Pectoralis Major Tendon Repairs in the Active-Duty Population

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Abstract

Rupture of the pectoralis major tendon is an uncommon injury that typically occurs in young, active people. Of this injury population, active-duty military personnel represent a unique, athletic subset that is commonly treated with operative repair.

For the retrospective case series reported here, we hypothesized that active-duty soldiers with acute and chronic pectoralis major tendon ruptures treated with operative repair would have high levels of patient satisfaction, quick return to work and sports, and few long-term complications.

We retrospectively reviewed all pectoralis major tendon rupture repairs performed at our institution between 2000 and 2007. Charts were thoroughly reviewed, and patients were asked to complete DASH (Disabilities of the Arm, Shoulder, and Hand) and supplemental questionnaires. Paired Student's *t* test was performed, and *P*s were calculated to analyze statistical differences between immediate- and delayed-treatment groups.

Fourteen patients were identified. The most common mechanism of injury was bench-pressing weights. Overall DASH, Work Module, and Sports Module scores were good to excellent. There was a statistically significant difference between outcomes for the immediate- and delayed-treatment groups, with the immediate-treatment group having better overall DASH and Work Module scores. Patients had a 30% to 40% objective loss of strength after surgery.

Active-duty soldiers reported acceptable overall outcomes after both immediate and delayed treatment for pectoralis major tendon ruptures, but a statistically significant difference was found in overall DASH and Work Module scores between the treatment groups.

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Rupture of the pectoralis major tendon is a rare injury that occurs mostly in young, active people. Approximately 150 cases of this injury have been reported since Pâtissier[1] first described it in 1822. Although originally reported involving work-related accidents in the 19th and early 20th centuries, injuries related to athletic activity now constitute the majority of cases as modern trends toward fitness continue.[2] Bench-pressing weights is now responsible for an overwhelming majority of pectoralis major tears. Numerous case reports also document other mechanisms for ruptures among competitive weight lifters, gymnasts, rodeo riders, and football players, as well as laborers who fall from heights.[1,3-7] Peak incidence is in active men 20 to 40 years old. The active-duty military population, a unique subset of these patients, requires a high functional level for its day-to-day work.

Historically, treatment of pectoralis major tendon ruptures was nonsurgical for partial tears and for older, sedentary people. Treatment of myotendinous junction and tendon insertion tears has evolved toward surgical management in recent years. Younger, more active patients in particular benefit from the improved strength offered by surgical treatment. Results from several studies comparing operative and nonoperative treatment have shown that surgical repair provides better outcomes in terms of patient satisfaction, strength, cosmetic appearance, and return to work or competition.[1,4,5,7-10]

Optimal timing for repair is less clear and has been the subject of considerable debate. Some authors, citing more technically difficult surgery and inferior outcomes in ruptures repaired after 8 weeks, have advocated repairing injuries within 8 weeks after injury.[11,12] Based on their retrospective review of 33 cases, Aärimaa and colleagues[8] recommended early surgical intervention for optimal outcomes. Schepsis and colleagues[7] reported no significant subjective or objective difference between immediate and delayed repairs in their retrospective review of 17 patients.

In our study, we sought to further define the outcomes of immediate and delayed operative repair of pectoralis major tendon ruptures in a homogenous young, athletic, active-duty population.

Materials and Methods

After obtaining institutional review board approval, we retrospectively reviewed all pectoralis major tendon rupture repairs performed at our institution between 2000 and 2007. Diagnosis at time of presentation was based largely on clinical examination. In cases in which examination findings were equivocal, magnetic resonance imaging was used to confirm the diagnosis.

