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Return to Work Following Tibial Tubercle Osteotomy for Patellofemoral Osteoarthritis and Pain

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Abstract

Purpose. To evaluate the ability of patients to return to work following anteromedialization (AMZ) tibial tubercle osteotomy (TTO) due to isolated patellofemoral osteoarthritis or pain. **Methods.** Consecutive patients undergoing AMZ TTO were reviewed retrospectively at a minimum of 1 year postoperatively. Patients completed a subjective work questionnaire, a visual analog scale for pain, as well as a Kujala questionnaire and satisfaction questionnaire. **Results.** Fifty-seven patients (61 knees; average age: 32.7 ± 9.6 years) were contacted at an average follow-up of 4.86 ± 2.84 years postoperatively. The preoperative Kujala score improved from 55.7 ± 17.8 to 84.6 ± 15.8 at final follow-up ($P < 0.001$). Thirty-seven patients (64.9%) were employed within 3 years prior to surgery and 34 patients (91.9%) were able to return to work by 2.8 ± 2.6 months postoperatively. However, only 27 patients (73.0%) of patients were able to return to the same level of occupational intensity. Patients who held sedentary, light-, medium-, or high-intensity occupations were able to return to work at a rate of 100.0%, 93.8%, 77.8%, and 100.0% by 2.2 months, 3.0 months, 3.1 months, and 4.0 months, postoperatively. No patients underwent revision TTO or conversion to arthroplasty by the time of final follow-up. **Conclusion.** In patients with focal patellofemoral osteoarthritis or pain, AMZ TTO provides a high rate of return to work (91.9%) by 2.8 ± 2.6 months postoperatively. Patients with higher intensity occupations may take longer to return to work than those with less physically demanding occupations. **Level of Evidence.** III.

Keywords

tibial tubercle osteotomy, osteoarthritis, diagnosis, Fulkerson osteotomy

Introduction

Anterior knee pain due to isolated patellofemoral chondromalacia occurs in approximately 15% to 20% of symptomatic patients.¹ Focal chondral defects may cause pain, disability, and may progress to degenerative arthritis. Furthermore, patellofemoral arthritis may cause significant functional limitations—especially in patients who have higher levels of physical activity.^{2–5} Anteromedialization (AMZ) tibial tubercle osteotomy (TTO) can effectively treat patellofemoral osteoarthritis, lateral patellofemoral overload syndrome, and correct malalignment that may contribute to patellofemoral instability. This technique, as originally described by Fulkerson *et al.*⁶ realigns the extensor mechanism while decreasing contact forces along the patellofemoral joint. AMZ TTO results in an improvement in patient-reported outcome measures, high satisfaction, a high rate of return to sport, and portends a low rate of complications.^{7–15}

The ability to return to work (RTW) following surgical intervention is an important factor for patients and is a contributing variable toward patient satisfaction.¹⁶ Since AMZ

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TTO is commonly performed in younger patients who comprise the work-force, it is imperative to counsel patients on their timeline to RTW with regard to their occupational intensity status. Zarkadis *et al.*¹³ demonstrated that 78% of military service members were able to return to duty following TTO with concomitant autologous chondrocyte implantation (ACI) due to patellofemoral arthritis. However, additional information regarding RTW following TTO is limited.

The purpose of this investigation is to evaluate the ability of patients to RTW following anteromedialization tibial tubercle osteotomy due to isolated patellofemoral osteoarthritis or pain. We hypothesize that patients in higher-intensity occupations will demonstrate a lower rate of RTW and will have a higher duration of absence than those in lower-intensity occupations.

Methods

Institutional review board approval was obtained prior to initiating this investigation. Eighty consecutive patients who underwent unilateral or staged bilateral AMZ TTO by the senior author (B.E.S.S) due to isolated patellofemoral pain or osteoarthritis from March 2004 to January 2015 were identified. Indications for TTO were patients who were diagnosed with isolated patellofemoral pain or arthritis and/or had a cartilaginous lesion. Lateral or inferior patellar arthritis or cartilaginous lesions were indicated for surgery since these lesions benefited from AMZ TTO. However, patients with medial facet lesions were not indicated for AMZ TTO since this would overload the medial facet. Furthermore, patients were indicated for surgery if they underwent nonoperative treatment for at least 6 months, which included nonsteroidal anti-inflammatory drugs, physical therapy, knee extension brace, and joint injections. Patients were included in this investigation if they underwent AMZ TTO due to isolated patellar osteoarthritis or pain and had a minimum of 1-year follow-up. Patients were excluded if they underwent concomitant distalization due to patella alta. Patients who were undergoing concomitant TTO and MPFL reconstruction due to instability were excluded from this investigation. However, patients with previous history of patellar instability were eligible for inclusion if the instability was successfully treated and the primary purpose of the TTO was to treat osteoarthritis or pain.

