Arthroscopic-Assisted Pectoralis Minor Transfer for Irreparable Tears of the Upper Two-thirds of the Subscapularis Tendon: Surgical Technique

Marco Cartaya, M.D., Jean-David Werthel, M.D., and Philippe Valenti, M.D.

Abstract: Open transfer of the pectoralis minor through a deltopectoral approach has been described to treat irreparable tears of the upper two-thirds of the subscapularis. We present a less invasive arthroscopic-assisted technique for this transfer. Atraumatic dissection of the pectoralis minor and harvesting of the tendon with a bone chip from the coracoid process allow strong fixation with a double-button device on the lesser tuberosity. This arthroscopic technique allows assessment and treatment of associated intra- or extra-articular lesions and represents a promising option for the management of irreparable tears of the subscapularis.

Subscapularis (SSC) tendon tears are disabling lesions that lead to pain and loss of function.[1-4] When performed at early stages, arthroscopic repair is highly successful.[5] However, in the case of an irreparable tear, when the tendon is retracted to the level of the glenoid, with grade III or IV fatty infiltration, tendon repair is no longer an option,[6] and multiple solutions have been proposed in the literature to restore shoulder mechanics.[1,6-8] Several tendon transfers have been proposed with variable functional results and complications. These include transfer of the pectoralis major,[6,7,9,10] transfer of the pectoralis minor (Pm),[1] transfer of the teres major, and transfer of the latissimus dorsi.[8]

Transfer of the Pm is an invasive procedure that involves extensive dissection. This transfer, relying on tendon-to-bone healing, was described in 1997 by Wirth and Rockwood,[9] and a modification of this transfer, relying on bone-to-bone healing, has been described more recently by Paladini et al.,[1] showing improvements in active forward flexion (50°) and the Constant score (41 points) without excessively limiting external rotation. This technique involves harvesting the Pm with a bone chip from the coracoid process, and it is suitable for that 41% of patients with an isolated SSC tear presenting with a grade III lesion according to the series and classification of Lafosse et al.[11] The purpose of this Technical Note is to describe an arthroscopic-assisted method to transfer the Pm with a bone chip from the coracoid process for the treatment of irreparable tears of the SSC (Video 1).

Surgical Technique

Patient Positioning, Diagnostic Arthroscopy, and Portal Placement

The patient is positioned in the beach-chair position with no traction on the upper limb to easily mobilize the humerus as needed during the procedure. The arthroscope is initially introduced through the standard posterior portal. A diagnostic examination with special emphasis on the anterosuperior cuff and long head of the biceps is performed to confirm the presence of an irreparable tear of the SSC tendon. Then, 3 anterior portals are used consecutively: anteroinferior (AI) portal, anterolateral portal, and superior coracoid expanded portal (SCEP) (Fig 1).

While the arthroscope is positioned in the posterior portal, a radiofrequency ablation device (VAPR; DePuy

From the Paris Shoulder Unit, Institut de la Main, Clinique Bizet, Paris, France.

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Address correspondence to Marco Cartaya, M.D., Av Atlantico, Urb, Rio Negro, Manzana 2 Casa 27, Puerto Ordaz, Estado, Bolivar, Venezuela 8050. E-mail: drmarcocartaya@gmail.com

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Fig 1. Right shoulder portals: standard posterior portal; anterolateral portal, 2 cm distal to anterolateral corner of acromion; anteroinferior portal, 2 cm distal to coracoid tip and just lateral to conjoint tendon; and superior coracoid expanded portal, just above coracoid process.

Mitek, Raynham, MA) is inserted through the AI portal and the rotator interval is dissected. The coracohumeral ligament, middle glenohumeral ligament, long head of the biceps, and anterior capsule are all excised, and the coracoid process, conjoint tendon (CT), and coracoacromial ligament are all dissected and identified (Fig 2).

Dissection of Pm

The arthroscope is then removed from the posterior portal and inserted into the anterolateral portal with the radiofrequency ablation device still in the AI portal. After identification of the lateral aspect of the coracoid, CT, and coracoacromial ligament, progressive dissection is performed over the coracoid until the insertion of the Pm, at the medial aspect of the coracoid, is observed while care is taken to preserve these structures (Fig 3).

