Pectoralis Major Muscle Injuries: Evaluation and Management

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Abstract

Pectoralis major muscle tears are relatively rare injuries that primarily occur while lifting weights, particularly when doing a bench press. Complete ruptures are most commonly avulsions at or near the humeral insertion. Ruptures at the musculotendinous junction and intramuscular tears usually are caused by a direct blow. The patient may hear a snap at the time of injury and report pain, weakness, swelling, or muscular deformity. Physical examination can reveal ecchymosis, a palpable defect, asymmetric webbing of the axillary fold, and weakness on resisted shoulder adduction and internal rotation. A detailed history and physical examination can be augmented by radiologic studies, including magnetic resonance imaging. Non-surgical treatment is now recommended only for the older, sedentary patient or for proximal muscle belly tears. Surgery, whether early or delayed, consistently yields superior results compared with nonsurgical management. Prompt diagnosis and timely intervention likely will produce improved results.


Approximately 150 reported cases of pectoralis major muscle tears have been reported since Patissier first described them in 1822. More than half have been identified in the past 30 years. Initially caused by horse- and work-related accidents, this injury has become increasingly associated with strenuous athletic activity, most notably football, wrestling, waterskiing, rugby, and weight lifting. Excluding infants, the reported age range of patients with this injury is from 16 to 91 years, with the peak in athletes aged between 20 and 40 years. With the exception of reported cases in female nursing home residents with an unknown mechanism of injury, pectoralis major muscle injuries occur almost exclusively in men. Weight lifting is the cause of almost half of these injuries, with the bench press being the most common inciting exercise.

Because of the rarity of this condition, it may be missed at initial presentation or misdiagnosed as a sprain and managed nonsurgically. Hanna et al. reported that 50% of their 12 patients with unrepaired tears were diagnosed late or initially were misdiagnosed. A marked percentage of tears involve only the sternal head, leading to the impression of an incomplete tear, when in fact there is a complete tear of the sternal head. In a review of 29 cases, Park and Espiniella reported that 90% of patients treated surgically (9/10) showed good to excellent results, whereas only 58% of patients treated nonsurgically (7/12) showed good results. Zeman et al. reported excellent results in four of four patients treated surgically. The five patients treated nonsurgically reported strength deficits that limited return to athletic activity. Given the trend toward improved results with surgical repair of complete tears, it is important to raise awareness about pectoralis major muscle injury.

The general population is increasingly interested in health and fitness, and strength training and participation in strenuous sports activities are integral to many people’s lifestyles, regardless of age or sex. As a result, ruptures of the pectoralis major muscle likely will be seen more often than

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in the past. Proper understanding of the anatomy, mechanism of injury, clinical findings, and management options is essential to expedite diagnosis and maximize the functional outcome of this rare but often debilitating injury.

**Anatomy and Function**

The pectoralis major muscle arises as a broad sheet in two divisions. The superior half, which forms the clavicular head, originates from the medial clavicle and the upper portion of the sternum. The inferior half, which makes up the sternal head, arises from the distal end of the sternum, the aponeurosis of the external oblique muscle, and the costal cartilage of the first six ribs. These fibers then converge and rotate 90° onto each other before uniting to form the tendinous insertion on the humerus, lateral to the bicipital groove. The most inferior muscle fibers insert superiorly and posteriorly to the clavicular head, and the upper sternal fibers attach more distally (Fig. 1).

The pectoralis major muscle fibers are unique in that they are composed of different lengths and in that the relative fiber length changes as the muscle length changes. It is thought that, because of its wide origin and varied fiber direction, the muscle does not retract far when ruptured. Some early authors thought those factors made complete ruptures infrequent.

The investing fascia of the pectoralis major muscle is continuous with the fascia of both the brachium and the medial antebrachial septum. Clinically, this fascia presents as a palpable cord extending through the axilla and continuing down the medial arm (Fig. 2). This presentation often is mistaken for an intact pectoralis major tendon on clinical examination and during intraoperative exploration (Fig. 3).

