy With Concomitant Medial Meniscal Allograft Transplant

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Purpose: (1) To examine the timeline of return to sport (RTS) and return to work (RTW) after high tibial osteotomy (HTO) with concomitant medial meniscal allograft transplant (MAT), (2) to evaluate the degree of function on RTS and RTW, and (3) to identify reasons patients do not return to sport- or work-related activity. **Methods:** Patients undergoing HTO plus MAT were reviewed retrospectively at a minimum of 2 years postoperatively. The exclusion criterion was any concomitant procedure except cartilage restoration for focal full-thickness medial femoral condylar defects. Patients completed a subjective sport and work questionnaire, a visual analog scale for pain, the Single Assessment Numeric Evaluation, and a satisfaction questionnaire. **Results:** Twenty-two patients (aged 35.1 ± 8.1 years) were included at 9.3 ± 3.7 years postoperatively. Sixteen patients participated in sports within 3 years before surgery, and 14 patients (87.5%) returned to sport by 9.7 ± 3.8 months postoperatively. Only 7 patients (43.8%) returned to their preinjury status. Eighteen patients were employed within 3 years before surgery, and all patients returned to work; however, only 16 patients (88.9%) returned at the same occupational intensity by 3.1 ± 2.4 months. The rates of RTW for light-, medium-, and heavy-intensity occupations were 100%, 75.0%, and 85.7%, respectively, whereas the duration of RTW was 2.1 months, 2.3 months, and 4.8 months, respectively. Of the patients, 20 (90.9%) reported at least 1 complaint post-operatively, with 13 patients (59.1%) returning to the operating room for recurrent symptoms, including 1 patient who received a knee replacement by 7.75 years postoperatively. **Conclusions:** In patients with medial meniscal deficiency and varus deformity, HTO plus MAT provided high rates of RTS (87.5%) and RTW (100%) by 9.7 months and 3.1 months, respectively. It is imperative that clinicians manage expectations because patients may RTS and RTW after HTO plus MAT; however, return to high-intensity activities or occupations may be unlikely or delayed. **Level of Evidence:** Level IV, retrospective case series.

Meniscal allograft transplant (MAT) is an acceptable treatment modality in patients with meniscal deficiency that reduces pain, improves function, and delays the progression of osteoarthritis in the affected compartment.[1,2] MAT has shown statistically significant improvements in patient-reported outcome measures

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regarding function and quality of life, as well as good long-term survivorship until graft failure (73.5% and 60.5% at 10 years and 15 years, respectively).[3-6] Concomitant malalignment, ligamentous instability, and significant chondral defects may result in poorer outcomes after MAT.[4,7] Therefore, it is imperative to correct all sources of pathology at the time of surgery to optimize the MAT's chances of survival.

In patients with medial meniscal deficiency and varus malalignment, high tibial osteotomy (HTO) can be performed concomitantly with MAT (HTO plus MAT). It is likely that a synergistic relation exists between knee realignment and meniscal restoration. Improving the mechanical axis optimizes meniscal healing, whereas improving the meniscal status reduces pain after HTO.[8] Results after HTO plus MAT are limited, and in active patients, adequate patient-reported outcome scores or survivorship may not truly recapitulate treatment success after HTO plus MAT. After HTO, patients who are motivated may be more likely to participate in more strenuous activities.[9] Furthermore, as the age of retirement increases, return to work (RTW) may be an important determinant of patient outcomes.[10] Therefore, return to sport (RTS) and RTW may be more important outcomes in this cohort of patients.

The purposes of this investigation were (1) to examine the timeline of RTS and RTW after HTO with concomitant medial MAT, (2) to evaluate the degree of function on RTS and RTW, and (3) to identify reasons patients do not return to sport- or work-related activity. We hypothesized that a high proportion of patients would be able to RTS and RTW after HTO plus MAT; however, return to the preoperative activity intensity or high-intensity sports may be limited.