Patients with a functional telephone number or email address were contacted to complete a subjective and detailed questionnaire regarding their work status following AMZ TTO. This questionnaire assessed demographic characteristics, pre- and postoperative work status, as well as patient satisfaction. Patients who were unable to be contacted for follow-up had a disconnected phone number or did not respond to attempts to have the questionnaire

mailed to their home. This questionnaire has been used previously to describe work-related outcomes following orthopedic procedures.¹⁷⁻²⁴ Patients were inquired if they held occupations within 3 years prior to surgery to ensure that a cohort that comprised the workforce at the time of surgery was included in the investigation. Work-intensity status was stratified into low-, medium-, and high-intensity occupational demands based on guidelines set forth by the U.S. Department of Labor (**Table 1**).¹⁹ Patients also completed the Kujala questionnaire and the Visual Analogue Scale for Pain.²⁵ Preoperative diagnosis, demographic information, comorbidities, intraoperative variables, complications, and surgical history were collected from patient records. Preoperative radiographs, including anteroposterior, lateral, and bilateral Merchant views were used to measure patellar height.²⁶ Magnetic resonance imaging was also used to assess for cartilage lesions, osteochondral fragments, trochlear dysplasia, as well as the tibial tubercle–trochlear groove (TT-TG) distance. The senior author reviewed operative reports to assign the location and severity of patellar lesions using the Pidorigano and Outerbridge classification systems.^{11,27,28}

Surgical Technique

Diagnostic arthroscopy was performed prior to tibial tubercle osteotomy. Loose body removal and lateral release was indicated if the patella could not be moved to the neutral position during examination under anesthesia. Following diagnostic arthroscopy, a 5- to 6-cm longitudinal incision was made along the lateral edge of the tibial tuberosity beginning at the proximal tubercle and extending distally. Capsulotomies were made on either side of the patellar tendon along its insertion on the superior aspect of the tuberosity. The medial and lateral borders of the patellar tendon were freed with blunt dissection to enable the tendon to be mobilized and protected during tuberosity transfer.

The length of the TTO shingle was outlined with electrocautery to ensure a shingle of at least 5 cm.²⁹ The anterior compartment of the tibia was elevated from the subperiosteal tibia and two 0.045-mm Kirschner wires were placed from medial-to-lateral at the proximal and distal aspects of the planned osteotomy site as a template for a freehand osteotomy cut. The slope of the osteotomy was determined by the angle of the proximal Kirschner wire with respect to a perpendicular axis. The location of the arthritic lesions determined the degree of medialization or anteriorization. A 40-mm sagittal saw blade was used to cut the tibia based on the direction of the Kirschner wires and osteotomes were used to complete the osteotomy.

At the proximal patellar tendon insertion site, a laterally based biplanar cut was made,⁶ while a uniplanar cut was made at the distal insertion site. Following completion of the osteotomy proximally, an incomplete fracture was

Table 1. Categorization of Work by Demand.^a

Demand Level	Description
Sedentary	Exerting up to 10 pounds of force occasionally or 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 of time. Jobs are considered sedentary if walking and standing are required occasionally and all other sedentary criteria are met
Light	Exerting up to 20 pounds of force occasionally, up to 10 pounds of force frequently, or a negligible amount of force constantly. If lifted weight is a negligible amount, a job may be rated as light work if it requires (1) walking or standing to a significant degree, (2) sitting a significant amount of time but requires constant pushing/pulling of controls, or (3) working at a production pace, where an individual constantly pushes or pulls negligible weight.
Moderate	Exerting 20-50 pound of force occasionally, 10-25 pounds of force frequently, or negligible to 10 pounds of force constantly.
Heavy	Exerting 50-100 pounds of force occasionally, 25-50 pounds of force frequently, or 10-20 pounds of force constantly to move objects.