The tendon, which is approximately 5 cm wide, 1 cm long on the anterior surface, and 2.5 cm long on the posterior surface, consists of two laminae. The anterior lamina is created by the clavicular head, and the posterior lamina is formed by the sternal head. In their anatomic analysis, Wolfe et al. describe a trilaminar tendon (Fig. 4). The nerve supply is derived from the lateral (C5-C7) and medial (C8-T1) pectoral nerves from the lateral and medial cords, respectively, which enter the muscle on its deep medial aspect. The lateral pectoral nerve supplies the clavicular head and medial portion of the sternal head. The medial pectoral nerve enters the deep surface of the pectoralis minor muscle, supplying it and the lateral portion of the sternal head. The pectoral branch of the thoracoacromial artery is the main blood supply of the muscle.

The pectoralis major muscle is a powerful internal rotator, flexor, and adductor of the arm. Although sometimes considered unnecessary for normal shoulder function, it is important for carrying out strenuous activities because it is a main source of power for the upper torso in competitive athletes. It also forms the anterior axillary fold and is important cosmetically to bodybuilders.

**Pathogenesis**

Rupture of the pectoralis major muscle is most commonly caused by an indirect mechanism, such as forced abduction against resistance, involun-
ary contraction, and severe traction on the arm. In weight lifting, the injury occurs during the eccentric phase of contraction, when more tension is generated. Patients may report feeling a “pop” or tearing sensation as they move from maximal eccentric contraction to concentric contraction. In their cadaveric studies mimicking the bench press motion, Wolfe et al reported that the inferior fibers of the muscle respond disproportionately during the final 30° of humeral extension and are at a mechanical disadvantage when placed under external load, thereby making them more vulnerable to injury. Further observations indicate that the injury tends to occur at low speeds with the arms abducted and externally rotated, placing the inferior fibers at maximal stretch. Therefore, during the bench press, the lower sternal head fibers are subjected to an inordinate amount of stress and are the first fibers to rupture.

In one study, 83 of 94 patients reported an indirect mechanism of injury. The most common type of injury among these patients was avulsion of the tendon at the site of insertion. Of 86 surgically verified cases, 78 were described as complete. In all, there were 56 tendon avulsions, 21 ruptures at the myotendinous junction, 4 bony avulsions, 3 ruptures in the tendon substance, and 2 muscle belly tears. This analysis contradicted earlier reports that the muscle belly or myotendinous junction was most commonly affected. Muscle belly tears, unlike distal tears, usually are associated with direct trauma, such as motor vehicle accidents and crushing injuries.

Steroid use also may make a tendon more susceptible to injury. Steroid use and vigorous training may increase muscle strength at a rate to which the tendon cannot adapt, leaving it at greater risk for injury. Analysis of the effects of steroids on rat tendons demonstrated that the tendons became stiffer, could not absorb as much energy, and failed with less elongation. Those effects seemed to be reversible with discontinuation of steroid use.

**Diagnosis**

**History and Physical Examination**

Most patients recall the specific incident related to the pectoralis muscle injury. They often report a tearing sensation with or without a pop, painful limitation of motion, localized swelling, ecchymosis, and weakness. It is not uncommon for patients to initially treat the injury as they would a sprain or strain, with rest and ice. However, persistent weakness and asymmetry once the swelling and bruising have resolved usually suggest the presence of a more severe injury.
Findings on examination often correlate with the location of the injury. Patients with proximal tears or muscle belly tears may demonstrate ecchymosis only over the anterior chest wall; those with the more common distal tears present acutely with ecchymosis and swelling over the arm or axilla. A palpable defect may be obscured by swelling, an intact fascial covering, or the overlying (uninjured) clavicular head. However, the classic webbed appearance of the thinned-out anterior axilla can be accentuated by abducting the arm to 90°, especially after the swelling has subsided. Comparison with the uninjured side is essential to evaluate any asymmetry. Chest wall deformity can be enhanced by contraction of the muscle or by resisted adduction as the muscle is retracted medially. In chronic cases, retracting the muscle medially may pull adherent overlying soft tissue (Fig. 5). Shoulder motion also may be limited by pain. Weakness in adduction and internal rotation of the arm are usually clinically evident. Isokinetic testing with a dynamometer can help assess the patient’s strength deficits and assist in surgical selection. Nevertheless, this condition still is primarily diagnosed clinically. When all of the findings are present, the assumption is that a complete rupture of the pectoralis major muscle, particularly of the sternal head, has occurred.

