

Anteromedializing Tibial Tubercle Osteotomy for Patellofemoral Instability: Occupational and Functional Outcomes in U.S. Military Service Members

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Abstract

This article sought to determine rates for return to work, pain relief, and recurrent patellofemoral instability for military service members undergoing tibial tubercle osteotomy (TTO) for persistent lateral patellar subluxation or dislocation. Patient demographic and surgical variables were isolated from the medical records of active duty service members with at least 2 years of postoperative follow-up, and correlated with return to work, pain improvement, recurrent patellofemoral instability, and perioperative complications. There were 51 service members (58 primary TTOs) with an average follow-up of 3.3 (range, 2.0–6.7) years. Service members had an average of 2.8 (1–12) instability events preoperatively. At a minimum of 2 years postoperatively, 41 (80%) military service members returned to full active duty service. Among the 58 TTOs, there was a 46% improvement in the patient-reported visual analog score from 4.1 to 2.2 ($p < 0001$). The postoperative recurrent instability rates were patellar dislocation (5.1%) and patellar subluxation (15.5%). Concomitant proximal realignment was performed in 48% of cases, which did not affect return to service, postoperative patellar instability events, or pain improvement ($p > 0.05$). The overall complication rate was 10%. Postoperative tibial fractures occurred in 6.9% of TTOs. At short- to mid-term follow-up, 80% of service members undergoing TTO for patellofemoral instability returned to military duty with significant improvement in pain scores and a moderate perioperative complication and postoperative instability rate. This study is a level IV therapeutic case series.

Keywords

- ▶ tibial tubercle osteotomy
- ▶ anteromedialization
- ▶ patellar instability
- ▶ military
- ▶ functional outcome

Lateral patellofemoral instability, which includes both subluxation and complete patellofemoral dislocation, depends on the complex interaction between the dynamic stabilizers and the static bony and soft-tissue restraints, and patellar dislocation accounts for 2 to 3% of all knee injuries.¹ The patellar dislocation incidence rate within the U.S. general

population has been reported to be between 2.3 and 6.8 per 100,000 person-years, with over half of all injuries resulting from athletic activities.^{2–4} Military service members have increased rates of patellar dislocation injuries of between 69.2 and 77.4 per 100,000 person-years, ostensibly because of their greater occupational and physical demands.^{5,6} These

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large-scale population studies have identified prior patellar dislocation,³ younger age,²⁻⁶ female sex,⁵ participation in athletic activities,^{2-4,6} soft-tissue laxity/disruption,⁶ and anthropometric measures⁶ as risk factors for patellar dislocation. Additional anatomic and radiographic risk factors associated with patellofemoral joint instability include abnormal bony anatomy^{2,7} (e.g., patella alta, trochlear dysplasia, increased tibial tubercle–trochlear groove distance, and patellar tilt) and soft-tissue factors⁶ (e.g., medial retinaculum laxity, medial patellofemoral ligament disruption, and weakened vastus medialis).

U.S. military service members must pass frequent physical fitness evaluations and perform jobs with substantial occupational demands. Organized aerobic activity, strength training and the performance of core military tasks to include marching at least 2 miles with an additional 40 pounds of equipment, participating in tactical field training, and deploying in a resource-limited environment for up to 12 months are required of military service members.⁸ Additionally, all military service members undergo scheduled semiannual physical fitness testing that includes a timed aerobic event and meeting weight and body composition standards.⁸⁻¹⁰ If a military service member cannot attain the outlined occupational and physical requirements, the service member may be medically separated from the military.

