Osteoarthritis Progression of the Shoulder: A Long-Term Follow-Up After Mini-Open Rotator Cuff Repair

Abstract

Objective

This study aimed to investigate: 1) whether the primary repair of rotator cuff tears can prevent the progression of osteoarthritis (OA), and 2) whether the quality of postoperative cuff integrity affects the incidence of osteoarthritic changes.

Methods

A total of 86 patients treated with mini-open repair for rotator cuff tears over a minimum of 10 years of follow-up (mean±standard deviation (SD) 11.1±1.0 years) were retrospectively analyzed. Preoperative and postoperative radiographs of the affected and unaffected sides were compared, and the degree of OA was evaluated under the Samilson and Prieto classification. Magnetic resonance imaging was used to evaluate cuff integrity, classify patients into good and poor cuff integrity groups, and compare the degree of OA between the two groups.

Results

OA deteriorated either significantly or to a similar degree on both sides postoperatively. However, OA progressed in significantly more cases on the affected side. A comparison between the aforementioned cuff integrity groups showed that the postoperative OA of the poor cuff integrity group was significantly worse than that of the good cuff integrity group on the affected side.

Conclusion

Our study showed that even if rotator cuff tears are repaired, the progression of osteoarthritic changes cannot be halted. The progression of OA was affected by cuff integrity. Rotator cuff dysfunction due to poor cuff integrity were risk factors for shoulder arthritis.

Key words: osteoarthritis, primary repair of rotator cuff, cuff tears, cuff integrity

Abstract word count: 223 words

Introduction

There is no clear consensus on the characteristics of osteoarthritis (OA) of the shoulder joint after rotator cuff repair. Contributing factors for OA include systemic factors, such as age, gender, ethnicity, and genes, as well as local factors, such as the load on weight-bearing joints, history of trauma, obesity, and changes in the joint structure due to fractures.[1] Rotator cuff tears that are accompanied by OA progression and pain are diagnosed as rotator cuff tear arthropathy (RCTA).[2] OA of the shoulder joint is categorized into either primary or secondary OA. Secondary OA cases are commonly found in Asian populations,[3] and RCTA is one of the representative diseases of secondary OA.

Chalmers et al. followed up 67 shoulders for a median duration of eight years with small to medium-size asymptomatic rotator cuff tears and found that 22% of patients exhibited OA progression .[4] Gerber et al. followed up 46 shoulders for a minimum of 10 years after latissimus dorsi transfer for massive rotator cuff tears and found that 48% of patients showed OA progression.[5] From these reports, we inferred that rotator cuff tears could be a local factor (especially in patients with trauma history) for OA, and that the progression of OA and RCTA may be prevented for cases with tear sizes that allow for primary rotator cuff repair. However, to the best of our knowledge, there were no reports that directly addressed this subject matter.

Moreover, as to whether or not the quality of the primary rotator cuff repair (quality of postoperative cuff integrity) affects the incidence of osteoarthritic changes, some researchers have reported varying results regarding the association between the degree of OA progression and rotator cuff integrity.[6-9] One report demonstrated minimal progression of OA despite poor cuff integrity.[6] In contrast, others have reported that the maintenance of cuff integrity is correlated with the degree of OA progression after rotator cuff repair.[7-9] Thus, the association between the degree of postoperative OA progression and cuff integrity remains unclear.

The purposes of this study are to clarify 1) whether the progression of osteoarthritic changes can be halted with rotator cuff repair, and 2) whether the quality of postoperative cuff integrity affects the incidence of osteoarthritic changes.

Materials and Methods

Study population

A total of 86 shoulders of 86 patients underwent primary repair for rotator cuff tears at our hospital between March 1998 and June 2004. For all cases, the follow-up periods were over a minimum of 10 years (mean±standard deviation (SD) 11.1±1.0 years). The following patients were excluded from this study: bilaterally operated patients, deceased patients, patients who underwent re-operation within the previous 10 years, patients who developed a shoulder disorder due to cerebral infarction, and patients who developed a shoulder disorder due to trauma. Ultrasound examination was performed at final examination, and cases with cuff tears on the unaffected side were excluded.

