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A NEW TECHNIQUE FOR AUGMENTATION OF MASSIVE ROTATOR CUFF RECONSTRUCTION USING THE BICEPS TENDON ALONG WITH TENODESIS

Orthopaedics

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ABSTRACT

The purpose of this study is to describe a new, minimally invasive massive rotator cuff tear reconstruction technique that uses the biceps tendon and to compare the results of this novel technique with primer repair. Eighteen patients were operated on a minimally invasive biological reconstruction of the massive rotator cuff tear using the biceps tendon, together with tenodesis. A further 23 patients underwent operations using anchors during the same period. The difference in postoperative UCLA scores between the two groups was not statistically significant, but the postoperative Constant score was significantly higher for the new technique, while the postoperative VAS score was significantly lower for the new technique. Massive rotator cuff tear reconstruction using the biceps tendon as a graft, together with tenodesis, was feasible using the technique described here and was associated with good middle term clinical and functional outcomes, with a low re-rupture rate.

KEYWORDS

Massive rotator cuff tear, massive rotator cuff reconstruction, biceps tendon, tenodesis

INTRODUCTION

A tear of the rotator cuff is defined as massive when it is greater than 5 cm in diameter *(4,5,14,15)*. These tears are typically classified as acute or chronic, but most of them are chronic in nature. In chronic tears, the muscle belly of the cuff shows fatty changes, while the tendon itself is retracted and the torn end of the cuff cannot be advanced into the original footprint; osteoporosis and osteoarthritis are accompanying diseases *(4,5,11,15)*. These factors preclude primary tendon-to-bone repair in many cases, but also lead to a high rate of failure after surgical repairs when compared with smaller tears *(5)*.

Several surgical techniques with promising clinical results have been described for biological reconstruction of massive rotator cuff tears (MRCTs); most of these involve the use of patch augmentation, superior capsular reconstruction and bridging reconstruction or tendon transfers *(3,4,5,11,15)*. The majority of tendon transfer techniques use the latissimus dorsi for massive irreparable posterosuperior tears, in order to restore posterior force coupling, especially in young, active, and well-motivated patients *(3,6,7)*. Another option is the modified L-Episcopo procedure, which is suitable for older patients with obvious abduction and external rotation lag, and restores the balance between the internal and external rotators *(10)*. Patch augmentation techniques, by contrast, use biodegradable structures, extracellular matrix–based patches, and degradable synthetic scaffolds *(8)*. The use of synthetic materials or allografts, such as fascia lata or human dermal allografts, in patch augmentation techniques or superior capsular reconstruction procedures may facilitate tendon healing and improve clinical outcomes with low re-tear rates. However, both tendon transfer techniques and graft augmentation procedures necessitate large exposures or the use of supplementary materials and are technically difficult *(9,11)*.

The purpose of this study is to describe a new, minimally invasive MRCT reconstruction technique that uses the biceps tendon and to compare the results of this novel technique with primer repair. We hypothesize that this reconstruction is feasible in practice and will provide good clinical results with low re-rupture rates.

MATERIALS AND METHODS

The prospective controlled study was approved by the Institutional Review Board, and was conducted according to the declaration of Helsinki and Good Clinical Practice. Informed consent was obtained from all individual participants included in the study.

The tear size was measured preoperatively by MRI and 41 patients with tears greater than 5 cm in diameter were included in the study. During the surgery, primer saturation using anchors was preferred if the tear was amenable to that technique. However, if the torn edges of the cuff could not be brought sufficiently close, the new technique was used (Fig. 1). A total of 18 patients (6 male, 12 female; mean age 62.8 years) were operated on between November 2010 and June 2014 by one surgeon, who performed a minimally invasive biological reconstruction of the MRCT using the biceps tendon, together with tenodesis. A further 23 patients (8 male, 15 female; mean age 60.8 years) underwent operations using anchors during the same period. All patients were asked if they would consider undergoing their operations again and if they were satisfied with their functional outcomes. All patients were evaluated clinically (using a VAS score) and with subjective questionnaires (the UCLA shoulder score and Constant score) preoperatively and postoperatively at the last follow-up. Radiological evaluation included magnetic resonance imaging (MRI) and radiographs.

STATISTICAL ANALYSES

The SPSS statistical software package (SPSS, version 22.0 for Windows; SPSS Inc., Chicago, Illinois, USA) was used to perform all statistical calculations. Wilcoxon's Matched-Pair Test with 95% confidence intervals was used for statistical analysis.

A value of $p < .05$ was considered significant in all statistical analyses. All data are expressed as mean ± standard deviation values.

