Original Article

Senior Military Rank Is Associated With Higher Rates of Return to Running and Unrestricted Activity Among Military Servicemembers After Surgical Repair of Patellar Tendon Rupture at 1-Year Follow-up

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Purpose: To evaluate 1-year outcomes in active-duty servicemembers who underwent patellar tendon rupture repair and to identify baseline variables associated with return to activity. **Methods:** We performed a retrospective review of all active-duty servicemembers undergoing primary patellar tendon rupture repair between 2009 and 2014. All patients had a minimum 12-month follow-up. Demographic variables were recorded, as well as ability to return to impact activities and remain on active-duty status. Rates of recurrent rupture and revision surgery were identified. Univariate analysis was performed to assess relations between outcomes and baseline variables. **Results:** A total of 123 patients met the inclusion criteria (average age, 33.5 ± 6.6 years; 99% male patients) with a mean follow-up period of 4.3 ± 2.2 years. Whereas 67.4% of patients returned to running at an average of 8.3 months from index surgery, only 42.4% of patients resumed unrestricted occupational function. Higher rates of return to running were observed among patients with senior military rank ($P = .046$). Senior military rank was also associated with a higher rate of return to unrestricted active-duty status ($P = .006$). Logistic regression analysis showed an association between postoperative pain (odds ratio [OR], 0.684; 95% confidence interval [CI], 0.56-0.84; $P < .001$) and return to running, between postoperative pain (OR, 0.77; 95% CI, 0.60-0.98; $P = .033$) and return to active duty, and between rank (OR, 2.06; 95% CI, 1.04-4.07; $P = .037$) and return to active duty. Patients who sustained injuries during deployment had a higher rate of recurrent rupture (26.1% vs 9.3%, $P = .028$). **Conclusions:** At 1-year follow-up, approximately two-thirds of military servicemembers undergoing primary patellar tendon repair had returned to running after surgery, whereas fewer than one-half returned to full military duty. Younger age and more senior military rank were associated with higher rates of return to running. Additionally, servicemembers of higher rank, particularly officers, had statistically higher rates of return to unrestricted activity. **Level of Evidence:** Level IV, therapeutic case series.

Patellar tendon rupture (PTR) is a debilitating injury that often requires surgical repair. Among military servicemembers, PTRs accounted for 23% of all major tendon ruptures, second only to Achilles tendon ruptures.[1] Previous studies have shown that among nonmilitary populations, PTR repair results in satisfactory outcomes.[2-5]

Although PTR represents a relatively common injury, few studies in the literature have reported outcomes of surgical treatment in military populations. In a case

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series, Enad and Loomis[6] evaluated outcomes among 13 active-duty servicemembers who underwent surgical repair and observed that 12 of 13 servicemembers returned to full duty at an average of 13 months postoperatively, with good to excellent functional outcomes reported in 61.5% of patients. More recently, Fredericks et al.[7] retrospectively evaluated the incidence of PTR and rerupture rates among servicemembers. They observed an incidence rate of 6 per 100,000 person-years and found that most patients were able to return to previous levels of activity. However, assessments of the outcomes at 1-year minimum follow-up have not previously been undertaken, and functional outcomes have not been well articulated in the military population.

The purposes of this study were to evaluate 1-year outcomes in active-duty servicemembers who underwent PTR repair and to identify baseline variables associated with return to activity. We hypothesized that there would be a high rate of return to military duties with a low complication profile.

Methods

After institutional review board approval was obtained, all military servicemembers and beneficiaries receiving direct or purchased care through the Military Health System between 2009 and 2014 were retrospectively reviewed using the Military Health System Management Analysis and Reporting Tool (M2) databases. Patient undergoing patellar tendon repair at military treatment facilities were identified through Current Procedural Terminology codes (27385, 27386, and 27380) combined with *International Classification of Diseases, Ninth Revision* codes (M66.261, M66.262, M66.269, 727.66, 844.8, and 891.2) for diagnoses related to PTR or tear.

