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# Optimizing pectoralis major tendon repair: a modified knotless suture anchor technique using high-strength suture and tape

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**Background:** Rupture of the pectoralis major (PM) tendon is infrequent but has shown an increased incidence in athletes, particularly weightlifters during bench presses. Various techniques for repair exist, yet no established gold standard has been defined.

**Methods:** We present a modified surgical technique utilizing knotless suture anchors for PM tendon repair. The technique involves bringing the tendon end superiorly and inferiorly to the decorticated bone surface, ensuring broader tendon-to-bone contact. Knotless anchors with a unique suture locking mechanism facilitate tension adjustment. Additionally, the repair's strength is reinforced by employing both surgical tape and high-strength suture.

**Results:** The utilization of both surgical tape and high-strength suture in conjunction with knotless suture anchors provides a secure and stable construct. This approach minimizes the risk of failure, reduces the potential for neurovascular injury associated with bicortical drilling, preserves imaging quality due to the absence of metal artifacts, and helps avoid the risk of fracture associated with traditional methods. However, surgeons should be aware of a potential disadvantage of increased surgical costs compared to traditional techniques.

**Conclusion:** Our modified technique offers multiple advantages, including increased tendon-to-bone contact, enhanced stability, reduced neurovascular risks, and avoidance of potential fractures. This makes it a valuable option for successful PM tendon repairs. Surgeons should consider its benefits and weigh them against the associated costs for optimal patient care.



Rupture of the pectoralis major (PM) tendon is a relatively rare but increasingly recognized injury, commonly observed in athletes, particularly weightlifters, especially during bench presses.[1,2,6] While various techniques for PM repair have been explored, the restoration of the tendon to its anatomical insertion has gained popularity, yet a definitive gold standard for repair techniques and fixation options remains elusive.[3,12,13]

In this article, we introduce a feasible and reproducible option for PM repair. Our modified surgical technique involves using suture materials loaded onto knotless anchors to secure a broad tendon-to-bone attachment site without creating a trough. This approach, achieved with the aid of a high-speed burr, aims to minimize the risk of proximal humerus fracture or neurovascular injuries while ensuring stable fixation through a unique suture locking mechanism. This technical note provides comprehensive details of our approach, offering an alternative option for successful PM repairs.

## Surgical technique

### *Clinical and physical examinations*

A 32-year-old male mixed martial arts fighter experienced sudden pain in his left shoulder while performing weightlifting exercises, presenting 4 days before undergoing surgery. The patient denied any pre-existing medical conditions or the use of anabolic steroids. (Video 1)

During the physical examination, notable findings included ecchymosis, asymmetry of the axillary fold, and bulging at the origin of the pectoralis muscle on the chest (Fig. 1). Plain radiographic imaging did not reveal any abnormalities. However, further assessment using magnetic resonance imaging demonstrated a complete avulsion of the sternal head of PM tendon from its insertion site (Fig. 2).

Institutional review board approval was not required for this technical note.
Informed consent for publication of all data in the manuscript was obtained from all individual participants included in the study.

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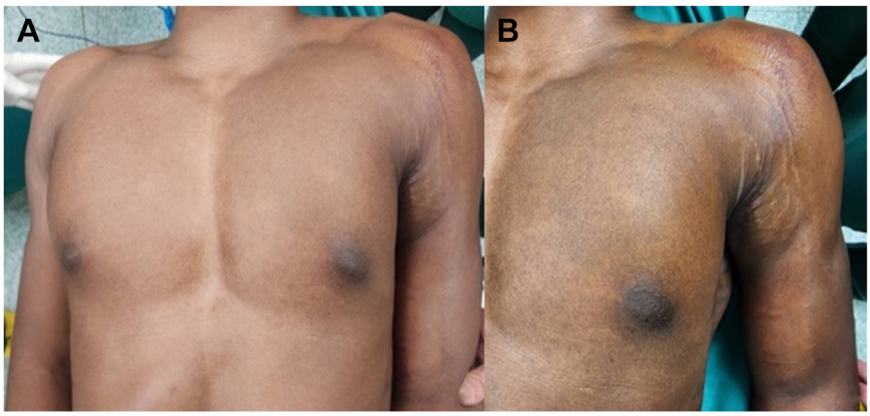


**Figure 1** Clinical presentation of a pectoralis major tendon rupture, showing asymmetry of the axillary fold (**A**), ecchymosis, and bulging at the origin of the pectoralis on the chest (**B**).

