Results of Arthroscopic Transosseous Rotator Cuff Repair Using the ArthroCuff System: A Prospective Study

Bellal S Rajsirish¹, Senthilvelan Rajagopalan², Ravi Nehru³, Sridhar G Rajagopalan⁴, Omprakash⁵

ABSTRACT

Introduction: Rotator cuff tears are one of the common cause of shoulder pain and disability. Transosseous cuff repair is still considered as the gold standard against which other techniques are compared. We studied the functional outcome of 50 patients with rotator cuff tear treated by our novel reusable arthroscopic transosseous repair system (ArthroCuff).

Materials and methods: We performed a prospective study involving 50 patients with full thickness rotator cuff tears during the period from January 2017 to December 2107. Repair was done with the ArthroCuff system. The patients were followed up periodically at 6 months and 1 year; 2 years functional outcome was assessed for pain, Oxford Shoulder score and active range of motion.

Results: At the end of 1 year and 2 years, all our patients had significant improvement in their Oxford Score, range of motion and pain relief. Two patients were trailing behind the mean at 6 months but they improved at 12 months. The results are comparable with other available transosseous systems and arthroscopic double row repair techniques.

Conclusion: Arthroscopic transosseous repair though a reliable and cost-effective alternate to suture anchors, is not widely available in India. So, in association with the National Hub for Healthcare Device Development, we developed ArthroCuff. For cost-conscious countries a reusable system to provide a robust rotator cuff repair is the need of the hour and we believe surgeons and patients can benefit from the multiple advantages that exist with this system.

Keywords: Anchorless cuff repair, Arthroscopy, Biological repair, Cuff repair, Transosseous equivalent, Transosseous rotator cuff repair.

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INTRODUCTION

Arthroscopic surgery in shoulder rotator cuff repair provides multiple advantages, which include inspection of glenohumeral joint for pathologies, deltoid muscle insertion preservation, and earlier functional recovery.¹ (Pearsall, 2007 #10). Rotator cuff repair was conventionally performed using open transosseous technique² and was the gold standard against which the present systems of anchor configurations are compared against.³ A number of systems exist in the market to repair rotator cuff, and the most common are various configurations of anchors like single row, double row, and the transosseous equivalent repairs. More recently transosseous arthroscopic systems have become available combining the advantages of transosseous repair and arthroscopy. Almost all devices available in the market are disposable single-use systems. In a cost-conscious market such as India, the reusable system put the patient under significant duress because of significant economic burden. To overcome the cost issues and provide the advantage of arthroscopic repair, we developed a reusable system for arthroscopic transosseous cuff repair called "ArthroCuff" and here we report the results of arthroscopic cuff repair using this system. Our system confers the mechanical and biological advantages of the open transosseous repair system while retaining the benefit of being an arthroscopic procedure. Herein we discuss the senior author's experience of the ArthroCuff system with respect to its surgical technique and outcome assessed using Oxford shoulder score, pain scale, and range of motion. We also report the few complications experienced with this system.

MATERIALS AND METHODS

All our patients who had full thickness rotator cuff tears underwent arthroscopic transosseous bone tunnel fixation using the novel

^{1,2,4}Department of Orthopedic Surgery, Muller Ortho Hospital, Chennai, Tamil Nadu, India

³Department of Orthopedic Surgery, Narayani Institute of Health Science, Vellore, Tamil Nadu, India

⁵Healthcare Department, National Hub for Healthcare Instrumentation Development, Anna University, Chennai, Tamil Nadu, India

Corresponding Author: Senthilvelan Rajagopalan, Department of Orthopedic Surgery, Muller Ortho Hospital, Chennai, Tamil Nadu, India, Phone: +91 956622533, e-mail: Velansenthil78@gmail.com

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system (ArthroCuff, SPowerN, Chennai). They were prospectively followed up from index surgery and outcomes measured at 6 months, one year, and 2 years. The study period was between January 2017 and December 2017 and the inclusion criteria were full thickness rotator cuff presenting to the clinic, and age above 18 years with a minimum follow-up of 2 years. All our patients with degenerative cuff tears had conservative management for at least 3 months before surgery. Patients were also included if the initial repair using ArthroCuff was unsuccessful or if they required additional supplemented anchor fixation. Preoperative Oxford shoulder scores, range of movements in forward flexion, and scapular plane abduction and rotations were recorded. All patients had preoperative MRI scans and cuff preoperative repair status was recorded according to Gouttallier staging. Patients were

