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의학석사 학위논문

Characteristics and outcomes of L- shaped and reverse L- shaped rotator cuff tears

L자형 및 역L자형 회전근 개 파열의 특징 및 결과

2023년 8월

서울대학교 대학원

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Characteristics and outcomes of L- shaped and reverse L- shaped rotator cuff tears

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Abstract

Aims

The aim of this study was to compare the characteristics and outcomes of L- shaped and reverse L- shaped rotator cuff tears.

Methods

A total of 82 shoulders (81 patients) after arthroscopic rotator cuff repair were retrospectively enrolled. The mean age of the patients was 62 years (SD 6), 33 shoulders (40.2%) were in male patients, and 57 shoulders (69.5%) were the right shoulder. Of these, 36 shoulders had an L- shaped tear (group L) and 46 had a reverse L- shaped tear (group RL). Both groups were compared regarding characteristics, pre- and postoperative pain, and functional outcomes. Muscle status was assessed by preoperative MRI, and retear rates by postoperative ultrasonography or MRI.

Results

Patients in group RL were significantly older than in group L ($p = 0.008$), and group RL was significantly associated with female sex (odds ratio 2.5 (95% confidence interval 1.03 to 6.32); $p = 0.041$). Mean postoperative pain visual analogue scale (VAS) score was significantly greater (group L = 0.8 (SD 1.5), group RL = 1.7 (SD 2.2); $p = 0.033$) and mean postoperative American Shoulder and Elbow Surgeons (ASES) score was significantly lower in group RL than group L (group L = 91.4 (SD 13.1), group RL = 83.8 (SD 17.9); $p = 0.028$). However, postoperative mean VAS for pain and ASES score were not lower than the patient acceptable symptom state scores. Mean retracted tear length was significantly larger in group

L (group L = 24.6 mm (SD 6.5), group RL = 20.0 mm (SD 6.8); p = 0.003). Overall retear rate for 82 tears was 11.0% (nine shoulders), and retear rates in group L and RL were similar at 11.1% (four shoulders) and 10.9% (five shoulders), respectively (p = 1.000). No significant intergroup difference was found for fatty degeneration (FD) or muscle atrophy. Within group L, postoperative FD grades of supraspinatus and subscapularis worsened significantly (p = 0.034 and p = 0.008, respectively). Mean postoperative pain VAS (male = 1.2 (SD 1.8), female = 1.3 (SD 2.0)) and ASES scores (male = 88.7 (SD 15.5), female = 86.0 (SD 16.8)) were similar in male and female patients (p = 0.700 and p = 0.475, respectively). Regression analysis showed age was not a prognostic factor of postoperative pain VAS or ASES scores (p = 0.188 and p = 0.150, respectively).

Conclusion

Older age and female sex were associated with reverse L– shaped tears. Although the postoperative functional outcomes of patients with reverse L– shaped tears were satisfactory, the clinical scores were poorer than those of patients with L– shaped tears. Surgeons should be aware of the differences in clinical outcome between L– shaped and reverse L– shaped rotator cuff tears.

Keyword : L–shaped, reverse L–shaped, rotator cuff tear, clinical outcome

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Chapter 1. Introduction

Rotator cuff tear (RCT) is the most common cause of shoulder complaints. Identifying the shapes of RCTs is important for determining the repair method.[1] McLaughlin et al.[2] first described tear shapes as transverse rupture, vertical split, and retracted. However, Davidson and Burkart[3] proposed a new classification based on RCT shape, as Type 1 (crescent-shaped tear), Type 2 (longitudinal tear, including U- and L-shaped), and Type 3 (massive contracted tear). They recommended repair methods should be determined according to these geometric patterns, and suggested these patterns be used as a basis for communication and comparing outcomes.

Millett and Warth[4] reported that L-shaped and reverse L-shaped tears account for approximately 30% of all full thickness RCTs and that both have transverse and longitudinal components. These tears resemble U-shaped tears but differ because one edge is more mobile than the other. L-shaped tears (also described as anterior L-shaped tears) have a longitudinal portion extending anteriorly into or to near the rotator interval, whereas reverse L-shaped tears (also described as posterior L-shaped tears) have a longitudinal portion extending posteriorly between supraspinatus (SST) and infraspinatus (IST).[4,5]

The shape of RCT is important to facilitate anatomic repair. If surgeons did not recognize tear shape appropriately, it could be resulted in suboptimal and high-tension repair, and can also lead to "dog ear" deformity.[5] Watson et al.[6] failed to find a relation between RCT shape and outcomes, but only crescent-shaped, L-shaped, and U-shaped tears were compared as the number of reverse L-shaped tears included was too small for analysis. To our knowledge, no previous study has compared the characteristics and outcomes of L-shaped and reverse L-shaped tears.