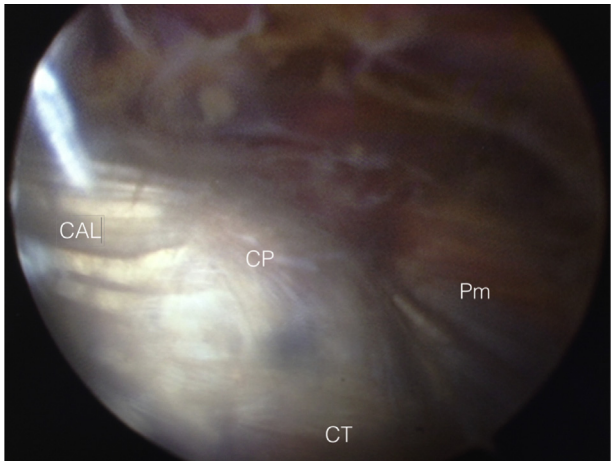

Fig 3. Extra-articular view of right shoulder in beach-chair position through anterolateral portal. (CAL, coracoacromial ligament; CP, coracoid process; CT, conjoint tendon; Pm, pectoralis minor.)

Once the insertion of the Pm is identified, the SCEP is established and dissection is continued through this access. The anterior border of the Pm is dissected and is isolated from the CT by releasing any expansion between the 2 tendons (Fig 4). During this step, the musculocutaneous nerve is located and is released if its branch going to the CT is thought to be in the way of the transfer. The posterior border of the Pm is then identified and carefully dissected with only coagulation until visualization of the brachial plexus.

Harvesting and Preparation of Pm

The SCEP is enlarged to 20 mm to allow the introduction of a 10-mm chisel that is used to perform an osteotomy of the medial wall of the coracoid process with the Pm tendon (Fig 5). Special care must be taken

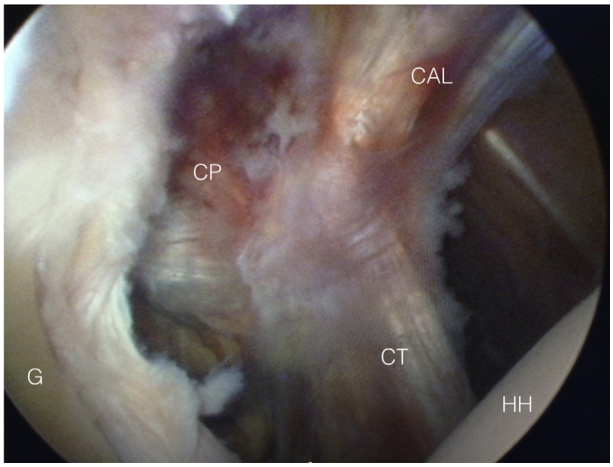

Fig 2. Intra-articular view of right shoulder in beach-chair position through posterior portal. (CAL, coracoacromial ligament; CP, coracoid process; CT, conjoint tendon; G, glenoid; HH, humeral head.)

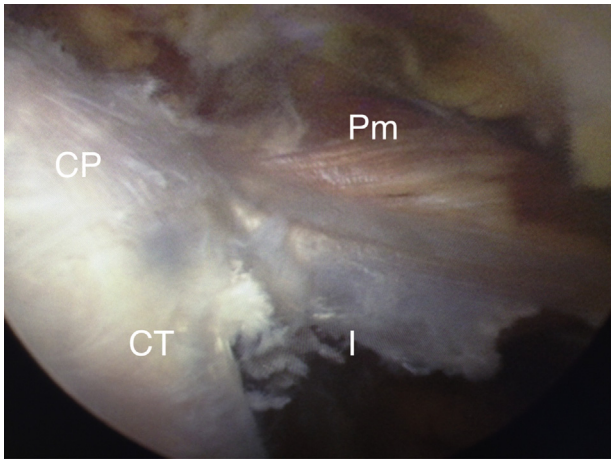

Fig 4. Extra-articular view of right shoulder in beach-chair position through anterolateral portal. The interval (I) between the pectoralis minor (Pm) and conjoint tendon (CT) is shown. (CP, coracoid process.)