In reviewing moderately sized studies with conservative treatment of first-time patellar dislocation and greater than 2-year follow-up, the rate of repeat dislocation ranges from 17 to 49%.^{3,11-15} However, nearly 50% of patients have either pain, functional limitations, or decreased activity levels following a first-time patellar dislocation,^{2,11,13,14} and posttraumatic patellofemoral arthritis may be exceedingly common with long-term follow-up, regardless of instability recurrence.^{16,17} Given the preponderance of repeat patellar instability and suboptimal patient-reported outcomes, there is an increased interest in surgical management. A recent systematic review comparing nonoperative and operative treatment of first-time patellar dislocations found that surgical management may lower the rate of recurrent dislocation, but did not improve functional outcome scores.¹⁸ Both proximal- (e.g., lateral release, medial patellofemoral ligament reconstruction, and medial imbrications) and distally-based methods [e.g., tibial tubercle osteotomy(TTO)] have been recommended to diminish the risk of subsequent patellar instability and restore patients to athletic function.¹⁹⁻²¹ Recent literature has also emphasized the importance of recognizing and correcting axial and coronal plane malalignment, which is commonly assessed with measurement of both tibial tubercle–trochlear groove distance and quadriceps angle when considering optimal treatment algorithm.^{19,21-27} Numerous surgical procedures have been described for patellar instability including the anteromedialization of TTO as described by Fulkerson et al,²⁸ but no agreement on the optimal procedure has been reached. Anteromedialization of TTO has favorable clinical outcomes^{20,22-27,29-31} and offers the added benefits of partially correcting abnormal patellar mechanics and kinematics, unloading the patellofemoral joint, and correction of patella alta, when present.³²

The surgical and occupational outcomes of anteromedialization of TTO for patellofemoral instability within a high-demand, athletic military cohort have not been investigated. The purpose of this study was to determine rates for return to work; pain relief; recurrent patellofemoral instability; and perioperative complications in a large, homogeneous, active population following anteromedialization of TTO for patellofemoral instability with a minimum of 2 years of occupational outcome. We hypothesize that anteromedialization of TTO predictably decreases knee pain and recurrent patellofemoral instability events in a cohort of military service members and allows them a reliable return to previous lower extremity function.

Methods

After institutional review board approval, the Military Health System Management Analysis and Reporting Tool (M2) database was queried to identify active duty service members who underwent a TTO (Current Procedural Terminology Code 27418) for patellofemoral instability or recurrent patellar dislocations (International Classification of Diseases, Ninth Revision codes 836.3, 836.4, 718.36) at any military facility between 2006 and 2012. Inclusion criteria were active duty members of the U.S. Army, Navy, Marines, or Air Force with the primary diagnosis of patellofemoral instability or recurrent patellar dislocation with at least 2 years of postoperative follow-up. Exclusion criteria were applied to nonactive duty status, cases of lateral maltracking without a documented instability event, individuals with less than 2 years of clinical follow-up, and non-TTO periarticular osteotomies about the knee. All TTO cases were described as anteromedializing procedures of the tibial tubercle within the medical record. Additionally, concomitant surgical procedures including medial patellofemoral ligament reconstruction, lateral release, and medial reefing were identified and classified as proximal realignment procedures for subsequent analysis. When available, additional data regarding physical and radiographic findings such as the quadriceps angle and tibial–tubercle trochlear groove distance were extracted from the medical record.

The U.S. Department of Defense electronic health record (Armed Forces Health Longitudinal Technology Application [AHLTA], version 3.3) was queried to confirm the accuracy of the Current Procedural Terminology Code coding of incident TTO for each service member previously identified in the M2 database. Demographic information including laterality, sex, age, body mass index (BMI), tobacco use, military rank, number of preoperative patellar instability events, and prior ipsilateral knee surgery were recorded (► **Table 1**). The incidence and types of perioperative complications following patellofemoral surgery were recorded. Rank groups were classified as either junior rank (junior enlisted service members [E1–E6]) or senior rank (senior enlisted noncommissioned officers [E7–E9]; warrant officers [WO1–WO5]; and commissioned officers [O1–O6]).

