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Case series of *pectoralis major* rupture requiring operative intervention sustained on the Royal Marines 'Tarzan' assault course

Jonathan Evans¹, Chris Smith² and Paul Michael Guyver³

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Abstract

We present (with intra-operative imaging) four patients who sustained *pectoralis major* (PM) ruptures on the same piece of equipment of the 'Tarzan' assault course at the Commando Training Centre, Royal Marines (CTCRM). Recruits jump at running pace, carrying 21 lbs of equipment and a weapon (8 lbs) across a 6-foot gap onto a vertical cargo-net. The recruits punch horizontally through the net, before adducting their arm to catch themselves, and all weight, on their axilla. All patients presented with immediate pain and reduced function. Two had ruptures demonstrated on magnetic resonance imaging, one on an ultrasound scan and one via clinical examination. All four patients were found, at operation, to have sustained type IIIE injuries. All patients underwent PM repair using a unicortical button fixation and had an uneventful immediate postoperative course. Patient 1 left Royal Marines training after the injury (out of choice; not because of failure to rehabilitate). All other patients are under active rehabilitation, hoping to return to training. Review of 10 years of records at CTCRM reveal no documented PM rupture prior to our first case in October 2013. There has been no change to the obstacle or technique used and all patients deny the use of steroids.

Keywords

Button; major; pectoralis, Royal Marines, rupture

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Introduction

Royal Marines training is regarded as one of the longest and hardest infantry training courses in the world. Many injuries have been regularly associated with training, such as stress fractures of metatarsals, femoral neck and tibia.¹

The 'Tarzan' assault course is one of the four commando tests completed in 'Test Week' at the conclusion of Royal Marine Commando training. In the build up to this, recruits will regularly train on the course, practicing on the equipment with increasing loads and improving the completion time. One particular obstacle, 'the Chasm jump', involves recruits jumping at running pace, carrying 10 kg of body mounted equipment and a weapon (3.6 kg) across a 6-foot gap onto a vertical cargo net. The recruit punches their arm horizontally through the net, and then forcibly adducts the shoulder to catch himself on his axilla before dismounting the net.

The *pectoralis major* (PM) muscle plays an important role in flexion adduction and internal rotation of the shoulder. The first description of a PM rupture was by Patissier in 1822 in a French boy lifting a heavy piece of meat from a hook.² Pectoral ruptures are historically described as rare; however, in recent times, their incidence has increased with increased participation in competitive sport and the popularity of weight training.^{3,4} Ruptures of the PM tendon can either be

¹Princess Elizabeth Orthopaedic Centre, Royal Devon and Exeter NHS Foundation Trust, Exeter, UK

²Royal Devon and Exeter Hospital (Wonford), Exeter, UK

³Royal Devon and Exeter Hospital, Barrack Road, Exeter, UK

Corresponding author:

Jonathan Evans, Princess Elizabeth Orthopaedic Centre, Royal Devon and Exeter NHS Foundation Trust, Barrack Road, Exeter EX2 6LR, UK.
Email: jonathanevans1@nhs.net

Table 1. Classification of *pectoralis major* ruptures.

Classification	Description
I	Muscle sprain
II	Partial tear
IIIA	Complete tear – muscle origin
IIIB	Complete tear–muscle belly
IIIC	Complete tear–myotendinous junction
IIID	Complete tear–tendinous
IIIE	Bony avulsion from insertion
IIIF	Muscle tendon substance rupture

complete or incomplete; and can be of the sternal fibres, clavicular fibres or both.^{9,12,16}

There is a general consensus that surgical intervention plays an important role in recovering strength, particularly in the young patient with complete tears.^{5–9} A review article by Merolla et al. details both the classification and surgical options in depth;¹⁰ however, a general system of classification is seen in Table 1.^{11–13}

The sternal portion is the most commonly involved,^{9,12} with the IIID being the most common classification of the injury in approximately 65% of cases.¹¹

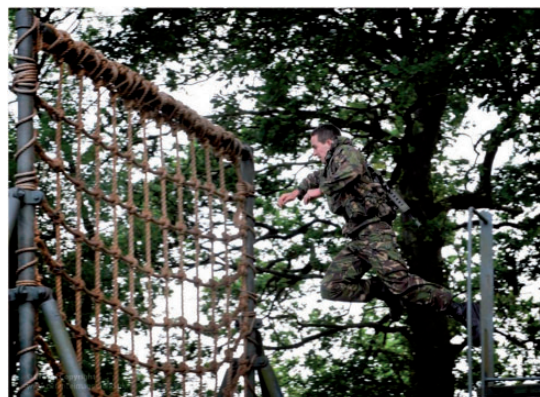
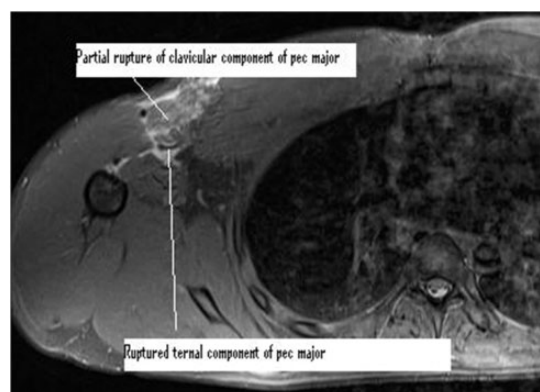
The mechanism of injury was also discussed by Merolla et al.,¹¹ with eccentric contraction of the musculotendinous unit being to blame in most cases of participants in rugby, football, boxing, wrestling and water skiing.^{9,14,15} Rarer cases have, however, been described with an abducted extended arm resisting forces,^{16–18} such as in windsurfing.

