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CASE REPORT

BONY AVULSION INJURY OF THE PECTORALIS MAJOR IN A 19 YEAR-OLD MALE JUDO ATHLETE: A CASE REPORT

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ABSTRACT

Background and Purpose: Bony avulsion of the pectoralis major muscle is a rare but potentially devastating injury for athletes. Pectoralis major rupture typically occurs in 20 to 39 year-old males. The shoulder region is one of the most frequently injured areas in Judo athletes. The purpose of this case report is to describe diagnosis and treatment following a pectoralis major bony avulsion due to an atypical mechanism of injury in a young Judo athlete.

Case Description: A 19-year-old military cadet and competitive judo athlete reported to a direct-access sports physical therapy clinic 7 weeks after incurring a shoulder injury during a judo match. He complained of shoulder pain and weakness with the inability to perform pushups. He presented with horizontal adduction weakness and visible discontinuity of the pectoralis muscle with resisted adduction.

Outcomes: Radiographs demonstrated a bony avulsion of the pectoralis major from its humeral attachment. The patient underwent surgical repair of the lesion the next week and was able to resume most military cadet activities within 5 months post-operation.

Discussion: Bony avulsions are exceptionally rare injuries, and are even more uncommon in athletes under the age of 20. It is important for clinicians to perform a thorough history and physical examination in order to avoid missing this diagnosis. Surgery is likely the best option for a young athletic population; while conservative management may be optimal for the older, inactive population.

Level of Evidence: 4

Keywords: Athlete, avulsion, martial arts, pectoralis major, rupture

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BACKGROUND AND PURPOSE

Pectoralis major (PM) avulsions are rare but potentially devastating injuries for athletes with the potential to cause significant weakness as well as cosmetic defects. Mild strains and partial tears of the PM are relatively common and often result in favorable outcomes following conservative treatment.[1,2] Bony avulsion of the PM, however, is uncommon with very few published cases between 1822-2010.[1,2]

The PM is a unique, triangular-shaped muscle with many attachment sites allowing function throughout a wide variety of motions. The PM is described as having two "heads", a clavicular head and a sternal head.[3] The clavicular portion of the muscle originates from the medial aspect of the clavicle and the sternal portion from the sternum and cartilage of the first six ribs.[3] The two heads insert via a single tendon on the lateral lip of the bicipital groove; the muscle fibers twist on each other so that the lowest part of the muscle fibers insert highest on the humerus.[4] The PM functions as an adductor, flexor, and internal rotator of the humerus, contributing to nearly every upper extremity activity.[3,4]

PM rupture typically occurs in 20 to 39 year-old males.[2,5-8] It is most commonly ruptured during weightlifting activities, specifically the bench press.[1,2] Wrestling is the second most common mechanism of injury followed by a small number of cases reported in various other sports, such as rappelling, parachuting, ice hockey, skating, and soccer.[2,5,7-9] The use of anabolic steroids can be a contributing factor to an increased incidence of PM rupture.[8] De Castro Ponchini and colleagues reported that 16 out of 20 individuals with PM ruptures in their study were taking steroids.[7]

Rupture can occur at various sites in the muscle but is typically grouped into 3 categories: muscle origin or belly injuries, musculotendinous junction and tendon insertion injuries, and bony avulsion at the humerus.[2] PM rupture at the musculotendinous junction or tendon insertion at the humerus is by far the most common site reported.[2,5] A systematic review of PM injuries reported that 245 out of the 365 published cases occurred at the musculotendinous junction, with only 5 bony avulsions at the humerus.[2] It is important to distinguish between bony avulsion and tendon avulsion as there have been many reports of avulsions in the literature referring specifically to tendon avulsions.[9-12]

Judo is one of the most practiced sports in the world.[13,14] It is a grappling style martial art with emphasis on dynamic throws and submissions (forcing the opponent to surrender using "joint lock" or "choke" hold positions). The nature of the sport can lead to significant injuries due to the high velocity of the maneuvers used. Sprain injuries are the most common type of judo injury, followed by contusions.[15] The upper extremity is the most frequently injured region during judo competition, with the shoulder being one of the most commonly affected parts of the body.[13,15-17]

Bony avulsions are very rare among PM ruptures, and it is even more uncommon for a complete PM rupture to occur in an individual under the age of 20 with few cases reported in the literature.[18,19] To the authors' knowledge, there are no previously reported cases of PM bony avulsion injuries in martial arts athletes. The purpose of this case report is to describe diagnosis and treatment following a PM bony avulsion due to an atypical mechanism of injury in a young Judo athlete.