The mean age at the time of operation was 60.4 years (SD: ±7.3years). The study included 46 male shoulders and 40 female shoulders (right, 63; left, 23).

Preoperative tear size was assessed during open surgery and was classified according to the classification of DeOrio and Cofield.[10] In all, 16 tears were small (< 1 cm in length), 52 were medium (1–3 cm), 11 were large (3–5 cm), and 7 were massive (> 5 cm).

This is a retrospective study. The study protocol was approved by the [blinded for submission] Ethics Committee (Reference Number: [blinded for submission]), and written informed consent was obtained from all patients prior to surgery. The methods were carried out in accordance with the approved guidelines.

Surgical procedure and postoperative rehabilitation

In all patients, surgery was performed by the same shoulder surgeon using the mini-open deltoid split approach.[11,12] A 3-cm skin incision was made starting from the mid-point of the anterior edge of the acromion toward the axilla. The anterior deltoid muscle was divided longitudinally along the myofibers. The degenerative coracoacromial ligament was resected, and acromioplasty was carried out visually according to the Neer method.[13] The rotator cuff tear was repaired with a transosseous suture while keeping the position at 0° shoulder abduction after the degenerated edge of the cuff tear was resected.

All patients received postoperative therapy based on the same rehabilitation program. The postoperative arm was fixed with a shoulder abduction pillow for two to four weeks at 70° abduction and 30° horizontal flexion. Elbow joint active flexion/extension exercises, shoulder girdle (trapezius, rhomboids major and minor, levator scapulae, and serratus anterior) relaxation, and passive shoulder joint range of motion (ROM) training were started on the day after surgery. Two to four weeks after surgery, the pillow was replaced with a smaller shoulder abduction pillow. Three to five weeks after surgery, active ROM training was initiated in the neutral (zero) position. Three months after surgery, muscular strength reinforcement training was started on the extrinsic muscles, and light work was permitted. Heavy labor and sports were permitted without restriction six months after surgery.

Evaluation using radiographs

Radiographs of the affected and unaffected sides were obtained preoperatively and 10 years postoperatively using the same settings. The radiograph consisted of an anteroposterior exposure with the shoulder in internal rotation, external rotation, and elevation positions.

The radiographs were analyzed by an experienced and blinded shoulder joint surgeon with no knowledge about the disease history and clinical findings of each patient. The degree of OA on the radiograph was compared between affected and unaffected sides and between the preoperative and 10-years postoperative time points.

We evaluated the degree of OA by using the Samilson and Prieto classification.[14] OA was divided into four grades: 0 = normal, 1 = mild (osteophytes less than 3 mm on the humeral head), 2 = moderate (osteophytes between 3 and 7 mm on the humeral head or the glenoid rim), and 3 = severe (osteophytes of more than 7 mm with or without articular incongruity).

We classified patients into either OA progression or no change group on the affected side. The medical histories, preoperative degree of OA, and shoulder function were compared between the two groups. Shoulder function was preoperatively evaluated according to the University of California Los Angeles (UCLA) shoulder score by the same physician and followed up for more than 10 years postoperatively.[15]

Evaluation using magnetic resonance imaging

More than 10 years postoperatively, patients underwent magnetic resonance imaging (MRI), a GPFLEX coil with a 1.0 Tesla unit (Signa Horizon Lx1.0T, GE Healthcare, Chicago, IL, US).

MR images were analyzed by an experienced and blinded shoulder joint surgeon with no knowledge about the disease history and clinical findings of each patient. Using spin echo proton weighted sequences (repetition time: 3000 ms, echo time: 7.4 ms, matrix: 256×192), spin-echo T2 weighted sequences (repetition time: 3000 ms, echo time: 90 ms, matrix: 256×192), and gradient echo $T2^*$ weighted sequences (repetition time: 440 ms, echo time: 20 ms, flip angle 30°) were obtained. Sections were 4 mm thick with a 1-mm gap between sections.