^aOccasionally—activity or condition exists for up to one-third of the time. Frequently—activity or condition exists from one-third to two-thirds of the time. Constantly—activity or condition that exists from two-thirds to most of the time. All physical demand requirements are in excess of the previous level.

created such that the periosteum remained attached at the distal insertion site. The tibial tuberosity was transferred en bloc with the extensor mechanism to achieve the appropriate anteriorization and medialization. The amount of medialization was based on the preoperative TT-TG, with the goal of achieving a postoperative TT-TG between 7 and 10 mm. The offset of the osteotomy was measured with an osteotome and the shingle was then fixed with two 4.5-mm fully threaded cortical screws. Any excess or protruding bone was removed with a small rongeur.

Rehabilitation Protocol

Patients were placed on nonweightbearing status with a hinged knee brace locked in extension for four weeks to allow the osteotomy site to heal then patients are allowed to progressively advance their weightbearing status until they achieve full weightbearing by 6 weeks. At 2 weeks postoperatively, a home exercise program with quadriceps strengthening isometric exercises was initiated. Patients were progressed to formal physical therapy if there was radiographic evidence of healing at the osteotomy site at 6 weeks. Patients were allowed to advance to all activities as tolerated by 6 months postoperatively.

Statistical Analysis

Statistical analysis was performed 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, while frequencies and percentages were used to report discrete variables. The Fischer exact test was used to compare rate of RTW while analysis of variance was used to compare duration of RTW across different occupational intensities. Paired-sample *t*

tests were used to assess changes in patient-reported outcome measures. A binomial logistic regression was performed to assess the effect of demographic and surgical variables on patient likelihood of returning to work. All tests for statistical significance were performed using 2-sided hypothesis testing with statistical significance set at $P \leq 0.05$.

Results

Patient Demographics

Fifty-seven patients (61 knees; 71.3%) were contacted at an average follow-up of 4.86 ± 2.84 years (range: 1.5-11.7 years) postoperatively. Of these, 37 patients (40 knees) were employed within 3 years of surgery (64.9%). Patient demographics are provided in **Table 2**. Seventy-one percent of patients had evidence of underlying trochlear dysplasia on preoperative imaging.

The most frequently reported indications to pursue a TTO were pain relief (90.0%), a desire to stay active (40.0%), improve motion (17.5%), and to RTW (12.5%). Fifteen knees (37.5%) underwent 1.5 ± 0.7 procedures prior to the AMZ TTO. Eleven knees (27.5%) underwent a previous arthroscopic knee procedure, 7 knees (17.5%) underwent a lateral release, and 5 knees (10.0%) received a previous patellar cartilage procedure (2 microfracture and 2 chondroplasty). Two knees (5.0%) successfully underwent previous medial patellofemoral ligament reconstruction for patellar instability without evidence of recurrence. The sole indication of the TTO was to provide pain relief. At the time of AMZ TTO, concomitant lateral release (70.0%), chondroplasty (70%; 62.5% patellar, 7.5% trochlea), anterior compartment release (20.0%), articular cartilage transplantation (DeNovo; Zimmer, Warsaw, IN) for patellar cartilage defects

Table 2. Patient Demographics.

Variable	Data
Age at the time of surgery, y, mean ± SD	32.7 ± 9.6
Age at the time of follow-up, y, mean ± SD	37.6 ± 11.3
Body mass index, kg/m ² , mean ± SD	23.4 ± 3.2
Gender, n (%)	
Female	31 (83.7)
Male	6 (16.3)
Caton-Deschamps Index, mean ± SD	1.1 ± 0.1
TT-TG distance, mm, mean ± SD	13.6 ± 3.4
Smoking status, n (%)	3 (8.1)
Dejour classification, n (%)	
Normal	9 (29.0)
A	9 (29.0)
B	5 (16.1)
C	7 (22.6)
D	1 (3.2)
Preoperative diagnosis, n (%)	
Osteoarthritis	27 (67.5)
Pain	16 (40.0)
Patella overload	11 (27.5)
Instability	7 (17.5)

TT-TG = tibial tubercle–trochlear groove.