Therefore, the purpose of this study was to compare the characteristics and clinical outcomes of these RCT types. We hypothesized that there would be no difference in clinical outcomes following arthroscopic repair of L-shaped and reverse L-shaped RCTs.

Chapter 2. Methods

This retrospective case-control study was conducted on 82 shoulders of 81 patients selected from 680 shoulders of 660 patients that underwent arthroscopic rotator cuff repair for the treatment of acute and chronic full-thickness RCT at the authors' institution from January 2015 to June 2020. RCTs were diagnosed by physical exam and preoperative magnetic resonance imaging (MRI) within 3 months of surgery. We did not set an upper age limit for rotator cuff repair. However, when pre-operative MRI showed cuff tear arthropathy or severe fatty degeneration (FD) (≥3) in elderly patients (> 70 years of age), we usually recommended reverse total shoulder arthroplasty after conservative treatment rather than rotator cuff repair.

All surgeries were performed by a single surgeon (K.S.H.). In all cases, the surgeon classified RCT shape based on intraoperative findings as; crescent-shaped, L-shaped, reverse L-shaped, U-shaped, or another shape. Among the 680 shoulders, there were 344 (50.6%) crescent-shaped tears, 64 (9.4%) L-shaped tears, 91 (13.4%) reverse L-shaped tears, 172 (25.3%) U-shaped tears, and 9 (1.3%) tears with some other shape (e.g., V-shaped tears). Shoulders with a crescent-shaped, U-shaped, or another tear shape were excluded. Furthermore, patients involved in a prospective study were also excluded (24 cases). Of the remaining 155 cases, 73 were excluded because of a massive RCT (15 cases), follow-up for < 1 year: loss of follow-up (16 cases), enrollment in a prospective study (24 cases), or lack of images or follow-up scores (18 cases). A patient selection flow diagram is provided in Figure 1. Finally, 82 shoulders were enrolled in this study. Thirty-six shoulders had an L-shaped tear (group L) and 46 had a reverse L-shaped tear (group RL). At 1 year after surgery, 49 shoulders underwent MRI (22 with an L-shaped tear and 27 with a reverse L-shaped tear). Results were analyzed separately.

All protocols were approved by our Institutional Review Board (IRB

No: H-2108-135-1246)

Measurement of clinical outcomes

Visual analogue scale (VAS) for pain, Simple Shoulder Test (SST) scores, and American Shoulder and Elbow Surgeons (ASES) scores were used to assess clinical outcomes. All scores were assessed preoperatively and at each postoperative outpatient visit (5 weeks, 3 months, 6 months, 1 year, and then annually). Active range of motion (ROM) was also assessed preoperative and at each postoperative outpatient visit. Forward flexion, external rotation with the affected arm at side, and internal rotation at back were measured by the same surgeon. Internal rotation at back was assessed using vertebral levels, which were numbered serially (1-12 for T1-T12, 13-17 for L1-L5, 18 for sacrum, and 19 for buttock).[7] For the analysis, we used preoperative outcome variables and outcomes at last outpatient clinic follow-up visits.

Measurement of radiologic variables

Shoulder MRI was performed using a 1.5 T (Signa HDxt 1.5T, GE Healthcare, Milwaukee, Wisconsin, USA) or 3.0 T (Magnetom Trio/Verio, Siemens Medical Solutions, Erlangen, Germany) MRI scanner with dedicated shoulder coils. RCT size, FD grade, and degree of muscle atrophy were evaluated by preoperative MRI. To quantify tear sizes, anterior to posterior widths (AP widths) were measured using sagittal image, and medial to lateral lengths (ML lengths) was measured using coronal image that showed largest tear sizes. ML lengths indicated degrees of rotator cuff retraction. FD grades were evaluated for each muscle using the MRI-based 5-stage grading system developed by Goutallier-Fuch et al.,[8,9] and degrees of muscle atrophy were evaluated using the MRI-based 3-stage grading system developed by Lim et al.[10] All radiologic variables were obtained from the routine radiologic reports submitted by musculoskeletal radiologists not involved in this study.

Repair integrities were assessed by ultrasonography (SONO) at each follow-up visit (5 weeks, 3 months, and 6 months) by musculoskeletal radiologists and were rated as follows: Grade 1 - normal tendon status, Grade 2 - insufficient tendon thickness, and Grade 3 - partial or complete retear. We defined grade 3 as retear of a repaired rotator cuff tendon.[11] To determine final results, MRI was performed at 1 year postoperatively. Although all patients were recommended to take postoperative MRIs, considerable portion of patients refused postoperative MRI for financial reasons after they recover. Finally, 49 of the 81 patients underwent postoperative MRI. In MRI, repair integrity was assessed using Sugaya classification.[12] Sugaya types 4 and 5 were defined as retear of a repaired rotator cuff tendon. For patients that underwent MRI at 1 year after surgery, these MRI results were used to assess final repair integrities, and for the other patients, SONO results obtained at 6 months were used. Tear sizes, FD grades, degrees of muscle atrophy, and repair integrities were assessed by consensus of musculoskeletal radiologists using routine MRI reports.

