

# Injuries to the Pectoralis Major

Seth D. Dodds<sup>1</sup> and Scott W. Wolfe<sup>2</sup>

1 Department of Orthopaedics and Rehabilitation, Yale University School of Medicine, New Haven, Connecticut, USA

2 Weill-Cornell Medical College, Hospital for Special Surgery, New York, New York, USA

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## Abstract

Pectoralis major injuries typically occur in active individuals participating in manual labour or sports. While these injuries are rarely reported, the actual incidence of pectoralis tears among all shoulder injuries is unknown. Diagnosis can usually be made based on a patient’s history and physical examination. However, ultrasound and magnetic resonance imaging are helpful tools for diagnosis and pre-operative planning. Specific treatment options should be based on the severity of the injury and the patient’s individual needs. Nonoperative management consisting of immobilisation and physical therapy can offer a functional result with return of shoulder motion and activities of daily living. In recent studies, operative repair of pectoralis major rupture has been shown to restore normal chest-wall muscle contours and pre-operative strength (even in competitive athletes). Although complications such as re-rupture, infection, and heterotopic ossification do occasionally occur, favourable results should be expected when surgical repair is performed either acutely or in a delayed fashion.

## 1. Background

Injuries of the pectoralis major muscle are uncommon. There have been case reports in the literature describing ruptures of the pectoralis major in different populations of patients, ranging from

high-performance athletes to nursing home residents.<sup>[1-4]</sup> These reports have been supplemented in recent years by more comprehensive studies investigating various treatment strategies for these injuries.<sup>[5-8]</sup> While conservative management can lead to a functional result, restoration of pre-injury

strength and appearance can only be achieved with surgical repair. Specific treatment of this injury should be tailored to a patient's activity level and daily living needs on an individualised basis.

## 2. Incidence

No formal investigations have been performed to assess the incidence of pectoralis major injuries with respect to overall shoulder injuries. Earlier studies in the literature documented both work-related injuries and accidents as common sources of pectoralis tears. More recently, weightlifting injuries dominate the wide array of sports-related pectoralis injuries that have been reported. In their meta-analysis of 112 patient outcomes, Bak et al.<sup>[5]</sup> found a median age of 28 years (range 16–67 years) at the time of rupture. All cases were men, and although hand dominance was not accounted for in every case, the majority were dominant-sided injuries. There is a consensus in the literature that this is a rare injury, but some authors believe that it may be underreported.<sup>[1,6-8]</sup> In fact, Schepesis et al.<sup>[6]</sup> suggested that with the increased popularity in weightlifting and recreational sports the incidence of these injuries may be rising.

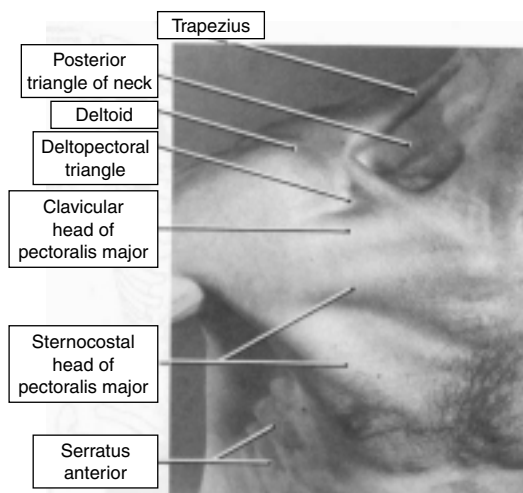
Not all pectoralis major injuries are sustained by young athletes or manual labourers. There have been two recent studies observing these injuries in the elderly. Goriganti et al.<sup>[2]</sup> reported a case of a 79-year-old male who experienced a tear of the pectoralis major while undergoing gait-training rehabilitation after a transtibial amputation. The authors theorised that the patient sustained the injury by overcompensating with his upper extremities during the therapy session. The second report involved pectoralis major injuries in nursing home residents. Beloosesky et al.<sup>[3]</sup> reported seven patients (out of 1162 nursing-home residents) who experienced tears from unknown aetiology. All patients were fully dependent, and cognitively impaired. Injuries likely occurred during patient transfers or other types of patient re-positioning by staff – even during changing of patient gowns (elbow flexion combined with forced shoulder abduction and external rotation). Age-related changes to

the muscle itself also play a role in these injuries to elderly patients: stiff and atrophic skeletal muscle is more susceptible to damage during transfers and patient positioning.