(10.0%), meniscal debridement/meniscectomy (10.0%), trochlear microfracture (10.0%), patellar debridement (10.0%), fat pad debridement (5.0%), plica debridement (2.5%), synovial debridement (2.5%), retinacular debridement (2.5%), abrasion arthroplasty (2.5%), osteophyte removal (2.5%), loose body removal (2.5%), and retinacular reconstruction (2.5%) was performed.

Outerbridge grade 3 or 4 patellar lesions were present in 30 knees (78.9%) while concomitant trochlear lesions were found in 15 knees (39.5%; 2 Outerbridge 1, 4 Outerbridge 2, 1 Outerbridge 3, 8 Outerbridge 4). Twenty-six knees (68.4%) had type 1 patellar lesions along the inferior pole of the patella according to the Pidorian classification system (Table 3).

Postoperative Complaints and Complications

Twenty-three patients (57.5%) reported at least one complaint with their knee by the time of final follow-up. The most common complaints were chronic pain (45.0%), stiffness (12.5%), nerve injury (2.5%), fracture (2.5%), or instability (2.5%). Eleven patients (27.5%) returned to the operating room 1.2 ± 0.4 times for residual symptoms. Nine knees (22.5%) underwent removal of hardware while only a single knee (2.5%) each underwent incision and drainage, anterior compartment release, chondroplasty, meniscal repair, and excision of the infrapatellar branch of the saphaneous nerve due to symptomatic neuroma. No patients underwent revision AMZ TTO or progression of

Table 3. Location of Patellar Lesions and Distribution of Outerbridge Grade.

Outerbridge Grade	Pidorian Classification				
	None	Type I	Type II	Type III	Type IV
0	3 (7.9)	—	—	—	—
1	—	2 (5.3)	—	—	1 (2.6)
2	—	1 (2.6)	1 (2.6)	—	—
3	—	12 (31.6)	—	—	3 (7.9)
4	—	11 (28.9)	—	—	4 (10.5)

Table 4. Average Postoperative Kujala Score Based on Outerbridge Score and Location of Lesion.

Outerbridge Grade	Pidorian Classification					Total
	None	Type I	Type II	Type III	Type IV	
0	82.3	—	—	—	—	82.3
1	—	65.5	—	—	94.0	75.0
2	—	39.0	78.0	—	—	58.5
3	—	83.6	—	—	75.7	82.0
4	—	90.0	—	—	92.3	90.6
Total	82.3	83.2	78.0	—	86.3	84.6

symptomatology that required total knee or patellofemoral arthroplasty.

Validated Outcomes

The preoperative Kujala score improved from 55.7 ± 17.8 to 84.6 ± 15.8 (*P* < 0.001). The improvement in the Kujala score was clinically significant as the minimal clinically important difference in this patient population was 11.9. The average postoperative Kujala score based on Outerbridge rating and location of the lesion is provided in Table 4. Thirty-six patients (90.0%) felt at least somewhat satisfied with the outcome of their TTO and 34 patients (80.0%) noted that their knee feels at least slightly better than preoperatively. Furthermore, 37 patients (92.5%) felt that their TTO provided at least some improvement in their quality of life, and 29 patients (72.5%) stated that their knee felt normal with activities of daily living. The average postoperative pain score was 1.8 ± 2.1.

Work Outcomes

Thirty-four patients (91.9%) were able to RTW by 2.8 ± 2.6 months (range: 0.25-10.0 months) postoperatively. However, only 27 patients (73.0%) of patients were able to return to the same level of occupational intensity. Patients who held sedentary, light-, medium-, or high-intensity occupations were able to RTW at a rate of 100.0%, 93.8%, 77.8%, and 100.0%, respectively (Table 5). There was no relationship

Table 5. Rate and Duration of Return to Work Stratified by Occupational Intensity.

Occupational Intensity	Working Before TTO (n)	Working After TTO (n)	Rate of RTW (%)	Average Time to RTW (Months)
Sedentary	10	10	100.0	2.2 ± 1.7
Light	16	15	93.8	3.0 ± 3.3
Medium	9	7	77.8	3.1 ± 2.8
Heavy	2	2	100.0	4.0 ± 2.8
Total	37	34	91.9	2.8 ± 2.6

TTO = tibial tubercle osteotomy.

between the rate ($P = 0.3$) or duration ($P = 0.8$) of RTW and occupational intensity.