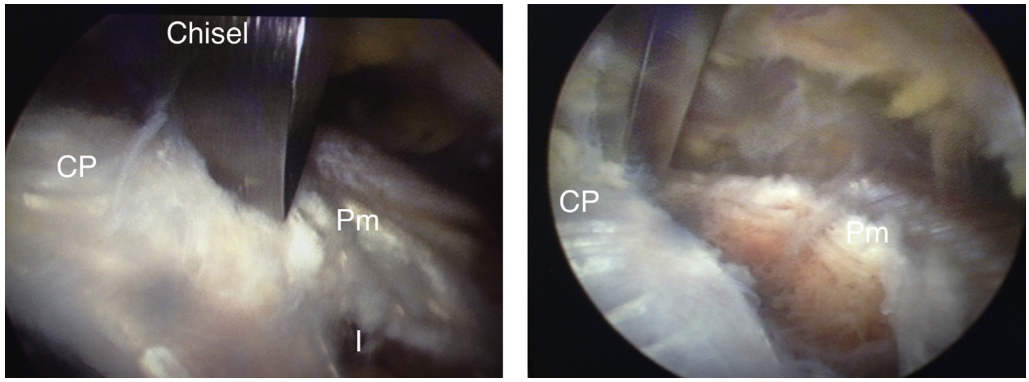

Fig 5. Extra-articular view of right shoulder in beach-chair position through anterolateral portal. The pectoralis minor (Pm) is detached with a coracoid process (CP) bone chip. (I, interval.)

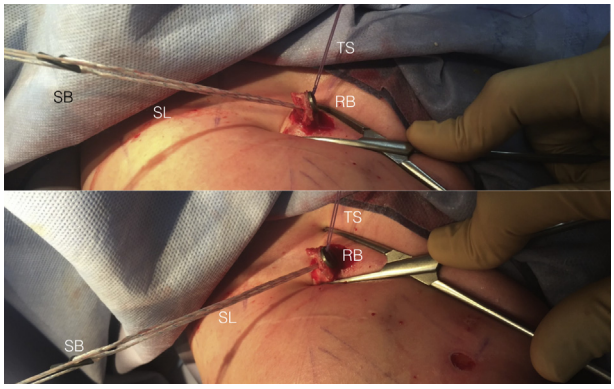

Fig 6. View of right shoulder in beach-chair position. Straight button (SB), suture loop (SL), round button (RB), and transosseous sutures (TS). It should be noted that the round button is attached to the cortical side of the bone chip, whereas the rest of the system is on the cancellous side of the bone chip.

to prevent lesions to the brachial plexus during this step.

Once full mobilization of the bone chip with the Pm is possible, the bone chip is exteriorized through the SCEP with a retriever and sutured to a double-button device (ZipTight Fixation System for AC Joint Repair; Biomet, Warsaw, IN) so that the round button is fixed on the cortical side of the chip and the rest of the system (suture loop and small button) remains on the cancellous side of the bone chip (Fig 6). To accomplish this, a transosseous suture forming a closing loop is made through the chip with a No. 2 high-strength nonabsorbable suture (MaxBraid; Biomet) with a small needle. Once this step is completed, the tendon is reinserted into the shoulder.

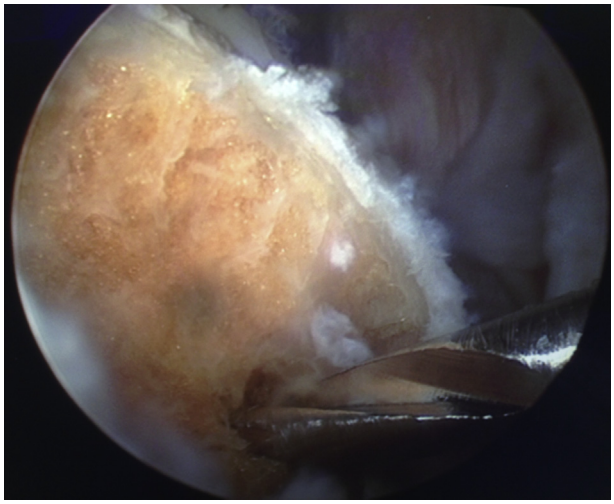

Fig 7. View of right shoulder in beach-chair position through anterolateral portal. The eyelet guide is in the center of the subscapularis footprint preparation through the anteroinferior portal.