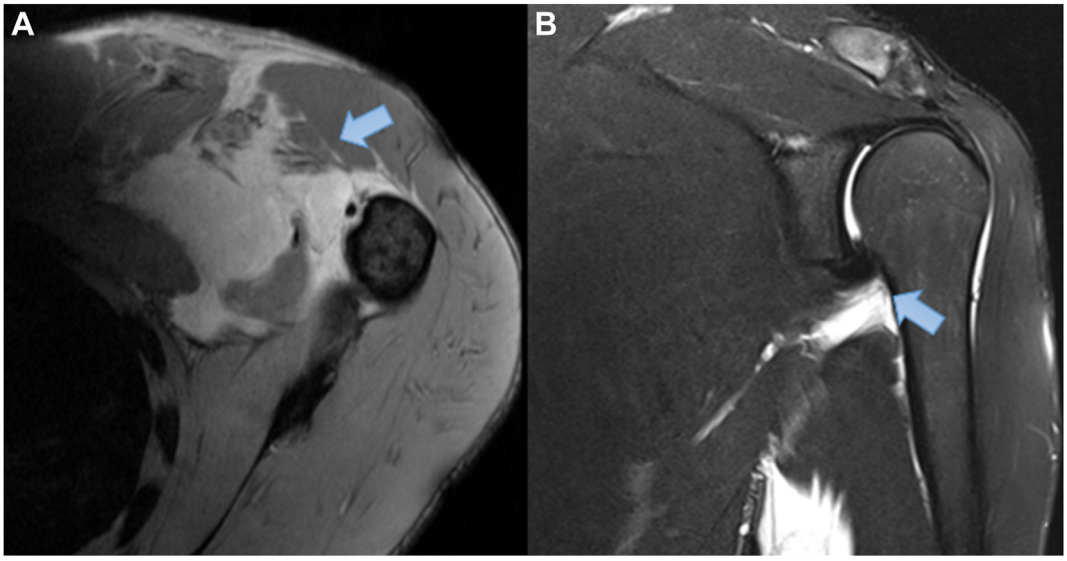


**Figure 2** (**A**) Axial and (**B**) coronal view magnetic resonance imaging of the *Left* shoulder, with arrows indicating a complete tear of the sternal head of the pectoralis major tendon.

*Patient positions*

A modified beach chair position at 45° is used for this surgical technique. The operative extremity is sterilely prepared and draped, and the arm is attached to the limb positioner (AssistArm; ConMed, Largo, FL, USA). We prefer this setting, which allows for better control of the operative extremity, and the surgical assist team does not need to hold the limb, enabling them to focus on other critical tasks.

*Surgical incision planning and approach*

The modified deltopectoral approach (Fig. 3, *A*) was employed, with the incision marked proximally over the coracoid and distally slightly more medial to facilitate ease of repair and tendon retrieval. A surgical incision of 6-8 cm was made. Careful dissection was performed medial to the deltoid, with special attention to preserving and retracting the cephalic vein laterally. Blunt dissection was then carried out to identify the coracoid, conjoined tendon, and bicipital groove, providing guidance for the subsequent dissection. It is essential to remain lateral to the coracoid during the initial approach to prevent injury to medial neurovascular structures.