Methods

This investigation was a retrospective review of patient data. Institutional review board approval was obtained before initiation of this investigation. The registry was queried for patients who underwent HTO with concomitant MAT from 2004 to 2015 by the senior author. These dates for inclusion were chosen because 2004 represents the earliest year that patient records could be obtained at our institution and 2015 represents the latest time point at which minimum 2-year follow-up could have been obtained by us. The inclusion criteria for this study were patients who received HTO plus MAT and were available for minimum 2-year follow-up. Patients who underwent concomitant osteochondral allograft transplantation (OCA) were included in the investigation. Patients who previously underwent meniscectomy, a cartilage procedure (MAT, OCA, autologous chondrocyte implantation, or microfracture), or anterior cruciate ligament reconstruction were also included in the analysis. Patients were excluded if they were aged 18 years or younger at the time of surgery (n = 2) or underwent bilateral HTO within 3 years of each other (n = 1). Indications for HTO plus MAT included age younger than 65 years, greater than 5° of varus deformity, and evidence of medial meniscal deficiency on magnetic resonance imaging or previous knee arthroscopy.

Patients with a functional telephone number or e-mail address were contacted to complete a detailed, subjective survey regarding sport and work outcomes, as well as patient satisfaction. As part of the survey, patients were also asked to complete the Single Assessment Numeric Evaluation (SANE), the Marx Activity Scale, and a visual analog scale for pain. Those who were unable to be contacted for follow-up either had a disconnected phone number or did not respond to attempts to have the questionnaire mailed to their home. The sport and work questionnaire has been previously used to describe outcomes after orthopaedic procedures.[10-15] Patient-reported activities were stratified into low-, medium-, and high-intensity lower-extremity demands (Table 1),[11,13,15,16] and occupational intensity was divided into high, medium, low, or sedentary occupations (Table 2).[10,12] Preoperative diagnosis, demographic information, complications, and surgical history were collected from patient records. Preoperative radiographs were assessed by 2 reviewers (J.N.L. and A.A.) for the degree of osteoarthritis using the Kellgren-Lawrence grading system, and operative reports were reviewed for the degree of varus correction.

Surgical Techniques

Meniscal Allograft Transplant. Diagnostic arthroscopy is performed using standard anteromedial and anterolateral portals. The medial meniscus is assessed, and all remaining meniscal tissue is removed. The integrity of the cartilage in the medial and lateral compartments is also assessed, and any chondral defects can be treated with OCA. The senior author typically performs MAT with the slotted bone plug technique in cases with concomitant HTO because fixation of the graft occurs above the level of the osteotomy. This technique was used by the senior author in every patient included in this investigation. A slot connecting the anterior and posterior meniscal root attachments is created on the

Table 1. Categorization of Sport by Intensity

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

Table 2. Categorization of Work by Occupational Demand

Demand Level	Description
Sedentary	Sedentary work involves exerting up to 10 lb of force occasionally or a negligible amount of force frequently to lift, carry, push, pull, or otherwise move objects. Sedentary work involves sitting most of the time but may involve walking or standing for brief periods. Jobs are considered sedentary if walking and standing are required occasionally and all other sedentary criteria are met.
Light	Light work involves exerting up to 20 lb of force occasionally, up to 10 lb of force frequently, or a negligible amount of force constantly. If the amount of lifted weight is negligible, a job may be rated as light work if it (1) requires walking or standing to a significant degree; (2) involves sitting a significant amount of time but requires constant pushing and/or pulling of controls; or (3) requires working at a production pace, in which an individual constantly pushes or pulls negligible weight.
Moderate	Moderate work involves exerting 20-50 lb of force occasionally, 10-25 lb of force frequently, or a negligible amount to 10 lb of force constantly.
Heavy	Heavy work involves exerting 50-100 lb of force occasionally, 25-50 lb of force frequently, or 10-20 lb of force constantly to move objects.

NOTE: All physical demand requirements are in excess of the previous level. "Occasionally" is defined as an activity or condition that exists for up to one-third of the time; "frequently," an activity or condition that exists from one-third to two-thirds of the time; and "constantly," an activity or condition that exists from two-thirds to most of the time. All data were adapted from the U.S. Department of Labor, Office of Administrative Law Judges.

tibial plateau. The MAT is introduced into the medial compartment through an accessory posteromedial incision, and the bridge is inserted into the slot. Once the graft is fully seated, the bridge is secured with interference screw fixation. The meniscal allograft is also secured to the remnant meniscus and capsule with vertical mattress sutures.

High Tibial Osteotomy. A longitudinal incision is made along the anteromedial portion of the proximal tibia, and the medial collateral ligament is elevated from the periosteum. With the knee flexed to 10°, 2 osteotomy drill pins are inserted on the medial tibial diaphysis and directed toward the fibular head under fluoroscopic guidance. The proximal tibia is cut along the anterior, posterior, and medial borders with an oscillating saw and osteotomes, leaving the lateral cortex intact. An HTO wedge plate is inserted along the anteroposterior plane (opening wedge osteotomy system; Arthrex, Naples, FL). Two 6.5-mm cancellous screws are inserted proximally, and two 4.5-mm cancellous screws are inserted distally. The osteotomy site is packed with cancellous bone chips or harvested bone autograft (distal femur, proximal tibia, or iliac crest).