Multivariate Analysis

On multivariate analysis, age ($P = 0.1$), body mass index ($P = 0.7$), TT-TG ($P = 0.7$), Caton-Deschamps ratio ($P = 0.3$), Dejour classification ($P = 0.3$), lesion location ($P = 0.9$), Outerbridge classification on the patella ($P = 0.1$) or trochlea ($P = 0.7$), occupational intensity ($P = 0.7$), patient satisfaction ($P = 0.9$), symptoms of instability ($P = 0.3$), and tobacco users ($P = 0.9$) were not predictive of RTW. However, female gender (odds ratio = 1.3, 95% CI [1.1-1.7], $P = 0.02$) was a positive predictor of RTW.

Discussion

In this investigation, we demonstrated that 91.9% of patients were able to RTW by 2.8 ± 2.6 months following antero-medialization tibial tubercle osteotomy for isolated patellofemoral pain or osteoarthritis. There was no difference in the rate or duration of RTW based on occupational intensity; however, female gender was a positive predictor of RTW. AMZ TTO is commonly performed in young, active patients who comprise a significant proportion of the work force; therefore, it is imperative that physicians adequately counsel patients regarding their ability to RTW following operative management.

RTW is an important factor for patients following elective procedures; however, RTW outcomes following AMZ TTO due to isolated patellofemoral osteoarthritis or pain are limited. Therefore, the results of this investigation can be compared to other knee osteotomies. The rate of RTW in this investigation (91.9%) is similar to the rate following high tibial osteotomy (85%-90%)^{30,31} as well as distal femoral osteotomy (91%).³² Furthermore, the rate of RTW following AMZ TTO is much higher than the rate of return to duty (69%-78%) reported among military servicemembers.^{13,33} The variation in these rates may be due to the inclusion of patients who have lower occupational intensities than active military members or differences in defining return to duty or work. Following ACI for OA, patients were unable to RTW for 3.4 months.³⁴ The results of the

present investigation substantiate the findings by Pestka *et al.*³⁴ by demonstrating a similar duration until RTW (2.8 months) as well as dose-dependent relationship between occupational intensity and duration of absence from work. However, the variation in duration of RTW may be attributed to the inclusion, in their study, of 65.4% of patients with a diagnosis other than patellofemoral arthritis.³⁴ ACI on the medial or lateral femoral condyle may be associated with a higher morbidity than patellofemoral ACI, which may result in additional absence from work.

Although statistically insignificant, patients in higher intensity occupations were absent from work for a longer duration than those in lower intensity occupations. Following AMZ TTO, patients are instructed to maintain nonweight-bearing status in a locked knee extension brace for 6 weeks postoperatively. The rehabilitation protocol may be most conducive to patients who occupy sedentary or low intensity occupations as they may be able to RTW in full capacity or make accommodations to return in some degree. Following ACI, approximately 90% of patients younger than 30 years experienced no reduction in occupational intensity while half of patients older than 50 years decreased the level of work.³⁴ Older patients may have additional comorbidities or decreased activity intensity, which may contribute to the inability to RTW. Zarkadis *et al.*¹³ demonstrated that age less than 30 years and junior enlisted service members were independent risk factors for failure to return to duty. Younger, junior enlisted service members are more likely to hold more physically demanding positions than older, senior enlisted members, which can prevent successful return to active duty. This finding highlights the interrelationship between age, occupational intensity, and the ability to RTW following operative management for isolated patellofemoral osteoarthritis. It is important to note that the relationship between occupational intensity and the duration until RTW may be skewed by the inclusion of only 2 patients who held high-intensity occupations. Economic need, social factors, disability coverage, comorbidities, and health insurance coverage are among several factors that effect a patient's motivation to RTW. Therefore, it is imperative that physicians appropriately counsel patients regarding their ability to RTW following AMZ TTO since preoperative expectations impact clinical outcomes.^{35,36}

