



Successful surgical repair of a full-thickness intramuscular muscle belly rupture of pectoralis major



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Pectoralis major (PM) tendon ruptures are well documented in the literature; however, PM full-thickness intramuscular rupture of the muscle belly is rare, with only 6 other cases reported to date.^{1,3,4,6,16,17} Five of the 6 cases were surgically repaired. Four of these reported good to excellent results,^{3,16,17} based on the Bak Criteria,³ though they did not include both pre- and postoperative magnetic resonance imaging (MRI) or assess other outcome measures such as high-level functional tests. One case was treated conservatively and did not achieve an “excellent” outcome¹⁷; however, the exact outcome was not specifically reported.

We present the only case to our knowledge with pre- and postoperative MRI, Bak Criteria assessment, and postoperative PM-specific functional testing—including isokinetic dynamometer strength, maximal arm active range of motion, and functional scores.

Case presentation and methods

A 34-year-old right hand–dominant male soldier developed sudden right chest wall pain while doing high-intensity burpee exercises. He trialed rest, physiotherapy, and light training, but had ongoing pain and unilateral weakness doing pushups (limited to

15). He presented to the surgical clinic following failed conservative treatment, 4 weeks after injury, with a palpable defect in the muscle belly of the right PM. Three-tesla (3-T) MRI (Royal Philips Achieva, Amsterdam, the Netherlands) demonstrated a full-thickness tear in the sternocostal head of his PM measuring 45 mm superior to inferior, with a 20-mm separation gap (Fig. 1).

The patient underwent surgical repair, followed by a 6-month structured rehabilitation program. Ethics approval was gained from the institutional review board to evaluate postoperative functional capacity, the patient gave his consent to be part of the research, and additionally all of the research was conducted ethically according to international standards.¹⁵

Surgical technique

Under a general anesthetic, and after 1000 mg intravenous cephalexin, a skin incision was made centered over the palpable muscle defect. The subcuticular tissue was undermined and the defect identified, opened, and explored. It consisted of a large hemerosous, fluid-filled cavity with no evidence of muscle healing following over 4 weeks of nonoperative treatment. The full-thickness PM muscle defect (Fig. 2) was located in the muscle belly of the sternocostal head of the PM. Based on the Teitjen Classification,^{3,19} the defect was a 2B, with the clavicular head of PM intact.

The cavity was débrided, and the edges of the muscle apposed using a modified Kessler technique—with 5 interrupted core sutures of 2-mm FiberTape (Arthrex Inc, Naples, FL, USA), and a

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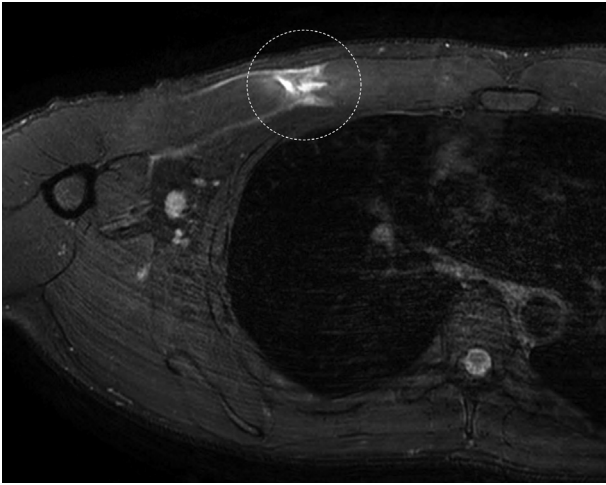


Figure 1 Preoperative transverse magnetic resonance image: right pectoralis major (..... surrounds defect).

1-0 polydioxanone (PDS*II, Ethicon, Somerville, NJ, USA) locked running suture to the epimysium (Fig. 3). The repair was stable when passively ranging the arm and applying tension to the PM intraoperatively.

Postoperative care and rehabilitation

The patient wore a broad arm sling for 6 weeks. A single post-operative ultrasound-guided platelet-rich plasma injection was administered to the muscle repair site at 2 weeks postsurgery. Passive range of motion exercises and stretching commenced after sling removal at 6 weeks. The patient commenced light strength training at 3 months and progressive strength training at 4 months with physiotherapist supervision.