Rehabilitation Protocol

After HTO plus MAT, patients are restricted to non–weight bearing or heel-touch weight bearing for the first 6 weeks postoperatively and are allowed to progress to full weight bearing after this time point. For the first 2 weeks after surgery, patients are advised to use a brace locked in extension at all times. Thereafter, the brace can be removed at night until 6 weeks postoperatively, and its use can then be fully discontinued. Patients may advance range of motion as tolerated; however, maintaining full extension during the first 2 weeks is encouraged by sleeping with the brace locked at 0° of extension.

Statistical Analysis

Statistical analysis was conducted using Microsoft Excel (Microsoft, Seattle, WA). Descriptive analysis of continuous variables included means and standard deviations, whereas frequencies and percentages were used to report discrete variables.

Results

Demographic Characteristics

From 2004 to 2015, 29 patients who met the inclusion criteria underwent HTO with concomitant medial MAT. Of these patients, 22 (75.9%) were available for final follow-up at an average of 9.3 ± 3.7 years (range, 3-13 years) postoperatively. Patient demographic characteristics are provided in Table 3. Concomitant OCA was performed in 13 patients (59.1%); however, no patients who received autologous chondrocyte implantation or microfracture were included (Table 3). In 20 patients (90.9%), at least 1 previous operation had been performed on the ipsilateral knee before their HTO, which included medial meniscectomy (n = 18, 81.8%), anterior cruciate ligament reconstruction (n = 3, 13.6%), and microfracture (n = 2, 9.1%).

Table 3. Demographic Characteristics for Patients Undergoing HTO Plus MAT

Demographic Characteristic	Data
Age, yr	35.1 ± 8.1 (19-53)
Body mass index	27.1 ± 4.2 (22.3-39.3)
Male sex	16 (72.7)
Operation on dominant leg	12 (54.5)
Average amount of correction, °	7.9 ± 1.7 (5.0-12.5)
Concomitant OCA	13 (59.1)

NOTE. Data are presented as number (percentage) or mean ± standard deviation (range).

HTO, high tibial osteotomy; MAT, meniscal allograft transplant; OCA, osteochondral allograft transplantation.

Kellgren-Lawrence grade 1 or 2 was present in 11 knees (50.0%). The decision to pursue HTO plus MAT was made to relieve pain (n = 15, 68.2%), stay active (n = 10, 45.5%), and/or improve motion (n = 9, 40.9%).

Complications

A total of 13 patients (59.1%) returned to the operating room on 2.1 ± 1.3 occasions for meniscal debridement or meniscectomy (n = 8, 36.4%), hardware removal (n = 4, 18.2%), further cartilage procedures (chondroplasty and osteochondral transplant [n = 2, 9.1%]), and/or irrigation and drainage (n = 1, 4.5%). A single patient (4.5%) with preoperative Kellgren-Lawrence grade 3 medial-compartment osteoarthritis underwent a total knee replacement by 7.75 years after HTO plus MAT.

Outcome Scores

Preoperative outcome scores were not available for patients included in this investigation. At the time of final follow-up, the average SANE score was 64.0 ± 26.2, the average visual analog scale pain score was 3.4 ± 2.7, and the average Marx Activity Scale score was 2.0 ± 2.9 (range, 0-10). Of the patients, 14 (63.6%) reported being at least somewhat satisfied with their HTO plus MAT and 16 (72.7%) stated that they would still proceed with the operation after experiencing the entire process. In the postoperative period, 90.9% of patients reported at least 1 complaint after HTO plus MAT. The most common complaints were stiffness (n = 12, 54.5%), occasional pain (n = 9, 40.9%), chronic pain (n = 6, 27.3%), instability (n = 6, 27.3%), frequent swelling (n = 5, 22.7%), and catching and/or locking symptoms (n = 5, 22.7%).