Surgical techniques and Rehabilitation protocols

All surgeries were performed arthroscopically in the lateral decubitus position under general anesthesia. An arthroscope was introduced into the glenohumeral joint through a posterior viewing portal, and intra–articular pathologies were examined carefully. Before January 2019, biceps tenotomy or subpectoral tenodesis was performed for patients with biceps pathology. Biceps tenotomy was usually performed for female patients aged ≥ 65 with a low activity level, and subpectoral tenodesis was performed for other patients.[13,14] After January 2019, a modified biceps rerouting procedure was performed for patients with biceps pathology. Acromioplasty was performed selectively in cases with a lateral projecting spur or a bird beak spur. As mentioned above, RCT shapes were carefully evaluated.

Rotator cuff repair was performed using a single row repair technique. In each case, the cuff footprint was prepared using a motorized rasp taking care to minimize decortication and not violate the cortex. After determining tear configuration, the end of the mobile side of the tear was used to cover the footprint using a corner suture inserted near the immobile end. Another suture anchor was placed in the middle of exposed footprint as a tension bearing suture. For modified biceps rerouting, unlike the original procedure performed by Kim et al.,[15] a 3−stranded anchor was inserted 5 mm posterior to the original biceps groove on the medial margin of the footprint to fix the biceps tendon. One strand of the inserted anchor was used to fix the long head of biceps tendon with a wrap−around suture and the other two strands were incorporated into the cuff repair. When a concomitant substantial partial subscapularis (SSC) tear was present, it was also repaired.

All patients wore an abduction brace after surgery for immobilization. Active wrist and hand motion were encouraged while maintaining the brace, which was removed 5 weeks after surgery and controlled passive ROM exercises (forward flexion, abduction, and external rotation) were started. Active−assisted ROM exercises were started at 3 months after surgery.

Statistical analysis

Statistical analyses were performed using SPSS version 23.0 (IBM SPSS Statistics, Chicago, IL). The independent T or the Mann−Whitney U test were used to compare quantitative variables, Pearson’s chi−square test or Fisher’s exact test were used to compare qualitative variables, and the paired T−test or Wilcoxon’s signed rank test were used to compare preoperative and postoperative FD grades and degrees of muscle atrophy. Simple linear regression analysis was used to identify prognostic indicators of clinical outcomes. ANOVA followed by Dunnett’s T3 post hoc test was used to compare quantitative variables with respect to biceps procedure type (biceps tenotomy, subpectoral biceps tenodesis, modified biceps rerouting procedure, and shoulders that did not require a biceps procedure). All reported P values are two−sided, and statistical significance was accepted for p values < 0.05.

Chapter 3. Results

Mean age at the time of surgery in the group L and RL were 60 ± 8 years (range, 38–74 years) and 63 ± 5 years (range, 55–79 years), and mean follow-up periods were 30 ± 20 months (range, 12–73 months) and 32 ± 20 months (range, 12–72 months), respectively (Table 1). Mean age was significantly greater in group RL (p=0.008), and female gender was significantly associated with group RL (OR=2.5, p=0.041). No case of concomitant SSC full-thickness tear was encountered, but 10 patients (5 in each group) had partial full-thickness SSC tear. Among them, 6 patients (2 in the group L) underwent concomitant SSC repair during surgery. Prevalence of concomitant SSC tears were similar (p=0.742). Also, these 10 patients underwent a biceps procedure during surgery (tenotomy: 4, subpectoral tenodesis: 5, modified biceps rerouting procedure: 1). Trauma histories, diabetes mellitus, body mass indices, symptom durations, biceps procedure types, and follow-up periods were no different in the two groups.

Preoperative pain VAS, SST, ASES scores, and pre- and postoperative ROMs were not significantly different in the two groups (Table 2). However, mean postoperative pain VAS was significantly higher and mean postoperative ASES score was significantly lower in group RL (p=0.033 and p=0.028, respectively). Mean ML length was significantly greater in group L (p=0.003) (Table 3), but FD grades and degrees of muscle atrophy were similar. The overall retear rate was 12.1%, and retear rates in groups L and RL were similar (13.8% and 10.8%, respectively; p=0.742). No postoperative complication (e.g., infection, fracture, or revision surgery due to retear) occurred. Separate analysis was performed on 49 patients that underwent postoperative MRI (Table 4), and postoperative FD grade and degree of muscle atrophy were not significantly different for L-shaped and reverse L-shaped tears.

Preoperative and postoperative radiologic variables are summarized in Table 5. FD grades of SST and SSC in patients with an L-shaped tear were significantly poorer postoperatively (p=0.034 and p=0.008, respectively) but non-significantly different in patients with reverse L-shaped tear. FD grades of IST in patients with a reverse L-shaped tear were non-significantly poorer postoperatively (p=0.083). Degrees of SST muscle atrophy tended to improve postoperatively in both groups but without significance (p=0.180 and p=0.180, respectively).