Results

A repeat 3-T MRI at 6 months after surgery demonstrated closure of the full-thickness muscle defect seen on the preoperative MRI, with minimal scar tissue present (see Figs. 4 and 5). Mild generalized muscle atrophy was noted, consistent with the restrictions postsurgery.

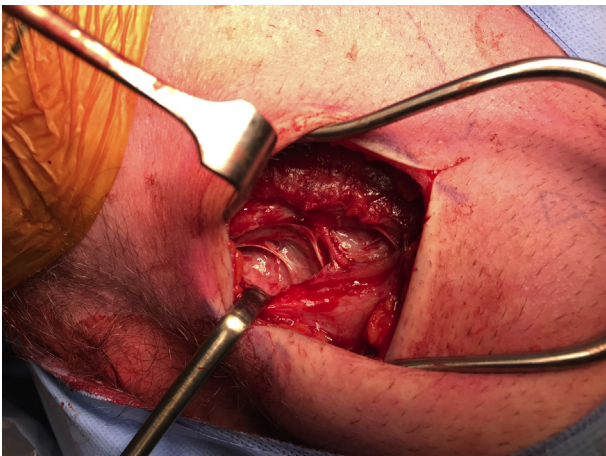


Figure 2 No evidence of muscle healing at 4 weeks with a retracted defect in the pectoralis major sternocostal head.

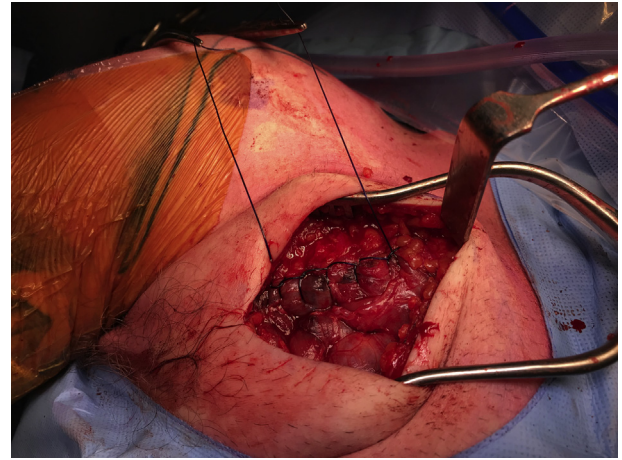


Figure 3 Placing of 1-0 polydioxanone epimysium locking suture over the deep core sutures.

A comprehensive clinical and function assessment was performed at 7 months postsurgery. The Bak Outcome Criteria,¹ used for PM tendon rupture, were applied to remain consistent with the majority of the cases reported in the literature.^{3,17} Peak isokinetic arm strength was measured bilaterally at 90°/s using a Biodex System 4 Pro dynamometer (Biodex Medical Systems, New York, NY, USA). The operative side had an adduction peak torque deficit of 19% (92 Nm operative vs. 113 Nm nonoperative), an internal rotation peak torque deficit of 9% (49 Nm vs. 54 Nm), and a flexion peak torque deficit of 8% (58 Nm vs. 63 Nm). Given the mild generalized muscle atrophy on the MRI, and the time frame postsurgery, this deficit is expected to improve with ongoing strength training.

In United States Military Academy volunteers, the Upper Quarter Y-Balance Test is a reliable test of active range of motion, with no difference reported in dominant and nondominant arms in healthy males.²⁰ Hence, the nonoperative arm can be used as a “normal” comparator for the operative arm.²⁰ The patient had a 4-cm deficit in reach for the operative arm in each direction (medial, superolateral, inferolateral).