Other case reports that have been published emphasise a specific athletic endeavour or manoeuvre that has caused tears of the pectoralis major insertion.<sup>[4,9-12]</sup> Most of these studies reported a return to sport and restoration to the previous level of athletic function following surgical repair of the ruptured tendon.

## 3. Anatomy

The pectoralis major muscle fills the chest wall just lateral to the sternum. It lies superficial to the pectoralis minor muscle on the anterior aspect of the rib cage. In its course from medial to lateral, the muscle forms the anterior axillary fold (figure 1). The function of the pectoralis major muscle is primarily to bring the arm towards the axial skeleton. Primarily, it adducts the humerus. Secondly, it internally rotates and forward flexes the humerus.

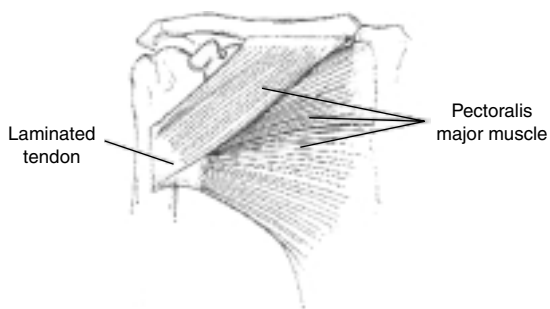


**Fig. 1.** Photograph showing the superficial anatomy of the pectoralis major muscle and its surrounding structures (reprinted from Moore,<sup>[13]</sup> with permission from the publisher Lippincott Williams & Wilkins).

The pectoralis major has a broad-based origin with two distinct heads: a superior clavicular head and an inferior sternocostal head, itself divided into two portions. These muscle bellies expand and converge in a lateral direction to insert on the humerus as distinct tendinous laminae. In their anatomic analysis of the pectoralis major muscle, Wolfe et al.<sup>[8]</sup> found the pectoralis major to have three tendinous laminae. As shown in figure 2, the clavicular head inserts distal and anterior on the humerus, forming the anterior lamina. The manubrial portion of the sternocostal muscle belly inserts onto the humerus as the middle tendinous lamina. Lastly, the inferior fibres from the lower sternum, 5th and 6th ribs, and aponeurosis of the external oblique muscle fuse in a twisting fashion to insert on the proximal and posterior aspect of the insertion site of the muscle, forming the posterior lamina. The three laminae insert onto the proximal humerus just lateral to the bicipital groove.

Branches from the thoracoacromial artery and lateral thoracic artery provide the vascular supply to the pectoralis major. After piercing the clavipectoral fascia, the thoracoacromial artery gives off clavicular and pectoral branches, which provide vascular nourishment to the wide-based pectoralis major muscle. In an anatomic study, Manktelow et al.<sup>[15]</sup> found that a branch from the lateral thoracic artery supplied the inferior portion of the sternocostal muscle belly in 70% of their specimens. They also demonstrated that the distinct muscle bellies were supplied by independent vascular branches from the thoracoacromial and lateral thoracic arteries, enabling free transfers of distinct portions of the muscle.

This muscle has been documented to be innervated by the medial and lateral pectoral nerves as they branch off the brachial plexus (C5–T1 roots).<sup>[13,16]</sup> However, in a detailed anatomic study of the pectoral nerves, Aszmann et al.<sup>[17]</sup> demonstrated that there are three branches of pectoral nerves. In fact, the authors contend that the pectoral nerves should be referred to according to their anatomic origins: superior, middle and inferior. The superior pectoral nerve arises from the supe-



**Fig. 2.** Illustration demonstrating the anatomy of the distinct pectoralis major muscle laminae and common insertion (reprinted from Curtis,<sup>[14]</sup> with permission from the publishers W.B. Saunders).

rior trunk of the brachial plexus (C5/C6) and supplies the lateral clavicular portion of the pectoralis major. The middle pectoral nerve leaves the middle trunk (C7) and then divides into superficial and deep branches. The superficial middle pectoral nerve supplies the medial clavicular and upper sternocostal parts of the pectoralis major. The deep middle pectoral nerve forms a plexus with the inferior pectoral nerve from the inferior trunk (C8/T1), and innervates the inferior portion of the sternocostal head of the pectoralis major.