Fig. 1: Lateral position with arm suspended in traction for routine inspection

Fig. 2: Accessory lateral portal made 3 cm below the acromion to pass the "ArthroCuff" jig

followed up at 2 weeks, 6 weeks, and 3 months, and thereafter every 3 months. Follow-up MRI was not routinely taken unless patients had persistent pain, acute injury, or a suspected re-tear. Range of motion and Oxford scores measured at the most recent clinical follow-up are reported. The minimum period of clinical follow-up was 24 months. Intraoperative and postoperative complications, duration of surgery, and pain scales were noted. Any further procedures like manipulation, shoulder injections, or resurgery were also documented. Comparison made between pre- and postoperative Oxford Outcome scores were done using SPSS 21.0.

ArthroCuff System

The novel arthroscopic transosseous rotator cuff repair system was developed by the senior author in conjunction with the National Hub for Healthcare Instrumentation Development, Anna University, Chennai, Tamil Nadu, India. Mechanical testing, calibration, and validation was done in the Department of Mechanical Engineering, Anna University, Chennai.

Surgical Technique

All surgeries were carried out by the senior shoulder elbow surgeon. We prefer lateral position with the affected arm suspended in traction. All our patients undergo the procedure under interscalene block with sedation. We proceed with the diagnostic arthroscopy by doing a glenohumeral joint inspection through the posterolateral portal and at this stage a biceps tenotomy if indicated is performed. With the scope in the subacromial space, a subacromial clearing bursectomy, morphology, and mobility assessment of the cuff tissue and the footprint preparation are performed using standard techniques (Fig. 1). An accessory lateral portal is made about 3 cm below the lateral end of acromion to pass the "ArthroCuff" jig which is later needed to pass the loop transport shuttle sutures. This portal is slightly lower than normal lateral portal done routinely so as to accommodate the free passage of the instrument under the acromion (Fig. 2). Next a superior portal in line with the medial footprint of the rotator cuff is made to aid the passage of entry awl for the jig: the pilot hole. This is made using the 3.9 mm diameter straight awl. It is tapped up to the laser mark. This vertical hole additionally also allows for bone marrow to seep into the repair which improves the biology and could aid healing (Fig. 3). The ArthroCuff jig is introduced through the lateral portal. The jig facilitates a cannulated handle through which a 2.9 mm drill bit is used to prepare the transverse tunnel. The transverse tunnel which

Fig. 3: Entry awl for the jig: the pilot hole

is about 20 mm distal to the tip of the greater tuberosity, intersects the vertical drill hole, forming an L shape from the lateral border of humerus to the footprint area of the head (Fig. 4). For better cutout strength, the transverse tunnel should be placed as distal as possible without compromising the axillary nerve. The design of "ArthroCuff" jig is such that the vertical arm is 20 mm and lateral arm is 15 mm, and this allows for maximal volume of bone in the transosseous tunnel and minimized suture cutout (Fig. 5). A shuttle suture is introduced in the locking screw tip mechanism. The introducer with screw tip mechanism is introduced into the lateral aspect of transosseous jig and screwed onto the tip of the "ArthroCuff" jig. Subsequently the jig is withdrawn along with the transosseous loop through the accessory lateral portal. Using the loop as a suture shuttle two no. 2 fiber wires are passed into each tunnel. Using a retrograde suture passer, sutures were passed through the rotator cuff as medial as possible and standard arthroscopic sliding knots are used (Fig. 6). Various suture configurations like simple, mattress, or transosseous equivalent can be utilized in this system, needed as per the scenario. In our system the knots fall over the lateral cortex and close to the entry point of the transverse tunnel. This confers the advantage of a knotless system and the tangential pull vector provides a large area of cuff compression over the footprint (Fig. 7).

