



# Clinical Outcomes and Complications during the Learning Curve for Reverse Total Shoulder Arthroplasty: An Analysis of the First 40 Cases

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**Background:** The purpose of this study was to investigate the results and complications during the learning curve of reverse total shoulder arthroplasty (RTSA) for rotator cuff deficiency.

**Methods:** We retrospectively reviewed the first 40 cases of RTSA performed by a single surgeon. The mean age of patients was 72.7 years (range, 63 to 81 years) and mean follow-up period was 26.7 months (range, 9 to 57 months). Clinical outcomes were evaluated using a visual analog scale (VAS) for pain, the University of California at Los Angeles (UCLA) shoulder score, American Shoulder and Elbow Surgeon (ASES) score, subjective shoulder value (SSV), and active range of motion (ROM). Intraoperative and postoperative complications were also evaluated.

**Results:** The average VAS pain score, UCLA score, ASES score, and SSV improved from 6.9%, 12.8%, 29.0%, and 29.0% before surgery to 1.6%, 27.0%, 73.3%, and 71.5% after surgery, respectively ( $p < 0.001$ ). The mean forward flexion, abduction, and external rotation improved from 68.0°, 56.9°, and 28.0° before surgery to 131.0°, 112.3°, and 38.8° after surgery, respectively ( $p < 0.001$ ,  $p < 0.001$ , and  $p = 0.021$ ). However, the mean internal rotation did not improve after surgery ( $p = 0.889$ ). Scapular notching was observed in 33 patients (51.5%). Eight shoulders (20%) had complications, including 2 major (1 deep infection and 1 glenoid fixation failure) and 6 minor complications (3 brachial plexus injuries, 2 acromial fractures, and 1 intraoperative periprosthetic fracture).

**Conclusions:** The first 40 cases of RTSA performed by a single surgeon during the learning curve period showed satisfactory short-term follow-up results with an acceptable complication rate.

**Keywords:** *Shoulder, Arthroplasty, Reverse, Outcome, Complication*

An irreparable massive rotator cuff tear or cuff tear arthropathy is one of the challenging clinical conditions facing orthopedic surgeons.<sup>1)</sup> Managements of irreparable massive rotator cuff tears include conservative treatment, arthroscopic surgery, tendon transfer, and arthroplasty. Reverse total shoulder arthroplasty (RTSA) can significantly improve substantial shoulder pain and dysfunction

that cannot be reliably treated with other options.<sup>2)</sup>

The most common indication for RTSA is rotator cuff deficiency including cuff tear arthropathy or irreparable massive rotator cuff tear, and numerous studies described RTSA produced satisfactory clinical outcomes.<sup>3-10)</sup> However, the overall complication rates of RTSA have widely varied from 0% to 75%.<sup>10-14)</sup> In some series, complications were noted in up to 50% of cases.<sup>10)</sup>

Over the last decade, the incidence of RTSA has risen exponentially, and this has entailed an increasing number of complications and reoperations.<sup>11)</sup> Zumstein et al.<sup>14)</sup> described that RTSA is a complex procedure with a considerable learning curve. Although many studies have described substantial intraoperative and postoperative

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complications after RTSA, few studies have reported on the operating surgeon's experience with the procedure.<sup>12,13</sup> In addition, it is still not clear whether the RTSA learning curve has been accurately described. Kempton et al.<sup>12</sup> described that the early complication-based learning curve for RTSA was approximately 40 cases, reporting a high complication rate in the first 40 cases. The local complication rate was higher in the first 40 shoulders (23.1%) versus the last 160 shoulders (6.5%).

The uncertainty in the complication risk may make some less experienced surgeons wary of performing this procedure.<sup>12</sup> A clinical study of RTSA during the learning curve will provide information necessary to establish surgical decisions and planning for beginners. The purpose of this study was to investigate the results and complications during the learning curve of RTSA for rotator cuff deficiency.