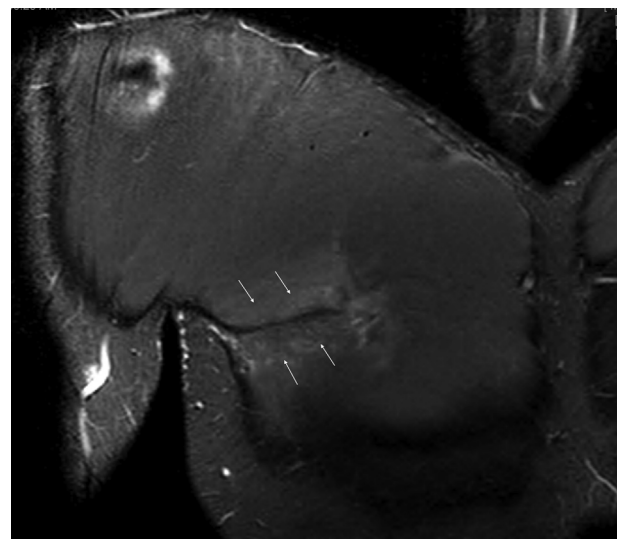


Figure 4 Postoperative coronal magnetic resonance image: right pectoralis major (← point to defect apposed with minimal scar tissue).

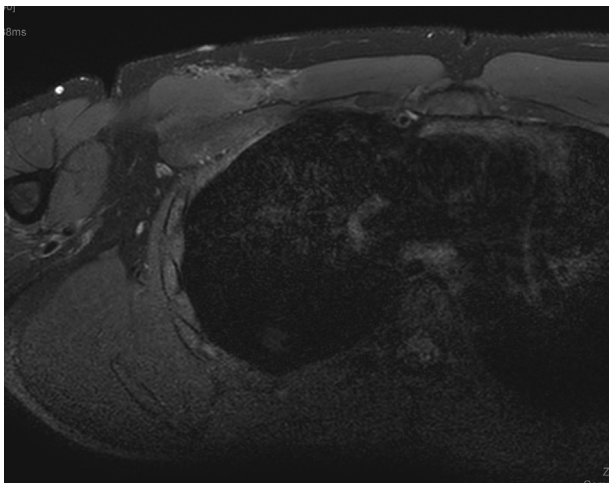


Figure 5 Postoperative transverse magnetic resonance image: right pectoralis major.

There are no specific and validated scores for assessing PM function in high-functioning athletes. We decided on the Kerlan-Jobe score for overhead pitchers as the best available substitute questionnaire for assessing this patient's function. It assesses shoulder pain, weakness, instability, and participation in high-level sports on a visual analog scale and is both valid and reliable.^{2,5,11} The patient scored 96.5 of a possible 100, whereas normal scores for high-functioning pitchers are >90%.¹¹

The patient reported no pain (0 of 10 on a visual analog scale pain score), was happy with his cosmetic appearance, and self-reported being at "90% strength" and "very satisfied" with his overall function. He had passed his basic military fitness tests, including 62 pushups, and had returned to military training 7 months after surgery.

The overall outcome of the patient was rated as "good" based on the Bak Criteria,¹ with no pain or cosmetic defect, a slight restriction in range of motion, and less than 20% defect in isokinetic peak torque compared with the contralateral side. This overall outcome was consistent with the outcomes seen in other surgically treated cases of full-thickness intramuscular rupture reported in the literature.^{3,4,16,17}

Discussion

Healing following muscle trauma is challenging, as the regenerative capacity of injured muscle tissue is limited.^{9,14} Rather, fibrosis often develops at the site of injury, which can cause incomplete functional return and the likelihood of repeat injury.⁹ There are 4 key interrelated and time-dependent stages of muscle healing following injury: (1) necrosis/degeneration, (2) inflammation, (3) regeneration, and (4) fibrosis.⁹ The first 2 stages occur within minutes and continue for up to 2 weeks. Muscle regeneration begins about week 1, peaks in week 2, and then declines over weeks 3 and 4. The formation of fibrotic scar tissue occurs last, especially with incomplete or failed muscle regeneration. It starts in week 2, then increases in size and continues for many weeks. Minimizing the formation of scar tissue is key to improving the regeneration of muscle and the functional outcomes of skeletal muscle repair.⁹

Treatments to prevent fibrosis and improve healing for intramuscular ruptures

The best treatment for muscle injury on the whole is unclear.^{9,18} Biological approaches have been proposed to limit fibrosis and

enhance regeneration; these include the delivery of human recombinant proteins to the injury site and the use of antifibrosis agents (eg, decorin)^{7,9}; however, they are not widely used in clinical practice because of a paucity of clinical evidence.¹⁴ Conservative measures and physiotherapy treat the vast majority of mild muscle injuries. For the rarer cases of serious injury, that is, full-thickness and separated muscle tears with a large intramuscular hematoma, there is evidence that surgery improves muscle regeneration and functional outcomes.^{1,9,12,14,15} It is hypothesized that the surgical apposition of the injured muscle ends, reduces the volume of the muscle defect, and subsequently reduces deep scar tissue formation.⁹