FOLLOW-UP

During the immediate postoperative period, the patients are put on an arm sling pouch. Rehabilitation starts with gentle short chain

Fig. 4: ArthroCuff jig is introduced through the lateral portal

Fig. 5: Lateral drill hole placed as laterally and distally as possible for maximal bone strength

Fig. 6: Shuttling the sutures across tunnel using the novel suture lock screws

Fig. 7: Knot placed overlying the lateral aspect of greater tuberosity

Fig. 8: Follow-up of one of our patients at the end of 1 year

exercises on day 2 with much emphasis on elbow and hand range of motion. Provided patient tolerance, pendulum exercises were started at postoperative week 2 followed by a passive range of motion exercises at week 3 and passive assisted range of motion exercises at week 4. Active range of motion exercises were started at week 5 and resistance exercises at the 3rd month. They were assessed periodically at 2 weeks, 4 weeks, 6 weeks, and 3 months and every 3 months thereafter up to 2 years (Fig. 8).

RESULTS

In our study we had 50 patients, whose age ranging from 32 to 71 years (mean, 56.9 years). Out of them 22 were female and 28 male. 61.5% of them had degenerative tear and 38.5% had traumatic tears. The preoperative Goutallier stage was as shown in Figure 9. Most of them were stage II or less. Preoperatively the size of the

tear was assessed radiologically using cofield classification. Seven patients had small tears, 13 patients had medium-sized tear and six patients had large tears. The average time from symptom to surgery was on a mean 221 days in patients with degenerative tear and 19 days in patients with traumatic tear. We did not face any intraoperative complications in our patients. The average duration of the procedure was 78.33 minutes.

Patients were assessed at the end of 6 months, 12 months, and 2 years for range of motion, visual analog score, and Oxford shoulder score. The findings are as shown in Table 1. We had a statistically significant improvement in the values compared to the preoperative scores and the values were also comparable with other studies. We had a few patients who were falling behind the mean during follow-up. Three patients had persistent pain and required further steroid injections at 6 weeks.

DISCUSSION

Transosseous suture technique provides a greater footprint coverage, more contact area, and a linear compression as compared with other suture anchor techniques like single row, double row, or transosseous equivalent repairs. This should theoretically provide a better healing potential and initial fixation strength of repair.^{4,5} The initial fixation strength is mainly due to the tangential compression force in a tunnel repair technique, leading to a superior tuberosity-tendon fixation and limited interface micromotions.⁶ The lateral portal in our study for the introduction of the jig is 3 cm from the tip of the acromion along its anterior border. This is in consideration

Fig. 9: Goutallier staging of the cuff lesion

Table 1: Comparison of preoperative and postoperative outcomes at one year

Variable	Preoperative mean value	Postoperative 1-year mean value	p value
Forward flexion	118°	166°	<0.05
Abduction	87°	140°	<0.05
External rotation	12°	55°	<0.05
Visual analog scale	7.38/10	2/10	<0.001
Oxford shoulder score	17.432	40.730	<0.001

of the normal anatomical variations of the course of the axillary nerve,⁷ which is usually 6.1 ± 0.7 cm from the top anteriorly and 7 cm posteriorly.⁸ We did not have any axillary nerve injury in our study. Cadaveric biomechanical studies by Behrens et al. have compared the initial fixation strength of suture bridge rotator cuff repair construct to the traditional transosseous suture construct. They showed similar results with respect to load to failure and cyclical testing.⁹ In another study comparing transosseous Xbox configuration with the suture bridge technique also fared a similar pullout strength.¹⁰ It has been shown by Caldwell et al. that the ultimate strength to failure can be significantly improved by placing the lateral tunnel more distal (>10 mm) or tying the sutures over a wider bone bridge.¹¹ The design of our transosseous jig (vertical 20 mm, transverse 15 mm) allows for maximal lateral cortical purchase to prevent suture cutout and inherently enables a wide bone bridge (Fig. 10). The void created by the tunnel in the lateral cortex was considered to be a stress riser and certain authors used cortical augments to fill the void. But studies have shown no benefit with cortical augments.¹² We did not use any cortical augmentation in our patients and did not experience any intraoperative cutouts. One reason could be the design of our jig system and comparatively lower mean age group undergoing cuff repair in our study group. Multiple advantages exist with this system which include, better footprint coverage, better milieu for repaired tissue healing, and cost effectiveness. The average tear size in our group was 2.2 mm and our outcomes mirrored the improvement in Oxford scores at 6 months and 2 years postoperatively which is similar to a number of reported studies. Shoulder arthroscopy has become quite an expensive procedure with the need to use multiple suture anchors. Since ArthroCuff is an autoclavable, reusable implantless system, it provides significant cost cutting which is the need of the hour for a cost-conscious country like India.