Surgical technique

Patients were placed in a 70º beach chair position, and diagnostic arthroscopy was performed under general anesthesia. The degree of cuff tear and the status of the biceps tendon were evaluated from the standard posterior portal. A subacromial bursectomy was then performed from the lateral portal in all patients and acromioplasty was carried out when indicated. The torn ends of the cuff, together with intraarticular adhesions and the coracohumeral ligament, were released. The table was then adjusted to the 30º beach chair position. Using an anterolateral approach, a mini incision with a mean of 3.7 cm (range, 3.2 to 4.1 cm) was made over the acromion, extending from obliquely from anterior-superior to postero-inferior. The fibers of the deltoid were split from the acromion and extended inferiorly beyond the bicipital groove. While protecting the ascending branch of the circumflex humeral artery, the bicipital groove was trimmed with a 5.5 mm burr to facilitate tendon-to-bone healing. The elbow was held in 90° of flexion and a staple was inserted into the proximal end of the bicipital groove to utilize tenodesis and to fix the distal end of the reconstruction in a single action. This was followed by tenotomy of the biceps tendon from the superior labrum with a curved Bowie to obtain the maximum tendon length. The proximal end of the tendon was put into a flabellate shape, a divergent type cleft was created, and both ends were sutured directly with nonabsorbable sutures to the torn edges of the cuff, enabling a suitable tension over the repair area. Depending on the shape of the tear margin, convergence sutures and/or additional suture anchors were used to strengthen the repair (Fig. 2 and 3).

Postoperative rehabilitation

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A shoulder abduction brace providing 45º of abduction was recommended to all patients for 3 weeks. Passive ROM exercises were begun thereafter, including pendulum, forward flexion, and external rotation exercises. Strengthening exercises was initiated at postoperative 6^{th} week.

RESULTS

The mean follow-up time was 38.17±10.81 months for the primer repair group, and 36.61±12.31 months for the new technique (p=0.668). The mean duration of the surgery, at 34.30±6.32 minutes for the primer repair group and 45.39±6.83 minutes for the new technique, was significantly longer for the new technique ($p<0.05$). The mean number of anchors required for the procedures was 1.91±1.51 for the primer repair group and 1.72±0.57 for the new technique, but this difference was not statistically significant (p=0.253).

The mean preoperative UCLA, Constant, and VAS scores were 10.97±3.01, 26.89±2.79, and 6.39±0.89, respectively, for primer repair group and 10.22±3.25, 27.66±3.28, and 6.26±0.98, respectively, for the new technique. None of these differences were statistically significant (Table I).

Table I. The mean (±sd) scores, follow-up times, durations of the surgery, and numbers of anchors.

	New Technique (n=18)	Primer Repair (n=23)	p Value
Preop UCLA Scores	10.22±3.25	10.97±3.01	0.712
Preop Constant Scores	27.66±3.28	26.89±2.79	0.651
Preop VAS Scores	6.26±0.98	6.39±0.89	0.825
Follow-up (Months)	36.61±12.31	38.17±10.81	0.668
Duration of the Surgery (Minutes)	45.39±6.83	34.30±6.32	**0.000***
Number of Anchors	1.72±0.57	1.91±1.51	0.253

The mean postoperative UCLA, Constant and VAS scores were 28.73±2.01, 78.34±3.05, and 3.68±0.87, respectively, the primer repair group and 32.88±2.91, 82.35±2.55, and 1.76±0.62, respectively, for the new technique. The difference in postoperative UCLA scores between the two groups was not statistically significant, but the postoperative Constant score was significantly higher for the new technique, while the postoperative VAS score was significantly lower for the new technique (Table II).

Table II. The mean (±sd) scores, and times to return to normal activity.

	New Technique (n=18)	Primer Repair (n=23)	p Value
Postop UCLA Scores	32.88±2.91	28.73±2.01	0.051
Postop Constant Scores	82.35±2.55	78.34±3.05	**0.042***
Postop VAS Scores	1.76±0.62	3.68±0.87	**0.038***
Time to Return Activity (Weeks)	15.67±3.80	13.78±2.23	0.055

Patients were able to return to a sufficient functional level for activities of daily living at an average of 13.78±2.235 weeks in the primer repair group, and 15.67±3.804 weeks in the new technique group (Fig. 4), and these differences were not statistically significant (p=0.055). At final follow up, all but three patients in the new technique group (16.7%) and three patients in the primer repair group (13%) reported that they would be willing to undergo their operations again. All except one patient (5.5%) in the new technique group and two patients in the primer repair group (8.6%) were very satisfied with their functional outcomes. Two patients in the new technique group (11.1%). and two patients in the primer repair group (8.7%) experienced re-rupture; one of two re-ruptures in the new technique group was from the tenodesis area and the other was from the augmentation area, according to Sugaya's criteria.

Figure Legends:

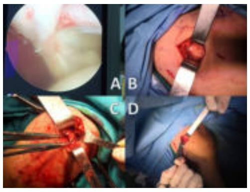

Fig. 1. Arthroscopic examination of the shoulder (A). A massive tear of the rotator cuff (B). If the torn edges of the cuff could be brought close together, the primary repair technique was used (C). If the torn edges of the cuff could not be brought close together, the novel technique was used (D).

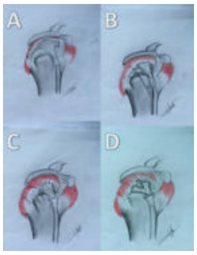

Fig. 2. The illustrations of the procedure. The massive rotator cuff tear (A). The torn edges of the cuff could not be able to bring closer (B). A staple was inserted into the proximal end of the bicipital groove to utilize both tenodesis and to fix the distal end of reconstruction in a single action (C). After tenotomy of the biceps tendon from the superior labrum with a curved Bowie, the proximal end of the tendon was put into a flabellate shape, a divergent type cleft was created, and both ends were sutured directly with nonabsorbable sutures to the torn edges of the cuff, enabling a suitable tension over the repair area (D).