## METHODS

We retrospectively reviewed the first 40 cases of RTSA performed by a single surgeon between 2010 and 2015. The indications for surgery were cuff tear arthropathy and pseudoparalysis with an irreparable massive rotator cuff tear. Painful pseudoparalysis was defined as active shoulder elevation < 90° in the presence of full passive forward elevation. Of the 40 patients, 24 patients had cuff tear arthropathy and 16 patients had massive irreparable rotator cuff tears.

There were 33 women and 7 men. The average age at the time of surgery was 72.7 years (range, 63 to 81 years). The dominant shoulder was involved in 29 cases (72.5%) and the average duration of the symptoms was 46.0 months (range, 2 to 180 months). Six patients (15.0%) had a previous history of operation including rotator cuff repair (4 cases) or arthroscopic debridement (2 cases). The average duration of follow-up was 26.7 months (range, 9 to 57 months).

The surgery was performed with the patient in the beach chair position under general anesthesia using a deltopectoral approach. The Aequalis reverse shoulder system (Tornier, Montbonnot Saint Martin, France) was used in 29 cases, Comprehensive reverse shoulder system (Biomet Inc., Warsaw, IN, USA) in 6 cases, and Anatomical reverse shoulder system (Zimmer Inc., Warsaw, IN, USA) in 5 cases. The shoulder was immobilized in a sling for 6 postoperative weeks. Passive range of motion (ROM) exercises were initiated 2 weeks after surgery. Active ROM exercises were started 6 weeks after surgery.

Clinical outcomes were evaluated using a visual

analog scale (VAS) for pain, the University of California at Los Angeles (UCLA) shoulder score, American Shoulder and Elbow Surgeon (ASES) score, and subjective shoulder value (SSV). Radiological outcomes were assessed by serial plain radiographs. Active ROM was evaluated in terms of forward flexion, abduction, and external rotation with the arm at the side and internal rotation with the arm at the back. A complication was classified as minor when there was no compromise of outcome and little or no treatment was required; a major complication was considered to have occurred when the final outcome was compromised or reoperation was required.

The IBM SPSS ver. 22.0 (IBM Co., Armonk, NY, USA) was used for all data analyses. To compare the preoperative and final clinical scores and ROMs, we used the paired *t*-test. To determine the correlation between clinical outcomes and various parameters, such as age, sex, involved side, duration of symptoms, diagnosis, previous operation, and implant design, we used the Pearson correlation analysis and Mann-Whitney *U*-test. Statistical significance was set at  $p < 0.05$ .

## RESULTS

Table 1 shows improvement in clinical scores and ROMs. The average VAS pain score, UCLA score, ASES score, and SSV improved from 6.9%, 12.8%, 29.0%, and 29.0% before surgery to 1.6%, 27.0%, 73.3%, and 71.5% after surgery,

**Table 1.** Preoperative and Postoperative Data for Clinical Outcomes

Variable	Preoperative	Postoperative	p-value
Clinical score			
VAS score	6.9 ± 2.1	1.6 ± 2.2	< 0.001*
UCLA score	12.8 ± 5.0	27.0 ± 7.5	< 0.001*
ASES score	29.0 ± 14.3	73.3 ± 24.4	< 0.001*
SSV (%)	29.0 ± 18.5	71.5 ± 23.9	< 0.001*
Shoulder ROM			
Forward flexion (°)	68.0 ± 44.3	131.0 ± 35.6	< 0.001*
Abduction (°)	56.9 ± 38.1	112.3 ± 32.4	< 0.001*
External rotation (°)	28.0 ± 19.6	38.8 ± 18.5	0.021*
Internal rotation	L3	L3	0.889

Values are presented as mean ± standard deviation.

VAS: visual analog scale, UCLA: University of California at Los Angeles, ASES: American Shoulder and Elbow Surgeon, SSV: subjective shoulder value, ROM: range of motion.