The outcomes analyzed were the current military status of the service member 2 years or more following TTO for patellofemoral instability, changes in visual analog scores

Table 1 Risk factors for medical separation following tibial tubercle osteotomy for patellofemoral instability ($N = 51$ service members)

	Patients, <i>n</i> (%)	Medical separation, <i>n</i> (%)	No medical separation, <i>n</i> (%)	OR (95% CI)	<i>p</i> -Value
Sex					
Male	27 (53)	3 (11)	24 (89)	0.30 (0.07–1.35)	0.1165
Female	24 (47)	7 (29)	17 (71)	–	
Rank group					
Junior rank (E1–E6)	34 (67)	7 (21)	27 (79)	1.21 (0.27–5.42)	0.8032
Senior rank (E7 and above)	17 (33)	3 (18)	14 (82)	–	
Age					
< 29	32 (63)	9 (28)	23 (72)	7.04 (0.82–60.8)	0.076
≥29	19 (37)	1 (5)	18 (95)	–	
Tobacco use					
Yes	12 (24)	4 (33)	8 (67)	2.75 (0.63–12.1)	0.181
No	39 (76)	6 (15)	33 (85)	–	
Preoperative instability events					
1	9 (18)	1 (11)	8 (89)	–	
≥ 2	42 (82)	9 (21)	33 (79)	2.18 (0.24–19.8)	0.4882
Bilateral procedure					
Yes	7 (14)	1 (14)	6 (86)	0.65 (0.07–6.09)	0.7044
No	44 (86)	9 (20)	35 (80)	–	
Chondral repair/reconstruction					
Yes	3 (6)	0 (0)	3 (100)	0.52 (0.02–17.2)	0.7166
No	48 (94)	10 (21)	38 (79)	–	
Prior procedure					
Yes	9 (18)	0 (0)	9 (100)	0.16 (0.01–3.54)	0.2481
No	42 (80)	10 (24)	32 (76)	–	
BMI					
≤ 25	21 (41)	7 (33)	14 (67)	4.5 (1.01–20.1)	0.0492
> 25	30 (59)	3 (10)	27 (90)	–	
BMI continuous				0.84 (0.68–1.04)	0.1119
Total	51	10 (20)	41 (80)		

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

(VAS) and occurrence of postoperative patellar instability. The VAS are a verbal subjective pain value reported by the patient at a value from 0 to 10 and scores were documented at the time of the original patient encounter and at the final orthopedic clinic visit. Previous studies have defined an improvement of two points or a 30% reduction in the VAS score as a clinically significant difference.^{33–35} Postoperative patellar instability includes patellofemoral dislocations or subluxations as documented in the medical note.

The occupational requirements of military service members are described in detail within the standards of medical fitness for the Air Force, Army, and Navy.^{8–10} The Physical Profile (DA 3349) within the e-Profile electronic profiling system (version 3.17, Medical Operational Data System, Falls

Church, VA) is used to record all physical duty limitations in addition to final medical separations. All military service members in the TTO for patellofemoral instability cohort with documented initiation of a knee-related medical separation after TTO were identified and cross-referenced using the electronic medical record, U.S. Physical Disability Agency database, or the e-Profile system, and these individuals were classified as clinical failures for the current study.

Univariate analysis was used to assess the relationship between the independent patient demographic and surgical characteristic variables and the outcomes of a service member being medically separated, postoperative patellar dislocation and subluxation events and change in VAS. Significant independent predictor variables were established as those that

sustained *p*-values less than 0.05 with odds ratio (OR) and 95% confidence interval (CI) exclusive of 1. SAS software, version 9.4 (SAS Institute, Cary, NC), was used to perform all calculations.