Cuff integrity was evaluated with the classification reported by Sugaya et al.[16] The classification types were as follows: type Ⅰ, repaired cuff appeared to have sufficient thickness compared with normal cuff with homogenously low intensity on each image; type Ⅱ, sufficient thickness compared with normal cuff associated with partial high intensity area; type Ⅲ, insufficient thickness with less than half the thickness when compared with normal cuff, but without discontinuity; type Ⅳ, presence of a minor discontinuity in only 1 or 2 slices on both oblique coronal and sagittal images; type Ⅴ, presence of a major discontinuity observed in more than 2 slices on both oblique coronal and sagittal images.

We classified patients into either a good cuff integrity group (Type Ⅰ, Ⅱ, and Ⅲ) or bad cuff integrity group (Type Ⅳ and Ⅴ). The medical histories and the degree of OA were compared between the two groups.

Statistical analysis

Mann-Whitney's U test was used to compare the degree of OA on radiographs between the affected and unaffected sides and between preoperative and 10-year postoperative observation. Mann-Whitney's U test was also used to compare the age, degree of OA, UCLA score between the good cuff integrity group and the poor cuff integrity group in addition to the OA progression and no change group. The chi-square of independence test was used to compare the gender, affected side, history of trauma, and tear size between the good cuff integrity group and the poor cuff integrity group in addition to the OA progression and no change group. Statistical analysis was performed by using the Statcel software (version 3; OMS Institute, Tokyo, Japan) with the significance level set at 5%.

Results

Evaluation using radiographs

None of the patients had severe OA (Samilson and Prieto stage 3) in any categories. In the preoperative classification of OA, there was no significant difference between the unaffected and affected sides ($P = 0.46$). In the classification of OA 10 years postoperatively, OA of affected sides was significantly worse than that of unaffected sides ($P < 0.001$). On the affected side, OA was significantly worse 10 years postoperatively than preoperatively ($P < 0.001$). On the unaffected side, OA was also significantly worse 10 years postoperative than preoperatively ($P = 0.039$) (Table 1).

In regards to the degree of OA progression, 55% of patients had OA progression on the affected side (no change: 39 cases, 1 stage worse: 41 cases, 2 stages worse: 6 cases), while 19% had OA progression on the unaffected side (no change: 70 cases, 1 stage worse: 16 cases, 2 stages worse: 0 cases).

The OA progression group comprised of 47 cases and the no change group comprised of 39 cases on the affected side. The preoperative UCLA score of the OA progression group was significantly worse than that of the no change group ($P = 0.0090$). The postoperative UCLA scores showed no significant differences between the OA progression and no change groups (P = 0.70). Patients with fair or poor UCLA scores (<27) were considered symptomatic, which resulted in six cases with OA progression (12.8%) and one case with no progression (2.6%). Other items showed no significant differences between the two groups (Table 2).

Evaluation using magnetic resonance imaging (MRI)

The good cuff integrity group comprised of 65 cases and the poor cuff integrity group comprised of 21 cases. Tear size of the poor cuff integrity group was significantly larger than that of the good cuff integrity group (P = 0.0044). Other items showed no significant differences between the two groups (Table 3).

On the unaffected side, there were no significant differences between the good and poor cuff integrity groups 10 years postoperatively (P = 0.23). On the affected side, OA in the poor cuff integrity group was significantly worse than that of the good cuff integrity group 10 years postoperatively (P = 0.0024) (Table 4).

Complications

There were no intraoperative or perioperative complications. No patients had neural injuries or wound infection problems.

