

# Recent Updates Regarding Outcomes and Complications of Reverse Total Shoulder Arthroplasty

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Indications of reverse total shoulder arthroplasty (RTSA) have been consistently extended by technical advancements in reverse arthroplasty prosthesis, continuous development of the implants, accumulated experiences and its successful treatment outcomes; accordingly, its use has rapidly increased. RTSA has been performed for a variety of indications, with variable outcomes depending on the initial diagnosis. However, controversial opinions still exist regarding the design of reverse arthroplasty prosthesis (medialized or lateralized design and the neck-shaft angle of the humeral prosthesis), suture of the subscapularis tendon, use of cement during placement of the humeral prosthesis, and surgical procedures; therefore, these should be investigated so that they can be better understood.

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## Introduction

The primary indications of reverse total shoulder arthroplasty (RTSA) include cuff tear arthropathy and irreparable massive rotator cuff tear. With recent improvements in reverse shoulder arthroplasty implant and technical advancements, there have been improvements in surgical outcomes of the RTSA.<sup>1,2)</sup> Accordingly, its recent indications have been extended to cases such as acute proximal humerus fracture, non-union or malunion after proximal humerus fracture (proximal humerus fracture sequelae), primary osteoarthritis with or without cuff tears, rheumatoid arthritis with or without cuff tears, failed open reduction and internal fixation of proximal humerus fracture, failed shoulder arthroplasty, severe shoulder joint instability, chronic anterior dislocation, tumors and severe osteoporosis. Overall, surgical outcomes of the RTSA are satisfactory. Indeed, the 10-year survival rate prior to revision surgery has been reported to be approximately

92%.<sup>3)</sup> In addition, surgical outcomes are reportedly comparable to those of anatomic total shoulder arthroplasty.<sup>4)</sup> Moreover, patients undergoing RTSA have been shown to have equivalent or better quality of life on the 36-Item Short Form Survey instrument when compared with their age- and sex-matched normal controls.<sup>5)</sup> However, indications of the RTSA are very diverse, resulting in variations in surgical outcomes depending. Thus, research regarding the recent update on the surgical outcomes of RTSA according to the indications of the RTSA is necessary to provide accurate prognoses of RTSA.

Therefore, this study reviewed recent updates on surgical outcomes of RTSA depending on its indications. In addition, key issues or controversial opinions about RTSA were addressed. Finally, relevant factors that may affect its surgical outcomes were analyzed.

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## Surgical Outcomes of the Reverse Total Shoulder Arthroplasty for Cuff Tear Arthropathy and Massive Rotator Cuff Tears

Both cuff tear arthropathy (CTA) and massive rotator cuff tears are the most traditional indications of RTSA. Of various indications of RTSA, the 10-year survival rate has been reported to be the most excellent in the CTA and massive rotator cuff tears.<sup>6)</sup> Various authors have reported excellent results after RTSA in patients with CTA or massive rotator cuff tears.<sup>7-10)</sup> Al-Hadithy et al.<sup>7)</sup> reported that the mean age-adjusted Constant and Oxford scores improved from 34.2 to 71.0 points and 15 to 33 points, respectively, and the mean abduction and forward flexion improved from 64° to 100° and 55° to 110°, respectively. Moreover, Samuelsen et al.<sup>8)</sup> reported that the active abduction was improved from 57.5° to 132.4° at a mean follow-up of 3 years, while the active external rotation improved from 20.1° to 39.4°. Additionally, revision-free survival was 99% and 91% upon 2- and 5-year follow-up, while reoperation-free survival was 97% and 90%, respectively. Recently, Petrillo et al.<sup>11)</sup> conducted a systematic review of recently published studies regarding surgical outcomes of the RTSA for its traditional indications. These authors analyzed a total of 408 shoulder joints of 396 patients (mean age: 71.9 years and the mean follow-up period: 35.3 months). The reverse shoulder arthroplasty implants included Delta III (DePuy Orthopaedics, Warsaw, IN, USA) (206 cases; 50.5%), Arrow (FhOrthopaedics, Mulhouse, France) (76 cases; 18.6%), RSP (DJO Surgical, Austin, TX, USA) (60 cases; 14.7%), the Zimmer Trabecular Metal Shoulder System (Zimmer, Warsaw, IN, USA) (27 cases; 6.6%) and Aequalis (Tornier SAS, Montbonnot, France) (3 cases; 0.7%). Surgical outcomes showed American Shoulder and Elbow Surgeons (ASES) scores of 72.2 points, Constant scores of 60.3 points, University of California Los Angeles scores of 26.9 points, Simple Shoulder Test (SST) scores of 7.5 points and pain visual analogue scale scores of 1.8 points. The upper extremity elevation had an angle of 124.4°, while external rotation with the arm at side produced an angle of 27.7° and that with the arm at 90° generated an angle of approximately 47°. Among postoperative complications, acromial fracture and heterotopic ossification occurred frequently, with an overall incidence of approximately 17.4% (71 cases). Moreover, the number of cases requiring revision surgery was 7.4% (30 cases). Factors causing poor surgical outcomes included younger age, preoperative high functional class, neurological deficits, poor deltoid muscle tension and poor teres minor, each of these deserves special attention.<sup>11)</sup>