Results

A total of 51 active duty military service members were identified with 58 knees undergoing anteromedialization of TTO for patellofemoral instability (44 unilateral, 7 bilateral). The mean age of the patients at the time of TTO was 28.1 (standard deviation [SD]: 7.01, range: 20–56) years, while the average BMI was 26.2 kg/m² (SD: 3.8, range: 19–36). At the time of surgery, patients had an average of 2.8 (range: 1–12) patellar dislocation or subluxation events. The majority of patients were male (53%), were younger than 29 years (63%), had BMI greater than 25 kg/m² (59%), were junior rank group (67%), had 2 or more preoperative instability events (82%), did not use tobacco (76%), and underwent a unilateral TTO (86%; ►Table 1). The average follow-up from the time of surgery was 3.3 (SD: 15.5, range: 2.0–6.7) years. Those patients who underwent bilateral staged TTO procedures had an average time interval of 11.8 months (SD: 13.9, range: 0–36). There were 10 knees in 9 service members who underwent a prior ipsilateral knee surgical procedure, including 7 diagnostic knee arthroscopies, 2 meniscal repairs, and 1 anterior cruciate ligament reconstruction. Distinct patellofemoral cartilage defects were noted in 16 patients (8 medial patellar facet, 3 lateral femoral condyle, 3 central patellar, and 2 trochlear lesions), and 7 of these lesions were of high grade (e.g., Outerbridge,³⁶ grade 3 or 4). Cartilage restoration procedures that were concurrently performed with TTO included two autologous chondrocyte implantation and one particulated juvenile allograft cartilage procedure. Fixation of each TTO was achieved with two screws (78%) or three screws (22%). The quadriceps angle averaged 19.8 degrees (SD: 3.9, range: 12–26) for the 17 knees for which it was available. The tibial-tubercle trochlear groove distance was available for 21 knees and averaged 18.3 mm (SD: 4.5, range: 12–26).

At a minimum occupational follow-up period of 2 years postoperatively, 41(80%) military service members returned to full active duty service or fulfilled their remaining service obligations, while 10 (20%) were medically separated secondary to persistent, rate-limiting knee symptoms. Univariate analysis revealed that BMI ≤ 25 was the only significant predictor of medical separation following anteromedialization of TTO (OR = 4.50; 95% CI: 1.01, 20.14; *p* = 0.49; ►Table 1).

The average VAS pain score demonstrated a significant improvement from 4.1 (SD: ± 2.1, range: 0–9) at baseline to 2.2 (SD: ± 1.6, range: 0–6) postoperatively (*p* < 0.0001). Improvements in the pain scores following anteromedializing TTO were similar regardless of patient's sex, age, BMI, tobacco use, military rank group, number of preoperative patellar instability events, unilateral versus bilateral procedure, or occurrence of a previous ipsilateral knee procedure (►Table 2). Of the 58 knees undergoing anteromedialization of TTO, there were a total of 12 (21%) knees with at least 1 postoperative patellar instability event at final follow-up,

including 1 of 12 patients with a concomitant medial patellofemoral ligament reconstruction: 9 (15.5%) cases of recurrent patellar subluxation and 3 (5.2%) cases of documented patellar dislocation. All of these patients were managed nonoperatively with a period of bracing and physical therapy. There were no statistically significant associations between postoperative patellofemoral instability events and patient-based surgical characteristics (►Table 2).

The anteromedialization of TTO was performed in conjunction with a concomitant proximal realignment procedure in 28 of the 58 knees (48%) and included 14 isolated lateral releases, 10 isolated medial patellofemoral ligament reconstructions, 2 medial reefing procedures, and 2 medial patellofemoral ligament reconstructions combined with a lateral release (►Table 3). When comparing isolated anteromedializing TTO patients to those who had an anteromedializing TTO with a concomitant proximal realignment procedure, there was no difference in medical separation (OR = 3.03; 95% CI: 0.71, 12.8; *p* = 0.13), VAS (OR = 0.04; 95% CI: -1.13, 1.21; *p* = 0.95), or the presence of postoperative instability (OR = 2.18; 95% CI: 0.58, 8.27; *p* = 0.25; ►Table 3).

Among the 58 knees undergoing anteromedialization of TTO for patellofemoral instability, there were 4 major local complications (6.9%) and 2 minor local complications (3.4%; ►Table 3). The major complications included three postoperative fractures through the osteotomy site and one fracture through the patellar medial patellofemoral ligament anchor site, and two of these knees subsequently underwent open reduction and internal fixation. The minor complications included one case of postoperative arthrofibrosis successfully treated with manipulation under anesthesia and arthroscopic lysis of adhesions and one case of a superficial wound infection uneventfully treated with oral antibiotics. Additionally, 16 patients (31%) had hardware-related symptoms that resolved with hardware removal. No patients underwent a secondary patellofemoral realignment procedure.