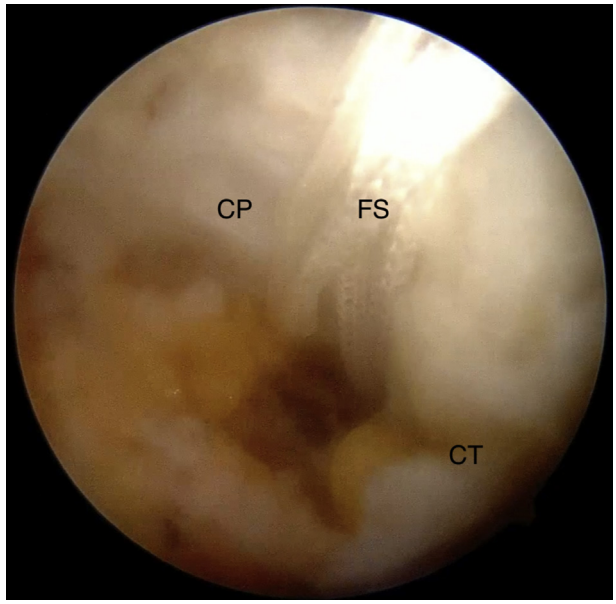

Fig 8. Extra-articular view of right shoulder in beach-chair position through anterolateral portal. The implant's free sutures (FS) are being pulled below the coracoid process (CP) through the anteroinferior portal. (CT, conjoint tendon.)

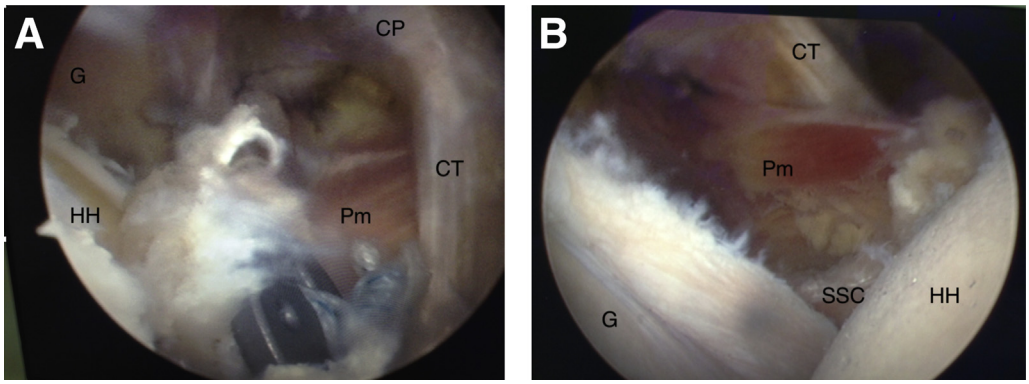

Fig 9. (A) Extra-articular view of right shoulder in beach-chair position through anterolateral portal. The pectoralis minor (Pm) transfer is in place after closing the implant's suture loop. (B) Intra-articular view of right shoulder through posterior portal. The correct positioning of the transfer is checked. One should note the relation between the conjoint tendon (CT), pectoralis minor (Pm), and subscapularis (SSC) remnant. (CP, coracoid process; G, glenoid; HH, humeral head.)

Preparation of Lesser Tuberosity and Fixation of Pm

The footprint of the SSC is prepared with an arthroscopic burr (4.0-mm Formula burr; Stryker, Kalamazoo, MI) through the AI portal, creating a concave zone matching the shape of the bone chip. This preparation needs to be thorough to ensure good bone-to-bone contact and to avoid anterior impingement between the round button and the CT during internal rotation.

