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ORIGINAL ARTICLE

Anatomic study of pedicled bipolar teres major transfer for irreparable posterosuperior rotator cuff tears

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Background: Treatment of rotator cuff (RC) tears has not included bipolar muscle-tendon transfers to date. The objective of this study was to verify the feasibility of pedicled bipolar teres major (TM) transfer over and under the long head of the triceps brachii (LHT) and compare its versatility with monopolar transfer in a model of supraspinatus (SS) tears in cadavers.
Methods: In 6 shoulders of cryopreserved cadavers, we re-created complete SS tears, conducting monopolar and bipolar TM transfers over and under LHT. We compared the morphology of the SS and TM, defect coverage, angle between the transferred TM and major SS axis, and axillary nerve overlap with each technique.
Results: The TM and SS were morphologically similar. Defect coverage was significantly lower with monopolar transfer (12 ± 4 mm) than with bipolar transfer (39 ± 9 mm under the LHT, $P = .003$, and 38 ± 8 mm over the LHT, $P = .004$). The bipolar transfer course over the LHT was the nearest to the SS axis (39° ± 11°, $P = .005$). We found a greater axillary nerve overlap with bipolar transfer under the LHT (27 ± 8 mm) than with bipolar transfer over the LHT (1 ± 2 mm, $P = .005$) or monopolar transfer (0 mm, $P < .001$).
Conclusion: Bipolar TM transfer is possible without neurovascular pedicle interference, obtaining greater RC defect coverage and the closest path to the SS axis when conducted over the LHT compared with monopolar or bipolar transfer under the LHT. Accordingly, it can be considered an alternative option for the treatment of posterosuperior RC defects.
Level of evidence: Anatomy Study; Cadaveric Dissection

Keywords: Rotator cuff injuries; supraspinatus muscle; teres major muscle; tendon transfer; shoulder; irreparable

In 1988, Gerber et al[16] first described latissimus dorsi (LD) transfer from the medial humeral insertion to the lateral side of the supraspinatus (SS) muscle to treat irreparable massive posterosuperior rotator cuff (RC) tears, drawing a parallel with the sequelae of obstetric brachial paralysis, for which tendon transfers have proved useful.[8,19,24,25,34] Many authors

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subsequently used LD transfer for the reconstruction of massive irreparable posterosuperior RC tears by open surgery[2,11,12] or arthroscopic procedures.[33,40] Other muscles currently used for the same purpose are the trapezius[31] or teres major (TM), combined with the LD[17] or alone.[23]

Authors have conducted free or pedicled bipolar muscle transfers (eg, LD or gracilis) in various reconstructions and in elbow flexion restoration under different conditions.[10,13,27,42,44] Pedicled bipolar LD transfers have also been proposed for the reconstruction of RC lesions,[35] although pedicled bipolar TM transfer has only been reported in breast[20] and chest wall reconstructions after burns, in the latter case alongside the LD.[32] In shoulder diseases, this bipolar transfer has been studied only in the treatment of sequelae after obstetric brachial paralysis.[6] We have found no evidence of its application for irreparable RC tendon tears.

With this background, we studied a human cadaveric model of complete SS tears to test the feasibility of isolated pedicled bipolar transfer of the TM over or under the long head of the triceps brachii (LHT) and compare its versatility with that of conventional monopolar transfer.

Materials and methods

This is an experimental study of musculotendinous transfers in a cadaveric model of RC lesions. We carried out the investigation in 6 forequarter specimens from 6 fresh-frozen cadavers of persons aged between 60 and 78 years at death (3 men and 3 women) who had given informed consent for their use for scientific purposes.[28,36] All specimens were dissected, after thawing at room temperature, in the Department of Human Anatomy, School of Medicine, University of Granada (Spain), between October and December 2016. We studied 3 right and 3 left shoulder specimens and performed neurovascular dissections with the shoulder supine and dissections of the muscle-tendon units with the shoulder prone.

Procedure

We removed the skin, subcutaneous tissue, and fatty tissue of the axillary groove, re-creating full-thickness full-width SS tears by a transdeltoid approach (Fig. 1). Next, we detached the deltoid from the acromion, external third of the clavicle, and scapular spine, respecting the humeral insertion and axillary nerve (AN) innervation (Fig. 2).