Discussion

When compared with the civilian population, a young, athletic cohort of U.S. military service members has a greater than 10-fold higher risk for patellofemoral instability due to their moderate- to high-demand occupational profile.^{5,6} The current investigation sought to evaluate the functional and occupational outcomes within a military cohort following anteromedialization of TTO and has considerable merit, as these service members following rehabilitation are again subjected to and must meet the demanding physical fitness and occupational demands required of military service that bestows an ongoing increased risk of patellofemoral instability. The rate of return to preoperative function among military patients following anteromedialization of TTO for patellofemoral instability is 80% at a minimum of 2-year follow-up, and this can be deemed moderately successful considering their medium to very heavy³⁷ occupational demands.^{38,39} By comparison, a study of 36 civilian patients with anteromedialization of TTO for patellar maltracking reported that only 44% of patients returned to moderate or

Table 2 Subjective VAS scores and postoperative instability events following TTO for patellofemoral instability ($N = 58$ knees)

	Knees, n	Mean pain score preoperative	Mean pain score postoperative	Mean difference (95% CI)	p -Value	Instability events ≥ 1	OR (95% CI)	p -Value
Sex								
Male	31 (53)	3.7	2	1.7 (0.9–2.6)	0.3163	5 (19)	Referent	–
Female	27 (47)	4.7	2.4	2.3 (1.5–3.1)	–	7 (29)	1.81 (0.49–6.72)	0.3742
Rank group								
Junior rank (E1–E6)	39 (67)	4.3	2.2	2.0 (1.3–2.7)	0.8341	7 (21)	Referent	–
Senior rank (E7 and above)	19 (33)	3.9	2	1.9 (0.8–3.0)	–	5 (29)	1.61 (0.42–6.10)	0.4856
Age								
< 29	36 (62)	4.1	2.3	1.8 (1.1–2.6)	0.5138	5 (16)	Referent	–
≥ 29	22 (38)	4.2	2	2.2 (1.3–3.2)	–	7 (37)	3.15 (0.83,11.9)	0.0918
Tobacco use								
Yes	15 (26)	3.7	2.6	1.1 (–0.3–2.4)	0.061	2 (17)	0.58 (0.11–3.11)	0.525
No	43 (74)	4.3	2	2.3 (1.7–2.9)	–	10 (26)	Referent	–
Preoperative instability events								
1	9 (16)	5.3	2.2	3.1 (0.7–5.5)	0.095	3 (33)	1.83 (0.38–8.81)	0.4491
≥ 2	49 (84)	3.9	2.2	1.8 (1.2–2.3)	–	9 (21)	Referent	–
Bilateral procedure								
Yes	14 (24)	3.6	1.6	2.0 (1.0–3.0)	0.9736	0 (0)	0.17 (0.01–3.97)	0.2726
No	44 (76)	4.3	2.4	2.0 (1.3–2.7)	–	12 (27)	Referent	–
Chondral repair/reconstruction								
Yes	3 (5)	6	1.7	4.3 (2.9–5.8)	0.0572	1 (33)	1.68 (0.14–20.4)	0.6824
No	55 (95)	4.1	2.2	1.9 (1.3–2.4)	–	11 (23)	Referent	–
Prior procedure								
Yes	10 (17)	3.5	2.4	1.1 (–0.7–2.9)	0.1659	1 (11)	0.35 (0.04–3.15)	0.3504
No	48 (83)	4.3	2.1	2.2 (1.6–2.8)	–	11 (26)	Referent	–
BMI								
≤ 25	23 (40)	4.7	2.6	2.1 (1.1–3.1)	0.683	6 (29)	1.60 (0.44–5.89)	0.4794
> 25	35 (60)	3.8	1.9	1.9 (1.1–2.6)	–	6 (20)	Referent	–
BMI continuous				–			1.06 (0.90–1.25)	0.4861
Total	58					12		

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; TTO, tibial tubercle osteotomy; VAS, visual analog score.

heavy labor, although this failed to classify the patient's preoperative occupational demand level.²⁹ The only significant risk factor for medical separation following anteromedialization of TTO was BMI ≤ 25 . However, the clinical significance of this finding is difficult to ascertain because of the narrow BMI range evidenced by a standard deviation of 3.8 kg/m² within the military cohort.