Genetic abnormalities, such as Poland’s syndrome and congenital absence of the pectoralis major muscle (commonly the sternocostal head), may present as atrophy over the thorax and weakness in adduction and internal rotation.

Imaging

Conventional radiographs are recommended during the initial evaluation to rule out bony avulsions, fractures, or dislocations. Humeral fractures may give evidence of an associated pectoralis major muscle rupture when the distal fragment of a two-part proximal humeral fracture is displaced posterolaterally because such displacement is in the opposite direction of the natural deforming pull of this muscle. The characteristic finding of a pectoralis major muscle rupture is soft-tissue swelling and absence of the pectoralis major shadow. Radiographs cannot accurately determine the extent of the injury, however.

Ultrasound also has been used successfully, with good correlation at surgery. Tears are identified by uneven echogenicity and muscle thinning in comparison with the opposite side. Although computed tomography may detect a pectoralis major muscle tear, it is limited by its inferior soft-tissue contrast quality. Magnetic resonance imaging (MRI) is widely accepted as the modality of choice when attempting to confirm or evaluate possible tears of the pectoralis major muscle.

The use of MRI to accurately assess the grade of injury, site, and, in some cases, amount of retraction correlates very well with surgical findings. MRI may be helpful in the acute setting when clinical diagnosis is difficult. In addition, the increased sensitivity of MRI may enable efficient diagnosis, thereby avoiding surgical delay and the accompanying possibility of subsequent development of adhesions, muscle retraction, and atrophy. Diagnosing and surgically treating this injury earlier may allow athletes a timely return to competition.

MRI can help differentiate between complete, partial, and intramuscular tears in both acute and chronic cases. It also can help identify patients who would benefit most from surgical repair. The exact location of a pectoralis major injury can be seen on MRI scans. MRI also may be used to monitor interval healing, muscle quality, and hematoma resolution before returning a patient to competitive sports. Ohashi et al reported that T2-weighted axial images were the most useful for acute and subacute tears because on T1-weighted images, a fresh hematoma or hemorrhage may be indistinguishable from
adjacent muscle, thereby making the diagnosis of injury more difficult. In contrast, chronic injuries, which tend to produce more fibrous tissue and scarring, are best evaluated on T1-weighted axial images. Connell et al. recommended using coronal images to determine the grade of partial tearing.

**Classification**

Tietjen15 proposed a classification system to assist in the diagnosis and management of pectoralis major muscle injuries based on the extent and site of injury. Type I injuries consist of muscle contusions and sprains and type II injuries, of partial tears. Type III injuries, which consist of complete tears, are further subdivided according to location: A, muscle origin; B, muscle belly; C, myotendinous junction; and D, tendon. According to Tietjen, patients with type IIID injury are the best candidates for surgical repair; all others likely can be initially managed nonsurgically. This classification system provides a guideline for evaluating ruptures of the pectoralis major muscle, but the rupture can be more simply defined as partial or complete with involvement of only the sternal or of both heads, and as proximal or distal.

**Management**

**Nonsurgical Management**

Nonsurgical management is recommended for proximal tears (tears at the sternoclavicular origin) and some partial tears. In older or sedentary individuals, nonsurgical management may be sufficient, even for complete tears, because repair of this muscle is not necessary for performing normal activities of daily living. Connell et al. recommended using coronal images to determine the grade of partial tearing.

Complete tears and high-grade partial tears, however, do leave the individual with a cosmetically disfiguring bulge or defect and a significant strength deficit. Furthermore, healing and return of functional strength may be slow. Patient age, activity level, and cosmetic desires, as well as the type of tear, are vital to determine the proper method of care. Although some partial tears can be managed nonsurgically, ecchymosis, swelling, and tenderness make it difficult to determine the extent of the injury in the acute setting. MRI or repeated clinical examinations may be needed as the acute inflammation resolves.