Sub-analysis was performed to evaluate the effects of gender and age on clinical outcomes. For all 82 shoulders, postoperative pain VAS and ASES scores of male and female patients at final follow-up visits were similar (p=0.700 and p=0.475, respectively), and regression analysis showed age was not a prognostic factor of postoperative pain VAS or ASES scores (p=0.188 and p=0.150, respectively). When the 82 shoulders were divided into four groups by biceps procedure type (biceps tenotomy, subpectoral biceps tenodesis, modified biceps rerouting procedure, and no biceps procedure), no significant intergroup difference was observed for tear shapes, retear rates, or age (Table 6). However, female gender was significantly associated with biceps tenotomy (p=0.029), and ANOVA and post hoc testing showed preoperative SST scores of patients that underwent biceps tenotomy were significantly lower than those that did not and those of patients that underwent subpectoral tenodesis (p=0.008 and p=0.019, respectively).

Chapter 4. Discussion

To our knowledge, this study is the first study to clarify the importance of reverse L−shaped tears. Among all cases that underwent arthroscopic rotator cuff repair from January 2015 to June 2020, 91 cases (13.4%) had a reverse L−shaped tear and 64 cases (9.4%) had an L−shaped tear. Sallay et al.[5] reported a prevalence of 10% for L−shaped tear and 20% for reverse L−shaped tear, which concurs with our observations.

In the present study, group RL was older than group L, and female gender was associated with group RL. In a previous study, patient age was positively correlated with presence of the rotator cable.[16] Also, Burkhart et al.[17] in a cadaveric study reported that hypertrophy of the rotator cable develops gradually as the cable has to take on increasing loads with age. Therefore, more RCTs may occur along the rotator cable than the rotator crescent in older patients, which suggests that reverse L−shaped tears are more likely than L−shaped tears in older patients. However, no previous study has investigated the association between gender and tear shape. Our results indicate further studies are required on the association between female gender and reverse L−shaped tear development.

In the current study, the overall retear rate was 12.1%, and retear rates in group L and RL were 13.8% and 10.8%, respectively, which are lower than previously reported rates.[18] Retear rates in group L and RL were similar, but postoperative pain VAS and ASES scores were poorer in the RL group. Since reverse L−shaped tears are not uncommon, surgeons should be aware that if a reverse L−shaped tear is detected during surgery, postoperative clinical outcomes may be poorer. However, the patient acceptable symptom state (PASS) scores for ASES, SST scores, and pain VAS are 78.0, 8.4, and 1.7, respectively.[19,20] Because postoperative scores in group RL were not lower than PASS scores, outcomes of reverse L−shaped tear were satisfactory. Furthermore, mean ML length was larger in group L than in group RL. In a biomechanical study by Mesiha et al.,[21] tears affecting the anterior insertion of the rotator cuff cable were found to result in increased retraction, and in a clinical study, Cho et al.[22] observed tears with anterior disruption of the rotator cable were associated with greater and more advanced FD. These results are consistent with our observation.

A separate analysis was performed on 49 patients that underwent postoperative MRI. FD grades of SST and SSC in patients with an L-shaped tear worsened significantly after surgery. As mentioned above, L-shaped tears invade the anterior rotator cable and are associated with more advanced FD,[22] which may explain why FD grades of SST and SSC in patients with an L-shaped tear worsened after surgery. Since reverse L-shaped tears invaded IST, IST FD grades in patients with a reverse L-shaped tear showed a non-significant tendency to worsen after surgery. Previous studies have shown that SST muscle atrophy improves after surgery,[23,24] and we observed a similar non-significant trend in both tear groups. Since degree of muscle atrophy was evaluated in cross-sectional MRI Y view, it is questionable whether muscle atrophy improvements were related to volumetric changes. After repair, muscle belly retracts laterally, and muscle atrophy may appear to be improved. Therefore, to evaluate surgery-induced changes accurately in rotator cuff muscle, total muscle volume should be calculated. Chung et al.[25] conducted a similar study but were unable to evaluate whole muscle volume up to the scapular medial border because muscle volumes were measured only up to 2 cm medial in MRI Y view. Further studies are needed to clarify this issue.

As mentioned above, biceps tenotomy was performed on female patients aged ≥ 65 with a low activity level, and thus, female gender was associated with biceps tenotomy, and preoperative SST scores of patients with biceps tenotomy were lower than others. However, subanalysis showed gender and age did not predict postoperative pain VAS or ASES scores, which suggests tear shape influences clinical outcomes.