## Outcomes of Reverse Total Shoulder Arthroplasty for Acute Proximal Humerus Fracture

In cases of acute proximal humerus fracture, indications of RTSA include severe osteoporosis in the elderly, 3- or 4-part fracture, head split fracture, pathological fracture, an inability to achieve a union of the fracture site using hemiarthroplasty and the concurrent presence of pre-existing irreparable rotator cuff tear. In these cases, there has been a rapid increase in the use of RTSA. There has also been a change in the trend in that the frequency at which RTSA is used has become similar to or greater than that of bipolar shoulder arthroplasty.<sup>12,13)</sup> Longo et al.<sup>14)</sup> conducted a meta-analysis of 13 recently published studies investigating application of RTSA in 256 cases of acute proximal humerus fracture. They found that the mean age of patients was 75.5 years and the mean follow-up period was 27.8 months. Thus, these authors reported mean ASES scores of 70.3 points and Constant scores of 56.7 points. They also reported that the upper extremity elevation had an angle of 113.4°, while external rotation with the arm at side produced an angle of 11.8°, that with the arm at 90° of abduction generated an angle of approximately 35.5° and internal rotation produced an angle of approximately 38°. There were also a total of 36 cases (13.9%) of post-operative complications including seven cases of infection and five cases of dislocation. Moreover, 82 cases (31.7%) of scapular notching and 28 cases (10.8%) of heterotopic ossification were observed, as well as 55 cases (21.2%) of malunion or non-union of the fracture site. Finally, there were nine cases (2.9%) of revision surgery.

In most cases of the acute proximal humerus fracture, hemiarthroplasty and reverse total arthroplasty were performed. Accordingly, many studies have been conducted to compare surgical outcomes between the two modalities. Several systematic reviews of these comparative studies were performed. According to studies conducted before 2015,<sup>15-17)</sup> there was an overall good recovery of forward flexion patients undergoing RTSA. In addition, patients undergoing hemiarthroplasty achieved a good recovery of external rotation that was an advantageous modality in that it caused less complications. There were also no significant differences in functional outcomes between the two modalities. Accordingly, both modalities have their own advantages and disadvantages, with outcomes that have been reported to be similar.<sup>15-17)</sup> However, a recent systematic review conducted in 2016 and 2017 indicated that surgical outcomes of RTSA have been shown to be better than those of hemiarthroplasty in terms of functional outcomes, complications and revision surgery. In addition, the RTSA have shown that the angle of external rotation is comparable to hemiarthroplasty.<sup>13,18,19)</sup> We believe that this improvement of external rotation of RTSA mainly arises from the development and increased use of implants with

lateralized design. Even though the results of RTSA are reliable in that tuberosity healing is not essential for the action of RTSA, we should not neglect the tuberosity because tuberosity healing is still important to achieving active external rotation strength after RTSA.<sup>20,21)</sup>

