J Shoulder Elbow Surg (2016) ■■, ■■–■■

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ORIGINAL ARTICLE

Difference in vascular patterns between transosseous-equivalent and transosseous rotator cuff repair

Atsushi Urita, MD, PhD[a], Tadanao Funakoshi, MD, PhD[a,*], Tatsunori Horie, RT[b,c], Mutsumi Nishida, PhD[b,d], Norimasa Iwasaki, MD, PhD[a]

[a]*Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine, Sapporo, Japan*
[b]*Diagnostic Center for Sonography, Hokkaido University Hospital, Sapporo, Japan*
[c]*Department of Radiological Technology, Hokkaido University Hospital, Sapporo, Japan*
[d]*Division of Laboratory and Transfusion Medicine, Hokkaido University Hospital, Sapporo, Japan*

Background: Vascularity is the important factor of biologic healing of the repaired tissue. The purpose of this study was to clarify sequential vascular patterns of repaired rotator cuff by suture techniques.

Methods: We randomized 21 shoulders in 20 patients undergoing arthroscopic rotator cuff repair into 2 groups: transosseous-equivalent repair (TOE group, n = 10) and transosseous repair (TO group, n = 11). Blood flow in 4 regions inside the cuff (lateral articular, lateral bursal, medial articular, and medial bursal), in the knotless suture anchor in the TOE group, and in the bone tunnel in the TO group was measured using contrast-enhanced ultrasound at 1 month, 2 months, 3 months, and 6 months postoperatively.

Results: The sequential vascular pattern inside the repaired rotator cuff was different between groups. The blood flow in the lateral articular area at 1 month, 2 months, and 3 months ($P = .002$, .005, and .025) and that in the lateral bursal area at 2 months ($P = .031$) in the TO group were significantly greater than those in the TOE group postoperatively. Blood flow was significantly greater for the bone tunnels in the TO group than for the knotless suture anchor in the TOE group at 1 month and 2 months postoperatively ($P = .041$ and .009).

Conclusion: This study clarified that the sequential vascular pattern inside the repaired rotator cuff depends on the suture technique used. Bone tunnels through the footprint may contribute to biologic healing by increasing blood flow in the repaired rotator cuff.

Level of evidence: Basic Science Study; Anatomy

Keywords: Rotator cuff tear; contrast-enhanced ultrasound; vascularity; transosseous-equivalent repair; transosseous repair; biologic healing

Arthroscopic rotator cuff repair (ARCR) in a patient with a rotator cuff tear is one of the most common procedures in shoulder surgery. This procedure helps to reduce shoulder pain and to improve motion by facilitating the successful healing of a torn rotator cuff.[40] However, a recurrent tear often occurs after ARCR and can become a major problem. To prevent

This study was approved by the Institutional Review Board of Hokkaido University Hospital: No. 010-0069.

*Reprint requests: Tadanao Funakoshi, MD, PhD, Department of Orthopaedic Surgery, Hokkaido University School of Medicine, Kita 15, Nishi 7, Sapporo 060-8638, Japan.

E-mail address: tfunakoshi@gmail.com (T. Funakoshi).

1058-2746/$ - see front matter © 2016 Journal of Shoulder and Elbow Surgery Board of Trustees. All rights reserved.
http://dx.doi.org/10.1016/j.jse.2016.06.010

recurrent tears, several suture techniques for ARCR have been modified, focusing on improving the biomechanical properties at the repaired rotator cuff tendon, thereby increasing the primary fixation strength and providing a wide contact area.[14,31,38] Nevertheless, recurrent tears after rotator cuff repair remain a major concern.[2,15,20,34] The biologic environment around the repaired tendon should be considered in trying to achieve successful tendon-to-bone healing.

The vascularity inside the tissue is one of the most crucial factors for healing of damaged tissue.[25] The literature shows that the edges of the torn rotator cuff tendons are atrophic and avascular and that healing after surgical repair occurs through cellular proliferation and vascular ingrowth, which originate mainly from peribursal soft tissue and bone.[3,16,26,37] These studies indicate that vascularity inside the repaired tendon plays an important role in biologic healing at the tendon-to-bone insertion after rotator cuff repair.

Contrast-enhanced ultrasound (CEUS) is used to characterize the vascularity of the rotator cuff. Several authors have used CEUS and have reported enhanced blood flow patterns in rotator cuff tissues.[1,5,12,13,16,33] These authors have suggested that the blood flow inside the repaired rotator cuff tendon changes postoperatively and that these changes may affect the healing of the tendon-to-bone insertion. However, no studies have compared the effect of different suture techniques on blood flow inside the repaired rotator cuff.