The patient is initially placed in a sling for comfort and is directed to rest and take analgesics as necessary. The patient is begun on early shoulder mobilization and unresisted stretching exercises, then advanced to resisted strengthening exercises when mobility is normal and pain has improved, usually at 6 to 8 weeks after injury. Patients should be instructed on proper weight lifting techniques to decrease the risk of rupture or re-injury. One technique involves lowering the weight to no more than 4 to 6 cm above the anterior chest wall, which minimizes eccentric stresses placed on the pectoralis major muscle. In addition, a narrower grip on the bench press no wider than 1.5 times the biacromial width also can reduce stress on the muscle.

**Surgical Management**

Surgical repair provides the greatest outcomes in patient satisfaction, strength, cosmesis, and return to competitive sports. Any complete tear (including isolated sternal head tears) involving either the myotendinous junction or the tendon insertion site should be repaired. A meta-analysis of the literature on pectoralis major muscle injuries revealed that patients repaired surgically had 88% excellent or good results compared with 27% for patients treated nonsurgically. Hanna et al. performed a retrospective analysis on 21 patients with 22 complete tears and reported objective results based on isokinetic testing. Peak torque returned to 99% of that of the uninjured side in patients treated surgically versus only 56% in patients treated nonsurgically.

Some authors recommend acute diagnosis and repair within 8 weeks of injury for optimal results, asserting that delayed surgery is more difficult and less predictable. However, repairs delayed from 3 months to 13 years from initial injury have been performed with comparable results. A retrospective analysis by Schepsis et al. on 17 patients demonstrated no significant subjective or objective difference between acute and delayed repairs, both of which did markedly better than nonsurgical treatment. Subjective results were calculated based on a patient questionnaire that assessed postoperative strength, pain, motion, cosmesis, and overall satisfaction. The acute repair group scored 96%; the delayed group, 93%; and the nonsurgical group, 51%. On isokinetic adduction strength testing, results were given as strength percentages of the uninjured arm. The surgical group

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**Figure 6** T2-weighted coronal MRI scan of a pectoralis major intramuscular tear (arrow).
demonstrated greater success, with acute repairs averaging 102%; delayed repairs, 94%; and the nonsurgical group, 71%. Some authors attribute the success of delayed surgical repair only to those torn muscles whose retraction was limited by either adhesion or an intact portion of the tendon.\textsuperscript{23,33-35}

**Surgical Options**

Most types of surgical repair have provided good results. In almost all cases, the deltopectoral approach is used, with the patient in a modified beach-chair position. Most techniques recommend some form of suturing through drill holes.\textsuperscript{6,10,11,18,35,36} Schepsis et al\textsuperscript{4} described a technique in which a 5-cm trough is made lateral to the bicipital groove and medial to any remaining distal tendinous attachment. Using no. 5 nonabsorbable sutures, two sets of horizontal and vertical modified Kessler sutures are used to grasp the muscle and fascia. The sutures are then passed and tied through four drill holes made 1 cm lateral to the trough. Any remaining distal tendon is oversewn into the muscle. Schepsis et al\textsuperscript{4} performed this technique on six acute and seven delayed repairs. This trough–and–drill-hole technique also has been used successfully in a 13-year-delayed repair\textsuperscript{35} and in a rupture associated with an anterior shoulder dislocation.\textsuperscript{37}

In another series of 16 cases, two rows of drill holes were used at the site of insertion, and sutures were passed through the holes with a crochet hook.\textsuperscript{11} The sutures then were passed into the torn tendon and tied with the arm in adduction and internal rotation. In the one case in which only a partial tear with good tendon attachment was noted, a primary repair of the muscle to the tendon was performed. Greater mobilization was required in the chronic cases because of adhesions, but this did not seem to increase the difficulty of repair. Pain was relieved in all cases. All but one patient experienced full return of motion. Deformity was corrected in all but the two patients who underwent delayed repairs 5 years after initial injury and who did not have a completely normal contour. Strength was fully restored in 13 of the patients; the others experienced marked improvements. Of the two patients with delayed repairs, one improved in horizontal adduction strength from 50% to 80%, and the other improved from 60% to 84%. Similar techniques have provided good results in other series, including one case of rerupture that initially was fixed with periosteal sutures.\textsuperscript{9,36} Good outcomes have been achieved in nine cases repaired by attaching the ruptured end of the pectoralis major tendon to the humerus with periosteal sutures.\textsuperscript{10,22}