## Outcomes of Reverse Total Shoulder Arthroplasty for Proximal Humerus Fracture Sequelae

There are four types of proximal humerus fracture sequelae. Type 1 refers to the collapse or necrosis of the humeral head. Type 2 refers to non-reducible dislocation or fracture-dislocation. Type 3 refers to non-union of the surgical neck. Type 4 refers to severe malunion of the fracture site.<sup>22)</sup> Of these, Types 3 and 4 are mainly managed by the RTSA. Holton et al.<sup>23)</sup> conducted a systematic review of recently published studies of RTSA in cases of proximal humerus fracture sequelae. Thus, these authors analyzed a total of 234 cases from nine studies, where the mean age was 69.7 years and the mean follow-up period was 39 months. The results indicated that the ASES scores were 50.1 to 63.0 points, the Constant scores were 46.6 to 65.5 points and the SST scores were 3.2 to 6.0 points. These authors also reported that the upper extremity elevation had an angle of 90.0° to 120.5°, the external rotation of the arm at side had an angle of 6° to 30° and internal rotation at the 3rd to 4th lumbar level. The overall incidence of complications was reported to be approximately 9.5% (Raiss et al.<sup>24)</sup>: 1 humeral shaft fracture, 1 infection, 1 dislocation, and 1 aseptic loosening) to 41% (Kılıç et al.<sup>25)</sup>: 1 acromial fracture, 5 infections, 4 hematomas needing surgery, 1 neuropraxia, 3 subluxations, and 2 disconnections of components). Overall, surgical outcomes of the RTSA in cases of proximal humerus fracture sequelae were poorer relative to CTA, massive rotator cuff tears or arthritis. Of these, surgical outcomes were poorest in cases of Type 3. However, when compared with hemiarthroplasty in cases of proximal humerus fracture sequelae, RTSA has better surgical outcomes in terms of functions and complications.

## Outcomes of Reverse Total Shoulder Arthroplasty for Glenohumeral Osteoarthritis

Osteoarthritis of the glenohumeral joint can commonly be classified according to the Walch classification system.<sup>26)</sup> In cases of advanced osteoarthritis, defects of the posterior region of the glenoid are prevalent, as shown in those of Walch B2 type or C type. This deserves special attention. In these cases, reaming, bone graft or cementing can be used during pre-treatment of the glenoid prior to placement of baseplate in the prosthesis, otherwise pre-treatment can be performed using a wedge-

shaped baseplate. McFarland et al.<sup>27)</sup> recently reported surgical outcomes of RTSA for a total of 42 patients with primary osteoarthritis accompanied by severe bone defects of the glenoid without rotator cuff tear (mean age, 71 years old; minimum follow-up period, 2 years). There were 18 cases of Walch A2 type, five cases of B2 type and 18 cases of C type. Moreover, surgery consisted of reaming without bone graft through medialization of the baseplate. The results revealed considerable recovery of pain, range of motion (ROM) of the joint and functional outcomes. There was only one case of baseplate failure, for which revision surgery was performed. Although indications of the RTSA have been extended to osteoarthritis of the glenohumeral joint in the elderly with severe osteoporosis, anatomic total shoulder arthroplasty has commonly been conducted as a treatment modality in cases of osteoarthritis of the glenohumeral joint without rotator cuff tear. Steen et al.<sup>28)</sup> recently conducted a case-control analysis of surgical outcomes between the two modalities (24 RTSAs vs. 96 matched anatomic arthroplasties). After a minimum follow-up period of 2 years, there were no significant differences in ASES and SST scores (79.9 vs. 80.4 points and 7.9 vs. 7.8 points, respectively) in the forward flexion and external rotation (153.3° vs. 159.1° and 47.1° vs. 61.2°, respectively), and in postoperative complications between the two modalities. The results of RTSA appear to be comparable or even better in patients with osteoarthritis compared with CTA. Somerson et al.<sup>6)</sup> reported that the increase of postoperative scores compared with preoperative scores were higher in CTA than osteoarthritis in their meta-analysis.

## Outcomes of Reverse Total Shoulder Arthroplasty for Rheumatoid Arthritis

Patients with rheumatoid arthritis commonly have poor bone quality, a progression of joint destruction and a poor quality of rotator cuff tendon and muscle. Therefore, these patients would be vulnerable to acceleration of arthritis if they receive bipolar shoulder arthroplasty. Anatomic arthroplasty may cause complications such as progressive loosening of the prosthesis, bone erosion, progressive rotator cuff tear and arthropathy. Reverse arthroplasty has been used as an alternative method to resolve these problems, particularly fragile rotator cuff tendons and muscles and other complications. Postacchini et al.<sup>29)</sup> conducted a systematic review of five recently published studies of RTSA to treat 100 cases of rheumatoid arthritis. The results revealed that patients had a mean age of 60.2 years and a mean follow-up period of 46.4 months. Furthermore, all patients had a concurrent presence of the rotator cuff tear, most of which had a larger tear accompanied by joint destruction. The Delta III (DePuy), Aequalis (Tornier), and DJO (DJO Surgical) reverse prostheses were used, all of which employed a cemented stem. Furthermore, there were three cases of severe bone defects, for

which bone graft was performed. The results revealed that upper extremity elevation and external rotation had an angle of 115° to 138° and 5.8° to 46°, respectively. Moreover, most studies showed that the degree of subjective satisfaction was greater than 90%. There were also a total of 31 cases of complications (31%), including three cases of glenoid fracture and two cases of fracture of the scapular spine. In addition, there were eight cases of revision surgery.