#### 4. Pathophysiology/Mechanism of Injury

Injuries to the pectoralis major are typically dependent on the mechanism of the traumatic event. A direct blow to the pectoralis major muscle typically causes disruption of the muscle belly and resultant haematoma formation.<sup>[18]</sup> Traction injuries, as described by McEntire et al.,<sup>[11]</sup> may occur proximally from the clavicular, sternal, or chest-wall origins, or distally at the musculotendinous junction, or tendinous insertion. Maximal contraction while the arm is externally rotated, extended, and abducted can cause partial or complete tearing of the muscle. In this setting, tension has been applied to an eccentrically contracting muscle. Wolfe et al.<sup>[8]</sup> demonstrated in their biomechanical study that high external loads to the pectoralis major

while the humerus was in an extended position placed inferior muscle fibres at a significant mechanical disadvantage. In this position, if these loads persist, rupture may progress proximally to the sternocostal and clavicular fibres as well.

Weightlifting activities, especially the bench press, commonly subject the pectoralis major muscle to mechanically disadvantageous positions. In the bench press, the humerus is abducted and extended. With an overpowering weight, the pectoralis major can easily be injured, especially at the point of maximal eccentric contraction. A number of reports have described various cases of pectoralis major rupture caused by different physical activities. Each report describes a similar mechanism of injury – eccentric contraction of the muscle against extreme loads.<sup>[4,6,7,9-12]</sup>

## 5. Classification

Injuries to the pectoralis major have been classified to stratify the extent of a tear or rupture. Tietjen<sup>[19]</sup> proposed a straightforward, anatomic classification (table I) based on the location of the tear (origin, muscle belly or insertion) and its extent (partial vs complete).

## 6. Diagnosis

In the acute setting, initial swelling can make accurate diagnosis difficult. Many patients detail a history of an audible snap or even the sensation of tearing in their axilla,<sup>[20]</sup> accompanied by moderate to severe pain and loss of normal shoulder function. After the initial swelling and ecchymosis re-

solves, examination of the anterior axillary fold reveals an asymmetric, abnormal contour. Abnormal bulging of the anterior chest wall indicates that the pectoralis has retracted medially. With the arm at 90° of abduction, the humerus effectively separates from the torn muscle, creating a webbed appearance of the anterior axillary fold. The cosmetic defect of ‘webbing’ is an accentuation of the inferior border of the deltoid in the setting of a torn pectoralis major muscle.<sup>[8]</sup> In addition, the clavicular and brachial fascia often persist despite a complete pectoralis rupture, and form a relatively firm band across the axillary fold that can be mistakenly interpreted as a partially intact tendon. Repeat examination is mandatory during the acute period, as swelling and haematoma resolve.

Abnormalities in the appearance of the anterior chest wall caused by trauma must be differentiated from soft tissue tumours, infection, and even from congenital absence of the pectoralis major (Poland’s syndrome), which has been described as the most common congenital absence of a muscle.<sup>[9]</sup> Fractures, dislocations, and other injuries about the shoulder should also be included in the differential diagnosis.

Although difficult in the acute setting, muscle strength testing can be helpful in quantifying the pectoralis deficit and in following the progress of treatment. Some authors have employed isokinetic strength testing as an integral aspect of clinical studies comparing conservative with surgical management.<sup>[6-8,21-23]</sup> Isokinetic testing of the pectoralis major measures the strength of the pectoralis as the patient moves the arm from an abducted, externally rotated position across the chest to an adducted, internally rotated position. The unaffected extremity acts as a control against which recovery can be assessed.