CASE DESCRIPTION

Patient History

The patient was a 19-year-old male Judo athlete and cadet at the United States Military Academy, who presented to the direct-access physical therapy clinic during "walk-in" hours with left shoulder pain and weakness. The athlete described having injured his shoulder 7 weeks prior during a judo competition. He reported the mechanism of injury (MOI) occurred while he was prone, with his opponent pulling his left arm up and back into shoulder horizontal abduction. He was able to maneuver out of the position and finish the match, which lasted approximately three additional minutes. Immediately following the match, he was evaluated by the physician covering the competition and was told his injury was likely a muscle strain, and given instructions to use ice and rest his shoulder.

His primary complaint upon presentation to the physical therapist (PT) at the initial evaluation (nearly two months following the injury), was pain with reaching forward for objects (shoulder flexion)

and weakness with pressing activities, including the inability to perform a pushup over the past 7 weeks. During the subjective evaluation, he also indicated that ecchymosis had developed in the biceps region within a day following the initial injury. He denied previous injury to the shoulder or use of supplements or anabolic steroids. His past medical history included a left elbow open reduction internal fixation (ORIF) in 2007 following a dislocation injury, which he had fully recovered from. The patient was otherwise healthy without significant past medical history.

CLINICAL IMPRESSION #1

Due to the reported MOI, history of ecchymosis in the biceps region, and difficulty with pressing activities; the initial concern was for a strain injury of the pectoralis or biceps muscles. The differential diagnoses included: biceps strain, pectoralis strain, rotator cuff tear, acromioclavicular sprain, and intercostal muscle strain. The plan for evaluation included active range of motion (AROM), manual muscle testing (MMT), a thorough palpation exam, as well as special testing of the shoulder complex.

EXAMINATION

During the initial examination, the patient reported his resting pain as 0/10 and pain during reaching activities as 6/10 on a numerical pain rating scale (NPRS), with "0" being pain free and "10" being the worst pain imaginable. He completed several self-reported outcome measures, including the Shoulder Pain and Disability Index (SPADI), the Single Assessment Numeric Evaluation (SANE) and a Patient Specific Functional Scale (PSFS). The SPADI is a reliable tool for assessing outcomes in the shoulder,[20,21] and the SANE has been validated for multiple conditions.[22] The PSFS provides meaningful information regarding activities specific to individual patients, which may not be captured by other measures. The PSFS is used for all injuries in the author's facility and has been validated for various injuries.[23-25] The global rating of change (GROC) was also used to track the patient's opinion of his symptoms over time. GROC has been found useful when utilized in conjunctin with another outcome measure that assesses baseline status.[26,27] This patient's initial, 4 month, and 9 month outcomes scores are presented in Table 1. The PSFS activities were self-selected by the patient

Table 1. *Outcome Measures from Initial Evaluation. (A) Patient specific functional scale with activity breakdown. (B) Other outcome measures collected at initial evaluation included shoulder specific functional scale (SPADI), numerical pain rating scale (NPRS) and single assessment numerical evaluation (SANE).*

Patient Specific Functional Scale

(A)

Activity	Score (initial/pre-op)	Score (4 months post-op)	Score (9 months post-op)
Pushups	0	0*	10
Boxing	3	0*	10
Lifting	3	10	10
Judo	-	0*	10
Average Score (MDC = 2)	2	2.5	10

* Patient had not attempted activity yet due to protocol

(B)

Outcome Measure	Score (initial/pre-op)	Score (4 months post-op)	Score (9 months post-op)
SPADI (MDC=18)	44% (57/130)	0% (0/130)	0% (0/130)
NPRS (MDC=3)	6	0	0
SANE	70%	100%	100%
GROC (MCID = 2)	NA	+7	+7