### Outcomes of Reverse Total Shoulder Arthroplasty for Failed Fixation of Proximal Humerus Fracture

In cases of proximal humerus fracture, complications and revision surgery after surgical fixation of the fracture are commonly seen, with incidences of up to 35%.<sup>30)</sup> In these cases, poor surgical outcomes of hemiarthroplasty or anatomic total arthroplasty have been reported to be prevalent because of joint destruction, concurrent presence of rotator cuff tear and malunion or nonunion of the fracture site. RTSA has been applied to resolve these issues in the elderly.<sup>31)</sup> Recently, Grubhofer et al.<sup>32)</sup> analyzed 54 cases of RTSA that failed in patients treated for proximal humerus fracture. A mean period of 20 months had elapsed between RTSA and the initial surgery, and all surgical operations were performed using the Zimmer Trabecular Metal Shoulder System (Zimmer). After a minimum follow-up period of more than 2 years, the Constant scores were 55 points, the upper extremity elevation had an angle of 104° and the external rotation had an angle of 17°. In addition, there was one case of periprosthetic fracture, two cases of infection and one case of revision surgery due to hematoma. Surgical outcomes of the RTSA as a revision surgery varied depending on the types of initial treatment modalities for proximal humerus fracture. Dezfuli et al.<sup>33)</sup> analyzed differences in surgical outcomes of 13 cases of RTSA for the proximal humerus fracture, 13 cases of RTSA for nonunion or malunion following conservative management of the initial proximal humerus fracture, 12 cases of RTSA for complications of hemiarthroplasty for the initial proximal humerus fracture and 11 cases of RTSA for complications of the open reduction and internal fixation of the initial proximal humerus fracture. The mean age was 71 years, the minimum follow-up period was 2 years, and surgery was performed using the Equinox Platform System (Exactech, Gainesville, FL, USA). The results revealed that functional scores were significantly lower in patients who underwent RTSA as a revision surgery because of postoperative complications of initial hemiarthroplasty or initial fixation surgery relative to those who did not. In patients undergoing RTSA following failed fixation of the proximal humerus fracture, there was one case of infection and two cases of periprosthetic fracture. The overall incidence of postoperative complications showed no significant differences from other groups.

### Outcomes of Reverse Total Shoulder Arthroplasty as a Revision Surgery for Failed Shoulder Arthroplasty

The incidence of postoperative complications of the RTSA and anatomic arthroplasty is considerably high. Of the total cases of both surgeries, a substantial number of cases required revision surgery. Day et al.<sup>34)</sup> reported that patients undergoing anatomic shoulder arthroplasty had an overall incidence of complications of 22.6% and a frequency of revision surgery of 11.2%. This high incidence of complications might arise from infections or loosening or instability of prosthesis. Above all, rotator cuff tears and defects occurring as delayed complications after anatomic arthroplasty are the most responsible factors. In addition, the incidence of these complications was relatively higher in cases of severe osteoporosis and great initial comminution of the fracture site. In these cases, the RTSA should be considered a first line of treatment during revision surgery. Randelli et al.<sup>35)</sup> conducted a systematic review of nine recent studies (226 cases) investigating surgical outcomes of the RTSA in patients accompanied by rotator cuff tear who failed in shoulder arthroplasty and found ASES scores of approximately 52.1 to 67.7 points, an upper extremity elevation with an angle of 76° to 120° and an external rotation with an angle of 1.0° to 17.6°. These authors also reported that approximately 10% to 42% of the total patients required a revision surgery. Poor surgical outcomes can be predicted to some extent based on bone loss arising from removal of the humeral prosthesis, and appropriate measures against it, as well as prolonged operation time during revision surgery for failed shoulder arthroplasty. However, these problems are expected to improve to some extent with the recent development of arthroplasty using a stemless humeral implant. In association with this, Holschen et al.<sup>36)</sup> analyzed 44 cases of failed shoulder revision arthroplasty and found that the stemless implant group had better surgical outcomes than the stemmed implant group in terms of the upper extremity elevation (138.6° vs. 108.2°), external rotation (8.5° vs. 4.9°) and external rotation muscle strength (4.1 vs. 2.8). The reasons for the initial use of arthroplasty may also affect its surgical outcomes. Recently, Holschen et al.<sup>37)</sup> analyzed 44 cases of RTSA as a revision surgery for failed arthroplasty to compare 23 cases of osteoarthritis and 21 cases of proximal humerus fracture. They found that osteoarthritis as an initial indication was associated with better surgical outcomes (ASES scores: 71.3 vs. 58.9 points, Constant scores: 60.6 vs. 54.7 points, upper extremity elevation: 126.4° vs. 114.7°, and overall incidence of complications: 8.7% vs. 23.8%). Younger individuals use the shoulder joint more and therefore have a higher expectation of shoulder use than older individuals. It is also presumed that younger individuals might sustain a greater severity of shoulder joint injury. Therefore, it is generally believed that surgical outcomes might be poorer in younger than older individuals. How-