Excellent results were reported in two patients with delayed repairs who were treated by petaling the insertion site with an osteotome and then fixing the tendon with two 4.5-mm cannulated screws and spiked plastic soft-tissue washers.\textsuperscript{2} An acute repair of a complete tendinous tear was managed by reattaching the tendon to the humerus using three bone anchors and reinforcing the repair by oversewing the remaining distal tissue.\textsuperscript{26} The 19-year-old patient returned to collegiate football. There was concern about using this device because of the thin cortex that is usually present in this area, but the outcome did not seem to be altered. Barbed staples also have been used as fixators.\textsuperscript{38}

Rijnberg and Van Linge\textsuperscript{29} used direct suture approximation of the ruptured ends of the pectoralis major muscle to repair an acute myotendinous junction tear in a bodybuilder. The patient returned to his training program in 6 months. Liu et al\textsuperscript{23} achieved excellent results in one patient by sutureing the avulsed tendon to the clavicular fascia using nonabsorbable, interrupted heavy sutures. Muscle belly tears, although not often treated surgically, also have been repaired directly with good results.\textsuperscript{10}

**Surgical Technique**

**Acute Rupture (≤6 Weeks)**

The patient is placed in a modified beach chair position with the affected arm and shoulder prepared free to allow range of motion (ROM) during the procedure. A general anesthetic is preferred to achieve muscle relaxation and to facilitate mobilization of the torn muscle, particularly in chronic tears. A standard deltopectoral incision is used. The proximal extent is made slightly medial to allow access to the potentially retracted tendon. The distal incision is made slightly lateral to provide better access to the pectoralis major insertion. The anterior laminar fibers from the clavicular head usually are intact. Additionally, the anterior fascia of the pectoralis major tendon, which is continuous with the brachial fascia and the medial antebraochial septum, is also usually intact, giving the false appearance of an intact tendon. Blunt dissection is performed inferior and medial to the clavicular insertion. Occasionally, the anterior fascia and cord to the medial antebraochial septum are incised to allow better access to the ruptured sternal portion of the pectoralis major tendon, which lies posterior and usually is retracted medial to the clavicular insertion. The ruptured tendon end is identified and freshened with a scalpel. The tendon is mobilized, and stay sutures are placed for improved traction and tensioning.

The insertion of the pectoralis major tendon is identified just lateral to the long head of the biceps at the inferior portion of the incision. The long head of the biceps can be palpated at the bicipital groove. If the clavicular head is intact, the insertion will be posterior to the tendinous insertion of the anterior lamina, just lateral to the bicipital groove (Fig. 7). If the clavicular insertion also is ruptured, locating the commonly present residual fibers lateral to the biceps helps identify the tendinous insertion of the pectoralis major muscle.
Fixation of the torn pectoralis major muscle and tendon to the humeral insertion can be done with either a suture anchor or a bone trough. When using a suture anchor, the insertion site, which is lateral to the long head of the biceps (in the tendon footprint), is prepared with a burr to create a 3-cm × 1-cm area of bleeding bone. Care is taken not to decorticate the area, which would weaken the suture anchor strength. A suture anchor with a strong no. 2 or no. 5 braided nonabsorbable suture is preferred. Three to five anchors are placed, and a grasping stitch (eg, Krackow, modified Kessler) (Fig. 8) is sutured through the tendon with a single limb of the suture. The second limb of the suture is then brought through the tendon with a single throw and used as the post to tension and advance the tendon as the suture slides through the anchor. The arm is then held in neutral rotation, and the suture is tied. The remaining sutures are evenly spaced along the ruptured tendon and then tensioned and tied. Suture anchors can be used in acute tears, which can be repaired under little tension in patients with good bone quality.

When using a bone trough, a burr is used to create a 3-cm bony trough at the tendon insertion site. The superior portion of the trough is under-
cut with the burr. A 2-mm drill bit is used to create three to five equally spaced drill holes 1 cm distal to the trough edge. A strong no. 2 braided nonabsorbable suture is woven through the tendon, similar to the suture anchor technique. Three or four of these sutures are placed and passed through the drill holes using a suture passer. The arm is held in neutral rotation, and the sutures are tied over the bone bridge (Fig. 9). The bone trough technique is preferable in chronic ruptures, in ruptures that are repaired under some tension, and in patients with poor bone quality.