The study inclusion criteria were defined as active-duty servicemembers aged 18 to 60 years who sustained PTR with subsequent patellar tendon repair and had a minimum of 1 year of clinical follow-up. Patients were excluded if they were not on active-duty status, underwent a procedure other than patellar tendon repair, underwent concomitant multiligamentous knee reconstruction, underwent prior ipsilateral knee surgery or patellar tendon repair, and/or had less than 1-year clinical follow-up.

Patient Demographic Variables and Postoperative Outcomes

Four investigators (N.N., C.M., C.W., and K.A.S.) performed an independent, retrospective electronic medical record review of clinical encounters from the Armed Forces Health Longitudinal Technology Application to confirm clinical diagnoses and treatment interventions. Patient demographic and surgical variables were also collected, including age, sex, military status, military occupation, self-reported pain score on a visual analog scale (VAS), perioperative complications, development of secondary patellar osteoarthritis (OA), and concomitant or subsequent surgical procedures. Radiographic osteoarthritis (OA) was identified using anteroposterior-, lateral-, and sunrise-view radiographs of the knee, which were independently reviewed by 1 author (K.A.S.). Surgical failure was defined as subsequent PTR, need for secondary surgery, knee-related impact activity restriction, or knee-related medical discharge from the military (Medical Evaluation Board). Given the specific, often physically demanding nature of military service, each branch of the armed forces uses semiannual physical fitness tests and biometric data collection to ascertain readiness for military duties. Servicemembers who are unable to satisfy these physical requirements are either provided with a profile limiting their fitness activities or medically discharged from military service. Medical discharge data were identified using Physical Evaluation Board assessment to determine fit-for-duty status. Patients who finished their military commitment prior to separation were not classified as having a knee-related medical discharge from the military.

Statistical Analysis

All statistical analyses were performed using SAS software, version 9.4 (SAS Institute, Cary, NC). The study outcomes of interest were the rates of unrestricted military retention, return to running, and subsequent failure after primary patellar tendon repair. Univariate analysis was used to determine the association between independent patient variables and postoperative functional outcomes of servicemembers. A stepwise backward and forward propagation multivariate logistic regression model was used for multivariate analysis. Patient demographic variables were further stratified by age (<30 years, 30-40 years, and >40 years) and military rank (junior enlisted servicemembers [<E5], senior enlisted officers [E5-E9], and officers [>E9]). All statistical tests were 2 tailed, and the statistical difference was established at a 2-sided α level of .05 ($P < .05$). Averages are reported as mean ± standard deviation unless stated otherwise.

Results

Of the 525 patients identified by database review, 123 met the inclusion criteria (average age, 33.5 ± 6.6 years; 122 male patients), with an average follow-up period of 4.3 ± 2.2 years. A summary of demographic variables is provided in Table 1. Patients were excluded chiefly for errors in database coding, followed by patellar debridement and/or repair for patellar tendinitis or enthesopathy, insufficient follow-up, and/or revision surgery (Fig 1). The thickness and location of patellar tendon tears were documented in 58 patients

Table 1. Demographic Variables of Included Military Servicemembers Undergoing Primary Patellar Tendon Repair

Variable	Data
Age, mean ± SD, yr	33.5 ± 6.6
Age category, n (%)	
<30 yr	34 (27.6)
30-40 yr	72 (58.6)
>40 yr	17 (13.8)
Sex, n (%)	
Male	122 (99)
Female	1 (1)
Rank, n (%)	
Junior enlisted (<E5)	31 (25.2)
Senior enlisted (E5-E9)	71 (57.7)
Officer (>E9)	21 (17.1)
Follow-up, mean ± SD, yr	4.3 ± 2.2
Time to diagnosis, mean ± SD, d	17.5 ± 111.7
Time from injury to surgery, mean ± SD, d	23.1 ± 117.5
Injured while deployed, n (%)	22 (17.9)
Return to running, n (%)	83 (67.5)
Time to return to running, mean ± SD, d	249.7 ± 170.2
Return to duty, n (%)	39 (42.4)
Development of patellofemoral osteoarthritis, n (%)	48 (39)
Final VAS pain score, mean ± SD	1.8 ± 2.1
Recurrent patellar tendon tear, n (%)	15 (12.2)
Reoperation, n (%)	17 (13.8)
Postoperative extensor lag correction	3
Manipulation under anesthesia	3
Acute rerupture treatment	6
Repair revision	1
Scar revision	1
Other	3

SD, standard deviation; VAS, visual analog scale.

and 44 patients, respectively. Complete, full-thickness PTRs were found in 81% of these patients; of the tears, 73% were proximal, 9% were midsubstance, and 18% were distal. The average time from injury to surgical repair was 23.1 ± 117.5 days, with an average of 16.4 ± 27.0 days for deployed servicemembers and 24.6 ± 129.9 days for those not deployed.