The present study has several limitations. First, its retrospective nature may have caused selection bias. However, since the prevalence of L−shaped and reverse L−shaped tears showed trends similar to those previously reported,[5] we believe the effect of selection bias was minor. Second, follow−up period was relatively short. Longer follow−up period might have produce different results. Third, when MRIs were unavailable at 1 year, 6−month SONO results were used to determine final repair integrities. In one patient, 6−month SONO results and 12−month MRI findings were inconsistent, and thus, repair integrity may have been incorrectly evaluated. However, according to a study by Yoo et al.,[26] retears usually develop within 3 months of surgery, which indicates SONO at 6 months after surgery sufficiently defines repair integrity. Fourth, we used 2 different MRI modalities to evaluate rotator cuff statuses, and this might have affected the interpretation of rotator cuff tendon status or retear. Finally, several different biceps procedures were used to address biceps pathologies. However, postoperative pain VAS and ASES scores were no different for patients that underwent different biceps procedures.

Chapter 5. Conclusion

Older age and female gender were associated with reverse L-shaped tears, and postoperative functional outcomes were poorer for patients with a reverse L-shaped tear. Surgeons should be aware of clinical outcome differences between L-shaped and reverse L-shaped rotator cuff tears.

Bibliography

1. Henn RF, Kang L, Tashjian RZ, Green A. Patients' Preoperative Expectations Predict the Outcome of Rotator Cuff Repair. *J Bone Joint Surg Am* 2007;89(9):1913–1919.

2. McLaughlin HL. Lesions of the musculotendinous cuff of the shoulder. The exposure and treatment of tears with retraction. 1944. *Clin Orthop Relat Res* 1994;(304):3–9.

3. Davidson J, Burkhart SS. The Geometric Classification of Rotator Cuff Tears: A System Linking Tear Pattern to Treatment and Prognosis. *Arthroscopy* 2010;26(3):417–424.

4. Millett PJ, Warth RJ. Posterosuperior rotator cuff tears: Classification, pattern recognition, and treatment. *J Am Acad Orthop Surg* 2014;22(8):521–534.

5. Sallay PI, Hunker PJ, Lim JK. Frequency of Various Tear Patterns in Full-Thickness Tears of the Rotator Cuff. *Arthroscopy* 2007;23(10):1052–1059.

6. Watson S, Allen B, Robbins C, Bedi A, Gagnier JJ, Miller B. Does the Rotator Cuff Tear Pattern Influence Clinical Outcomes After Surgical Repair? *Orthop J Sport Med* 2018;6(3).

7. Oh JH, Kim SH, Lee HK, Jo KH, Bin SW, Gong HS. Moderate Preoperative Shoulder Stiffness Does Not Alter the Clinical Outcome of Rotator Cuff Repair With Arthroscopic Release and Manipulation. *Arthroscopy* 2008;24(9):983–991.

8. Fuchs B, Weishaupt D, Zanetti M, Hodler J, Gerber C. Fatty degeneration of the muscles of the rotator cuff: assessment by computed tomography versus magnetic resonance imaging. *J Shoulder Elbow Surg* 1999;8(6):599–605.

9. Goutallier D, Postel JM, Bernageau J, Lavau L, Voisin MC. Fatty muscle degeneration in cuff ruptures. Pre- and postoperative evaluation by CT scan. *Clin Orthop Relat Res* 1994;(304):78–83.

10. Lim HK, Hong SH, Yoo HJ, Choi JY, Kim SH, Choi JA, et al. Visual MRI grading system to evaluate atrophy of the supraspinatus muscle. *Korean J Radiol* 2014;15(4):501–507.

11. **Muniandy M, Niglis L, Claude Dosch J, Meyer N, Kempf JF, Collin P**. Postoperative rotator cuff integrity: can we consider type 3 Sugaya classification as retear? *J Shoulder Elbow Surg* 2021;30(1):97–103.
12. **Sugaya H, Maeda K, Matsuki K, Moriishi J**. Functional and structural outcome after arthroscopic full-thickness rotator cuff repair: Single-row versus dual-row fixation. *Arthroscopy* 2005;21(11):1307–1316.
13. **Lee HJ, Kim ES, Kim YS**. What happens to the long head of the biceps tendon after arthroscopic rotator cuff repair? *Bone Joint J* 2020;102-B(9):1194–1199.
14. **Oh JH, Lee YH, Kim SH, Park JS, Seo HJ, Kim W, et al.** Comparison of Treatments for Superior Labrum-Biceps Complex Lesions with Concomitant Rotator Cuff Repair: A Prospective, Randomized, Comparative Analysis of Debridement, Biceps Tenotomy, and Biceps Tenodesis. *Arthroscopy* 2016;32(6):958–967.
15. **Kim YS, Lee HJ, Park I, Sung GY, Kim DJ, Kim JH**. Arthroscopic In Situ Superior Capsular Reconstruction Using the Long Head of the Biceps Tendon. *Arthrosc Tech* 2018;7(2):e97–e103.
16. **Davis DE, Lee B, Aleem A, Abboud J, Ramsey M**. Interobserver reliability of the rotator cable and its relationship to rotator cuff congruity. *J Shoulder Elbow Surg* 2020;29(9):1811–1814.
17. **Burkhart SS, Esch JC, Jolson RS**. The rotator crescent and rotator cable: An anatomic description of the shoulder's "suspension bridge". *Arthroscopy* 1993;9(6):611–616.
18. **Cho NS, Rhee YG**. The factors affecting the clinical outcome and integrity of arthroscopically repaired rotator cuff tears of the shoulder. *Clin Orthop Surg* 2009;1(2):96–104.
19. **Kim DM, Kim TH, Kholinne E, Park JH, Shin MJ, Kim H, et al.** Minimal Clinically Important Difference, Substantial Clinical Benefit, and Patient Acceptable Symptomatic State After Arthroscopic Rotator Cuff Repair. *Am J Sports Med* 2020;48(11):2650–2659.
20. **Chamberlain AM, Hung M, Chen W, Keener JD, McAllister J,**