\*Statistically significant.

respectively ( $p < 0.001$ ). The mean forward flexion, abduction, and external rotation improved from 68.0°, 56.9°, and 28.0° before surgery to 131.0°, 112.3°, and 38.8° after surgery, respectively ( $p < 0.001$ ,  $p < 0.001$ , and  $p = 0.021$ ). However, the mean internal rotation did not improve after surgery ( $p = 0.889$ ).

Scapular notching was observed in 33 cases (51.5%). According to classification system proposed by Sirveaux et al.,<sup>8)</sup> it was classified as grade 1 in 12 cases, grade 2 in 2 cases, and grade 3 in 3 cases. There was no grade 4 scapular notching.

Eight shoulders (20%) had complications: 2 major (1 deep infection and 1 glenoid fixation failure) and 6 minor complications (3 brachial plexus injuries, 2 acromial fractures, and 1 intraoperative fracture) (Table 2).

The glenoid fixation failure was identified on plain radiographs taken 3 days after RTSA in 1 patient treated using an iliac crest bone graft for a large glenoid bone defect. Subsequently, he underwent resection arthroplasty.

One patient with an acute deep infection underwent debridement surgery, but it failed to control infection, which led to insertion of a temporary antibiotic-impregnated spacer after implant removal. The 2 patients with major complications refused to undergo any further revision arthroplasty.

There was no statistically significant relationship between final clinical scores and sex, involved side, diagnosis, or implant design ( $p > 0.05$ ). However, the patients with an older age or a history of previous operation showed a significantly lower VAS pain score ( $p = 0.038$  and  $p = 0.021$ , respectively) (Table 3).

## DISCUSSION

The advent of successful RTSA marked a new era in shoulder surgery.<sup>2)</sup> RTSA allows restoration of function in patients not amenable to any other treatment for severe rotator cuff deficiency.<sup>2)</sup> However, shoulder surgeons have been concerned that RTSA is a double-edged sword and must be used with caution. Although numerous studies have described RTSA produced satisfactory clinical outcomes,<sup>3-10)</sup> high complication and reoperation rates have also been reported.<sup>10,13)</sup> Therefore, proper patient selection and attention to technical details are needed to reduce high complication rates.<sup>2)</sup>

Previous studies revealed increases in complication rates and length of hospital stay following shoulder arthroplasties performed by surgeons with less experience and in hospitals with lower volumes.<sup>15,16)</sup> However, there is a paucity in the literature on the learning curve of RTSA. Of all the studies reporting the results and complications of RTSA, only two studies dealt with a complication-based learning curve for RTSA.<sup>12,13)</sup> Wierks et al.<sup>13)</sup> described the

**Table 2.** Intraoperative and Postoperative Complications

Variable	No.
Intraoperative complication	
Humeral metaphyseal fracture	1
Postoperative complication	
Brachial plexus injury	3
Acromion fracture	2
Infection	1
Glenoid fixation failure	1

**Table 3.** Correlations between Clinical Outcomes and Various Parameters

Variable	VAS score	UCLA score	ASES score	SSV
Age	0.038*	0.158	0.165	0.118
Sex	0.442	0.577	0.807	0.676
Involved side	0.881	0.185	0.148	0.196
Duration of symptoms	0.770	0.666	0.609	0.393
Diagnosis	0.192	0.134	0.212	0.331
Previous operation	0.021*	0.159	0.127	0.118
Implant design	0.266	0.776	0.948	0.826

VAS: visual analog scale, UCLA: University of California at Los Angeles, ASES: American Shoulder and Elbow Surgeon, SSV: subjective shoulder value.