## 7. Diagnostic Imaging

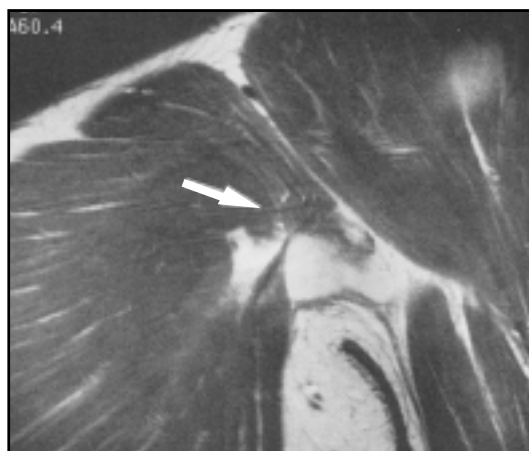
Although the diagnosis of pectoralis major muscle tears is generally made based on clinical examination alone, confirmation of the presence and location of a tear is helpful to guide surgical treatment. Initial work up of these injuries should

**Table I.** Anatomic classification of injuries to the pectoralis major based on location of the tear (origin, muscle belly or insertion) and its extent (partial versus complete)<sup>[19]</sup>

Type	Pectoralis major injury pattern
I	Contusion or muscle strain
II	Partial tear
III	Complete tear
III-A	Complete tear of the muscle origin
III-B	Complete tear of the muscle belly
III-C	Complete tear at the musculotendinous junction
III-D	Complete tear at or near the tendinous insertion

include plain radiographs to rule out any concomitant bony abnormalities. Cases of pectoralis major rupture with accompanying anterior glenohumeral dislocation<sup>[24]</sup> and proximal humerus fracture<sup>[18]</sup> have been reported in the literature. Additionally, in isolated pectoralis tendon avulsions, the avulsed bone fragment may be visualised on plain films.<sup>[25,26]</sup>

Computed tomography has been documented to be helpful when a bone fragment is present.<sup>[26]</sup> Ultrasound is an inexpensive imaging tool that has been shown to be diagnostic for pectoralis major muscle ruptures.<sup>[5,12,27]</sup> As ultrasound differentiates soft-tissue echogenicities well, the location of the tear can be identified using this modality.<sup>[26]</sup> Magnetic resonance imaging (MRI) also has been employed to diagnose and anatomically define pectoralis major tears (figure 3).<sup>[24,28-31]</sup> Miller et al.<sup>[30]</sup> proposed that MRI within hours of injury can confirm a diagnosis of pectoralis major tear when acute swelling may cloud physical examination findings. Connell et al.<sup>[28]</sup> concluded from their study of 15 pectoralis major injuries, that MRI enables the identification of partial versus complete tears, and acute versus chronic tears. Acute tears demonstrated oedema and haemorrhage in the area



**Fig. 3.** Magnetic resonance image of a pectoralis major tear (reprinted from Connell et al.,<sup>[28]</sup> with permission from the publishers Radiological Society of North America).

of the tear, while chronic tears revealed scarring and fibrosis.

## 8. Nonoperative Treatment

Nonoperative management of pectoralis major injuries consists of cryotherapy, rest and limited immobilisation with the humerus adducted, internally rotated and slightly flexed in the acute setting. After the initial pain of the injury has subsided, patients can begin physical therapy to optimise shoulder range of motion. Active strengthening exercises can begin as the patient demonstrates resolution of haematoma and painless shoulder motion.

