Biomechanical Effectiveness Of Glenohumeral Tendon Transfers Performed With Reverse Shoulder Arthroplasty To Restore External Rotation.

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Introduction: Loss of active elevation and external rotation is a rare but very debilitating condition. This happens in massive rotator cuff tears with a posterosuperior extension. Several publications have reported the results of a combined tendon transfer with a reverse shoulder arthroplasty (RSA) to treat both the loss of elevation and external rotation. However, the best transfer and best insertion location remain unknown. Our purpose was to compare the external rotation moment arm (ERMA) of different tendon transfers intended to restore external rotation after RSA.

Methods: Six, fresh frozen cadaveric hemi-thoraces were used on a custom-made testing device (Fig. 1). Electromagnetic tracking sensors (Liberty, Polhemus, Inc.) were rigidly fixed to the thorax, scapula, and humerus to record 3D kinematics. Ten glenohumeral muscles were attached via suture to a rotational potentiometer equipped pulley and pneumatic cylinder to record tendon excursion and apply a passive muscle force, respectively. To test the specimen, the arm was manually moved through the complete axial rotation range of motion through 3 cycles of motion while the abduction and flexion/extension position was held constant. Each specimen was tested in its native condition and after the implantation of a reverse shoulder joint prosthesis by an experienced shoulder surgeon. The implant used in this study was the Comprehensive® Reverse Shoulder System (Biomet, Inc.) with 0mm lateral offset. The tendon and joint displacement method was used to calculate ERMA for 12 tendon pairs. These 12 pairs were made of the combination of 3 different muscles--latissimus dorsi (LD), teres major (TM) and lower trapezius (LT), each moved to one of 4 insertion sites-- near the bicipital groove at the anterolateral aspect of the humerus (BG), adjacent to the insertion site of the teres minor (Tm), adjacent to the insertion site of the infraspinatus (IS) and diametrically opposite to the original latissimus dorsi and teres major insertion sites (Opp). The ERMA for each muscle in both its intact and multiple transferred positions were computed with the arm in both 0° and 90° of abduction.

Results: With the humerus at 0° of abduction, the transfers to the following insertion sites showed the largest ERMA relative to the other tested insertion sites: the latissimus dorsi transfer to the biceps groove (4.6mm), the teres major transfer to the infraspinatus (10.1mm), and the lower trapezius to the infraspinatus (7.1mm). However, with the humerus at 90° of abduction, this same pattern was not followed. At 90° of abduction, the transfers to the following insertion sites showed the largest ERMA relative to the other tested insertion sites: the latissimus dorsi transfer to the infraspinatus (23.8mm), the teres major transfer to the teres minor (9.9mm), and the lower trapezius to the teres minor (7.4mm).

Discussion: The effective ERMA of a muscle that has undergone a tendon transfer varies significantly with both the muscle origin and insertion site of the transfer. When associated to a RSA, the most
efficient tendon transfer to restore active external rotation with the humerus at 0° of abduction is the teres major to biceps groove transfer, however it remained quite low relative to the intact shoulder, questioning the clinical relevance of such a transfer. Alternatively, with the humerus at 90° of abduction, the latissimus dorsi to infraspinatus transfer proved to have an ERMA that was large enough to appear effective and clinically relevant.

**Significance:** As reverse shoulder arthroplasty becomes an increasingly popular procedure, the use of tendon transfers in cases of massive cuff tears to restore external rotation has become increasingly common option. This study has demonstrated that some tendon transfer options are largely ineffective at restoring external rotation function while others appear quite effective. The transfers the appear most effective, as determined by size of their external rotation moment arms, were the teres major to the biceps groove at 0° of abduction and the latissimus dorsi to the infraspinatus at 90° of abduction.

Figure 1: The novel experimental setup with cadaver hemisection. The electromagnetic tracking sensors, rotation potentiometers, and pneumatic cylinders used to apply passive muscle loading can be seen.

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