Discussion

Contributing factors for OA include systemic factors, such as age, gender, ethnicity, and genes, as well as local factors, such as the load on weight-bearing joints, history of trauma, obesity, and the joint structure.[1] Moor et al. reported that a short acromion with an inferiorly inclined glenoid would be associated with glenohumeral OA.[17] We initially focused our study on the progression of OA after rotator cuff repairs over time. In general, the development of OA is believed to be associated with age. Kobayashi et al. reported that the prevalence of shoulder OA in the respondents younger than 65 years was 11.1%, whereas those 65 years of age or older was 20.3%.[18] This study showed that OA of the shoulder progressed on both the affected and unaffected sides but occurred in significantly more cases on the affected side over a mean follow-up duration of 11.1 years postoperatively. Because the unaffected shoulder also showed OA, we confirmed that osteoarthritic changes occurred with age. Because the OA in the affected side had progressed to a more advanced stage compared to the unaffected side, we found that the progression of osteoarthritic changes cannot be halted even if the cuff tear had been once repaired.

Some investigators reported the rate of OA progression after primary rotator cuff repairs to be 18-20% at 9-10.5 years postoperatively.[19,20] In our study, 55% of patients had OA progression on the affected side. The rate of OA progression in our cases was greater than past reports. We believe the increased rate is likely due to the older age of our patients (mean age, 60.4 years) compared to past reports (mean age, 51-58.1 years), the fact that retear cases and many manual laborers were included in our study, and how we evaluated our radiographic data. Although classification systems tend to rely on radiography taken from a single direction, we evaluated our data from three directions, which consisted of an anteroposterior exposure with the shoulder in internal rotation, external rotation, and elevation positions. We believe this multi-directional evaluation enabled us to detect more subtle changes in the progression of OA compared to previous studies.

In comparing the OA progression and no change group, the preoperative UCLA score of the OA progression group was significantly worse than that of the no change group. The medical histories and preoperative degree of OA showed no significant differences between the two groups. Flurin et al. showed no associations linking the risk of glenohumeral osteoarthritis to the patient activity profile, history of trauma, or preoperative symptom duration. In contrast, statistically significant associations were identified between glenohumeral osteoarthritis and age, male gender, initial tear severity, and the pain/mobility components of the preoperative Constant score.[21] In this study, low preoperative shoulder function scores were similar, but our results were different in regards to age, gender, initial tear size compared to past reports. We suspected the low preoperative shoulder function score with poor range of motion and muscle strength developed abnormal shoulder movement, which may have been a risk factor for the progression of OA.

The postoperative UCLA scores showed no significant differences between the OA progression and no change groups. Elia et al. reported good clinical results after open rotator cuff repair at 11.4-years average follow-up, despite 69% of patients exhibiting OA progression.[22] Small changes in OA may not induce changes in shoulder function if the degree of OA is not severe.

Retear rates after rotator cuff repairs have been previously demonstrated to be proportional to initial tear size.[23] This study also shows tear size of the poor cuff integrity group was significantly larger than that of the good cuff integrity group.

Various theories have been reported concerning an association between the degree of OA progression and cuff integrity. One report shows a favorably low OA progression rate (32%), despite poor cuff integrity.[6] On the other hand, there are also reports that OA is more common after poor cuff integrity cases than good cuff integrity cases (good: 21%, bad: 100% [8]; good: 8.3%, bad: 36%[9]; good: 25%, bad: 46%[21]). We compared the degree OA between the good cuff integrity group and the poor cuff integrity group. On the affected side, the OA of the poor cuff integrity group was significantly worse than that of the good cuff integrity group 11.1 years postoperatively. Neer et al. reported that the causes of shoulder arthritis were shoulder instability due to rotator cuff dysfunction, decrease of the joint pressure, and decrease of the synovial fluid.[24] Konno et al. reported that the loss of rotator cuff function might lead to superior translation of the humeral head during arm elevation.[25] This abnormal superior migration may cause undue traction on the capsule and labrum, which may be a cause of shoulder arthritis. In our study, rotator cuff dysfunction due to poor cuff integrity were risk factors for shoulder arthritis.