Ebersole G, et al. Determining the Patient Acceptable Symptomatic State for the ASES, SST, and VAS Pain After Total Shoulder Arthroplasty. *J Shoulder Elb Arthroplast* 2017;1:247154921772004.

21. **Mesiha MM, Derwin KA, Sibole SC, Erdemir A, McCarron JA**. The biomechanical relevance of anterior rotator cuff cable tears in a cadaveric shoulder model. *J Bone Joint Surg Am* 2013;95(20):1817–1824.

22. **Cho NS, Moon SC, Hong SJ, Bae SH, Rhee YG**. Comparison of Clinical and Radiological Results in the Arthroscopic Repair of Full-Thickness Rotator Cuff Tears with and Without the Anterior Attachment of the Rotator Cable. *Am J Sports Med* 2017;45(11):2532–2539.

23. **Chung SW, Kim SH, Tae SK, Yoon JP, Choi JA, Oh JH**. Is the supraspinatus muscle atrophy truly irreversible after surgical repair of rotator cuff tears? *Clin Orthop Surg* 2013;5(1):55–65.

24. **Jo CH, Shin JS**. Changes in appearance of fatty infiltration and muscle atrophy of rotator cuff muscles on magnetic resonance imaging after rotator cuff repair: Establishing new time-zero traits. *Arthroscopy* 2013;29(3):449–458.

25. **Chung SW, Oh KS, Moon SG, Kim NR, Lee JW, Shim E, et al.** Serial Changes in 3-Dimensional Supraspinatus Muscle Volume after Rotator Cuff Repair. *Am J Sports Med* 2017;45(10):2345–2354.

26. **Yoo HJ, Choi JY, Hong SH, Kang Y, Park J, Kim SH, et al.** Assessment of the postoperative appearance of the rotator cuff tendon using serial sonography after arthroscopic repair of a rotator cuff tear. *J Ultrasound Med* 2015;34(7):1183–1190.

Abstract in Korean

연구 목적: 본 연구의 목적은 L자형 회전근 개 파열과 역L자형 회전근 개 파열의 특성과 그 임상적 결과를 비교하는 것이다.

연구 방법: 본 연구에는 관절경하 회전근 개 복원술 수술을 시행받은 총 82개의 어깨(81명)가 후향적으로 등록되었다. 환자들의 평균 연령은 62세(표준편차 6)였으며, 33개의 어깨(40.2%)가 남자였고, 57개의 어깨(69.5%)가 오른쪽 어깨였다. 이 중 36개는 L자형 회전근 개 파열(L 그룹)이었고, 나머지 46개가 역L자형 회전근 개 파열(RL 그룹)이었다. 두 그룹의 특성, 수술 전후 통증 및 기능적 결과를 비교했다. 회전근 개 근육의 상태는 수술 전 MRI 검사를 통해 평가했고, 수술 후 초음파 또는 MRI 검사로 재파열율을 평가했다.

결과: RL 그룹의 환자는 L 그룹의 환자보다 유의하게 나이가 많았고 (p=0.008), RL 그룹은 여성 성별과 유의하게 관련이 있었다(OR 2.5, p=0.041). RL 그룹의 평균 수술 후 VAS 점수가 L 그룹보다 유의하게 높았고(L 그룹=0.8, RL 그룹=1.7, p=0.033), 평균 수술 후 ASES 점수는 RL 그룹이 유의하게 낮았다(L 그룹=91.4, RL 그룹=83.8, p=0.028). 그러나, RL 그룹의 수술 후 VAS 점수와 ASES 점수는 수술 후 환자 만족도 점수보다 낮지 않았다. 파열의 ML 크기는 L 그룹이 유의하게 컸다(L 그룹=24.6mm, RL 그룹=20.0mm, p=0.003). 전체 재파열율은 11.0%(9개의 어깨)였으며, L 그룹과 RL 그룹의 재파열율은 각각 11.1%(4개) 와 10.9%(5개)로 유의한 차이가 없었다(p=1.000). 회전근 개 근육의 지방 변성 또는 위축에 대한 두 그룹 간 유의한 차이는 보이지 않았다. L 그룹의 극상건 근육과 견갑하건 근육의 수술 후 지방 변성 정도는 유의하게 악화되었다(p=0.034, p=0.008). 평균 수술 후 VAS 점수 및 ASES 점수는 남성과 여성 사이가 차이는 없었다