On the posterior aspect, we identified the TM muscle and its insertion on the scapula; the insertion tendon in the humeral diaphysis, which was individualized from the LD insertion tendon (Fig. 3); and the entry of the anterior aspect of the lower subscapular pedicle. We fully exposed the infraspinatus and SS in the same manner and dissected the quadrilateral space of Velpeau and the AN.

We dissected the deltopectoral sulcus by an anterior approach, locating the axillary artery and infraclavicular brachial plexus between the combined tendon and minor pectoral muscle. Branches of the subscapular artery, either the thoracodorsal artery or the circumflex scapular artery, provide the arterial supply to the TM. We identified the posterior secondary plexus trunk, from proximal to distal, and the lower subscapular, thoracodorsal, radial, and axillary nerves. We followed the first 2 up to the TM muscle to identify the entry point of the vascular-nerve pedicle.

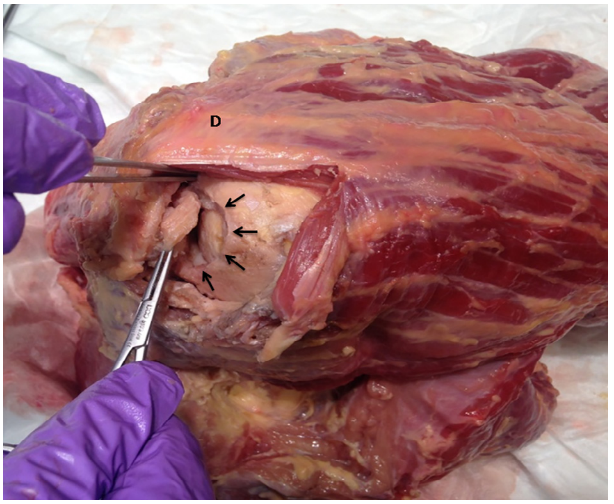

Figure 1 Re-creation of tendon defect in supraspinatus insertion (*arrows*) by transdeltoid approach. *D*, deltoid muscle.

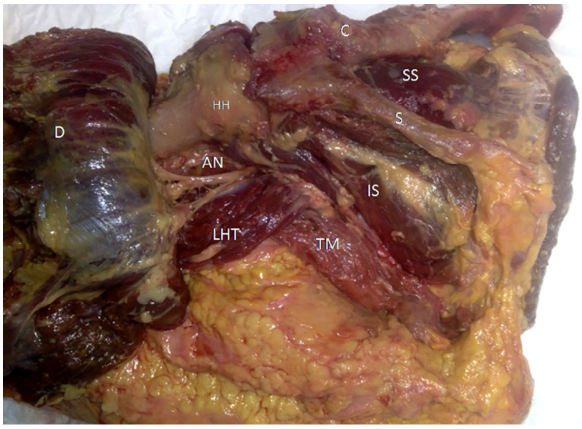

Figure 2 Posterior view of the shoulder showing disinsertion of the deltoid muscle (*D*) from its origin in the spinal column, acromion, and clavicle (*C*), respecting its innervation by the axillary nerve (*AN*). *SS*, supraspinatus muscle; *HH*, humeral head; *S*, scapular spine; *IS*, infraspinatus muscle; *LHT*, long head of triceps; *TM*, teres major muscle.

We sectioned the humeral insertion tendon of the TM, using a posterior approach, at the medial lip of the bicipital groove with the shoulder in internal rotation for monopolar transfer to the SS defect. We then released the muscle from its scapular origin, conducting bipolar transfer over or under the LHT (Fig. 4).

Once we had released the origin and insertion of the TM, the humeral insertion tendon was carried on the greater tuberosity at the level of the re-created RC lesion in the direction that created the lowest possible angle to the major axis of the SS (conditioned by the scapular spine in cases of transfer over the LHT or by the origin of the LHT in the infraglenoid tubercle in cases of transfer under the LHT). The muscle origin was not predetermined but rather was established after reaching the maximum tendon excursion permitted by the non-tensed length of the pedicle. Next, we fixed the humeral insertion and stretched the muscle to the original measured