ever, according to Black et al.,<sup>38)</sup> there were no significant differences between 32 cases of RTSA as a revision surgery for failed arthroplasty and their age-matched controls (33 cases of primary RTSA).

The outcomes of RTSAs according to each etiology are summarized in Table 1. Generally, surgical outcomes of RTSA in cases of glenohumeral osteoarthritis, CTA, massive rotator cuff tear and rheumatoid arthritis were quite satisfactory. However, the degree of satisfaction with surgical outcomes was relatively lower in patients undergoing RTSA as a revision surgery for repair of proximal humerus fracture and shoulder arthroplasty.

### Differences in Outcomes Depending on Several Issues Reverse Total Shoulder Arthroplasty

There is still debate regarding the factors that may affect surgical outcomes of the RTSA, which include medialization or lateralization of the center of rotation, the degree of humeral retroversion and neck-shaft angle, the suture of the subcapular tendon and differences between the cemented stem and the uncemented stem.

The basic concept of RTSA based on the Grammont design focuses on recovery of the upper extremity elevation by medially displacing the center of rotation and thereby improving stability. However, this remains problematic in that there is an increase in scapular notching and a decrease in the rotational force because of the medialized center of rotation. Therefore, joint prostheses with a more lateralized center of rotation have developed and become commercially available. Lawrence et al.<sup>39)</sup> conducted a systematic review of 13 recently published studies of RTSA and found that medialized products (Aequalis [Tornier] and Delta III [DePuy]) had slightly better upper extremity elevation and lower incidence of postoperative complications than lateralized ones (DJO [DJO surgical]). These authors also found that the lateralized products had considerably better levels of external rotation than medialized products.

Theoretically, there would be improvements in internal

rotation and decreases in overall impingement if there was a decrease in humeral retroversion. Conversely, there would be improvements in functional ROM as well as external rotation. If there was a increase in the humeral retroversion. Differences in surgical outcomes of RTSA depending on the degree of humeral retroversion have been studied. For example, Rhee et al.<sup>40)</sup> analyzed differences between a 20° retroversion group and a 0° retroversion group using the Aequalis product and found no significant differences in functional outcomes or ROM. However, the 0° retroversion group showed better outcomes in association with motions with internal rotation (e.g., back washing or brassiere wearing). Similarly, de Boer et al.<sup>41)</sup> compared surgical outcomes of the Aequalis product between the 20° retroversion group and the 0° retroversion group and found no significant inter-group differences in ROM, functional outcomes or muscle strength upon final follow-up. In addition, Kontaxis et al.<sup>42)</sup> compared surgical outcomes of the Zimmer Trabecular Metal Shoulder System (Zimmer) between the 0° to 10° retroversion group and the 20° to 30° retroversion group, demonstrating that there were no significant differences in the ROM and functional outcomes on final follow-up. These authors also added that there were no significant differences in activities of daily living in association with the internal rotation. Overall, it can be inferred that there were no significant differences in the humeral retroversion in a clinical setting, which is not in agreement with the theoretical assumptions.