This study has several limitations. First, the sample size of patients was small due to the study being performed at a single center; future research would benefit from multicenter studies with a larger sample size. However, since the clinical and imaging evaluations were conducted by different physicians who did not perform the surgery in a blinded manner, we believe that objective data was obtained. Secondly, our cases were evaluated using radiographic images which may lead to poor reproducibility. However, since patients underwent radiographic evaluation using identical settings and positions at the same institution, we believe that objective data was obtained. Thirdly, we used the Samilson and Prieto classification that was originally described for use in patients with dislocation arthropathy and did not use the Hamada classification and acromiohumeral interval that is specific to RCTA. Because none of the patients had severe OA in any categories, Samilson and Prieto classification enabled us to detect more subtle changes in the progression of OA compared to others. Fourthly, the study did not include MR images of the unaffected side. Although the unaffected side can include cases of asymptomatic rotator cuff tear, the unaffected side also did not undergo surgery for the 11.1-year duration of the study. Ultrasonic examination was performed at final examination, and there were no rotator cuff tears; thus, we believe unaffected side were normal shoulders.

Conclusion

Because the OA in the affected side had progressed to a more advanced stage compared to the unaffected side over a mean follow-up duration of 11.1 years postoperatively, we found that the progression of osteoarthritic changes cannot be halted even if the cuff tear had been once repaired. The progression of OA was affected by cuff integrity. Rotator cuff dysfunction due to poor cuff integrity were risk factors for shoulder arthritis.

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Table 1 : Comparison of the degree of osteoarthritis on radiograph between the affected and unaffected sides and between preoperative and 10-year postoperative time points.

	Samilson and Prieto Classification	Pre-Op (n)	10 Y Post-Op (n)	P-value
Affected Side	Stage 0	52	20	< 0.001
	Stage 1	31	42	
	Stage 2	3	24	
Unaffected Side	Stage 0	47	34	0.039
	Stage 1	36	46	
	Stage 2	3	6	
P-value		0.46	< 0.001	

Table 2: A comparison of the medical history, the preoperative degree of osteoarthritis, and the UCLA score between the OA progression and no change groups.

	OA progression (N=47)	No change (N=39)	P-value
Age (years) (mean±SD)	61.4 ± 6.8	59.3 ± 7.7	0.26
Gender (M/F)	26 / 21	20 / 19	0.88
Affected Side (right / left)	31 / 16	32 / 7	0.15
History of Trauma （yes/no）	18 / 29	7 / 32	0.067
Tear Size (small/moderate/ large/massive）	5 / 29 / 8 / 5	11 / 23 / 3 / 2	0.12
Pre-Op OA (stage: 0/1/2)	32 / 15 / 0	20 / 16 / 3	0.078
Pre-Op UCLA score	20.0 ± 3.6	22.0 ± 3.5	0.0090
10Y Post-Op UCLA score	32.3 ± 3.3	32.9 ± 2.9	0.70

SD: standard deviation

Pre-Op OA: preoperative osteoarthritis of the Samilson and Prieto Classification

Table 3: A comparison of the medical history between the good and bad cuff integrity groups 10 years postoperatively.

Cuff Integrity (Sugaya Classification)	Good (Type Ⅰ, Ⅱ and Ⅲ) (N=65)	Poor (Type IV and V) (N=21)	P-value
Age (years) (mean±SD)	60.7 ± 7.4	59.4 ± 6.9	0.55
Gender (M/F)	35 / 30	11 / 10	0.89
Affected Side (right / left)	48 / 17	15 / 6	0.95
History of Trauma（yes/no）	18 / 47	10 / 11	0.15
Tear Size (small/moderate/ large/massive）	15 / 42 / 5 / 3	1 / 10 / 6 / 4	0.0044

SD: standard deviation

Table 4：The degree of osteoarthritis were compared between the good cuff integrity group and poor cuff integrity group 10 years postoperatively.

		Samilson and Prieto Classification	Good Cuff (N=65)	Poor Cuff (N=21)	P-value
10 Y Post-Op	Affected Side	Stage 0	18	2	0.0024
		Stage 1	34	8	
		Stage 2	13	11	
	Unaffected Side	Stage 0	27	7	0.23
		Stage 1	34	12	
		Stage 2	4	2	