An eyelet drill pin is introduced through the AI portal and positioned at the center of the footprint preparation from anterior to posterior (this entry point can be translated superiorly at the superior part of the lesser tuberosity in cases of anterosuperior cuff tears) (Fig 7). Then, the pin is drilled across the humeral head, through the posterior humeral cortex, while care is taken to exit higher than 4.5 cm distal to the posterolateral angle of the acromion to avoid any injury to the axillary nerve. The drill pin is retrieved posteriorly through a small skin incision.

Table 1. Pearls and Pitfalls

Pearls
Partial repair of the subscapularis should be performed before the transfer.
The surgeon should use a sharp chisel when performing the osteotomy to avoid fractures.
The entire insertion of the tendon should be harvested.
Thorough preparation of the footprint should be performed, matching the shape of the bone chip.
Pitfalls
Failing to achieve complete visualization of the pectoralis minor insertion may lead to brachial plexus injury while harvesting.
A posterior drill pin exit that is too low may lead to axillary nerve injury.
If the traction sutures are not symmetrical and not pulled in an alternating manner when closing the system, internal loops may be created, leading to later loosening.
The technique is only applicable to skillful surgeons.

A 4.5-mm cannulated drill bit is passed over the pin to make a bone tunnel until crossing the posterior cortex. Care must be taken to maintain the drill pin in place during this step.

The sutures exiting from the coracoid bone chip are retrieved through the AI portal passing underneath the coracoid process and posterior to the CT (Fig 8) and are loaded in the eyelet of the drill pin and retrieved posteriorly by pulling the pin. The sutures are then carefully pulled to apply the straight button over the humeral posterior cortex. Once this is performed, the traction sutures of the ToggleLoc are pulled alternately until good compression of the bone chip on the lesser tuberosity is achieved under arthroscopic control. With

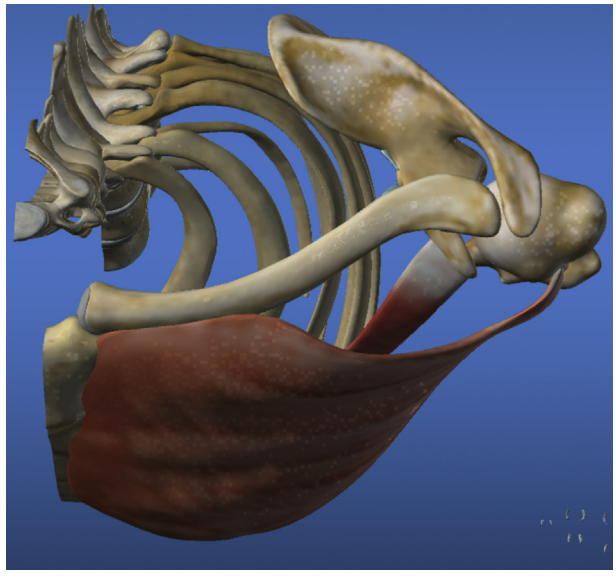

Fig 10. Situation of pectoralis minor versus pectoralis major in chest wall. One should note that the pectoralis minor origin is posterior with respect to the pectoralis major; thus the traction vector is closer to that of the subscapularis.

Table 2. Advantages and Disadvantages

Advantages
Minimally invasive arthroscopic procedure
Harvest of entire insertion of tendon with bone chip to avoid muscle wasting and to improve healing process
Strong bone-to-bone fixation
Arthroscopic assessment and treatment of associated lesions
Easy conversion to open surgery if needed
Disadvantages
Risk of lesions to brachial plexus and musculocutaneous nerve during dissection
Technically demanding: perfect knowledge of anatomy of nerves of shoulder is mandatory
More expensive than open procedure

the transfer in place, passive internal and external rotation is performed to check for any anterior impingement between the implant and the CT (Fig 9, Table 1).

Discussion

Despite advancement in treatments for rotator cuff tears and cuff tear arthropathy, management of irreparable anterosuperior cuff tears in younger patients remains challenging. Transfer of the Pm is a promising procedure that can restore a functional and pain-free shoulder in this group of young patients with Lafosse grade III tears of the SSC or Collin type A lesions, as shown by Paladini et al.[1] and Wirth and Rockwood.[9] Lafosse grades IV and V are contraindications for this procedure.