A large hematoma is often present surrounding the tendon (Fig. 3, *B*), which aids in identifying the tear site. The hematoma was carefully evacuated, and the area was irrigated with normal saline solution to improve visibility. Evaluation of the clavicular and sternal heads of the PM was conducted at this stage. The fibers of the clavicular head still remain intact within their insertion and will serve as a reference point (Fig. 3, *C*). Typically, the rupture is isolated to the sternal head and can be found retracted just medial to the axillary crease.

Next, with the tendon held using a Kocher clamp, the tendon stump was bluntly released in a 360° manner. The myotendinous unit was then whip-stitched using 2 strands of nonabsorbable, high-strength, ultrahigh-molecular-weight polyethylene and polyester tape (FiberTape; Arthrex, Naples, FL, USA) in a Krackow suture technique with a running locking fashion, accompanied by 2 strands of number 5 nonabsorbable, high-strength suture. (FiberWire; Arthrex, Naples, FL, USA) (Fig. 4). If the clavicular head is partially or fully torn, it is sutured using a similar technique. The 360° release of adhesions continued until the tendon could be reattached to the insertion site without tension.

The footprint of the sternal head of the PM tendon was identified at the lateral lip of the intertubercular sulcus, adjacent to the

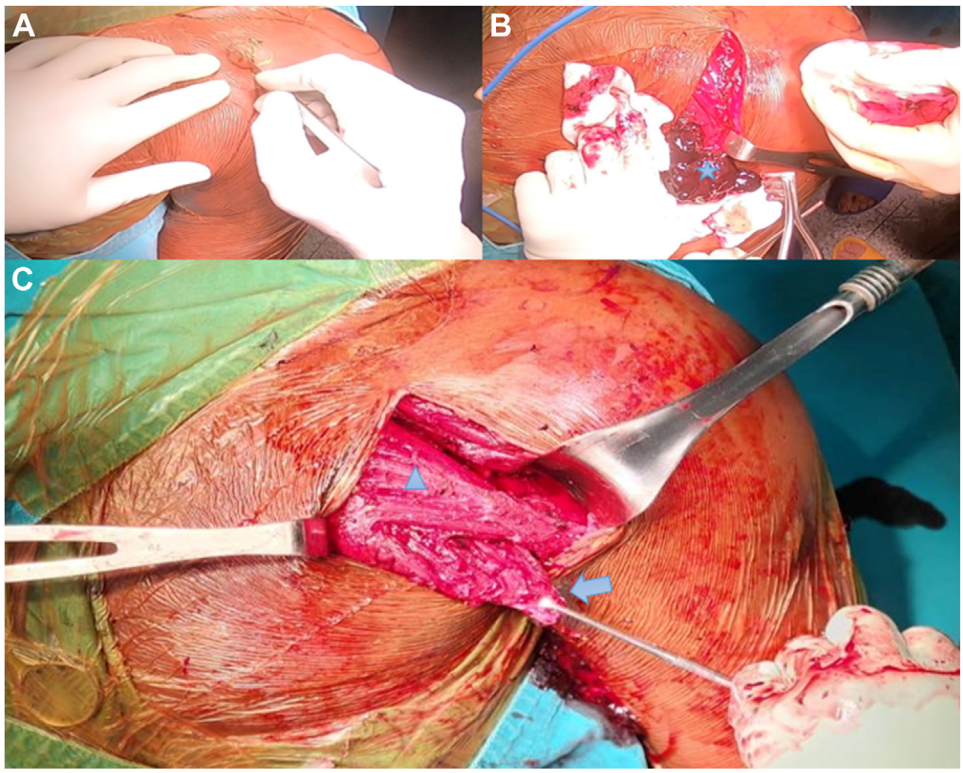


**Figure 3** (**A**) Modified deltopectoral approach for pectoralis major tendon repair. (**B**) A large hematoma, marked with a star, commonly encountered around the tear site of the tendon, aiding in tear identification. (**C**) Complete tear of the sternal head of the pectoralis major tendon (indicated by an arrow) with the intact clavicular head (marked with a triangle).