Return to Running and Return to Duty

Overall, 67.5% of servicemembers (n = 83) were able to return to running at an average of 8.3 ± 0.5 months from the index procedure. Rank and age were associated with the ability to return to running (Table 2). Commissioned officer status was associated with a higher likelihood of returning to running compared with enlisted soldier status (90.5% vs 62.8%, $P = .013$). When rank was subdivided into junior enlisted servicemembers versus senior enlisted servicemembers versus officers, officers showed superior rates of return to running as compared with junior-ranking soldiers ($P = .033$) (Table 2). A comparison of postoperative pain showed a significantly higher average VAS pain score among servicemembers who did not return to running when compared with those who did (2.9 ± 2.1 vs 1.2 ± 2.0, $P < .001$). Finally, logistic regression showed that only final pain score (odds ratio [OR], 0.684; 95% confidence interval [CI], 0.56-0.84; $P < .001$) was statistically associated with return to active duty.

Despite the ability to return to running, only 42.4% of servicemembers (n = 39) were able to return to full, unrestricted military duty by final follow-up. Military rank at the time of injury was the only variable associated with ability to return to duty, with officers showing a significantly higher rate than enlisted soldiers (77.8% vs 33.8%, $P < .001$) (Table 3). With further stratification of enlisted rank into junior and senior enlisted status, officer rank was significantly associated with a higher rate of return to unrestricted function ($P = .006$). The average VAS pain score was higher among military members who did not return to duty than among those who did (2.1 ± 1.9 vs 1.1 ± 2.1, $P = .038$). Finally, logistic regression showed that both final pain score (OR, 0.77; 95% CI, 0.60-0.98; $P = .033$) and rank (OR, 2.06; 95% CI, 1.04-4.07; $P = .037$) were statistically associated with return to active duty.

Patellar Tendon Rerupture and Surgical Morbidity

Recurrent PTRs developed in a total of 15 patients (12.2%) at an average of 303.1 ± 10.1 days, and 17 patients (13.8%) underwent subsequent surgical revision (Table 4). Servicemembers in whom the injury occurred at the time of deployment had higher rates of recurrent rupture (40% vs 16%, $P = .028$). However,

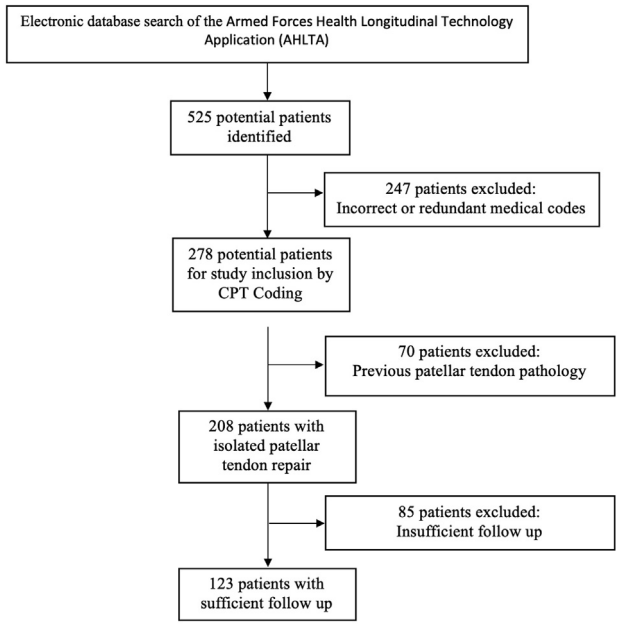

Fig 1. Flowchart of patients meeting inclusion and exclusion criteria and those lost to follow-up. (CPT, Current Procedural Terminology.)