(p=0.700, p=0.475). 회귀 분석 결과, 연령은 수술 후 VAS 점수 또는 ASES 점수의 예후 인자가 아니었다(p=0.188, p=0.150).

결론: 고령 및 여성 성별은 역L자형 회전근 개 파열과 연관이 있었다. 역L자형 회전근 개 파열 환자의 수술 후 임상적 결과에 대해 환자들은 만족했지만, L자형 회전근 개 파열 환자에 비해 좋지 않았다. 따라서 외과의는 L자형 회전근 개 파열과 역L자형 회전근 개 파열 사이의 임상적 결과의 차이를 알아야 한다.

주요어: L자형, 역L자형, 회전근 개 파열, 임상적 결과

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Table Legends

Table 1. Characteristics of patients with an L-shaped tear or a reverse L-shaped tear

Characteristic	Group L	Group RL	p-value
Shoulders, n	36	46	
Mean age, yrs (SD)	60 (8)	63 (5)	0.008*
Sex, M:F	19:17	14:32	0.041†
Mean BMI, kg/m^2 (SD)	25.7 (3.4)	25.7 (3.0)	0.989*
Mean symptom duration, mths (SD)	17.6 (25.7)	22.6 (27.0)	0.402*
Trauma history, Y:N	11:25	10:36	0.364†
Diabetes mellitus, Y:N	5:31	7:39	0.866†
Concomitant SSC tear, n			0.742‡
Total	0	0	
Partial	5	5	
No	31	41	
Biceps procedure, n			0.944‡
B1	15	19	
B2	7	8	
B3	8	9	
B4	6	10	
Mean follow-up, mths (SD)	30 (20)	32 (20)	0.886*

*Independent-samples *t*-test.
†Chi-squared test.
‡Fisher's exact test.
B1, without biceps procedure; B2, with biceps tenotomy; B3, with subpectoral tenodesis; B4, with modified biceps rerouting procedure; L, L-shaped tear; RL, reverse L-shaped tear; SD, standard deviation; SSC, subscapularis.

Table 2. Preoperative and Postoperative Clinical Variables

Variable	Group L (n = 36)	Group RL (n = 46)	p-value*
Preoperative			
Mean pain VAS (SD)	4.3 (2.4)	4.8 (2.4)	0.353
Mean SST score (SD)	4.5 (2.8)	4.5 (2.7)	0.964
Mean ASES score (SD)	59.6 (20.9)	55.3 (21.5)	0.371
Mean active ROM, ° (SD)			
Forward flexion	146 (26)	157 (20)	0.053
External rotation at side	39 (21)	40 (20)	0.761
Internal rotation at back	10 (4)	10 (3)	0.838
Postoperative			
Mean pain VAS (SD)	0.8 (1.5)	1.7 (2.2)	0.033
Mean SST score (SD)	10.0 (2.4)	8.8 (3.2)	0.076
Mean ASES score (SD)	91.4 (13.1)	83.8 (17.9)	0.028
Mean active ROM, ° (SD)			
Forward flexion	154 (15)	158 (12)	0.244
External rotation at side	31 (20)	26 (12)	0.189
Internal rotation at back	10 (3)	10 (3)	0.735

*Independent-samples *t*-test.
ASES, American Shoulder and Elbow Surgeons; L, L-shaped tear; RL, reverse L-shaped tear; ROM, range of motion; SD, standard deviation; SST, Simple Shoulder Test; VAS, visual analogue scale.

Table 3. Preoperative MRI variables of rotator cuff muscle status

Variable	Group L (n = 36)	Group RL (n = 46)	p-value
Mean tear size, mm (SD)			
AP width	16.9 (6.0)	15.2 (5.1)	0.155*
ML length	24.6 (6.5)	20.0 (6.8)	0.003*
Fatty degeneration, 0:1:2:3:4‡			
SST	5:13:18:0:0	4:24:17:1:0	0.819†
IST	4:21:10:1:0	2:33:10:0:1	0.907†
SSC	7:22:7:0:0	7:34:4:1:0	0.870†
Tm	11:20:4:1:0	8:31:6:0:1	0.315†
Muscle atrophy, 1:2:3§			
SST	18:18:0	22:23:1	0.771†
IST	35:1:0	44:1:1	0.530†
SSC	36:0:0	45:0:1	0.376†
Tm	34:2:0	42:2:2	0.366†

*Independent-samples *t*-test.
†Linear by linear association.
‡Based on Goutallier-Fuch classification.
§Based on visual MRI grading system.
AP, anteroposterior; IST, infraspinatus; L, L-shaped tear; ML, mediolateral; RL, reverse L-shaped tear; SD, standard deviation; SSC, subscapularis; SST, supraspinatus; Tm, teres minor.