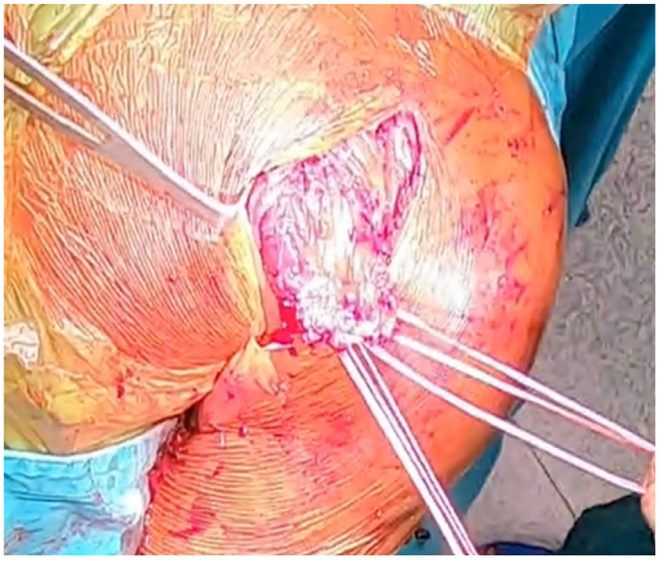

**Figure 4** Two No. 5 ultraresistant sutures and 2 surgical tapes used in a Krackow locked sutures configuration, placed within the bulk of the muscle-tendon unit, providing secure and stable fixation of the pectoralis major tendon.

long head of the biceps tendon. To prepare the site, a small high-speed bone burr was utilized to decorticate the bone and create a cortical area reaching a depth where cancellous bone became visible (Fig. 5). Following this, pilot holes were made using the specific punch down to the laser line, enabling the insertion of 2 knotless anchors in the superior portion of the prepared area and one anchor in the inferior portion. The tails of the superior part of the tape, along with 1 limb of the No.5 high-strength suture, are inserted into a superior knotless anchor (PopLok 4.5 mm; ConMed, Largo, FL, USA) (Fig. 6). The knotless anchor is inserted at the same angle as the punch, down to the level of the laser line, while applying counter pressure. Each suture is individually tensioned to bring the broad bulk of muscular tissue in approximation to the insertion site, and the suture is locked into the cleat on the handle. Once the red safety lever is disengaged, the anchor is deployed. The high-strength suture loaded into the knotless anchor serves as the post to be tied with the free limb. While maintaining tension on the post, the other free end of the high-strength suture is tied over the post to secure the repair. (Fig. 7) A similar technique is performed for the inferior anchor.

After the surgical repair, the shoulder is carefully external rotated to confirm the stability of the PM tendon. The PM tendon is anatomically restored, as indicated in the image (Fig. 8). The surgical area is extensively irrigated, and the wound is closed using a layered technique. Sterile dressings are then applied to the site.

Postoperatively, the patient underwent an anteroposterior shoulder X-ray (Fig. 9) to ensure the correct repair location by visualizing the holes created for anchor placement. The patient was advised to wear a sling for the first 6 weeks to promote adequate healing of the tendon–bone connection. During this period, specific limitations on shoulder movements are recommended, including restricting flexion to 90°, abduction to 30-45°, and external rotation to 30°. After the initial 6-week period, a gradual physical therapy program is initiated for the patient. The therapy begins with passive range of motion exercises, which are gradually advanced to active range of motion exercises. Resistance training is introduced between 8th to 12th weeks postoperatively, focusing on