Sport Outcomes

Within 3 years before their HTO plus MAT, 16 patients (72.7%) participated in at least 1 sport—leaving 16 patients for analysis of sport outcomes. Of those who previously participated in sports, 14 (87.5%) returned to sport after HTO plus MAT at an average of 9.7 ± 3.8 months. However, only 7 patients (43.8%) were able to return to the same level of activity intensity after HTO plus MAT. Of the patients who were able to RTS, 12 (85.7%) stopped participating in at least 1 sport that they were participating in before operative management. The most common reasons for ceasing participation in at least 1 sport included the prevention of further damage to the knee (n = 10, 83.3%), persistent pain (n = 7, 58.3%), the surgical procedure (n = 5, 41.7%), persistent swelling (n = 4, 33.3%), and fear of reinjury (n = 3, 25.0%). The average frequency of participation in sports before HTO plus MAT was 4.3 ± 1.9 days per week, which decreased to 3.0 ± 2.0 days per week after HTO plus MAT ($P = .06$). Of the patients, 7 (43.8%) described their postoperative physical fitness to be the same as or better than their preoperative fitness level.

Of the patients, 9 (56.3%) reported returning to a lower level of sport after surgery, 7 (43.8%) returned to the same level, and none (0.0%) returned to a higher level of sport. A total of 9 patients (56.3%) reported being at least somewhat satisfied with their ability to RTS after HTO plus MAT. Of these 9 patients, 6 (66.7%) were able to return to the same level of sports participation. After HTO plus MAT, 13 patients (81.3%) believed that their knee hindered their ability to participate in sports.

The sport-specific rates of RTS after HTO plus MAT were as follows: volleyball, 100% (2 of 2); yoga, 100% (2 of 2); cycling, 71.4% (5 of 7); light weight lifting, 75.0% (3 of 4); golf, 66.7% (4 of 6); softball, 50.0% (1 of 2); running, 50.0% (3 of 5); football, 0.0% (0 of 1); and basketball, 0.0% (0 of 3). Sport-specific rates of RTS are shown in Figure 1.

On subgroup analysis of patients who received concomitant OCA with their HTO plus MAT, 8 patients (61.5%) participated in at least 1 sport within 3 years before operative management. In comparison to patients who underwent HTO plus MAT, there was no difference in the RTS rate (100% vs 75.0%; $P = .1$), duration of RTS (10.3 ± 4.6 months vs 9.0 ± 3.0 months), or rate of return to the preinjury level of sport (50.0% vs 62.5%). Q8

Return to Work

A total of 18 patients (81.8%) were employed within 3 years before their HTO plus MAT, and all patients (100%) were able to RTW after surgery. However, only 16 patients (88.9%) were able to return at the same occupational intensity that they held before surgery. The average time to RTW at the same occupational intensity after HTO plus MAT was 3.1 ± 2.4 months. Four patients were covered by Workers' Compensation before their HTO plus MAT. Of these patients, 3 (75.0%) were able to return to the same occupation after surgery. The single patient who was unable to return to the same occupation was able to RTW in a lower-intensity position.

When stratified by level of intensity, patients who held light-, moderate-, and heavy-intensity occupations before their HTO plus MAT were able to return to their previous level of occupational intensity at rates of 100%, 75.0%, and 85.7%, respectively (Table 4). There was no difference in the level of occupational intensity and the rate of RTW or the duration until RTW.

On subgroup analysis of patients who received concomitant OCA with their HTO plus MAT, 9 patients (69.2%) were employed within 3 years before operative management. In comparison to patients who underwent HTO plus MAT, there was no difference in