**Chronic Rupture (>6 Weeks)**

For chronic ruptures, a larger incision extends both proximally and distally to facilitate soft-tissue dissection and tendon mobilization. A large amount of scar tissue is usually encountered, and it may give the impression of an intact tendon. The scar tissue is carefully excised, and the dissection is performed to delineate the injury pattern. Blunt dissection is used to carefully separate the scarred and retracted ruptured tendon end. With chronic ruptures, adhesions to the overlying subdermal layers, as well as to the chest wall, typically are present. A combination of blunt and sharp dissection is performed to release these adhesions and to mobilize the retracted tendon. Care must be taken when mobilizing deep to the muscle because the medial and lateral pectoral nerves enter the muscle on its deep surface medially, and overzealous dissection may injure them. The tendon is repaired once the pectoralis major muscle tendon is adequately mobilized (Fig. 10). Usually it is not necessary to augment the repair with autograft or allograft tissue, even with repairs done as late as 18 months after injury.

**Intramuscular Ruptures**

Intramuscular ruptures of the pectoralis major muscle, although rare, present a unique challenge. If surgery is indicated, the injured muscle belly can be repaired by using a modified Kessler technique. Multiple no. 2 braided nonabsorbable sutures are placed in three layers beginning in the posterior fascia, followed by a middle layer, and finally by placing a third layer through the anterior fascia and muscle. These three layers of interlocking grasping sutures evenly distribute the load among the sutures. The sutures are then repaired to the remaining muscle or tendon on the insertion side of the injury. Unfortunately, depending on the chronicity of the case, there is often little or no remaining sternal head muscle or tendon medially to which to sew. In such cases, the muscle belly is sutured to the remaining clavicular head tendon to provide additional length and to prevent overtightening the repair, which could lead to failure.

**Postoperative Rehabilitation**

The patient is kept in a sling for 4 to 6 weeks, depending on the type of repair and the tear pattern. The rehabilitation protocol is the same for both acute and chronic repairs. Repairs that require mobilization of the muscle or that are repaired under some tension are usually protected in a sling for 6 weeks. Passive pendulum exercises are begun immediately, and passive forward elevation with the arm adducted is allowed to 130°. The patient is instructed to avoid active abduction, forward elevation, and external rotation. At 6 weeks, gentle passive ROM is gradually progressed to full ROM over the ensuing 6 weeks. A gentle periscapular strengthening program is also added at 6 weeks. Additionally, isometric strengthening exercises are begun, although the patient should avoid shoulder adduction, internal rotation, and horizon-
tal adduction. At 3 months postoperatively, ROM should be full or nearly full, with an emphasis placed on regaining strength. Pectoralis major muscle strengthening is begun with single arm pulleys and bands and includes horizontal adduction, internal rotation, forward elevation, and shoulder adduction exercises. Rotator cuff and periscapular strengthening exercises also are included in the strengthening program. At 6 months postoperatively, the patient may begin push-ups and dumbbell bench presses with light weight and high repetition. The patient is returned to full activities between 9 and 12 months, although high-weight, low-repetition barbell bench pressing is discouraged indefinitely.

**Summary**

Rupture of the pectoralis major muscle is rare, but it can occur while lifting weights or participating in strenuous athletic activity. The mechanism of injury is commonly indirect, secondary to a sudden forceful overload of a maximally contracted muscle. In most patients, the site of the tear is at either the myotendinous junction or the tendinous insertion. The patient usually is able to recall the specific time of injury and presents with ecchymosis and swelling about the shoulder and with pain and weakness in adduction and internal rotation of the arm.

Diagnosis of pectoralis major muscle rupture is often made clinically, but further imaging or examination is occasionally required. MRI is the imaging modality of choice because it can be used to accurately assess the site and extent of rupture in both acute and chronic cases. Nonsurgical management is recommended only for proximal tears and elderly, sedentary patients. For all other complete tears, surgery is advocated to return the patient to full strength and function and to reduce cosmetic deformity.

**References**