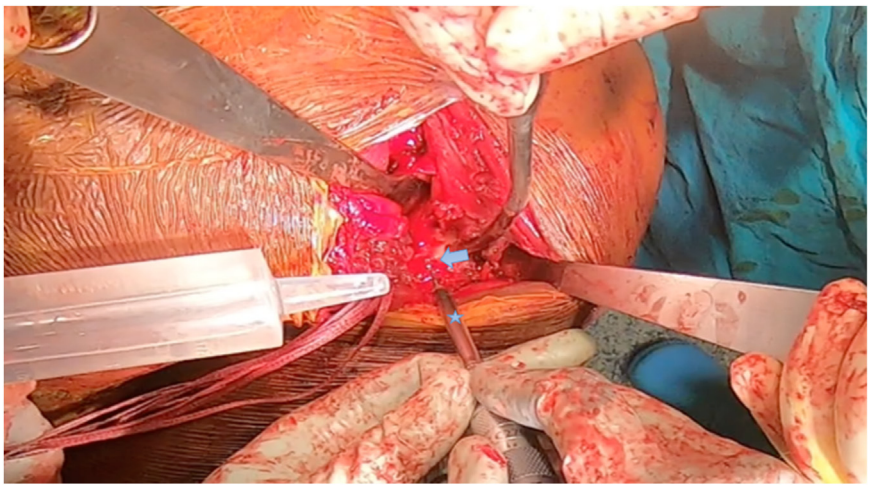

**Figure 5** The decorticated bone site, indicated by an arrow, was prepared at the footprint of the pectoralis major tendon using a high-speed burr, marked with a star. Thispreparation facilitates better healing of the repair by providing a stable and well-prepared attachment site, with an increased surface area for enhanced tendon-to-bone contact.

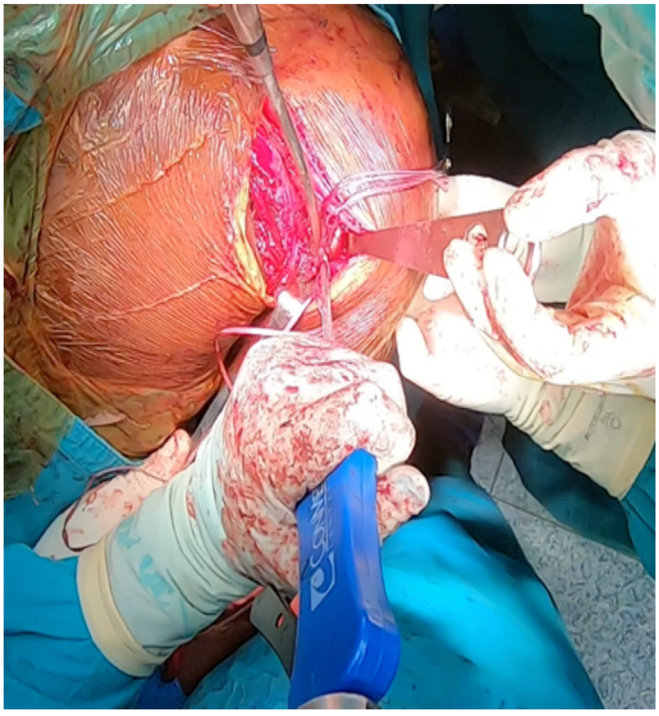

**Figure 6** The tails of the superior part of the surgical tape, along with 1 limb of the No. 5 high-strength suture, are inserted into a superior knotless anchor (PopLok 4.5 mm; ConMed, Largo, FL, USA). The knotless anchor is securely seated in the pilot hole.