We hypothesized that the sequential vascular pattern inside the repaired rotator cuff would differ between suture techniques and that bone tunnels through the footprint would increase the blood flow inside the repaired rotator cuff. The purpose of this study was to use CEUS to compare the sequential vascular patterns of rotator cuffs repaired by 2 suture techniques. The second objective was to investigate whether the blood flow in the repaired rotator cuffs using the transosseous rotator cuff repair would be superior to that using the transosseous-equivalent rotator cuff repair.

Methods

Patient enrollment

Between September 2013 and March 2015, 47 patients were eligible if they were scheduled for ARCR. Surgery was performed by 1 of 2 surgeons (A.U. or T.F.). A power analysis was performed to determine the sample size for each group. Assumptions about primary outcome values and variance were based on a previous study by Funakoshi et al.[13] The sample size was determined on the basis of the mean ± standard deviation of preoperative and postoperative vascularity in the peritendinous tissue in patients with ARCR. Our power analysis indicated that 9 patient samples in each group were required to detect this effect size with a power of 80% and α of .05. To account for possible loss to follow-up, 25 patients were enrolled in the study.

The criteria for inclusion in this study were the presence of a superior chronic full-thickness supraspinatus or infraspinatus tendon tear and an intact insertion of the subscapularis and teres minor tendons. The rotator cuff tear was classified as a small or medium full-thickness tear according to Cofield's classification.[7] Patients with a long head of biceps tendon disorder, history of tobacco use, or cardiovascular disease were included. Patients with a traumatic rotator cuff tear, isolated subscapularis or teres minor tear, large or massive rotator cuff tear, previous shoulder operation, or obvious glenohumeral osteoarthritis on preoperative radiographs were excluded.

The patients were randomized into 2 groups: 11 shoulders in 10 patients in the transosseous-equivalent rotator cuff repair (TOE) group and 14 shoulders in 14 patients in the transosseous rotator cuff repair (TO) group. Informed consent to participate in the study was obtained from each patient. The tear pattern, which agreed with the inclusion criteria, was confirmed at the time of arthroscopy. One patient in the TOE group and 1 patient in the TO group were lost to follow-up, 1 patient in the TO group was unable to undergo postoperative magnetic resonance imaging (MRI), and 1 patient in the TO group had inadequate ultrasound data, leaving 10 shoulders in the TOE group and 11 shoulders in the TO group in the study (Fig. 1).

All patients had chronic shoulder pain that had been treated preoperatively with medication, subacromial injection, and/or physical therapy for a minimum of 3 months. One patient in the TOE group and 1 patient in the TO group were smokers. No patient in the TOE group and 2 patients in the TO group had cardiovascular disease.

All patients underwent a physical examination before the operation and 3 and 6 months postoperatively. Three clinically based outcome scores were used. All patients were assessed preoperatively and postoperatively using the 35-point University of California–Los Angeles shoulder scoring scale,[10] the 100-point Japanese Orthopaedic Association score,[21] and the 100-point Constant-Murley score.[8,18]

The preoperative radiographic evaluation involved anterosuperior and scapular lateral fluoroscopically controlled views. There was no obvious glenohumeral osteoarthritis in this series. Computed tomography arthrography and MRI were performed preoperatively in all patients to confirm the full-thickness rotator cuff tear. In the current study, there were 7 small tears and 14 medium tears.

The pattern of rotator cuff tear was assessed according to the size criterion, under direct visualization during the operation using the arthroscope in the lateral portal. The tear area anteroposterior diameter and mediolateral diameter were measured and recorded in millimeters, as previously described.[17,22,23,41]

Surgical technique

All patients underwent shoulder arthroscopy in the beach chair position under general anesthesia and a preoperative interscalene block. A 30° arthroscope was used for visualization. Standard diagnostic arthroscopy was used to assess all intra-articular structures and the rotator cuff tendon through the anterior and posterior portals; this was followed by bursectomy and acromioplasty using Ellman's methods.[9]

After bursectomy of the subacromial space and débridement around the ruptured tendon, the footprint was identified on the greater tuberosity and abraded with a shaver until cancellous bone was exposed. One suture anchor (5.5-mm HEALIX ADVANCE BR Anchor; DePuy Synthes Mitek, Raynham, MA, USA) was placed at the medial edge of the greater tuberosity footprint at 45° to the footprint surface, and 6 threads were passed through the ruptured tendon without tying. Then 2 knotless suture anchors (VERSALOK; DePuy Synthes Mitek) were used to fix the threads at the lateral aspect of the greater tuberosity in the TOE group.[31,32] Each knotless suture