MDC: Minimal Detectable Change *MCID: Minimum Clinically Important Difference*

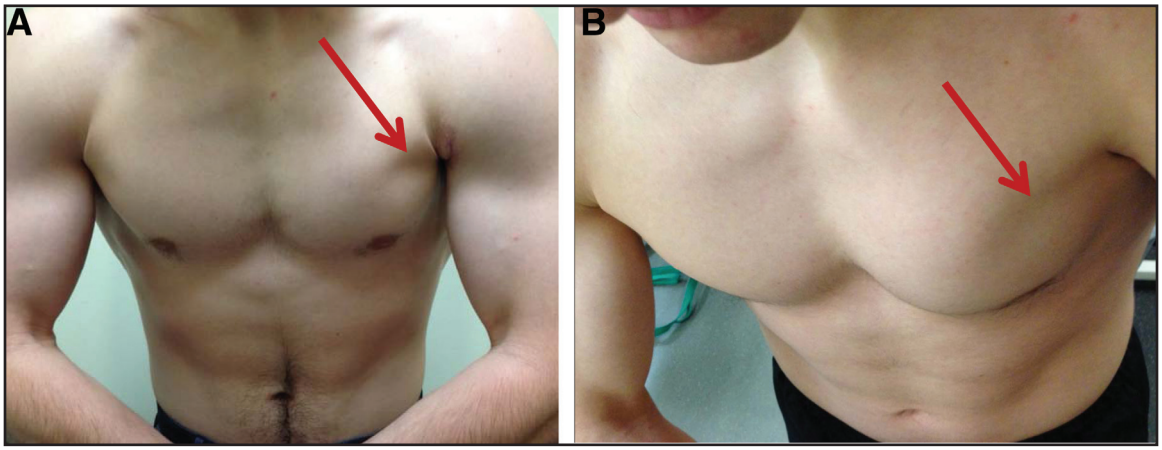

Figure 1. *The patient was asked to press his palms together to contract the pectoralis major muscles bilaterally. There is an indentation at the left axillary fold (arrow) when compared to the right side (A), indicating a pectoralis major rupture. The indentation is more apparent from a superior angle (B).*

and are reflective of activities (boxing, for example) which may not be typical for judo athletes, but are required of male cadets at the academy.

The initial physical examination included AROM and MMT in flexion, abduction, external rotation, and internal rotation; all results were within functional limits and equal bilaterally.[28] Horizontal adduction strength was graded as a 4/5 with pain produced at the anterior aspect of the shoulder.[28] The patient was tender to palpation over the axillary fold and exquisitely tender over the bicipital groove. When asked to press his palms together in front of his body (resisted horizontal adduction) to elicit a pectoralis major contraction, an obvious visible discontinuity of the pectoralis muscle in the left axillary fold was revealed (Figure 1).

CLINICAL IMPRESSION #2

Due to the reported mechanism, the patient's symptoms, and the axillary fold deformity during muscle contraction, the PT concluded that the injury was consistent with a pectoralis major rupture. Consistent with the American College of Radiology Appropriateness Criteria regarding shoulder injuries,[29] the therapist ordered shoulder radiographs (AP, Axillary-Y view, and Internal/External rotation). The Axillary-Y image revealed a pectoralis major bony avulsion from the humeral insertion (Figure 2).

INTERVENTION

The patient was referred to an orthopedic surgeon for further evaluation and surgical consideration due to the nature of the injury. Advanced imaging was determined unnecessary by the orthopedic surgeon, as physical exam and radiographs demonstrated conclusive evidence of the injury, and the patient was scheduled for surgical repair of the avulsion.

Surgical repair was performed 6 days following the initial PT evaluation (8 weeks after initial injury). The procedure was performed similar to the "preferred technique" described by Petilon and colleagues.[1] A 5 cm longitudinal incision was made