\*Statistically significant.

complication rate was higher for the first 10 patients than for the second 10 patients in 20 cases of RTSA at a minimum 3-month follow-up. They presented an intraoperative complication-based learning curve of 10 shoulders. In a study by Kempton et al.<sup>12)</sup> involving a series of 200 RTSAs performed in 191 patients by a single surgeon, the local complication rate was higher in the first 40 shoulders (23.1%) than in the last 160 shoulders (6.5%). They concluded that the complication-based learning curve for RTSA is approximately 40 cases and is thought to have a significant impact on the results of operation. The current study was conducted based on the complication-based learning curve reported by Kempton et al.<sup>12)</sup>

Werner et al.<sup>10)</sup> investigated 58 RTSAs indicated for irreparable massive rotator cuff tears with a mean follow-up period of 38 months: the relative Constant score improved from 29% to 64%, and forward flexion increased from 42° to 100°. Sirveaux et al.<sup>8)</sup> reported on 80 cases of RTSA performed for cuff tear arthropathy with a mean follow-up period of 44 months: the Constant score improved from 23 to 65 and forward flexion increased 73° to 138°. In our series, the average VAS pain score, UCLA score, ASES score, and SSV improved from 6.9, 12.8, 29.0, and 29.0% before surgery to 1.6, 27.0, 73.3, and 71.5% after surgery with a mean follow-up period of 26.7 months. The mean forward flexion, abduction, and external rotation improved from 68.0°, 56.9°, and 28.0° before surgery to 131.0°, 112.3°, and 38.8° after surgery, respectively. However, the mean internal rotation did not improve after surgery. Our findings are consistent with those of previous studies. Therefore, we believe that RTSA is a reasonable salvage option that produces good clinical outcomes in patients with an irreparable massive rotator cuff tear and cuff tear arthropathy.

Variable rates of problems, complications, reoperations of RTSA have been reported.<sup>14)</sup> Gerber et al.<sup>2)</sup> described that the complication rate of RTSA was approximately three times that of conventional shoulder arthroplasty. It is important to know the accurate complication rates of RTSA for patients who need to undergo the procedure. Therefore, proper patient selection and attention to technical details are needed to reduce high complication rates.<sup>2)</sup> Common complications of RTSA include instability, infection, implant loosening, nerve injury, acromial or scapular spine fracture, intraoperative fracture, and deltoid detachment. Zumstein et al.<sup>14)</sup> reviewed the complication rates of RTSA in 21 cohort studies with a follow-up greater than 24 months. There were 188 complications in 782 cases (24%). The most common complication was instability (4.7%), followed by infection (3.8%), aseptic glenoid loos-

ening (3.5%), and scapular stress fracture (1.5%). Werner et al.<sup>10)</sup> reported that the total complication rate was 50%, including all minor complications, and the overall reoperation rate was 33%. Wierks et al.<sup>13)</sup> reported an overall complication rate of 75% and a reoperation rate of 20%. Frankle et al.<sup>5)</sup> reported the overall complication rate and reoperation rate as 17% and 12%, respectively. In the current study, the overall complication rate was 20% and the reoperation rate was 5%. There were 2 major complications (1 deep infection and 1 glenoid fixation failure) and 6 minor complications (3 brachial plexus injuries, 2 acromial fractures, and 1 intraoperative fracture). Although our study included the first 40 cases of RTSA performed during the learning curve, these results were similar to or better than those previously reported in RTSA studies. What is important to note in this study is related to the analysis of complications. The complications we encountered include 3 brachial plexus injuries and 2 acromial stress fractures, but there was no case of dislocation or instability. We think that these complications occurred due to over-tensioning of the deltoid during surgery to prevent dislocation because less experienced surgeons are anxious about instability after RTSA. These results will help to inform the beginners of possible complications of RTSA.

Our study has several limitations. First, it had a retrospective design with a small number of patients. Second, implants used in the procedure were heterogeneous. Third, the follow-up period was too short. Without a long-term follow-up, it is not possible to determine the influence of surgical pitfalls or complications on the final clinical outcomes. Further long-term studies are needed to fully understand functional outcomes and complication rates of RTSA.

In conclusion, the first 40 cases of RTSA performed by a single surgeon showed satisfactory short-term follow-up results with an acceptable complication rate. Therefore, we believe that with stringent patient selection criteria and meticulous technique, RTSA can be a reasonable treatment modality for patients with cuff tear arthropathy and irreparable massive rotator cuff tears even among less experienced surgeons.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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