LIMITATIONS

The study has some limitations. We did not include a control group or a comparison technique for rotator cuff repair, although we did use historical data. It is a single-author study and the power of the study was not sufficient enough to compare the number of tunnels needed with respect to the cuff tear size. Additionally, routine follow-up imaging is not readily available as we did not perform them unless patient symptoms warranted.

CONCLUSION

ArthroCuff was developed to provide a transosseous arthroscopic system that is also cost-effective. Literature shows that the

Fig. 10: Development of the ArthroCuff prototype

arthroscopic transosseous rotator cuff repair irrespective of the system used has good to excellent outcomes. Considering a cost-conscious country like India, a reusable system to provide reliable and robust rotator cuff repair is the need of the hour. Although the learning curve does exist in this system, we can see that once the technique is learnt, the surgical time is similar to that of standard cuff repair. We need more comparative studies in Indian population to further establish the effectiveness of this technique in the long-term.

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REFERENCES

1. Wilson F, Hinov V, Adams G. Arthroscopic repair of full-thickness tears of the rotator cuff: 2- to 14 year follow-up. *Arthroscopy* 2002;18(2):136–144. DOI: 10.1053/jars.2002.30443.
2. Goutallier D, Postel J-M, Radier C, et al. Long-term functional and structural outcome in patients with intact repairs 1 year after open transosseous rotator cuff repair. *J Shoulder Elbow Surg* 2009;18(4):521–528. DOI: 10.1016/j.jse.2008.11.006.
3. Ramsey ML, Getz CL, Parsons BO. What's new in shoulder and elbow surgery. *J Bone Joint Surg Am* 2009;91(5):1283–1293. DOI: 10.2106/JBJS.I.00105.
4. Apreleva M, Ozbaydar M, Fitzgibbons PG, et al. Rotator cuff tears: the effect of the reconstruction method on three-dimensional repair site area. *Arthroscopy* 2002;18(5):519–526. DOI: 10.1053/jars.2002.32930.
5. Park MC, Cadet ER, Levine WN, et al. Tendon-to-bone pressure distributions at a repaired rotator cuff footprint using transosseous suture and suture anchor fixation techniques. *Am J Sports Med* 2005;33(8):1154–1159. DOI: 10.1177/0363546504273053. Epub 2005 Jul 6.
6. Ahmad CS, Stewart AM, Izquierdo R, et al. Tendon-bone interface motion in transosseous suture and suture anchor rotator cuff repair techniques. *Am J Sports Med* 2005;33(11):1667–1671. DOI: 10.1177/0363546505278252. Epub 2005 Aug 10.
7. Hoppenfeld S, de Boer P. The shoulder. In: *Surgical Exposures in Orthopaedics*. 2nd ed., Philadelphia, PA: JB Lippincott Co; 1994. pp. 1–65.
8. Fleega BA. Arthroscopic transhumeral rotator cuff repair: giant needle technique. *Arthroscopy* 2002;18(2):218–223. DOI: 10.1053/jars.2002.30661.
9. Green A. Rhode Island Hospital, Department of Orthopaedic Surgery, 2 Dudley street, Providence, RI 02903. *Am J Sports Med* 2012.
10. Kummer FJ, Hahn M, Day M, et al. A laboratory comparison of a new arthroscopic transosseous rotator cuff repair to a double row transosseous equivalent rotator cuff repair using suture anchors. *Bull Hosp J Dis* 2013;71(2):128–131.
11. Caldwell GL, Warner JP, Miller MD, et al. Strength of fixation with transosseous sutures in rotator cuff repair. *J Bone Joint Surg Am* 1997;79(7):1064–1068. DOI: 10.2106/00004623-199707000-00013.
12. Black EM, Lin A, Srikumaran U, et al. Arthroscopic transosseous rotator cuff repair: technical note, outcomes, and complications. *Orthopedics* 2015;38(5):e352–e358. DOI: 10.3928/01477447-20150504-50.