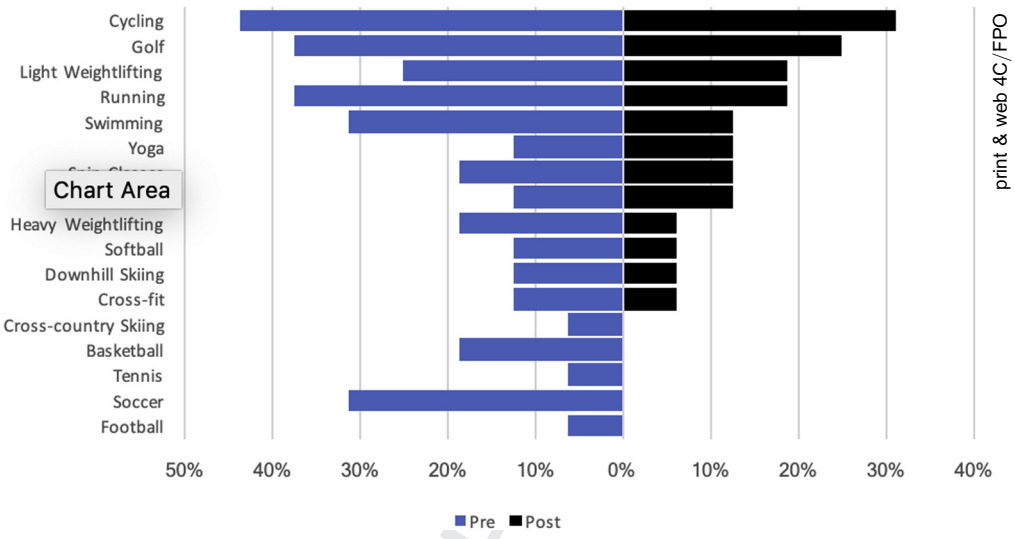

Fig 1. Direct return-to-sport rates after high tibial osteotomy with concomitant meniscal allograft transplant. (Post, postoperatively; Pre, preoperatively.)

the rate (100% vs 100%) or duration (2.5 ± 1.1 months vs 3.7 ± 3.3 months) of RTW.

Discussion

In this investigation, 87.5% of patients were able to RTS by 9.7 ± 3.8 months and 100% of patients were able to RTW by 3.1 ± 2.4 months after HTO with concomitant medial MAT. However, only 43.8% of patients who returned to sport were able to return to their preinjury level of activity. This investigation also reports sport-specific and occupational intensity–specific rates of RTW and RTS for patients undergoing HTO plus MAT. The results of this investigation are important for counseling patients preoperatively to manage postoperative expectations, and they attest to the safety and efficacy of HTO plus MAT.

It is imperative that the results of this investigation be compared with outcomes of alternative treatment options for meniscal deficiency, such as MAT without malalignment correction. The rate of RTS after HTO plus MAT in this investigation (87.5%) is higher than that in a previous meta-analyses (77%) assessing RTS after MAT alone.[17] This may be because of varying baseline demographic characteristics, such as age, sex distribution, patient population, and side (medial vs lateral); degree of preoperative osteoarthritis; and differing indications for surgery, as well as operative techniques (open vs arthroscopic, bone plug vs soft-tissue fixation). Reporting overall RTS may be misleading because patients may not be able to participate at their previous level of intensity on return. In this investigation, only 43.8% of patients were able to return to their previous level of sport. In a series of 89 patients, Zaffagnini et al.[18] reported a 74% RTS rate with 49% of patients able to return to their preinjury level of activity intensity after MAT. This case series is particularly noteworthy because of the number of concomitant HTO procedures that were included in the analysis (29%); however, a subgroup analysis of this cohort was not performed. Zaffagnini et al. also reported a similar trend showing that many patients may not be able to return to their previous level of activity intensity. HTO plus MAT carries a theoretical advantage that the HTO can off-load the medial compartment, which creates a more suitable environment for the meniscal allograft to incorporate into the host tissue. However, patients may still be limited in their ability to return to their previous level of sport. This information is imperative to discuss with patients during preoperative education to manage their expectations in the postoperative period.

After HTO plus MAT, patients have shown a statistically significant improvement in pain and functional scores.[19] Patients showed similar postoperative pain

Table 4. Rate and Duration of RTW at Same Level of Occupational Intensity

	Working Before HTO Plus MAT, n	Working After HTO Plus MAT, n	Rate of RTW, %	Time to RTW, Mean ± SD, mo
Light	7	7	100	2.1 ± 1.9
Moderate	4	3	75.0	2.3 ± 0.6
Heavy	7	6	85.7	4.8 ± 2.9
Total	18	16	88.9	3.1 ± 2.4

HTO, high tibial osteotomy; MAT, meniscal allograft transplant; RTW, return to work; SD, standard deviation.