Table 4. Postoperative MRI variables of rotator cuff muscle status

Variable	L (n = 22)	RL (n = 27)	p-value
Fatty degeneration, 0:1:2:3:4‡			
SST	2:6:13:1:0	0:14:13:0:0	0.536*
IST	2:10:9:1:0	0:19:7:0:1	0.848*
SSC	1:14:7:0:0	2:22:3:0:0	0.101*
Tm	4:13:4:1:0	4:20:2:1:0	0.639*
Muscle atrophy, 1:2:3§			
SST	12:10:0	17:10:0	0.555†
IST	21:1:0	25:2:0	0.681†
SSC	22:0:0	26:1:0	0.362†
Tm	20:1:1	25:1:1	0.841*

*Linear by linear association

†Fisher's exact test.

‡Based on Goutallier-Fuch classification.

§Based on visual MRI grading system.

IST, infraspinatus; L, L-shaped-tear; RL, reverse L-shaped tear; SSC, subscapularis; SST, supraspinatus; Tm, teres minor.

Table 5. Comparison of preoperative and postoperative radiologic variables of rotator cuff muscle status

Variable	L (n = 22)		p-value*	RL (n = 27)		p-value*
	Preoperative	Postoperative		Preoperative	Postoperative	
Fatty degeneration, 0:1:2:3†						
SST	4:7:11:0:0	2:6:13:1:0	0.034	1:15:10:1:0	0:14:13:0:0	0.317
IST	3:12:6:1:0	2:10:9:1:0	0.194	0:22:4:0:1	0:19:7:0:1	0.083
SSC	6:11:5:0:0	1:14:7:0:0	0.008	3:22:1:1:0	2:22:3:0:0	0.564
Tm	5:14:3:0:0	4:13:4:1:0	0.180	5:19:3:0:0	4:20:2:1:0	0.157
Muscle atrophy, 1:2:3‡						
SST	9:13:0	12:10:0	0.180	14:13:0	17:10:0	0.180
IST	21:1:0	21:1:0	1.000	26:1:0	25:2:0	0.317
SSC	22:0:0	22:0:0	1.000	26:0:1	26:1:0	0.317
Tm	21:1:0	20:1:1	0.317	25:1:1	25:1:1	1.000

*Wilcoxon's signed-rank test.
†Based on Goutallier-Fuch classification.
‡Based on visual MRI grading system.
IST, infraspinatus; L, L-shaped tear; RL, reverse L-shaped tear; SSC, subscapularis; SST, supraspinatus; Tm, teres minor.

Table 6. Characteristics and Clinical Variables of patients that underwent different biceps procedures

Variable	Group B1	Group B2	Group B3	Group B4	p-value
Shoulders, n	34	15	17	16	
Mean age, yrs (SD)	61 (1)	63 (1)	60 (2)	65 (1)	0.443*
Sex, n					0.029†
Male	15	1	9	8	
Female	19	14	8	8	
Tear shape, n					0.944†
L	15	7	8	6	
RL	19	8	9	10	
Re-tear, n					0.575†
Yes	2	2	2	3	
No	32	13	15	13	
Preoperative					
Mean pain VAS (SD)	4.1 (2.0)	5.1 (2.6)	4.2 (2.5)	5.3 (2.8)	0.251*
Mean SST score (SD)	5.0 (2.7)	2.7 (1.8)	5.4 (2.8)	4.0 (2.6)	0.015*
Mean ASES score (SD)	61.7 (17.7)	46.8 (21.4)	64.4 (21.3)	49.42 (23.2)	0.023*
Postoperative					
Mean pain VAS (SD)	1.0 (1.6)	1.4 (2.3)	1.2 (1.2)	1.8 (2.6)	0.786*
Mean SST score (SD)	9.5 (2.5)	8.2 (3.3)	10.8 (1.5)	8.3 (3.7)	0.013*
Mean ASES score (SD)	89.3 (15.2)	82.0 (19.9)	90.2 (9.7)	83.9 (19.9)	0.354*

*Analysis of variance.
†Chi-squared test.
ASES, American Shoulder and Elbow Surgeons; B1, without biceps procedure; B2, with biceps tenotomy; B3, with subpectoral tenodesis; B4, with modified biceps rerouting procedure; L, L-shaped tear; RL, reverse L-shaped tear; SD, standard deviation; SST, Simple Shoulder Test; VAS, visual analogue scale.

Figure Legends

Figure 1. Patient selection flow diagram.