Reverse arthroplasty prostheses are commercially available with neck-shaft angles varying from 135° to 155°, and surgical outcomes vary depending on the neck-shaft angle. Erickson et al.<sup>43)</sup> analyzed 2,222 cases from 38 published studies of RTSA and then compared outcomes among individuals receiving a neck-shaft angle of 135° vs. 155°. They found that the 155° neck-shaft angle group had a significantly smaller angle of external rotation and a significantly higher incidence of scapular notching than the 135° neck-shaft angle group (32.9° vs. 23° and 2.83% vs. 16.80%, respectively).

In cases with intact subscapularis tendon or reparable subscapularis tears, controversial opinions exist regarding the neces-

Table 1. Outcomes of Reverse Shoulder Arthroplasties according to Etiology (Focusing on Recent Systematic Reviews)

Variable	CTA/massive RCT <sup>11)</sup>	Acute proximal humerus fx. <sup>14)</sup>	Proximal humerus fx. sequele <sup>5)</sup>	Osteoarthritis <sup>28)</sup>	Rheumatoid arthritis <sup>16)</sup>	Failed fixation of prox. humeral fx. <sup>11)</sup>	Failed arthroplasties <sup>29)</sup>
Further flexion (°)	124.4	113.4	109.5	153.3	126.3	104	98.6
External rotation at side (°)	27.7	11.8	19.0	47.1	25.9	17	10.7
ASES score	72.2	70.3	56.5	79.9	-	-	60.3
Constant score	60.3	56.7	53.7	-	-	55	-
Overall complication rate (%)	17.4	13.9	24.1	8.3	31	-	-
Revision rate (%)	7.3	2.9	-	-	8	7.4	25.5

CTA: cuff tear arthropathy, RCT: rotator cuff tear, fx.: fracture, prox.: proximal, ASES: American Shoulder and Elbow Surgeons.

sity to suture the subscapularis tendon. Some advocate for the suture<sup>44,45)</sup> because they feel it plays an important role in improving anterior stability and raising the force of internal rotation. However, others do not advocate for the suture.<sup>46,47)</sup> These authors argue that repair of the subscapularis may further decrease the force of the external rotation and act as an adductor rather than an internal rotator. Thus, these authors maintain that repair of the subscapularis would prevent the deltoid muscle from elevating the arm. The need to suture the subscapularis tendon has been studied by several authors, all of whom agreed that the subscapularis tendon did not affect the ROM, functional outcomes, muscle strength or incidence of postoperative complications in patients undergoing RTSA.<sup>40,48-50)</sup> This leads to the speculation that it would not be mandatory to suture the subscapularis tendon during RTSA.

The use of cement during the placement of humeral prostheses for the RTSA raises the initial stability, but is disadvantageous in that it prolongs the operation time and makes it difficult to remove the prosthesis for a revision surgery. Therefore, there has been an increase in the use of cementless stems. In association with this, Phadnis et al.<sup>51)</sup> conducted a systematic review of 41 studies of RTSA (1,784 cases) and found that the use of cement was not associated with the ROM and functional outcomes, although the cementless stem group had a significantly lower incidence of complications. Based on these reports, it can be inferred that the use of cementless stem would be more beneficial in reducing the operation time and the difficulty of revision surgery. They recommended the use of cementless stem in RTSA, unless the cemented stem is inevitable, such as revision surgery or fracture surgery.

## Conclusions

Indications of RTSA have been persistently extended with technical advancements in reverse arthroplasty prosthesis, accumulated experiences and its successful treatment outcomes. Accordingly, its use has rapidly increased. This increase in use has been accompanied by continuous improvements in reverse arthroplasty prosthesis. In this situation, recent update in outcomes after RTSA deserve special attention. The RTSA has been performed for a variety of indications, their outcomes should be evaluated depending on the initial diagnosis. Moreover, its surgical outcomes also vary depending on the initial diagnosis. The surgical outcomes of RTSA in cases of glenohumeral osteoarthritis, CTA, massive rotator cuff tear and rheumatoid arthritis were quite satisfactory. However, the degree of satisfaction with surgical outcomes was relatively lower in patients undergoing RTSA as a revision surgery to repair proximal humerus fracture and shoulder arthroplasty. Moreover, controversial opinions still exist regarding the internal or external location of the center of rotation, the neck-shaft angle of the humeral prosthesis, suture of the

subscapularis tendon, use of cement during placement of the humeral prosthesis, the design of reverse arthroplasty prosthesis and surgical procedures. Accordingly, additional studies should be conducted to better understand these aspects of RTSA.

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