scores to patients undergoing HTO plus MAT[19]; however, patients in this investigation showed lower Marx Activity Scale scores and SANE scores in comparison to patients undergoing MAT.[18,20] Differences in activity levels and subjective functional scores may be a result of the increased morbidity associated with the osteotomy, expectations, or differences in baseline patient demographic characteristics. Although patients in this investigation reported fair to excellent outcomes on functional assessments, it is important to note that only 43.8% of patients were able to return to their preinjury level of activity and 62.5% of patients were satisfied with their ability to RTS. This finding highlights the ceiling effect of patient-reported outcome measures; therefore, statistically significant improvements in functional outcome measures may not be clinically relevant.[21,22] Evaluating RTS at the same level of activity intensity may provide a more accurate representation of outcomes in an active population. Furthermore, the rate of satisfaction suggests that participation in sports activity and the level of activity intensity could impact overall satisfaction and wellness. Despite a high overall rate of RTS, the direct rate of RTS for medium-and high-intensity activities, such as softball, basketball, football, tennis, and soccer, was low. The aforementioned sports incorporate a significant amount of cutting and lateral movement; therefore, they require greater lower-extremity physical demands. After HTO plus MAT, patients may be unable to meet the physical demands of high-intensity lower-extremity activities. Given the relation between preoperative patient education and subjective clinical outcomes,[23,24] clinicians should counsel patients that a high proportion of patients may RTS after HTO plus MAT; however, a return to high-intensity lower-extremity activities may be unlikely.

In this investigation, 100% of patients were able to RTW after HTO plus MAT; however, only 88.9% of patients were able to return to the same level or a higher level of occupational intensity that they held before surgery. Patients with higher-intensity occupations took longer to RTW than those with less physically demanding occupations, but this was statistically insignificant. However, patients with heavy-intensity careers were not negatively impacted in their ability to return to their previous occupations. The relation between occupational intensity and the duration of RTW may be multifactorial. The senior author implements a non−weight bearing or heel-touch protocol until 6 to 8 weeks postoperatively. This protocol may enable patients who work in sedentary or light professions to RTW sooner than those in higher-intensity vocations. Furthermore, the motivation to RTW is influenced by several variables including economic need, disability coverage, social influences, comorbidities, and health care benefits. It is possible that concomitant HTO may prolong the duration of RTW because of increased morbidity from an additional surgical procedure.

In this investigation, 59.1% of patients returned to the operating room on an average of 2.1 ± 1.3 occasions, and 90.9% of patients reported at least 1 complaint in the postoperative period. The rate of complications in this investigation is higher than what has previously been reported.[4,17,18] Variations in indications for further operative management and duration of follow-up, as well as patient expectations and imposed limitations, may contribute to the difference in the complication rate. Patients who have high-intensity occupations or are allowed to return to strenuous physical activities may experience further joint degeneration and, subsequently, further surgery to alleviate symptoms. HTO plus MAT allows patients to RTW and RTS and has a high rate of satisfaction; however, patients may continue to experience residual symptomatology, which may necessitate a return to the operating room. However, the rate of failure, as assessed by revision procedures or conversion to arthroplasty, remains low.

Limitations

It is important that the analysis of this investigation be interpreted within the context of the study's limitations. Preoperative differences in age or sex may inhibit the external validity of our findings. The wide range of patient ages in this investigation (19-53 years) may not truly be reflective of patients who traditionally undergo HTO plus MAT, which may inhibit the interpretation of these results. Patients who underwent previous cartilage or meniscal restoration procedures (n = 3) were included in this investigation. Although this represents a small proportion of patients, it may contribute to heterogeneity in the patient population. Our investigation was retrospective; this may result in recall bias. However, its design is similar to designs of previous studies that examined RTS, RTW, and patient satisfaction after orthopaedic procedures.[11,13-16,25] This study is also subject to nonresponse bias because 24.1% of patients were lost to follow-up. Preoperative patient-reported outcome measures were unable to be collected, which limits the interpretation of the postoperative measures obtained. Although it is not uncommon to treat chondral injuries at the time of MAT, the inclusion of patients who underwent concomitant OCA may affect the results of the investigation. Although a subgroup analysis of this cohort was performed, these results may be subject to type II error owing to the small sample size of each group. Furthermore, the results comparing the rate and duration of RTW stratified by occupational intensity are subject to type II error owing to the small sample size within each occupational intensity. Long leg radiographs were obtained as standard protocol for preoperative planning; however, these images were unavailable for

retrospective analysis. Furthermore, radiographic evaluation at final follow-up to evaluate whether continued sport or work participation may have led to progression of osteoarthritis was not performed.

Conclusions

In patients with medial meniscal deficiency and varus deformity, HTO plus MAT provided high rates of RTS (87.5%) and RTW (100%) by 9.7 months and 3.1 months, respectively. It is imperative that clinicians manage expectations because patients may RTS and RTW after HTO plus MAT; however, return to high-intensity activities or occupations may be unlikely or delayed.

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