Because of its anatomic situation and function, the Pm represents a good candidate to restore internal rotation because it has the following:

- A better vector of action in comparison with transfer of the pectoralis major (Fig 10)
- Adequate tendon excursion more similar to the SSC than the pectoralis major, as shown by Herzberg et al.[12]
- No excessive muscle tension after the transfer is in place
- Minimal exposure and tissue damage

Arthroscopic assistance makes it a less invasive procedure with a shorter recovery time. In addition, it has been proved that surgical repair around tendon insertions between homogeneous tissues (bone to bone) shows better mechanical and histologic healing properties than between heterogeneous tissues (bone-to-tendon healing)[3]; therefore, the success rate of the procedure could be enhanced by the use of bone-to-bone fixation (Table 2). In conclusion, we believe that arthroscopic-assisted Pm transfer combined with strong bone-to-bone fixation to the lesser tuberosity represents a promising option for the management of irreparable superior tears of the SSC; nevertheless, extensive knowledge of the anatomy of this particular region is advised to avoid injury to the musculocutaneous and axillary nerves during dissection.

References

1. Paladini P, Campi F, Merolla G, Pellegrini A, Porcellini G. Pectoralis minor tendon transfer for irreparable anterosuperior cuff tears. *J Shoulder Elbow Surg* 2013;22:e1-e5.
2. Arai R, Sugaya H, Mochizuki T, Nimura A, Moriishi J, Akita K. Subscapularis tendon tear: An anatomic and clinical investigation. *Arthroscopy* 2008;24:997-1004.
3. Leung KS, Chong WS, Chow DH, et al. A comparative study on the biomechanical and histological properties of bone-to-bone, bone-to-tendon, and tendon-to-tendon healing: An Achilles tendon-calcaneus model in goats. *Am J Sports Med* 2015;43:1413-1421.
4. Collin P, Matsumura N, Ladermann A, Denard PJ, Walch G. Relationship between massive chronic rotator cuff tear pattern and loss of active shoulder range of motion. *J Shoulder Elbow Surg* 2014;23:1195-1202.
5. Denard PJ, Jiwani AZ, Ladermann A, Burkhart SS. Long-term outcome of a consecutive series of subscapularis tendon tears repaired arthroscopically. *Arthroscopy* 2012;28:1587-1591.
6. Valenti P, Boughebri O, Moraiti C, et al. Transfer of the clavicular or sternocostal portion of the pectoralis major muscle for irreparable tears of the subscapularis. Technique and clinical results. *Int Orthop* 2015;39:477-483.
7. Jost B, Puskas GJ, Lustenberger A, Gerber C. Outcome of pectoralis major transfer for the treatment of irreparable subscapularis tears. *J Bone Joint Surg Am* 2003;85:1944-1951.
8. Elhassan B, Christensen TJ, Wagner ER. Feasibility of latissimus and teres major transfer to reconstruct irreparable subscapularis tendon tear: An anatomic study. *J Shoulder Elbow Surg* 2014;23:492-499.
9. Wirth MA, Rockwood CA Jr. Operative treatment of irreparable rupture of the subscapularis. *J Bone Joint Surg Am* 1997;79:722-731.
10. Werner CM, Steinmann PA, Gilbart M, Gerber C. Treatment of painful pseudoparesis due to irreparable rotator cuff dysfunction with the Delta III reverse-ball-and-socket total shoulder prosthesis. *J Bone Joint Surg Am* 2005;87:1476-1486.
11. Lafosse L, Jost B, Reiland Y, Audebert S, Toussaint B, Gobezie R. Structural integrity and clinical outcomes after arthroscopic repair of isolated subscapularis tears. *J Bone Joint Surg Am* 2007;89:1184-1193.
12. Herzberg G, Urien JP, Dimnet J. Potential excursion and relative tension of muscles in the shoulder girdle: Relevance to tendon transfer. *J Shoulder Elbow Surg* 1999;8:430-437.