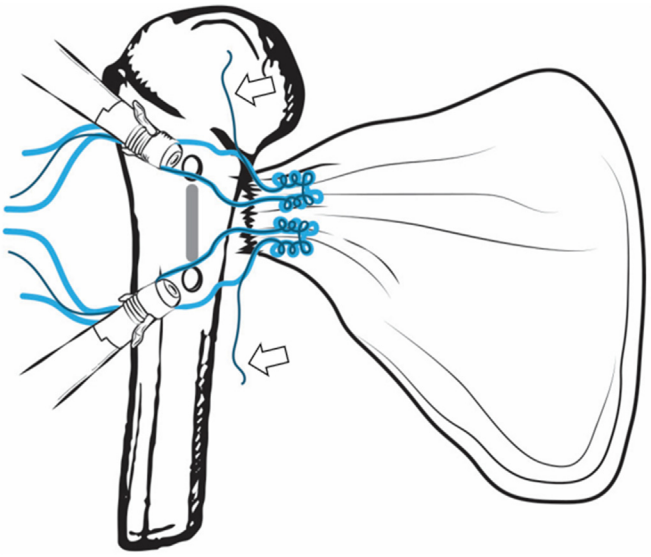

**Figure 7** Schematic drawing illustrating the technique of passing suture materials through the torn tendon and securing them to the knotless anchor. The figure demonstrates the method of utilizing 2 ends of surgical tape and 1 limb of No. 5 high-strength suture for each knotless anchor to achieve stable fixation of the pectoralis major tendon. The other end of No. 5 high-strength suture (arrow) will be securely tied to the end within the anchor, ensuring a secure and reliable approach for bringing the tendon back to its footprint.

strengthening the affected shoulder. At approximately the 12-week mark postsurgery, a comprehensive strengthening program is initiated. Fig. 10 displays clinical images captured 16 weeks after the surgery, revealing significant improvement and notable restoration of symmetry in the PM muscle, indicative of a successful repair and favorable postoperative outcome. The patient is allowed to return to sports activities once they have achieved adequate active and passive range of motion required for their specific sport, along with achieving a strength level greater than 90% when compared with their nonoperative shoulder.

## Discussion

PM tendon repair can be classified into 2 main surgical techniques: traditional transosseous suture fixation and various implant fixation techniques, including barbed staples,[5] screw and washer fixation,[10] cortical button,[12,20] and suture anchors.[9,19] However, none of these techniques have shown clear superiority over the others. In a 2011 biomechanical study conducted by Hart et al, different repair techniques were evaluated, and they did not find significant differences between the results of the transosseous reinsertion technique and suture anchor repair.[8] Each method was found to have its advantages and disadvantages. Similarly, Sherman et al compared transosseous sutures, suture anchors, and cortical

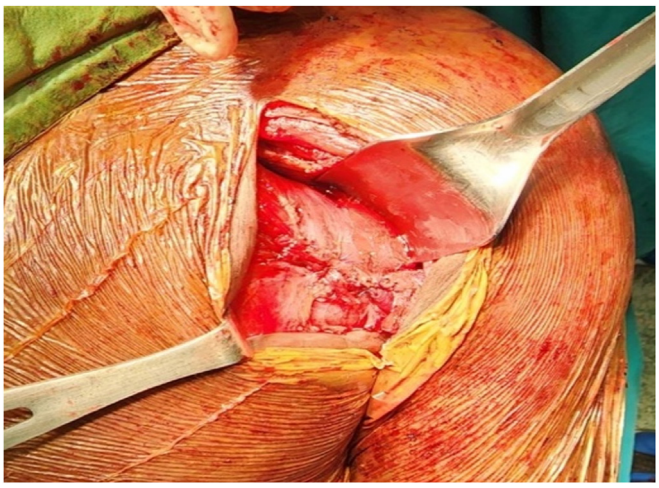

**Figure 8** The final image shows a successful repair of the sternal head of the pectoralis major tendon tear. The tendon is securely reattached to its anatomical insertion site, providing stability and strength for optimal postoperative recovery.