Among the 58 knees that underwent an anteromedialization of TTO procedure for patellofemoral instability, there was statistically significant decrease in the patient-reported VAS of 46% ($p < 0.0001$), which would be deemed a clinically important improvement.^{33–35} A recent meta-analysis concerning operative compared with nonoperative management of recurrent patellar dislocation patients found that a significantly higher rate of operative patients experienced no postoperative pain.⁴⁰ Additionally, VAS improvements following anteromedialization of TTO were similar across all demographic and surgical variables that were analyzed.

The postoperative patellar instability rates in military service members with a minimum of 2-year follow-up when reviewing all knees were patellar dislocation (5.2%) and patellar subluxation (15.5%), for a total of 21%. Previous reports of anteromedialization of TTO for patellofemoral instability, including subluxation, have reported postoperative patellar instability rates between 6.0 and 16.9%.^{26,27,30} Previously reported rates of dislocation after distal realignment procedures range from 1.5 to 15.2%.^{19,23,26,27,30,31}

Concomitant proximal soft-tissue procedures were performed in 48% of the knees in the current investigation. When comparing isolated anteromedializing TTO knees to those knees that underwent an anteromedializing TTO with a concomitant proximal realignment procedure, medical separation (27 vs. 11%) and postoperative patellar instability events (27 vs. 14%) occurred more frequently among the isolated anteromedializing TTO knees, although this failed to achieve statistical significance. Medial patellofemoral ligament

Table 3 Medical separation, VAS score improvement, postoperative instability events, and complications with and without concomitant procedures (N = 58 knees with TTO)

	Knees	Medical separation, n (%)	OR (95% CI), p-value	Mean improvement in VAS score	Mean difference (95% CI), p-value	Postoperative instability events ≥ 1 n (%)	OR (95% CI), p-value	Complications
No proximal realignment	30	8 (27)	3.03 (0.71–12.9), 0.1327	2	0.04 (–1.13–1.21), 0.9515	8(27)	2.18 (0.58–8.27), 0.2511	3
Proximal realignment (referent)	28	3 (11)	Reference group	1.96	Reference group	4 (14)	Reference group	3
MPFL reconstruction	10	2		2.1		1		2
MPFL reconstruction + lateral release	2	0		3.5		0		0
Medial reefing	2	0		0.5		0		0
Open lateral release	1	0		2		0		0
Arthroscopic lateral release	13	1		1.9		3		1
Total	58	11^a			1.98 (1.4–2.6), <0.0001	12		6

Abbreviations: BMI, body mass index; CI, confidence interval; MPFL, medial patellofemoral ligament; OR, odds ratio; TTO, tibial tubercle osteotomy; VAS, visual analog score.

^aThis value includes those 10 patients medically separated which included one patient undergoing bilateral procedures.

reconstruction with adjunctive TTO has been shown to be a more aggressive intervention that may be more prudent in cases with increased tibial tubercle–trochlear groove distance or severe trochlear dysplasia.^{24,25} A systematic review of complications following TTO included 188 patients who underwent concomitant medial patellofemoral ligament reconstruction and showed significant improvements in clinical outcome measures in all studies, with reported failures less than 9%.²⁴ Similarly, in this study, only 1 of the 12 patients with anteromedialization of TTO and concomitant medial patellofemoral ligament reconstruction experienced patellar subluxation, and there were no cases of subsequent dislocation. Additionally, 14 patients, all with preoperative patellar tilt, underwent an anteromedialization of TTO performed with a concurrent lateral release, which has been reported to have good results in the management of patellofemoral instability and may facilitate transfer of the tibial tubercle.^{31,41} Patellar realignment solely by lateral release is not recommended, as it has failed to improve anterior knee pain and instability at long-term follow-up.⁴² The decision to treat patellofemoral instability with TTO and a concurrent proximal soft-tissue procedure or reconstruction must balance the factors causing patellofemoral instability pain, loss of function, and risk of recurrence against the potential morbidity of the combined procedure.