Table I. Patients' Ages, Military Occupations, and Mechanisms of Injury

Patient	Age (y)	Military Occupation	Mechanism of Injury
1	34	Special Forces operator	Shoulder hyperextension while training
2	28	General surgery resident	Bench-press 225 lb
3	27	Infantry mortarman	Air assault rappelling injury
4	27	Aeromedical evacuation officer	Bench-press 365 lb
5	48	Maintenance technician	Bench-press 200 lb
6	37	Navy chief petty officer	Shoulder hyperextension during fall
7	38	Combat medic	Bench-press 315 lb
8	37	Navy SEAL	Bench-press 365 lb
9	28	Firefighter/semiprofessional football safety	Bench-press 185 lb
10	28	Navy supply officer	Bench-press 280 lb
11	28	Supply sergeant	Bench-press 225 lb
12	21	Infantry team leader	Bench-press 315 lb
13	27	Field artillery crew member	Bench-press 250 lb
14	32	Information systems analyst	Bench-press 265 lb

Table II. Patients' Aggregate Objective and Subjective Results

DASH	Work Module	Sports Module	Satisfied With Surgery	Function	Pain During Routine Activity	Pain During Strenuous Activity	Return to Work
12.74	16.96	39.38	7 (very) 6 (satisfied) 1 (unsatisfied)	5 (excellent) 5 (good) 3 (average) 1 (poor)	7 (none) 6 (mild) 1 (moderate)	3 (none) 7 (mild) 3 (moderate) 1 (severe)	7 (0-3 mo) 4 (3-6 mo) 1 (8 mo) 2 (9-12 mo)

Abbreviation: DASH, Disabilities of the Arm, Shoulder, and Hand.

Although surgical technique and specific type of repair varied over the course of the study, all surgeons sought secure fixation of the tendon to the anatomical site of insertion into the proximal humerus. Permanent locking sutures placed through the mobilized tendon end were anchored to the proximal humerus through drill holes or a fixation device, such as the Mitek GII® anchor (DePuy Mitek, Norwood, Mass) or the EndoButton® (Smith & Nephew Endoscopy, Andover, Mass). Charts were thoroughly reviewed for age, sex, occupation, mechanism of injury, surgical timing, surgical technique, repair type, and postoperative rehabilitation protocol.

After surgery, patients were asked to complete the DASH (Disabilities of the Arm, Shoulder, and Hand) questionnaire[13] and a 2-page supplemental questionnaire addressing injury specifics, military occupation, postoperative period, and long-term outcomes (Appendix). The review and questionnaire results were then analyzed; DASH, Work Module, and Sports Module scores were calculated; and the outcomes of the immediate repairs (<6 weeks) and the delayed repairs (>6 weeks) were then compared and analyzed with Student's *t* test.

Results

We identified 14 men (mean age, 31.4 years; range, 21-48 years) who had sustained pectoralis major ruptures and undergone operative repair at our institution between 2000 and 2007. The senior author performed 10 of 14 repairs but remained involved in decision making for all repairs. Patients' ages, military occupations, and mechanisms of injury are listed in Table I.

For 11 of the 14 patients, mechanism of injury was bench-pressing weights; mean reported weight bench-pressed at time of injury was 271.8 pounds (range, 185-365 pounds). The other 3 patients sustained forced shoulder hyperextension injuries by various mechanisms (rappelling, combat training, fall). No patients acknowledged anabolic steroid use in their preoperative histories. Operative repairs were performed 12 hours to 14 months after injury. Eight patients were repaired in the immediate period (<6 weeks), the other 6 in the delayed period (>6 weeks). At least 2 patients in the delayed-repair group reported significant delays, misdiagnosis, and seeing multiple providers before ultimate diagnosis and orthopedic referral.

Operative findings included 9 complete tears of both the sternal and clavicular heads and 5 partial tears. Of the 5 partial tears, 4 had the clavicular head intact or partially intact, and the fifth had the sternal head partially intact. All injuries occurred at the site of insertion into the humerus. In 11 repairs, permanent locking sutures were placed through the ruptured tendon and anchored to the proximal humerus through drill holes; in 2 repairs, permanent locking sutures were placed through the tendon end and secured to the proximal humerus with Mitek GII anchors; and, in the

Table III. Immediate- and Delayed-Repair Groups' DASH, Work Module, and Sports Module Scores