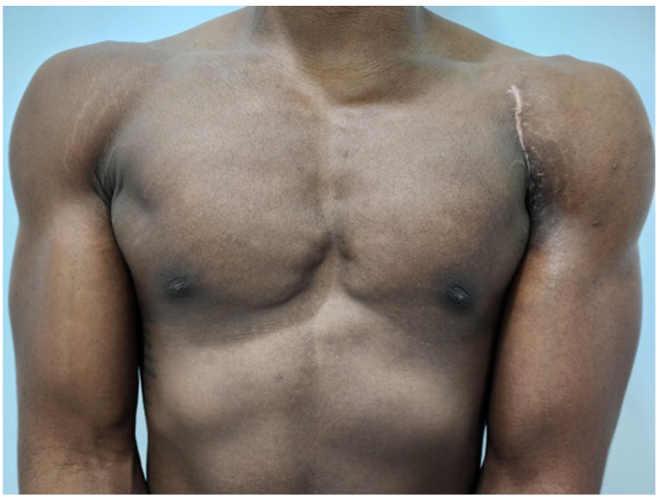

**Figure 10** Clinical pictures taken 16 weeks after surgery, showing significant improvement and nearly restored symmetry of the pectoralis major muscle, indicating successful repair and a favorable postoperative outcome.

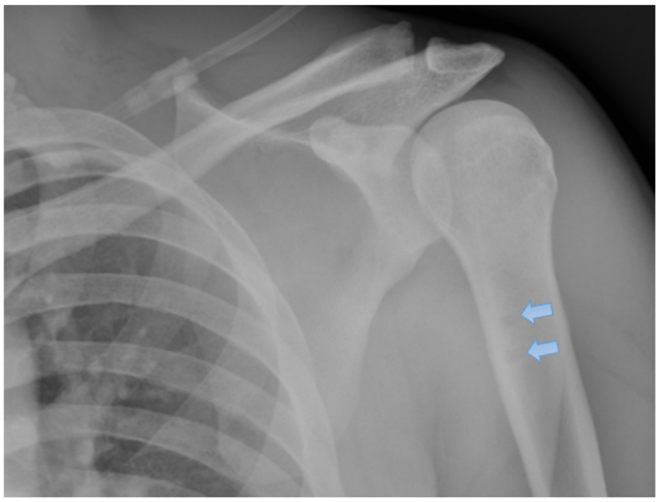

**Figure 9** Postoperative anteroposterior X-ray of the shoulder, with arrows indicating the locations of the 2 holes for bioabsorbable knotless anchor suture placement points.

button repair techniques and found no significant difference in cyclic loading or load to failure properties among these fixation methods.[18] Two systematic review and meta-analysis, reporting that transosseous, suture anchor, and cortical button techniques are all accepted options for PM tendon repair.[7,17]

The transosseous technique is a reliable method for reattaching the PM tendon to the humerus. It involves passing sutures through drilled tunnels in the humerus, ensuring secure tendon-to-bone fixation and promoting optimal healing and strength restoration. This technique distributes the load across multiple fixation points, minimizing the risk of failure and rerupture. Many patients have reported successful outcomes in terms of strength, range of motion, and overall functionality.[11,16] However, there is a potential risk of causing a fracture in the humerus during the procedure. This can happen while creating bone tunnels or inserting the hardware used for fixation. If an intraoperative fracture occurs, immediate recognition is crucial, and additional surgical intervention may be necessary to address the fracture appropriately before continuing with the tendon repair.

Cortical button fixation is another viable option for PM tendon repair, offering a robust and stable construct that allows for early rehabilitation and reduces the risk of repair failure.[13,15] The technique aims to reattach the tendon to its anatomical insertion site, optimizing muscle length-tension relationships and ultimately improving functional outcomes. However, 1 drawback is the presence of metallic artifacts on radiographs, which can sometimes make it challenging to interpret postoperative imaging. Furthermore, when using bicortical fixation methods, there is a potential risk of neurovascular injury. While the incidence of postoperative infection after open shoulder surgery is relatively rare (0.5%-4%),[14] in the event of an infection, all hardware must be removed to clear the infection. This includes intramedullary cortical buttons, which are made of metal. In such cases, removing a metal button from the intramedullary canal may require a large cortical window.