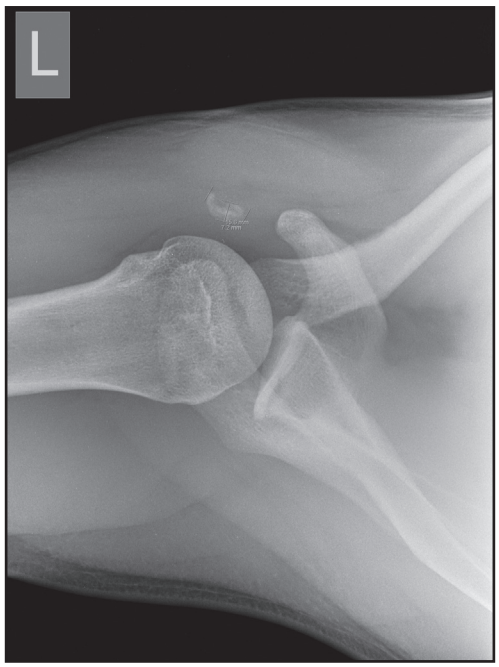

Figure 2. *In the axillary, or Y-view, radiographic image of the left shoulder there is a large bony avulsion fragment anterior to the glenohumeral joint, measuring 15.6 × 7.2 mm.*

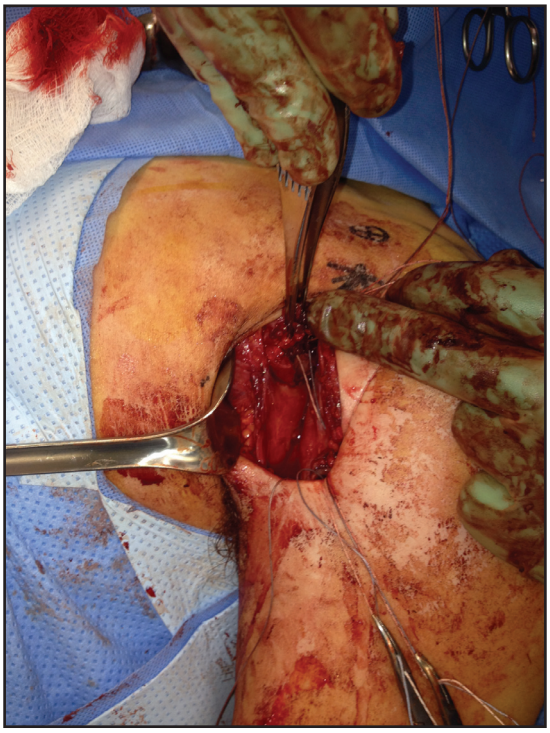

Figure 3. *Open pectoralis major tendon repair with sutures placed in the tendon stump and finger pointing to the small bony fragment.*

along the delto-pectoral interval, allowing for easy identification of the tendon stump and bony fragments. The tendon and muscle belly were mobilized and running, locking stitches were placed along the tendon stump. The surgeon used a burr to create a trough at the anatomic site of the pectoralis major insertion,[30] then two drill holes were placed into the trough and metal suture buttons with sutures were inserted and flipped in the medullary canal. Using the free suture ends the surgeon was able to reduce the tendon into the trough. Once the sutures were tied and the repair was tested through a range of motion, the skin was closed in layers and the arm placed into a sling (Figure 3).

REHABILITATION

Post-operative rehabilitation following PM tendon repair can vary somewhat, depending on patient-specific surgical considerations.[31] Patients are typically immobilized in a sling for 4 to 6 weeks.[1,32] It is important for the treating therapist to communicate with the surgeon, as the duration of immobilization often depends on the amount of mobilization and tension required to achieve fixation during the surgical repair.[1] Patients can be expected to regain full AROM within 3 months and progress strengthening exercises to be able to perform push-ups by 6 months.[1] Graduated post-operative rehabilitation, as described by Manske and Prohaska, facilitates safe and effective return to activity.[31] An example of the post-operative progression used in this case is presented in Appendix 1.

The patient was immobilized in a sling and rehabilitation was initiated immediately after surgery. Before discharge from the hospital the patient was instructed in pendulums and active-assisted range of motion. The surgeon and therapist communicated regarding the stability of the repair and it was determined that early mobilization should be encouraged. At 2 weeks post-operation the patient was allowed to take off the sling in safe environments (in his room) and begin gentle isometric exercises for the rotator cuff muscles. Within 4 weeks post-operation, sling use was completely discontinued. By 6 weeks post-operation he had regained full AROM in all directions and began low resistance isotonic strength training. He was able to progress neuromuscular and strength exercises and return to running within 3 months. Pushups and bench press were avoided until after four months post-operation and heavy resistance bench press was discouraged indefinitely.