The three main surgical options for fixation of the tendon are the use of suture anchors,⁵ bone tunnels¹⁹ or bone troughs.²⁰ The general principle however consists of anchoring in the remaining tendon stump to the bone therefore encouraging it to heal and regain strength.

Case Series

We present a series of four patients who sustained PM ruptures on the same piece of equipment of the ‘Tarzan’ assault course (Figure 1) during Royal Marines Training at the Commando Training Centre Royal Marines (CTCRM). The first case was identified in late May 2013 and the final case at the start of March 2014.

All patients presented to medical teams immediately on completion of the obstacle with pain and reduced function in the affected shoulder/arm. Pain was felt at

**Figure 1.** Chasm jump.**Figure 2.** Magnetic resonance images of rupture.

the moment of impact with the cargo netting in all cases where the axilla was in contact with the rope. The initial two cases were referred to the local Emergency Department; however, the pattern was recognized for the third and fourth patients, who were referred directly to a specialist shoulder team fracture clinic.

None of the patients were taking levoquinolone antibiotics (which have been associated with tendinopathy and tendon rupture but not necessarily PM rupture)²¹ at the time of injury and all denied the use of anabolic steroids on direct questioning.

Diagnostic imaging

The initial two cases underwent magnetic resonance imaging scans of the injured shoulder demonstrating rupture of the PM insertion; examples are provided in Figures 2 and 3. Case 3 had no imaging prior to operation and the decision was made on clinical findings. The fourth case underwent an ultrasound scan at CTCRM; this confirmed at least a partial PM rupture.



Figure 3. Magnetic resonance images of rupture.

This final case did not undergo any further imaging prior to operative exploration.

Operative technique

All patients underwent unicortical bone anchor (Pec Button, Arthrex, Naples, FL, USA) button fixation within 2 weeks of the initial injury and had an uneventful immediate postoperative course. All four patients required 'three-button' fixation and had surgery as a day-case procedure. The extent of the injuries as found at time of surgery was: patient 1 – 50% clavicular fibres avulsed, 100% sternal fibres avulsed; patient 2 – 90% clavicular fibres avulsed, 100% sternal fibres avulsed; patient 3 – 100% clavicular fibres avulsed, 80% sternal fibres avulsed; and patient 4 – 100% clavicular fibres avulsed, 70% sternal fibres avulsed.

Two specialist upper limb consultants performed two repairs each. A mini deltopectoral approach was used in all cases, with the cephalic vein taken laterally with the deltoid to reveal the tear. Once the tear was visualized, an assessment of the relative size of the tear in relation to the total pectoral insertion on the humerus was made. Figure 4 clearly shows the reflected insertion of PM that has been avulsed.

Identification of the footprint of the ruptured tendon on the humeral shaft is important in assessing the number of bone anchors to use in the repair (Figure 4). Once the area has been cleared, the bone can be prepared for the insertion of the unicortical bone anchors. Attached to each anchor are two fibre-wire sutures that are whip-stitched to the avulsed tendon. A 3.2-mm unicortical drill hole is made in the humerus through which the 'pec button' can be passed. The button sits inside the bone acting as an anchor preventing the repair from pulling the sutures away from the bone. Once the anchors are placed, the stitches attaching the button to the free edge of the PM can be tightened, thus repairing the defect.

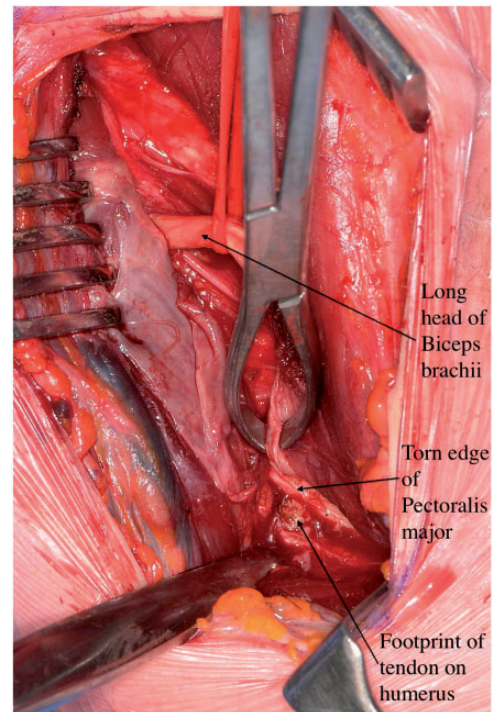


Figure 4. Assessment of extent of tear and visualization of bare area.

