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ORIGINAL ARTICLE

Bipolar pedicled teres major transfer for irreparable subscapularis tendon tears: an anatomic feasibility study

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Background: Subscapularis (SSC) tendon tears are a challenging problem because they can significantly alter shoulder mechanics and function. Tendon retraction and advanced fatty degeneration associated with a chronic tear may make it irreparable. Tendon transfers options for such tears are viable, but results in the setting of associated glenohumeral instability are inconsistent. With the potential to recreate the SSC line of pull, the teres major (TM) may be a viable option for transfer. This cadaveric study investigated the feasibility and outlined the steps of a bipolar, pedicled TM transfer for irreparable SSC tendon tears.
Methods: Eight fresh frozen cadaver torsos from 4 women and 4 men (average age, 84 years; range, 68-96 years) were dissected. Anatomic details comparing TM to SSC were examined, including muscle width, length, thickness, and line of pull in the scapular plane. In addition, a surgical technique was described for implementing the pedicled TM transfer.
Results: Measurements between the TM and SSC were comparable, with the exception of muscle belly width, which was significantly greater in the SSC. With transfer of the TM, there was no impingement or tension on the brachial plexus or the neurovascular pedicle of the TM. The line of pull of the TM relative to the SSC had a difference of 9°.
Conclusions: This study demonstrates that a bipolar TM tendon transfer is an anatomically feasible option for reconstruction of an irreparable SSC tendon tear. Further clinical studies are necessary to understand its outcome in in vivo conditions.
Level of evidence: Anatomy Study; Cadaver Dissection

Keywords: Teres major; irreparable; subscapularis; tear; transfer; bipolar

Irreparable subscapularis (SSC) tendon tears are a challenging problem. Unlike older or less active patients with arthritis, arthroplasty is not an option for young, active patients without glenohumeral joint pathology.[10,11,21,26] Primary repair of the SSC is preferred, but the tendon retraction and advanced fatty degeneration associated with a chronic tear may render it irreparable, with poor outcomes after

The Mayo Clinic Institutional Biospecimen Review Committee approved the protocol (study number: 17-004495/Bio00015382).

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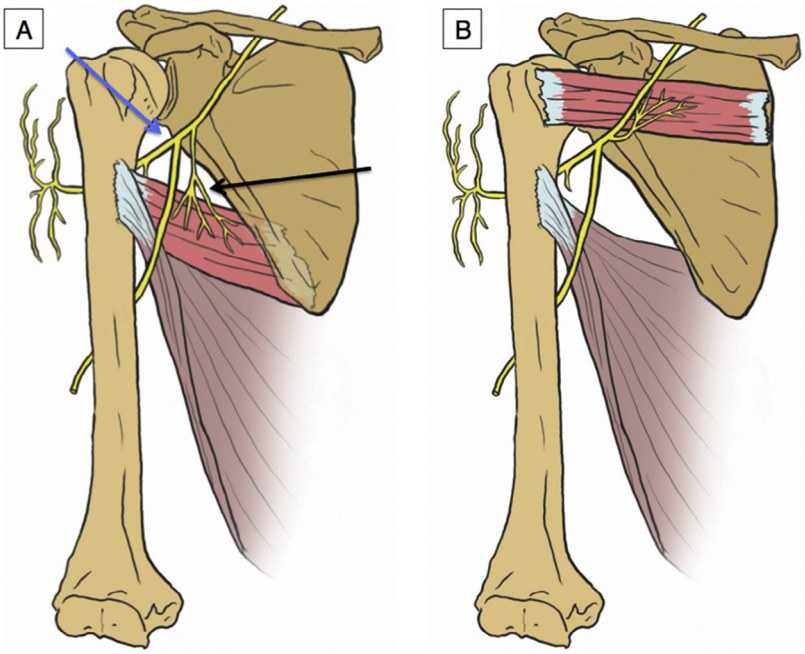

Figure 1 (**A**) Drawing shows the technique representing the teres major muscle in its native anatomic position with the direction of the anterior clamp (*blue arrow*), which is passed anterior to the humeral head and posterosuperior to the axillary nerve and the brachial plexus, and the direction of the posterior clamp (*black arrow*), which is passed anterior to the scapula and posterior to the thoracic wall. (**B**) Once transferred, the teres major muscle is positioned in the subscapularis fossa, superior to the axillary nerve and posterior to the brachial plexus.

fixation.[13,14,19] Chronicity of the tear and fatty infiltration of the SSC muscle belly have been shown to negatively correlate with successful repair.[9]

Biomechanically, the SSC serves as the anterior half of the transverse force couple that controls humeral head motion. Loss of this anterior restraint can lead to significant rotational and translational disturbances of the shoulder joint, and reconstructive options are necessary to stabilize the joint.[18,30]

Reconstruction options for an irreparable SSC tendon include static capsular reconstruction with allograft or dynamic reconstruction with tendon transfers. The Achilles tendon, iliotibial band, and semitendinosus tendon have been used as allografts for static stabilization of the anterior capsule. Outcomes of these grafts, however, have been variable.[16,31] Dynamic reconstruction options with muscle tendon transfers include the pectoralis major (PM), pectoralis minor, upper trapezius, and latissimus dorsi (LD) muscle tendons.[6,17,22,24] The PM is the most common of these transfers, with continued pain relief and function at 10-year follow-up.[20] Success, however, has been inconsistent in patients with a concomitant irreparable SSC tendon and associated anterior instability of the glenohumeral joint.[8]

Failure of these dynamic stabilizers can be partly attributed to a different muscle line of pull. Principles of tendon transfer include (1) an expendable donor, (2) a donor of adequate excursion, (3) a donor of adequate strength, (4) a straight line of pull, (5) synergistic muscle function, and (6) a single function per transfer.[25] The teres major (TM) muscle potentially meets the criteria relative to the SSC: it is expendable, and as a pedicled muscle, it can have adequate strength and excursion, a correct line of pull, and synergistic action as an internal rotator of the shoulder joint. Biomechanical and anatomic studies of the TM have been described in different applications, including flaps for soft tissue defect coverage and active, functional unipolar or bipolar transfers.[4,5,27-29,32]

This study presents the anatomy, discusses the feasibility, and outlines the steps of a bipolar, pedicled TM transfer for irreparable SSC (TM-SSC) tendon tears (Fig. 1). Our hypothesis is that the TM-SSC is an anatomically feasible transfer capable of functioning in place of an irreparable SSC tear.

Materials and methods

We performed a cadaveric study on 8 fresh frozen torsos from 4 women and 4 men with an average age of 84 years (range, 68-96 years). Before dissection, fluoroscopic examination confirmed a nontraumatic, intact glenohumeral joint without significant osteoarthritis or rotator cuff arthropathy.

Anatomic measurements

TM measurements were obtained with a slide caliper with an accuracy to 0.1 mm (Mitutoyo, Kawasaki, Japan), and all angles were measured with a goniometer. Dimensions of the TM muscle were measured before and after tendon transfer. Before the transfer, measurements included width of the tendon at its insertion, musculotendinous junction, and muscle belly at the level of the pedicle in addition to the maximum muscle thickness. The TM-SSC transfer was then conducted using the technique described below.