A total of four knees sustained a postoperative fracture following anteromedialization of TTO with two (5.2%) occurring at the distal osteotomy hinge and one (1.7%) at the patellar anchor site in a patient with a concomitant medial patellofemoral ligament reconstruction. Studies of greater than 190 anteromedializing TTOs have reported postoperative proximal tibia fracture rates of 1.0 to 2.6%.^{43,44} In a systematic review including 787 TTOs investigating postoperative complications, Payne et al⁴³ had an overall complication risk of 4.6% and found

the risk of any complication was increased when the periosteal hinge of the tibial tubercle was completely detached prior to fixation. In this study, all patients who sustained a postoperative fracture did so while being engaged in a sporting activity less than 8 weeks after TTO. The complications of immediate weight bearing and premature athletic activity after TTO have been described in previous studies.^{43–45} This complication can be avoided with appropriate preoperative counseling on activity restrictions coupled with patient compliance, as well as bicortical screw fixation of the osteotomy.⁴⁶ In this study, 31% of service members experienced symptomatic hardware at the osteotomy site, all of who underwent subsequent surgical removal with symptomatic relief. The military population may experience a high rate of painful hardware symptoms following anteromedialization of TTO due to frequent kneeling, crawling, squatting, or other load-bearing activities related to their military occupation.

It is noteworthy that the military service members treated with a TTO for persistent lateral patellar subluxation or dislocation were treated by multiple surgeons over the course of the study. In the past decade, treatment algorithms have evolved to where skeletally mature individuals with recurrent patellar instability and a normal patellar height, tilt, tubercle–trochlear groove distance without trochlear dysplasia are likely best served with an isolated medial patellofemoral ligament reconstruction.²¹ Based on the risk–benefit profile of the anteromedialization of TTO, the authors currently advocate for its use primarily in those patients with a high tibial tubercle–trochlear groove distance (>15 mm) and/or significant trochlear dysplasia with persistent lateral maltracking, potentially augmenting it with a medial patellofemoral ligament reconstruction to diminish subsequent risk of further instability.

Limitations

This study has several limitations, many of which are due to its retrospective nature. Mechanical axis alignment and tibial tubercle–trochlear groove distance could not be evaluated as standing anterior/posterior lower extremity full-length radiographs and axial magnetic resonance imaging/computed tomography scans were inconsistently available for all patients. This includes the quantity and quality of information that could be reliably extracted from preexisting medical records, including radiographic images, operative findings such as lesion-specific variables (e.g., medial patellofemoral ligament integrity), and involved surgical technique (e.g., degree of tibial tubercle translation, use of bone graft), and radiographic measurements (e.g., patellar height, tibial tubercle–trochlear groove distance). Any prospectively gathered outcome scores were also not available. Additionally, a military population has generally required nonmodifiable physical and occupational demands that may be difficult to perform following anteromedialization of TTO. Therefore, a service member may pursue a disability-associated medical separation as a protective measure to prevent further disability that would prevent civilian occupations as well.

Conclusion

In summary, this is the sole investigation consisting of a homogeneous patient cohort with moderate to heavy work demands undergoing TTO for patellofemoral instability, with a minimum of 2-year postoperative follow-up. After TTO, 80% of service members successfully returned to preoperative function or completed their military service. Postoperatively, patellar instability occurred in 21% of service members, whereas 6.9% of TTOs were complicated by a postoperative osteotomy fracture.

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