OUTCOMES

At four months post-operation the patient reported doing very well with full, pain free AROM and 5/5 strength throughout all shoulder movements. For additional protection of the surgical repair, he was allowed to return to judo practice at 6 months but not compete until 9 months post-operation. Table 1 shows the increase in all of his outcome measure scores, which were rated as completely normal at 9 months post-operation and all were above the clinically significant ranges by 9 months. At 4 months post-operation the protocol didn't allow him to return to pushups, boxing, or judo. At 9 months post-operation he had fully returned to all activities, including judo.

DISCUSSION

PM injuries typically occur from forced shoulder horizontal abduction and external rotation. They are most commonly seen in 20-39 year-old, male weightlifters. However, there are exceptional cases

in which physical therapists and other medical providers must be aware of the signs and symptoms of a PM rupture. Diagnosis begins with a thorough history, including inquiry regarding the mechanism of injury. Swelling and ecchymosis will usually be present in the injured athlete's anterior humerus with initial signs between 3-48 hours.[8] The defect seen with a complete PM rupture will be present in the axillary fold with abduction or resisted adduction, however, significant swelling may mask the defect for up to 3 weeks.[8] Pain and especially weakness with adduction and internal rotation motions are normally present.[8]

Upper extremity and shoulder related injuries are fairly common in judo athletes, yet the authors were unable to locate a single reported case of pectoralis muscle rupture or avulsion in this population. Since the most common mechanism of injury is related to bench press exercises, the patient was cautioned against heavy bench press resistance training indefinitely. To the authors knowledge there are no published studies describing the amount of tensile load a surgically repaired PM can tolerate.[31] Some of the "joint lock" positions and high-velocity dynamic throwing and takedown maneuvers in judo may indeed place significant strain on the repaired tissue, therefore the patient was advised to return to those activities no sooner than 9 months following surgery. The ultimate goal is to assist the patient in returning to their previous level of activity through a supervised, graduated rehabilitation program.[31]

This case is rare because not only is the athlete under the age of 20, his injury resulted in an atypical bony avulsion from a somewhat uncommon mechanism. Research has demonstrated that shoulder internal rotation of judo athletes in this age range is significantly higher compared to matched, healthy controls.[17] Although skeletal maturity was not assessed in this particular patient, previous authors have suggested that the skeletally immature population may be more susceptible to bony avulsion since tendons and ligaments are stronger than bone in the skeletally immature.[19] However, there are several reported cases of adults with bony avulsions.[33]

PM ruptures and avulsion have good reported outcomes with early surgical repair, but with delayed repair and conservative treatment the outcomes decrease respectively.[5,6,18,34] Return of strength with immediate repair (within 2 weeks) has been reported between 99-102%, reduced to 94% for chronic repairs, and between 56-71% when treated conservatively relative to the contralateral side.[34,35] The majority of published studies report improved strength gains after surgical repair compared to conservative treatment. Disregarding strength outcomes, some patients elect to have surgery merely for cosmetic reasons.

CONCLUSION

PM ruptures are uncommon and bony avulsions are extremely rare. It is important for clinicians to perform a thorough history and physical examination to avoid missing this diagnosis. Surgical outcomes appear to be time dependent and most studies report remarkably better results over conservative management. Surgery is likely the best option for young athletes, while conservative management may be optimal for the older, less active population.

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APPENDIX 1

Rehabilitation Protocol Utilized Following Pectoralis Major Repair

Phase	Goals	Therapeutic Exercises	Precautions

Phase 1 ***Protection*** *(generally first 2-6 weeks)*	• Patient education
	• Protection of surgical repair
		• Gentle PROM
		  • *below shoulder level*
		  • *ER to neutral*
		• Pendulum exercises
		  • *In sling first 1-2 weeks*
		  • *Progress to full pendulum after week 2*
		• Elbow, wrist, hand exercises with shoulder in neutral position
			• Avoid active shoulder ABD, FLEX, and ER minimum of 2 weeks
			• No lifting >1 pound
			• Wear sling at all times
			• Repairs that require significant mobilization or greater tension should be immobilized for full 6 weeks