Although no patients underwent revision AMZ TTO or conversion to arthroplasty, 27.5% of patients returned to the operating room for residual symptoms, with the most common indication being removal of hardware. Similarly, Zakardis *et al.*¹³ reported that 39.7% of knees returned to the operating room following TTO + ACI for patellofemoral arthritis with the majority of patients undergoing symptomatic removal of hardware. The rate of removal of hardware following AMZ TTO has been reported to be as high as 49%.^{14,37,38} Patients may undergo a hardware removal due to the relationship between the tibial tuberosity and subcutaneous tissue, which results in prominent hardware. Furthermore, 57.5% of patients in the present investigation reported at least one complaint with their knee by the time of final follow-up, with pain and stiffness being the most common complaints. Younger patients may participate in higher occupational or activity intensities, which may result in further degeneration of the patellofemoral joint or operative site. Thus, younger patients may experience more complications and residual symptomatology following operative management for isolated patellofemoral arthritis. AMZ TTO yields a high rate of satisfaction and enables patients to RTW; however, patients may continue to experience lingering symptoms or morbidity from the operative site. The rate of revision or conversion to arthroplasty remains low; therefore, AMZ TTO may minimize or delay the need for patellar arthroplasty in patients with isolated patellofemoral arthritis.

It is imperative that the analysis of this investigation must be interpreted within the context of its limitations. The predominance of females, wide age range, and inclusion of patients who were previously treated for patellar instability in this investigation may hinder the external validity of these findings. However, implementing a multivariate binomial logistic regression minimized the effects of confounding variables on RTW. Furthermore, this investigation is subject to recall bias due to its retrospective nature. However, the design of this investigation is similar to previous studies regarding RTW and patient satisfaction following orthopedic procedures.¹⁷⁻²⁴ This investigation is also prone to nonresponse bias as well as beta error since 28.8% of patients were unable to be contacted to complete the questionnaire. Last, radiographic evaluation at final follow-up was not performed to determine the effect of RTW and other activities on the progression of patellofemoral arthritis. However, no patients underwent conversion to knee arthroplasty at final follow-up, which suggests that arthritic progression is minimal.

Conclusion

In patients with focal patellofemoral osteoarthritis or pain, AMZ TTO provides a high rate of RTW (91.9%) by 2.8 ±

2.6 months postoperatively. Patients with higher-intensity occupations may take longer to RTW than those with less physically demanding occupations.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

Institutional review board (IRB), Hospital for Special Surgery, study (2014-051) was obtained prior to initiating this investigation.


Informed Consent

Not applicable.

Trial Registration

Not applicable.

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References

1. Stefanik JJ, Niu J, Gross KD, Roemer FW, Guermazi A, Felson DT. Using magnetic resonance imaging to determine the compartmental prevalence of knee joint structural damage. *Osteoarthritis Cartilage*. 2013;21(5):695-9. doi:10.1016/j.joca.2013.02.003
2. Duncan R, Peat G, Thomas E, Wood L, Hay E, Croft P. How do pain and function vary with compartmental distribution and severity of radiographic knee osteoarthritis? *Rheumatology (Oxford)*. 2008;47(11):1704-7. doi:10.1093/rheumatology/ken339
3. Duncan R, Peat G, Thomas E, Wood L, Hay E, Croft P. Does isolated patellofemoral osteoarthritis matter? *Osteoarthritis Cartilage*. 2009;17(9):1151-5. doi:10.1016/j.joca.2009.03.016
4. Kanneganti P, Harris JD, Brophy RH, Carey JL, Lattermann C, Flanigan DC. The effect of smoking on ligament and cartilage surgery in the knee: a systematic review. *Am J Sports Med*. 2012;40(12):2872-8. doi:10.1177/0363546512458223
5. Vasiliadis HS, Lindahl A, Georgoulis AD, Peterson L. Malalignment and cartilage lesions in the patellofemoral joint treated with autologous chondrocyte implantation. *Knee Surg Sports Traumatol Arthrosc*. 2011;19(3):452-7. doi:10.1007/s00167-010-1267-1
6. Fulkerson JP. Anteromedialization of the tibial tuberosity for patellofemoral malalignment. *Clin Orthop Relat Res*. 1983;(177):176-81.