Proponents of conservative management report that functional recovery ranges from satisfactory to excellent.<sup>[12]</sup> If the diagnosis of a partial tear can be confirmed conclusively with appropriate imaging studies, a trial of conservative treatment is warranted.<sup>[6,22]</sup> Scott et al.<sup>[23]</sup> suggested that all pectoralis injuries should be treated conservatively and those who do not show improvement in isokinetic strength testing should be offered surgery. However, recent studies and case reports suggest that adduction and internal rotation strength is permanently diminished in those patients managed nonoperatively for complete injuries.<sup>[1,5-8,32]</sup>

## 9. Surgical Treatment

Patients who elect surgical repair of a pectoralis major tear should expect restoration of normal or near-normal range of motion of the shoulder joint and the ability to perform pre-injury sports and activities of daily living.<sup>[11]</sup> For patients who desire cosmetic restoration of their chest-wall appearance, anatomic repair of a pectoralis tear offers improved chest-wall muscle contours at the expense of a noticeable incision. In a meta-analysis of 112 cases of pectoralis major rupture, Bak et al.<sup>[5]</sup> demonstrated that patients who undergo surgical repair have significantly decreased pain, as well as a higher rate of return of pre-injury strength and return to activities than patients managed conservatively.

Outcome studies that compare conservative with surgical treatment have demonstrated that surgical repair restored adduction and internal rotation strength, returned patients to pre-injury activity levels, and provided a superior cosmetic result.<sup>[5,8]</sup> Hanna et al.<sup>[33]</sup> demonstrated that surgically repaired injuries regained 97% of the strength of the uninjured arm versus 56% in non-operative patients. Wolfe et al.<sup>[8]</sup> measured isokinetic strength in nonoperatively treated patients and demonstrated a loss of 26% peak torque and a 40% work production when compared with the uninjured side. In patients treated with surgical repair, measurements of 109% peak torque and 113% work production were documented.

Some authors reported best results with repair of the ruptured tendon in the acute setting (within a few weeks of injury).<sup>[4,10,30]</sup> Typically, the surgical dissection in the acute setting is not complicated by adhesions between the disrupted muscle fibres and the chest wall and subcutaneous tissues. However, even with the presence of scar tissue and adhesions, successful surgical repair is still possible. Anbari et al.<sup>[20]</sup> obtained a good outcome in a chronic rupture with surgery 13 years after the original injury. Alho<sup>[32]</sup> reported a case of a delayed repair that required inferior-medial muscle origin release to mobilise the distal tendon stump sufficiently to allow anatomic repair. Kretzler and Richardson<sup>[7]</sup> repaired two chronic injuries approximately 5 years after injury and found improvement, but not full restoration of strength. Hanna et al.<sup>[33]</sup> studied ten cases and found that delay of surgery was not a significant factor in outcome. In comparing repairs of acute and chronic injuries to the pectoralis muscle, Schepsis et al.<sup>[6]</sup> found no difference in outcome between ruptures repaired acutely or in a delayed fashion. Delayed diagnosis of pectoralis major injuries does occur, and such cases are amenable to surgical treatment.

## 10. Surgical Technique

In cases of tears involving the musculotendinous junction or tendinous insertion, most authors recommend a deltopectoral incision. This expan-

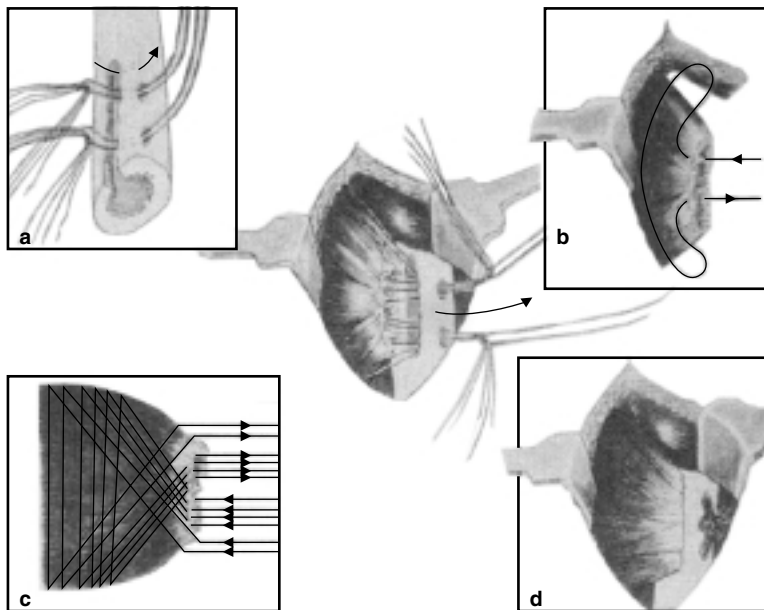
sile incision offers surgical exposure for releasing adhesions, mobilising the pectoralis major tendon, and direct repair to the insertion of the muscle on the humerus. The deltoid muscle can be retracted laterally to expose the torn pectoralis muscle. When the repair is delayed, adhesions between the torn muscle fibres and subcutaneous tissues must be dissected free to properly mobilise the pectoralis tendon.