Table 2. Statistical Analysis of Factors Associated With Return to Running After Patellar Tendon Repair

	Return to Running		
	Yes	No	*P* Value
Age, mean ± SD, yr	33.3 ± 6.4	34.1 ± 6.9	.491
Age category, n (%)			.233
<30 yr	26 (31.3)	8 (20)	
30-40 yr	48 (57.9)	24 (60)	
>40 yr	9 (10.8)	8 (20)	
Rank, n (%)			.046*
Junior enlisted	20 (24.1)	11 (28.2)	
Senior enlisted	44 (53)	27 (69.2)	
Officer	19 (22.9)	1 (2.6)	
Deployed during initial injury, n (%)	15 (18.1)	8 (20)	.489
VAS pain score at final follow-up, mean ± SD	1.2 ± 2.0	2.9 ± 2.1	<.001*

SD, standard deviation; VAS, visual analog scale.
*Statistically significant ($P < .05$).

age and military rank were not significantly associated with risk of recurrent rupture after primary PTR. Finally, logistic regression showed that injury at the time of deployment (OR, 3.41; 95% CI, 1.07-10.84; $P = .038$) was statistically associated with rerupture. At final follow-up, 39% of soldiers had radiographic evidence of patellofemoral OA, with development after 3.4 ± 1.9 years on average.

Discussion

The main finding of this study was that approximately two-thirds of military servicemembers returned to running after PTR repair. However, fewer than half of the current subset returned to unrestricted military duty. Those who returned to running were statistically younger and had a greater preponderance of higher military ranks than those who did not return to running. Comparison of return to active duty showed that servicemembers who returned were more likely to be of officer or senior enlisted rank than servicemembers who were not able to continue serving. Finally, deployed status at the time of injury was associated with an increased rate of recurrent PTR, and older age at the time of rupture was associated with a higher rate of patellofemoral OA development.

There is current evidence in the literature that shows that superior functional outcomes are achievable in athletes and very active patients undergoing surgical intervention for PTR. Studies have reported return-to-play and return-to-baseline rates between 52% and 100% among professional athletes.[3,4,6,8] The existing literature assessing the effect of PTR repair on return to military duty, however, is limited to only several small case series. In one such study, Enad and Loomis[6] reported the functional outcomes of 13 active-duty servicemembers undergoing primary surgical repair and rehabilitation according to an early range-of-motion protocol. Of the servicemembers, 12 (92%) were able to return to full duty at an average of 13 months after surgery, with good to excellent functional outcomes reported in 61.5% of patients. Although the rate of return to running in our study is comparable to return-to-play rates in athletes, the rate of return to active duty is lower. The lower rate of return to active duty may be explained by variables including age, enlisted rank, and assigned military position at the time of return, as well as longer length of follow-up from index surgery.

Prior studies in the sports literature have indicated that junior enlisted servicemembers have inferior outcomes after autologous chondrocyte implantation and tibial tubercle osteotomy for patellofemoral chondral defects and posterior cruciate ligament reconstruction.[8,9] Tucker et al.[8] evaluated the outcomes of active military patients who underwent surgical reconstruction of the posterior cruciate ligament and observed that servicemembers with lower enlisted ranks had inferior clinical outcomes compared with their more senior counterparts. In a case series in which ability to return to duty and outcomes were evaluated among military servicemembers undergoing autologous chondrocyte implantation and tibial tubercle osteotomy for patellofemoral chondral defects, Zarkadis et al.[10] found that junior rank was predictive of lower occupational outcomes. The results of our study support the association observed between rank and surgical outcomes in previous studies, which is likely due to higher levels of activity and combat experienced by junior-ranking members when compared with officers and more senior-ranking military members. Senior enlisted or officer status is also associated with a greater capacity to modify occupational physical activity and the workplace environment relative to lower-ranking