	DASH	Work Module	Sports Module	Satisfied With Surgery	Function	Pain During Routine Activity	Pain During Strenuous Activity	Return to Work
Immediate	7.50	7.81	30.20	4 (very) 4 (satisfied)	3 (excellent) 4 (good) 1 (average)	6 (none) 2 (mild)	2 (none) 5 (mild) 1 (moderate)	4 (0-3 mo) 3 (3-6 mo) 1 (8 mo)
Delayed	19.72	29.17	53.13	3 (very) 2 (satisfied) 1 (unsatisfied)	2 (excellent) 1 (good) 2 (average) 1 (poor)	1 (none) 4 (mild) 1 (moderate)	2 (mild) 2 (moderate) 1 (severe) 1 (N/A)	3 (0-3 mo) 1 (3-6 mo) 2 (9-12 mo)
P	.022	.018	.149					

Abbreviation: DASH, Disabilities of the Arm, Shoulder, and Hand.

final repair, permanent locking sutures were placed through the tendon and secured to the proximal humerus with an EndoButton. There was no significant difference in fixation type between immediate and delayed repairs, though the senior author observed that delayed repairs often required extensive mobilization of the scarred and retracted tendon off the chest wall to achieve adequate length for repair. In each case, adequate mobilization of the retracted tendon was achieved to enable insertion of the tendon into its anatomical site on the proximal humerus.

After surgery, all patients were immobilized in a sling to be worn for 6 weeks. Before discharge, they were evaluated by Physical Therapy and were given outpatient appointments to ensure proper therapy follow-up. Our therapy protocol called for wrist and elbow range of motion in the immediate postoperative period, followed by Codman exercises once pain allowed. After 4 to 6 weeks, all patients were advanced to limited forward flexion with the arm adducted, plus gentle passive- and active-assisted shoulder range of motion. All patients were allowed to advance gradually into a program of strengthening (3 months), pushups and dumbbell bench press (6 months), and, finally, unrestricted full activity (9-12 months). High-weight, low-repetition bench-pressing was discouraged indefinitely; only 1 patient returned to bench-pressing preinjury maximum weight.

On a 100-point scale (0, no disability; 100, total disability), mean postoperative DASH score was 12.74 (range, 0-42.5), mean Work Module score was 16.96 (range, 0-62.5), and mean Sports Module score was 39.38 (range, 0-100). Thirteen patients indicated they were satisfied or very satisfied with the outcome of their surgery; the 14th patient indicated he was unsatisfied. Table II lists the aggregate objective and subjective results for all patients. DASH scores are reported as means. In the optional comments section, 9 patients (4 immediate-, 5 delayed-repair) expressed dissatisfaction that their strength had not returned to its preinjury level.

The immediate- and delayed-repair groups' DASH, Work Module, and Sports Module scores (and *P*s) are listed in Table III. There were statistically significant differences between these groups in terms of overall DASH and Work Module scores.

Patients were also asked about the timing of their return to work and to weight lifting and about how much strength they lost. All immediate-repair patients except 1 returned to their functional work level within 6 months; the exception was an active-duty Navy SEAL who returned to full duty 8 months after surgery. Only 2 delayed-repair patients took more than 9 months to return to work. The majority of the study population began very limited weight lifting 6 months after surgery and took more than 1 year to return to a full lifting program. After surgery, 2 patients (1 acute, 1 chronic) discontinued their dedicated weight-lifting programs. All but 1 patient reported postoperative loss of strength in bench-pressing and pushups. Patients who continued their lifting programs had a mean 39% reduction in bench-press maximum weight and a mean 34% reduction in 2-minute pushup maximum based on subjective data.