The specific repair technique depends on location of the rupture. In tears of the musculotendinous junction, direct suturing of the ruptured ends may be performed. When the rupture occurs at the tendinous portion or the insertion of the pectoralis, the insertion site should be prepared for reapproximating the remaining tendon to the bony insertion. The distal end of the tendon is harnessed with non-absorbable sutures. Some authors recommend creating a bone trough just lateral to the sulcus bicipitalis, into which the distal tendon end can be inserted.<sup>[6,8]</sup> In most situations, the sutured tendon can be seated firmly back to its insertion site through drill holes in the humerus (figure 4) or with bone anchors.<sup>[18]</sup> If there is an avulsion injury, then the bone avulsion fragment with its tendon insertion should be anatomically reduced and internally fixated.<sup>[18,25,26]</sup>

Postoperative treatment typically consists of immobilisation of the shoulder with the humerus in an adducted, internally rotated, and slightly flexed position, which prevents tension on the pectoralis tendon repair. Duration of immobilisation varies according to location of tear, type of repair, and surgeon preference, but usually 4–6 weeks allows sufficient time for initial healing. Early range of motion exercises should be initiated at this time to avoid shoulder contractures. Active strengthening exercises are generally begun between 12–14 weeks post-injury.

## 11. Complications

Complications involving injuries to the pectoralis major muscle are rare, but they do occur. Operative complications include re-rupture at the repair site, scar widening and haematoma forma-



**Fig. 4.** Illustration depicting the reapproximation of the pectoralis major tendon to its insertion site using a bone trough and drill holes in the humerus (reprinted from Wolfe et al.,<sup>[8]</sup> with permission from the publishers *American Journal of Sports Medicine*).

tion. In cases treated both closed and operatively, infection of pectoralis major injury haematoma requiring surgical drainage and debridement has been acknowledged.<sup>[27,34]</sup> In fact, the first reported individual with a pectoralis major rupture died of acute sepsis secondary to an infection of the pectoralis rupture haematoma. Heterotopic ossification forming within the injured pectoralis muscle tissue also has been noted to occur.<sup>[35]</sup> Smith<sup>[36]</sup> reported a case of rhabdomyosarcoma which arose *de novo* from skeletal muscle 10 years after a ruptured pectoralis major muscle. Restriction of shoulder motion, new onset of pain, enlarging chest-wall mass, and clinical signs of infection should raise suspicion concerning an aberration from the natural course of healing of a pectoralis major muscle injury.

## 12. Conclusion

Pectoralis major muscle tears are significant injuries that typically occur in manual labourers and athletes. Nonoperative treatment can restore

shoulder and arm function; however, chest-wall deformity and relative weakness in adduction, internal rotation and forward flexion may persist. Surgical repair, either immediately or as much as 5 years following injury, has been shown to provide restoration of shoulder strength and correction of chest-wall deformity. Although significant complications such as re-rupture, infection, haematoma formation and heterotopic ossification can occur, they are rare and treatable. Specific treatment of pectoralis major injuries should be based on the severity of the injury and the patient's specific needs.

## Acknowledgements

No sources of funding were used to assist in the preparation of this manuscript. The authors have no conflicts of interest that are directly relevant to the content of this manuscript.

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Correspondence and offprints: *Scott W. Wolfe*, Weill-Cornell Medical College, Hospital for Special Surgery, 535 E. 70th Street, New York, USA.  
E-mail: wolfes@hss.edu