7. Liu JN, Wu HH, Garcia GH, Kalbian IL, Strickland SM, Stein BES. Return to sports after tibial tubercle osteotomy for patellofemoral pain and osteoarthritis. *Arthroscopy*. 2018;34(4):1022-9. doi:10.1016/j.arthro.2017.09.021
8. Fulkerson JP, Becker GJ, Meaney JA, Miranda M, Folcik MA. Anteromedial tibial tubercle transfer without bone graft. *Am J Sports Med*. 1990;18(5):490-7. doi:10.1177/036354659001800508
9. Carofino BC, Fulkerson JP. Anteromedialization of the tibial tubercle for patellofemoral arthritis in patients >50 years. *J Knee Surg*. 2008;21(2):101-5.
10. Fisher TF, Waterman BR, Orr JD, Holland CA, Bader J, Belmont PJ Jr. Tibial tubercle osteotomy for patellar chondral pathology in an active United States military population. *Arthroscopy*. 2016;32(11):2342-9. doi:10.1016/j.arthro.2016.03.027
11. Pidoriario AJ, Weinstein RN, Buuck DA, Fulkerson JP. Correlation of patellar articular lesions with results from anteromedial tibial tubercle transfer. *Am J Sports Med*. 1997;25(4):533-7. doi:10.1177/036354659702500417
12. Gillogly SD, Arnold RM. Autologous chondrocyte implantation and anteromedialization for isolated patellar articular cartilage lesions: 5- to 11-year follow-up. *Am J Sports Med*. 2014;42(4):912-20. doi:10.1177/0363546513519077
13. Zarkadis NJ, Belmont PJ Jr, Zachilli MA, Holland CA, Kinsler AR, Todd MS, *et al*. Autologous chondrocyte implantation and tibial tubercle osteotomy for patellofemoral chondral defects: improved pain relief and occupational outcomes among US Army servicemembers. *Am J Sports Med*. 2018;46(13):3198-208. doi:10.1177/0363546518800713
14. Payne J, Rimmke N, Schmitt LC, Flanigan DC, Magnussen RA. The incidence of complications of tibial tubercle osteotomy: a systematic review. *Arthroscopy*. 2015;31(9):1819-25. doi:10.1016/j.arthro.2015.03.028
15. Sherman SL, Erickson BJ, Cvetanovich GL, Chalmers PN, Farr J 2nd, Bach BR Jr, *et al*. Tibial tuberosity osteotomy: indications, techniques, and outcomes. *Am J Sports Med*. 2014;42(8):2006-17. doi:10.1177/0363546513507423
16. Agarwalla A, Gowd AK, Liu JN, Puzitiello RN, Cole BJ, Romeo AA, *et al*. Predictive factors and the duration to pre-injury work status following biceps tenodesis. *Arthroscopy*. 2019;35(4):1026-33. doi:10.1016/j.arthro.2018.10.144
17. Gowd AK, Liu JN, Garcia GH, Cabarcas BC, Agarwalla A, Nicholson GP, *et al*. Figure-of-eight reconstruction of the sternoclavicular joint: outcomes of sport and work. *Orthopedics*. 2019;42(4):205-10. doi:10.3928/01477447-20190523-03
18. Gowd AK, Garcia GH, Liu JN, Malaret MR, Cabarcas BC, Romeo AA. Comparative analysis of work-related outcomes in hemiarthroplasty with concentric glenoid reaming and total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2019;28(2):244-51. doi:10.1016/j.jse.2018.07.026
19. Agarwalla A, Christian DR, Liu JN, Garcia GH, Redondo ML, Yanke AB, *et al*. Return to work following isolated opening wedge high tibial osteotomy. *Cartilage*. Epub 2019 Jun 10. doi:10.1177/1947603519852417
20. Hurwit DJ, Liu JN, Garcia GH, Mahony G, Wu HH, Dines DM, *et al*. A comparative analysis of work-related outcomes after humeral hemiarthroplasty and reverse total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2017;26(6):954-9. doi:10.1016/j.jse.2016.10.004
21. Liu JN, Garcia GH, Wong AC, Sinatro A, Wu HH, Dines DM, *et al*. Return to work after anatomic total shoulder arthroplasty for patients 55 years and younger at average 5-year follow-up. *Orthopedics*. 2018;41(3):e310-e315. doi:10.3928/01477447-20180213-08
22. Puzitiello RN, Gowd AK, Liu JN, Agarwalla A, Verma NN, Forsythe B. Establishing minimal clinically important difference, substantial clinical benefit, and patient acceptable symptomatic state after biceps tenodesis. *J Shoulder Elbow Surg*. 2019;28(4):639-47. doi:10.1016/j.jse.2018.09.025
23. Garcia GH, Mahony GT, Fabricant PD, Wu HH, Dines DM, Warren RF, *et al*. Sports- and work-related outcomes after shoulder hemiarthroplasty. *Am J Sports Med*. 2016;44(2):490-6. doi:10.1177/0363546515613077
24. Garcia GH, Taylor SA, Mahony GT, DePalma BJ, Grawe BM, Nguyen J, *et al*. Reverse total shoulder arthroplasty and work-related outcomes. *Orthopedics*. 2016;39(2):e230-e235. doi:10.3928/01477447-20160119-03
25. Kujala UM, Jaakkola LH, Koskinen SK, Taimela S, Hurme M, Nelimarkka O. Scoring of patellofemoral disorders. *Arthroscopy*. 1993;9(2):159-63. doi:10.1016/s0749-8063(05)80366-4
26. Caton J, Deschamps G, Chambat P, Lerat JL, Dejour H. Patella infera. Apropos of 128 cases [in French]. *Rev Chir Orthop Reparatrice Appar Mot*. 1982;68(5):317-25.
27. Outerbridge RE, Dunlop JA. The problem of chondromalacia patellae. *Clin Orthop Relat Res*. 1975;(110):177-96. doi:10.1097/00003086-197507000-00024
28. Outerbridge RE. The etiology of chondromalacia patellae. 1961. *Clin Orthop Relat Res*. 2001;(389):5-8. doi:10.1097/00003086-200108000-00002
29. Grawe B, Stein S. Tibial tubercle osteotomy: indication and techniques. *J Knee Surg*. 2015;28(4):279-84. doi:10.1055/s-0035-1544973
30. Hoorntje A, Witjes S, Kuijjer PPFM, Koenraadt KLM, van Geenen RCI, Daams JG, *et al*. High rates of return to sports activities and work after osteotomies around the knee: a systematic review and meta-analysis. *Sports Med*. 2017;47(11):2219-44. doi:10.1007/s40279-017-0726-y
31. Ekhtiari S, Haldane CE, de Sa D, Simunovic N, Musahl V, Ayeni OR. Return to work and sport following high tibial osteotomy: a systematic review. *J Bone Joint Surg Am*. 2016;98(18):1568-77. doi:10.2106/JBJS.16.00036
32. Hoorntje A, van Ginneken BT, Kuijjer PPFM, Koenraadt KLM, van Geenen RCI, Kerkhoffs GMMJ, *et al*. Eight respectively nine out of ten patients return to sport and work after distal femoral osteotomy. *Knee Surg Sports Traumatol Arthrosc*. 2019;27(7):2345-53. doi:10.1007/s00167-018-5206-x
33. Locrotando T, Shaw KA, Jacobs JM, Bojescul JA. Return to duty following a tibial tubercle osteotomy. *J Surg Orthop Adv*. 2017;26(4):262-5.