Discussion

Although the number of pectoralis major tendon ruptures reported in the orthopedic literature is small, we expect to see an increasing number of these injuries given current fitness trends. In the study reported here, we sought to identify the expected outcomes of immediate versus delayed operative repair of pectoralis major tendon ruptures in highly functional athletes. The study population's mean postoperative DASH score was 12.74, indicating a minimal level of disability. Assessment of patient satisfaction showed that an overwhelming majority of patients (13/14) was satisfied or very satisfied with the overall outcomes of operative repair. In addition, a majority (10/14) reported postoperative functional level as good or excellent. Eleven patients successfully returned to full duty within 6 months. Patients returned to work more quickly than to sports. Although patients indicated overall satisfaction with outcomes, subjective pain during both routine and strenuous activity was commonly reported. In addition, though patients reported minimal functional disability (DASH), their inability to return to their high preoperative athletic performance levels was also commonly reported; this potential outcome should be mentioned during preoperative counseling.

Although pectoralis major tendon ruptures have been the subject of numerous recent and older studies, there is no consensus regarding optimal timing of repair. Unfortunately, most of these studies are small case series, and outcome measures are lacking in standardization—a reflection of the rarity of pectoralis major tendon ruptures and the difficulty in obtaining large groups of study patients with adequate follow-up or uniformity in patient population. A retrospective review of 33 cases over 21 years—conducted by Aärimaa and colleagues[8]—remains one of the larger studies recommending early surgical treatment to obtain optimal results. Its authors formulated an outcome system based on a variety of subjective and objective follow-up criteria but did not use a standardized outcome tool. Given our study population's outcomes and our use of a recognized upper extremity outcome measure, we also recommend early surgical intervention to optimize patient outcomes.

No patient in our study group indicated preoperative use of anabolic steroids—compared with 12 of 33 patients in the case series reported by Aärimaa and colleagues.[8] Interestingly, though those authors identified steroid use as a risk factor for tendon rupture, they also noted better outcomes among those patients because of the positive effects of steroids on muscle healing. In our patient population, steroid use can result in serious disciplinary repercussions, so a paucity of actual or reported steroid use in a military population would not be surprising.

Repair timing, immediate versus delayed, has been the subject of significant debate. Our data showed several trends regarding repairs made within 6 weeks after injury (immediate repairs) and repairs made more than 6 weeks after injury (delayed repairs). Compared with delayed repairs, immediate repairs led to statistically better overall DASH and Work Module scores. Although the differences are subtle and difficult to measure subjectively, compared with our delayed-repair patients, our immediate-repair patients returned to work slightly sooner and experienced slightly less pain with activity. We conclude that the outcomes of pectoralis major repairs are acceptable in both the immediate and delayed groups compared with historic nonoperative controls. However, review of our active-duty population indicated that repairs done within 6 weeks after injury produced the best overall outcomes and optimized recovery.

To determine why our results differ from those of some previous studies, we examined the makeup of our study population. Active-duty military personnel are young, athletic people with high functional requirements both before and after surgery. Although civilian patients may be more capable of modifying lifestyles to accommodate postoperative functional capabilities, active-duty soldiers are not always afforded that opportunity. Consequently, deficits in postoperative strength and endurance, though subtle among the civilian population, may become more obvious and limiting for active-duty military personnel.

Despite overall satisfaction with their repairs, all but 1 of our patients reported significant loss of strength—39% reduction in bench-press strength and 34% reduction in pushup strength. Admittedly, we were limited in our ability to obtain objective strength measurements after surgery given the dynamic nature of the active-duty population during wartime. Patients who had lifted the heaviest weight before injury tended to lose the most strength after surgery. This outcome was a particular source of distress to some patients, particularly those avidly involved in weight lifting. Although pectoralis major repairs tend to produce very good overall results, in our experience patients will likely not regain their preoperative levels of strength and endurance. This observation highlights the devastation caused by pectoralis major tendon ruptures, which often necessitate permanent postoperative training and activity modifications. The dichotomy between our study results and these notable postoperative strength deficits may be due in part to a shift in training philosophy and focus for the postoperative period. People who engage in competitive athletics, military training, and bodybuilding often modify their training regimens to accommodate any deficits. They may consequently retain a high level of endurance and strength while avoiding activities, such as heavy bench-pressing, that may predispose them to reinjury.