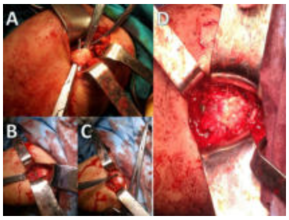

Fig. 3. The dissected biceps tendon (A). A staple was inserted into the proximal end of the bicipital groove to utilize tenodesis and to fix the distal end of reconstruction in a single action (B). After tenotomy of the biceps tendon from the superior labrum with a curved Bowie, the proximal end of the tendon was put into a flabellate shape, a divergent type cleft created, and both ends were sutured directly with nonabsorbable sutures to the torn edges of the cuff, enabling a suitable tension over the repair area (C). Depending on the shape of the tear margin, convergence sutures and/or additional suture anchors were used to strengthen the repair (D).

Fig. 4. Physical examination of a patient at the last follow-up. The range of motion was improved and the patient was free of pain.

DISCUSSION

MRCT reconstruction using the biceps tendon as a graft, together with tenodesis, was feasible using the technique described here and was associated with good middle term clinical and functional outcomes, with a low re-rupture rate (11.1%).

Only a few previous studies have reported MRCT reconstruction using the biceps tendon *(2,12,13,15)*. These previous techniques involved the attachment of the tenotomized biceps to the rotator cuff, and then suturing of the augmented repair into the greater tuberosity footprint. Three earlier studies by Rhee et al. *(15)*, Nassos et al. *(12)*, and Cho et al. *(2)* investigated the use of the biceps tendon for direct end-to-end repair or as an interpositional autograft to fill the gap between the cuff and footprint, but tenodesis of the remaining tendon was not mentioned. Obma et al. *(13)* used a weave technique for reconstruction to perform a subpectoral biceps tenodesis, and they also used the free biceps tendon graft as an interpositional graft to fill the gap. All these previous techniques differed from our new technique by either using the free biceps tendon graft or by covering the gap by diverging the course of the biceps tendon 90º laterally, without performing a tenodesis, as in the technique described by Nassos et al. *(12)*. Sano et al. *(17)* used a free biceps tendon graft, as well as performing a tenodesis into the bicipital groove, but their technique also differs from our new technique, as we accomplished both the augmented graft and the tenodesis with a staple inserted into the bicipital groove.

Boileau et al. *(1)* recommended biceps tenotomy or tenodesis to improve symptoms, especially in elderly patients. They did not perform acromioplasty or cuff repair, but the isolated biceps tenotomy or tendonesis alone were shown to improve Constant scores by an average of 20 points. Walch et al. *(18)* found similar improvements, with 87% patient satisfaction, when performing a tenotomy for palliative treatment of rotator cuff tears. Therefore, we adapted the technique of Rhee et al. *(15)*, who undermined the tenodesis and sutured the augmentation into the footprint, instead of simply providing a fixation for both cuff repair augmentation and tenodesis, with a staple into the bicipital groove rather than into the original footprint. This results not only gives a stable fixation but it may also improve graft to bone healing.

Nevertheless, these procedures still have failures. The glenohumeral force couple is extremely complex and only a few of its issues can be resolved by patch augmentation or tendon transfer procedures. We had two patients who experienced re-rupture and one patient who would not consider undergoing this operation again. The reported re-tear rate of MRCTs after biceps augmentation has a wide range, from 7.1% to 41.7% *(1,2,17)*. Most likely, two major reasons contribute to this problem: First is the degenerative changes at the biceps tendon itself and the accompanying fatty atrophy of the cuff muscles. Second is the interposing of the tendon between the torn ends and the footprint rather than covering the defect as a patch augmentation, which leads to undue stress on the repair site *(16)*.

Some limitations were still evident in our study. The most obvious was the small number of cases and the middle term follow up, which limits the generalizations that can be made to a larger patient population. All our patients are still being followed up prospectively and a longer-term follow up will be presented as a cohort study in the future. Second, evaluating tendon healing by MRI rather than second look arthroscopy might provide important information. However, the patients in this study have been involved in a long-lasting and tiresome rehabilitation program, so proposing a second operation to this patient group might be questionable.

CONCLUSION

The intention of this study was to show the results of a novel technique, and the data indicate that this novel technique provides similar (according to UCLA scores) or better (according to Constant and VAS scores) results than the primer repair in patients with MRCTs. The re-rupture rate (11.1%) was acceptable and compatible with the literature. The surgical techniques currently used to reconstruct MRCTs are cumbersome and can have additional morbidity or risk due to the difficulty of tendon transfer or use of supplemental material. We found that this novel technique, which does not need two separate repair sites, was useful for MRCT repair and that tenodesis also may improve patient scores. A low re-rupture rate was encountered in this small patient case series, but larger comparative studies are needed to review the safety of this approach compared with current standard tendon transfer or patch augmentation approaches.

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