34. Pestka JM, Feucht MJ, Porichis S, Bode G, Sudkamp NP, Niemeyer P. Return to sports activity and work after autologous chondrocyte implantation of the knee: which factors influence outcomes? *Am J Sports Med.* 2016;44(2):370-7. doi:10.1177/0363546515614578
35. Cole BJ, Cotter EJ, Wang KC, Davey A. Patient understanding, expectations, and satisfaction regarding rotator cuff injuries and surgical management. *Arthroscopy.* 2017;33(8):1603-6. doi:10.1016/j.arthro.2017.03.004
36. Oh JH, Yoon JP, Kim JY, Kim SH. Effect of expectations and concerns in rotator cuff disorders and correlations with preoperative patient characteristics. *J Shoulder Elbow Surg.* 2012;21(6):715-21. doi:10.1016/j.jse.2011.10.017
37. Tjoumakaris FP, Forsythe B, Bradley JP. Patellofemoral instability in athletes: treatment via modified Fulkerson osteotomy and lateral release. *Am J Sports Med.* 2010;38(5):992-9. doi:10.1177/0363546509357682
38. Johnson AA, Wolfe EL, Mintz DN, Demehri S, Stein BES, Cosgarea AJ. Complications after tibial tuberosity osteotomy: association with screw size and concomitant distalization. *Orthop J Sport Med.* 2018;6(10):2325967118803614. doi:10.1177/2325967118803614