Closed biceps brachii muscle belly rupture is a well-known injury of static line parachutists.⁸ A series by Kragh and Basamania¹² of 12 military parachutists with closed biceps brachii muscle belly rupture compared 9 who underwent immediate surgical repair with 3 who were treated nonoperatively. At 2 years, those who had surgery were more satisfied and had a significant improvement in supinator power compared with those treated conservatively (mean torque 11 and 5.8 Nm, respectively, $P < .05$).¹²

A report by Oliva et al¹⁴ reported on a 30-year-old male soccer player who lacerated his vastus medialis with a circular saw and underwent surgical repair. The suturing technique involved simple deep interrupted stitches into the muscle and including the epimysium. The patient returned to daily activities by 3 months, and at 6-year follow-up, the patient reported his outcome at 100% recovered, with muscle strength testing on a dynamometer revealing only a 14% loss in muscle strength compared with the contralateral side.¹⁴ MRI revealed the presence of minor ongoing scar tissue at the repair site,¹⁴ which is consistent with the biology of skeletal muscle healing discussed above.⁹

Compared with injury at the site of tendon insertion or musculotendinous junction, intramuscular tears are a technical challenge for surgeons because of the lack of reliable suture methods to hold the injured ends in apposition.^{13,14} This is partly because the scaffolding of muscle is weaker than the fibrous connective tissue of tendon, which can lead to suture pullout under load and failure of the surgical repair.¹⁸ Numerous suture techniques have been described (Kessler, Mason-Allen, Nicoladoni, Bunnell, horizontal, or modified versions or combination, etc), with no consensus on which is the best.¹⁸

PM muscle rupture and repair

The PM muscle is a powerful adductor and also an internal rotator and flexor of the arm.^{1,3,10} Activities where the arm is abducted, externally rotated, and extended (eg, bench press or burpee movement) predisposes the PM, and particularly the inferior portion of its tendon, to fail first.^{3,4,10,21}

Acute surgical repair of the PM tendon or reattachment of its insertion improves power and functional outcomes compared with conservative measures.^{1,3,10,17} There is limited evidence available for surgical repair of full-thickness PM injury involving the muscle belly, with 5 other cases in the literature.^{3,4,6,16,17} In the case series by Bak et al³ of 112 PM ruptures, the 2 muscle belly injuries were reported but not analyzed separately from the tendon or musculotendinous injuries.

A prospective cohort by Pochini et al¹⁷ reported 60 cases of complete PM rupture, including 2 muscle belly injuries. One was surgically repaired with an "excellent" outcome based on the Bak Criteria,³ whereas the other was treated nonsurgically and did not achieve an "excellent" outcome.¹⁷ Further specific outcome data were not provided.

A case report of a PM muscle belly rupture in a competitive skateboarder revealed improved dynamometer-measured

adduction power from –26% of contralateral side preoperatively, to –10% after surgical repair.¹⁶ Preoperative MRI was presented; however postoperative MRI assessment was not reported to document muscle healing after surgical repair.

Another case report of a PM muscle belly rupture, following blunt thoracic trauma, underwent surgery within 24 hours and was reported as “successfully” repaired with full-thickness sutures; however, MRI and functional outcomes were not reported.⁶

Conclusion

Full-thickness ruptures of the PM muscle belly are rare and have been treated surgically with good to excellent results reported. However, the outcome measures vary between studies, or are incompletely documented. Consequently, the best treatment for PM muscle belly rupture remains unclear. Based on the biology of muscle healing, we suggest PM muscle belly ruptures be considered separate from tendon ruptures. In this case report, a full-thickness and separated PM intramuscular rupture has undergone successful subacute surgical repair following failed conservative treatment. Although this study has only a short follow-up of 7 months, good to excellent functional outcomes were achieved and MRI evaluation indicated successful muscle healing. The patient also returned to high-intensity military training.

Disclaimer

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