Four chronic-repair patients underwent surgery more than 10 months after injury. Advocates of acute repair have cited excessive scarring and retraction of the tendon as reasons to try to avoid repairing ruptures during the chronic period.[6,12] In our population, we noted some difficulties while performing primary repairs during this period. However, the surgery was technically feasible with adequate mobilization of the pectoralis major tendon from the chest wall—the key in allowing repair without interposing tissue in these primary repairs.

Our data are limited by several weaknesses in our study. First, over an 8-year period, we collected data on only 14 patients. Even in our high-incidence population, the pectoralis major tendon injury remains an uncommon injury. A multicenter study conducted over a considerably longer period would likely be necessary to draw more statistically meaningful conclusions. In addition, the military patient population is subject to a unique set of job requirements that are difficult to measure with available outcomes measures. We feel that the DASH questionnaire, though specific to the upper extremity, does not fully encapsulate the functional demands of high-end athletes or active-duty soldiers, the subjects in this study. Our supplemental questionnaire was designed to address this deficit. Last, this was a retrospective cohort study. A prospective randomized study would eliminate biases inherent in a retrospective study. Although no study would likely randomize to early versus late surgical repair, it is possible that a selection bias exists such that patients undergoing surgery for chronic conditions obtain inferior results.

Despite these limitations, this study has several meaningful and applicable conclusions. Whether repaired acutely or chronically, patients obtain predictable good to excellent results in terms of satisfaction, functional recovery, and

return to work after surgery. Most patients have difficulty returning to high-demand athletic activity and aggressive weight-lifting regimens after surgery, but many seem to adjust their training regimens to accommodate. In our population, repairs made within 6 weeks after injury had slightly better outcomes than did repairs made after 6 weeks. Although these differences were subtle, immediate repairs seem to be optimal in terms of maximizing patient outcomes after surgery.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article. The views expressed in this article are those of the authors, and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the United States government.

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Appendix. Supplemental Questionnaire

Please answer all questions. Please feel free to write in responses that better describe your experience.

1. How did you injure yourself?

2. If while lifting, what exercise and how much weight were you lifting?

3. How much time passed from your injury to your final surgery?

4. What is your job or Military Occupational Specialty (MOS)?

5. How long after surgery did you return to your job or MOS?

❑ I have not or could not return to my preinjury job or MOS.
❑ 0-3 months
❑ 3-6 months
❑ 6-9 months
❑ 9-12 months
❑ >12 months

6. How long after surgery until you returned to full preinjury function at work?

❑ I have not yet returned to full preinjury function.
❑ 0-3 months
❑ 3-6 months
❑ 6-9 months
❑ 9-12 months
❑ >12 months

7. How long after surgery until you were able to return to weight lifting?

❑ I have not returned to weight lifting.
❑ <3 months
❑ 3-6 months
❑ 6-9 months
❑ 9-12 months
❑ >12 months

8. How much did you bench-press on average before surgery?

9. How much do you bench-press now on average?

10. How many pushups could you do on average before surgery?

11. How many pushups can you do now on average?

12. What recreational or professional sporting activities did you participate in before injury?

13. How has your participation in these activities changed?

14. In what specific activities do you now feel limited or experience pain compared with before surgery?

15. Do you have any cosmetic concerns after surgery (scar, different appearance from uninjured side, etc)?

16. How much pain do you have now with routine activities?

❑ None
❑ Mild
❑ Moderate
❑ Severe

17. How much pain do you have now with strenuous activities?

❑ None
❑ Mild
❑ Moderate
❑ Severe

18. How would you rate your overall level of function after surgery?

❑ Excellent
❑ Good
❑ Average
❑ Poor

19. How satisfied are you with the results of surgery?

❑ Very satisfied
❑ Satisfied
❑ Unsatisfied
❑ Very unsatisfied

20. As a result of your injury, has anything changed in how you exercise?

This paper will be judged for the Resident Writer's Award.