Rehabilitation/postoperative management

Following surgery, patients were placed into a Lancaster sling. Both surgeons limited all movements for the first 6 weeks before rehabilitation. One surgeon used a standard Bankart rehabilitation plan and the other based rehabilitation on a rotator cuff repair plan.

Following the 3-month medical review at our unit, patients were discharged back to the experienced physiotherapy and rehabilitation team at CTCRM.

As with most recruits returning from injury or illness, the patient was moved into a specialist rehabilitation class (Hunter Company) so that they could focus full time on return to training. In the case of our patients, the repair was protected when work was undertaken to retain or regain general physical/cardiovascular fitness. Time was also used to promote other key areas of Royal Marines development (education, Military knowledge, etc.). When appropriate, the in-house physiotherapy team then focused more on specific upper limb and shoulder rehabilitation. As with all recruits returning from injury or illness, once considered strong enough, they are put through a series of general return to training tests before being allowed to rejoin a full time training Troop. These functional tests have been developed over years by the Medical/Rehabilitation team at CTCRM and are not specific to this injury.

Case Reports

Case 1

Reviewed 6 weeks postoperatively with no complications, patient 1 decided to leave Royal Marines training after the injury, although he was not discharged because of failure to rehabilitate. He has been lost to follow-up as he is from out of the area and initially presented to our unit as a result of the location of the Commando Training Centre.

Case 2

Having returned to Commando training 7 months after repair, patient 2 successfully passed out of training (having completed all Commando tests, including the 'Tarzan' assault course), 9.5 months following initial injury.

Case 3

Similar to patient 2, patient 3 successfully returned to training 3 months after repair and subsequently passed out of training 5 months after injury.

Case 4

Three months postoperatively, with no complications to date, patient 4 was discharged to the care of MOD physiotherapy/rehab team. As a result of being an Officer cadet, he (for logistic and training reasons) can only return to training with the once-yearly intake of Young Officers. He is continuing with his rehabilitation and strength training with the intention of restarting training in September 2015.

Discussion

Although it is not possible to review the exact mechanism of injury in these cases, the medical team have postulated that over extension of the shoulder when forcefully adducting the arm may have lead to the rupture as a result of eccentric loading of the pec major tendon. If this were the case, the importance of use of the correct technique would be further cemented.

Review of the records of both the medical and rehabilitation teams at the Commando Training Centre revealed no other documented cases of confirmed or suspected pectoralis rupture in the previous 10 years. This gives an injury rate of 0.47 per 1000 recruits, which is approximately half of that seen for displaced femoral neck stress fractures in the same population (an unrelated injury but a frame of reference for incidence). Given that each recruit will complete the 'Tarzan' assault course an average of 10 times,

it may be suggested that this injury has an incidence of approximately one injury per 20 000 jumps.

There has been no change to the equipment or the technique taught during this time. No obvious reason for the sudden increase in this type of injury has been identified during this review. The pattern of the recruit's uniform did change in early 2013 (as with much of the rest of the UK Armed Forces); however, there was little change to the design of the uniform and no restriction of movement has been identified. The cargo net had not been replaced recently and the jump distance was unaltered.

Interestingly, review of records did reveal one case of a recruit who successfully completed training with a congenital absence of PM; this was only picked up when he sustained an unrelated lower limb injury.

The decision to operate was made based upon the fact that this was a group of high demand patients who wished to continue performing at this elite level. A 2006 article by Kakwani et al. reviewed 13 cases of PM rupture and showed that early surgery enabled 11 of the 13 to return to their pre-injury level of sports in a mean time of 8.5 months.²² All of the recruits who wished to return to the Royal Marines so far have gone on to complete Commando training. The highly experienced medical and rehabilitation team at CTCRM ensures that recruits do not re-enter training too early and the team also closely monitors progression before recruits are allowed to continue unrestricted. This graduated return to training is valuable not only for this injury, but also for all musculoskeletal injuries and offers recruits the greatest chance of completing training. To complete Royal Marines training, the recruits will have had to complete the Chasm jump obstacle a number of times, depending on the week of training in which they sustained their initial injury (both recruits who completed training did admit, however, to changing which arm they used to catch the netting). In addition to this, they will have had to complete all other Commando Tests and training exercises, as would all other recruits.

A study by Thomas et al. (unpublished results; Princess Elizabeth Orthopaedic Centre, Exeter, UK) looking at a biomechanical model of two methods of PM repair has suggested that gradual rehabilitation is favourable to an accelerated rehabilitation programme in these patients.

This case series describes complete ruptures requiring surgical fixation in a group of highly-trained recruits. However, medical practitioners attending to injuries sustained on this or similar obstacles should consider partial or complete rupture in patients presenting with shoulder pain. The growing popularity of civilian endurance events and obstacle courses means that these injuries may not be limited to the military population.

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