Phase 2a ***Motion*** *(generally weeks 4-8)*	• Scar mobility • Restore AROM • Painfree ADLs	• AAROM • *Supine assisted flexion wand exercise* • Scapular retraction & protraction • Progression to full AROM • Gentle “two-finger” isometrics in all planes • Aerobic conditioning (stationary bike – wearing sling) • Lower extremity resistance training allowed	• Wean from sling (may wear sling during lower body and aerobic exercises) • Avoid overhead activity • AAROM & AROM should be in painfree range • Avoid PROM horizontal abduction & shoulder flexion above 90°

Phase 2b ***Motion Progression*** *(generally weeks 6-10)*	• Progress AROM
	• Painfree ADLs
		• Continue Phase 2 exercises as needed
		• Progress ROM
		  • *Wand exercises*
		  • *Progress to pulley*
		• Upper body bike
			• Avoid overhead activity
			• Strengthening should be in painfree range
			• NO push-ups, heavy lifting, or sports participation
			• Avoid PROM horizontal abduction & shoulder flexion above 90°

Phase 3a ***Strength*** *(week 9 up to 3 months)*	• Maintain full AROM
	• Painfree strengthening progression
		• Continue Phase 2 exercises as needed
		• Neuromuscular & strength exercise progression
		  • *Body blade™ in front of body (below chest level)*
		  • *Two-hand chest ball toss*
		  • *Weight shifting onto UE (against wall)*
		  • *Cuff strengthening (IR/ER arm at side, FLEX & scaption at 60° to 90°*
		  • *Supine shoulder stabilization at 90°*
		  • *Scapular strengthening (ceiling “pushes” and light rows)*
		• Begin jogging and return-to-running program
			• In general, beginning strength exercises are performed with light resistance in ranges below shoulder level
			• No heavy lifting (varies by patient / athlete)
			• Avoid approaching 90° ABD and ER positions
			• No contact sports / activities
			• No military schools *(i.e., airborne or air assault school for military & cadets)*

Rehabilitation Protocol Utilized Following Pectoralis Major Repair *(continued)*

Phase	Goals	Therapeutic Exercises	Precautions
Phase 3b ***Strength Progression*** *(4 months to 8 months)*	• Progress painfree strengthening • Push-ups at own pace painfree • Return to most military and cadet activities	• Continue Phase 3 exercises as needed • Neuromuscular & strength exercise progression • *Body blade™ at 90° for FLEX, scaption* • *Two-hand overhead ball toss* • *Quadruped weight shifting* • *Push-up progression (inclined push-ups to knee to standard)* • *Cuff strengthening progression (add scaption to 120°)* • *Supine shoulder stabilization at 90°-120°* • *Scapular strengthening progression (standing forward "pushes" and rows)*	• In general, progression of strength exercises are performed with moderate resistance in ranges below 90°-120° • Avoid painful overhead activities • Avoid resistance in 90° ABD and ER positions • No contact sports / activities • No military schools *(i.e., airborne or air assault school for military & cadets)* • No chest press type exercises
Phase 3c ***Strength Progression*** *(6 months to 12 months)*	• Pass APFT push-up test at 6-8 months • Return to sports activities	• Neuromuscular & strength exercise progression • *Body blade™ approaching or at endrange* • *Two-hand overhead diagonal ball toss progressing to regular throwing toss* • *Weight shifting & progression to unstable platforms* • *push-up progression adding "push-up plus"* • *Progression of diagonal (chop and lift type) exercises* • *Supine shoulder stabilization at available ranges* • *Scapular strengthening progression (push-up plus)*	• In general, progression of strength exercises are performed with moderate to heavy resistance in full range and should be painfree • Avoid painful overhead activities • Avoid heavy resistance in 90° ABD and ER positions • No contact sports / activities until 9-12 months • No military schools *(i.e., airborne or air assault school for military & cadets)* until 9-12 months • Avoid heavy bench press type exercises indefinitely

Abbreviations: Abduction (ABD), Flexion (FLEX), External Rotation (ER), Internal Rotation (IR), Passive Range of Motion (PROM), Active Range of Motion (AROM), Active Assisted Range of Motion (AAROM)