Suture anchor repair is a widely used technique for reattaching the PM tendon to the humerus.[9,19] It offers secure fixation, promoting the anatomical restoration of the tendon and facilitating early rehabilitation. However, suture anchor repair has some limitations. One drawback is the reduced contact between the suture area and the tendon-to-bone interface, which may affect the overall stability of the repair. Additionally, local host reactions to metal or biodegradable anchors can occur, and metal anchors may interfere with imaging. Moreover, the stability of the repair heavily relies on the knot tying technique, which may not always provide the desired level of security. Once the suture is tied, it can be challenging to adjust or add additional sutures to enhance stability if needed.

In this article, we introduced a modified technique for repairing a ruptured PM tendon. Our main objectives include simplifying the surgical procedure, achieving a strong and dependable fixation, ensuring excellent patient outcomes, and reducing the risk of surgical complications.

The use of the limb positioner to support the operative extremity allows for a smooth, effortless, and stable limb placement, enabling the surgical team to focus on the procedure rather than holding the limb steady. For rotator cuff repair, previous studies have shown that surgical tape provides excellent biomechanical performance, and the combination of surgical taped with No. 5 high-strength suture results in significantly greater construct strength than traditional bone trough techniques.[4] To ensure a

**Table I**
Advantages, disadvantages, pearls, and pitfalls of the technique.

| Advantages | Disadvantages | Pearls | Pitfalls |
|---|---|---|---|
| Reinforced strength with high-strength suture and tape | Technique requires technical expertise | Consider predrilling with a small drill if bone is too hard. | Inadequate firmness during tensioning may lead to anchor slippage. |
| Avoidance of neurovascular risks | Higher associated costs | Firmly push the knotless anchor into the hole during tensioning. | |
| Flexible tension adjustment | Bioabsorbable anchors not visible on X-rays; indirect assessment via anchor placement holes. | Simultaneously pass high-strength suture and tape into the anchor. | |
| Dependable fixation not reliant on bone quality | | | |
| No metal artifact affecting imaging quality | | | |
| Low risk of proximal humerus fracture | | | |

more stable fixation, our technique employs both surgical tape and No. 5 high-strength suture in a running, locked configuration.

The utilization of knotless suture anchors in our technique offers significant advantages for PM tendon repair. By bringing the tendon end to areas both superior and inferior to the decorticated bone site, we achieve a broader area of tendon-to-bone contact, surpassing the point fixation provided by traditional suture anchors. This approach enhances the stability and strength of the repair, contributing to improved outcomes. Moreover, this approach eliminates the risk of neurovascular injury associated with bicortical drilling. The unique design of the knotless anchors enables flexible tension adjustment once the anchor is in place in the pilot hole. Additionally, tying the free limb of the high-strength suture to the preloaded knotless anchor allows for further tension adjustments after the other 3 limbs, which include 2 surgical tapes and 1 high-strength suture, are secured to the footprint. The dependable fixation ensured by the unique suture locking mechanism is less reliant on bone quality, ensuring consistent results. Additionally, the absence of metal artifacts preserves the quality of further imaging if needed. However, it is important to consider that this technique necessitates technical expertise and may involve higher costs compared to previous methods. It is noteworthy that the bioabsorbable anchors, while not directly visible on X-rays, can still be assessed indirectly through the anchor placement holes evident in postoperative X-rays. Nevertheless, our approach represents a promising option for achieving successful PM tendon repairs. Advantages and disadvantages of the proposed modified surgical technique utilizing knotless suture anchors using surgical tape and high-strength suture, along with pearls and pitfalls, are summarized in Table I.

## Conclusion

Our modified technique utilizing knotless suture anchors, combined with the use of surgical tape and high-strength suture, for PM tendon repair offers several advantages, including broader tendon-to-bone contact, avoidance of neurovascular risks, low risk of proximal humerus fracture, and flexible tension adjustment. While the technique requires technical expertise and may incur higher costs, the reinforced strength of the repair makes it a highly promising option for achieving successful PM tendon repairs.

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Conflicts of interest: The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

## Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.xrrt.2024.01.015.

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