Table 3. Statistical Analysis of Return to Duty After Patellar Tendon Repair

	Return to Duty		
	Yes	No	*P* Value
Age, mean ± SD, yr	32.7 ± 6.8	33.1 ± 5.7	.742
Age category, n (%)			.829
<30 yr	13 (31.7)	16 (31.4)	
30-40 yr	25 (61)	29 (56.9)	
>40 yr	3 (7.3)	6 (11.8)	
Rank, n (%)			.006*
Junior enlisted	9 (22)	19 (37.3)	
Senior enlisted	18 (43.9)	28 (54.9)	
Officer	14 (34.1)	4 (7.8)	
Deployed during initial injury, n (%)	5 (12.2)	9 (17.6)	.583
VAS pain score at final follow-up, mean ± SD	1.1 ± 2.1	2.1 ± 1.9	.038*

SD, standard deviation; VAS, visual analog scale.
*Statistically significant ($P < .05$).

Table 4. Statistical Analysis of Postoperative Recurrence After Patellar Tendon Repair

	Recurrence		
	Yes	No	*P* Value
Age, mean ± SD, yr	31.6 ± 6.3	33.9 ± 6.6	.212
Age category, n (%)			.495
<30 yr	6 (40)	28 (26.7)	
30-40 yr	8 (53.3)	61 (58.1)	
>40 yr	1 (6.7)	16 (15.2)	
Rank, n (%)			.354
Junior enlisted	6 (40)	24 (22.9)	
Senior enlisted	7 (46.7)	61 (58.1)	
Officer	2 (13.3)	20 (19)	
Deployed during initial injury, n (%)	5 (33.3)	11 (10.5)	.183
Secondary patellofemoral osteoarthritis, n (%)	3 (20)	45 (42.9)	.107

SD, standard deviation.

servicemembers. Additionally, higher levels of strenuous activity may lead to more pain, which was observed in patients who did not return to running or active duty.

In this study, there was a statistically significant increase in the revision rate among servicemembers who underwent PTR repair while deployed. Although surgical case load was not evaluated in this study, there may be an association between a reduced case load among active-duty surgical teams and poor patient outcomes.[11,12]

Existing studies have evaluated the association between high-demand occupational burden, as required in professional athletics or military service, and the development of tibiofemoral and patellofemoral OA.[13,14] OA is a leading cause of medical separation and disability in the US active-duty military population, with a reported incidence between 7.86 and 11.7 per 1,000 person-years.[10,15] Showery et al.[14] examined the incidence of primary and post-traumatic OA in US military servicemembers, showing 10-year increases of 45% and 100%, respectively. The study also reported an increased incidence of primary OA in both older patients and patients with higher military ranks. Although our study showed an increased risk of post-traumatic OA with older age, there was not a significant increase with senior enlisted or officer status.

Limitations

There are several limitations to this study that should be acknowledged. First, the retrospective nature of our study is confined by the information available in pre-existing medical records. Numerous Current Procedural Terminology codes are associated with patellar tendon repair, and given the retrospective nature of the study design, our analysis may not be completely inclusive. Second, the demands of military service are typically standardized and may be nonmodifiable, particularly among more junior-ranking individuals. As a result, patients may struggle to perform occupational requirements and may face medical discharge after patellar tendon repair. Third, aside from VAS pain scores, validated patient-reported outcome measures or other functional indices (e.g., Army Physical Fitness Test scores) were not included in this study. Fourth, the inherent demands of military duty may not provide sufficient time to recover from such a significant injury as PTR. Fifth, owing to the nature of the study, surgical procedure and postoperative rehabilitation protocol descriptions were not included in the study. Sixth, the study is limited to a short-term follow-up period. Seventh, although a review of medical records allowed for identification of patellofemoral arthritis at final follow-up, it is possible that arthritic changes were under-reported in radiographic readings. Finally, the reason for medical separation was often omitted from the limited-duty profile system, making it challenging to definitively determine the underlying cause of disability discharge.

Conclusions

At 1-year follow-up, approximately two-thirds of military servicemembers undergoing primary patellar tendon repair had returned to running after surgery, whereas fewer than one-half returned to full military duty. Younger age and more senior military rank were associated with higher rates of return to running. Additionally, servicemembers of higher rank, particularly officers, had statistically higher rates of return to unrestricted activity.

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