Problems, complications, reoperations, and revisions in reverse total shoulder arthroplasty: A systematic review

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The use of hemiarthroplasty in patients with an arthritic rotator cuff deficient shoulder has been shown to provide limited function and inconsistent pain relief.1,2,35,47,72,76,99 The semiconstrained reverse shoulder prosthesis, designed by Grammont in the late 1980s,39 was invented based on 2 biomechanical concepts: lowering the humerus and medialization of the center of rotation at the glenoid component. This design has the dual advantage of tensioning the deltoid muscle to increase its functional strength, and decreasing mechanical torque at the glenoid component, thus avoiding glenoid loosening.

The first series of reverse shoulder arthroplasty (RSA) with at least 2 years of follow-up confirmed the preliminary results, with excellent functional outcome and stable glenoid fixation.3-5,10,12,73,82,89,98 However, these series had a small numbers of patients and reported variable complication and revision rates of 15% to 50% and reoperation rates of 4% to 40%. One reason for the high variability was unclear definitions of complications and revisions, which varied markedly between the series. Furthermore, it is difficult to draw conclusions from small numbers of patients.

The purpose of the present study was to determine the incidence and functional significance of adverse events after RSA, including problems, complications, reoperations, and revisions. We established a study design and specific objectives before commencing the literature research. These objectives were (1) to perform a systematic review of the published literature to determine the overall rates of problems, complications, reoperations, and revisions after RSA; (2) to compare their influence on the final functional outcome; and, (3) to analyze the different problems, complications, reoperations, and revisions based on the etiology of the RSA.

Definitions

We defined a problem as an intraoperative or postoperative event that was not likely to affect the patient’s final outcome, including radiographic scapular notching, hematoma, heterotopic ossification, algodystrophy, phlebitis, intraoperative dislocations, intraoperative cement extravasation, or radiographic lucent lines of the glenoid.

A complication was defined as any intraoperative or postoperative event that was not likely to affect the patient’s final outcome, including fractures, infections, dislocations, nerve palsy, gelenoid loosening of humeral or glenoid components, modular stem or polyethylene disassociations, or glenoid screw problems.
Problems and complications were subcategorized as orthopedic complications of the patient’s shoulder (fracture, infection, hematoma, etc) or of the prosthesis (component disassembly or loosening, polyethylene disassociation, etc.).

Reinterventions were subcategorized into reoperations and revisions. Reoperations were defined as interventions requiring any return to the operating room for any reason relating to the shoulder, without altering or replacing any of the components. Revisions were defined as surgeries with total or partial exchange or removal of the components. Revisions were defined as surgeries with total or partial exchange or removal of the components. Liner exchanges and additions of humeral spacers were considered revisions.

**Literature search**

The systematic review was performed by following the relatively standard form according to Wright et al. We selected articles in Medline, EMBASE, and the Cochrane Central Register of Controlled trials, which were published between 1985 and December 2008, using the keywords shoulder, reverse, inverse, arthroplasty, prosthesis, delta, Grammont, fracture, problems, complications, reoperations, and revisions. Our MEDLINE and EMBASE search used a combination of terms derived from its thesaurus, including the exploded index terms shoulder, reverse, or inverse. All further facets were searched in combination with one of the terms or with Boolean operators. General search terms were used to prevent missing studies. The references of all relevant articles were manually cross-referenced to ensure that all possible articles were considered. The final analysis did not include studies that did not report complication rates or studies that were only cited as abstracts, case reports, or reviews. Two reviewers (M.P. and M.A.Z.) performed first- and second-stage screening.

**Data extraction**

The same 2 independent reviewers (M.P. and M.A.Z.) used a quality appraisal checklist to abstract the data from each of the studies that met the inclusion criteria. Demographic data included the study design, level of evidence, the number of cases and patients enrolled and their age and gender, and the duration and range of follow-up. The diagnosis leading to RSA was classified as irreparable massive rotator cuff tears (MRCT), cuff tear arthroplasty (CTA), primary osteoarthritis (OA), rheumatoid arthritis (RA), acute fracture (FX), posttraumatic fracture sequela (FS), tumor (T), or revision of a previous hemi or total shoulder arthroplasty (REV). Previous nonprosthetic shoulder surgery was also noted. Intraoperative data were recorded, including the prosthetic implant used, the surgical approach, the reattachment of the subscapularis in deltopectoral approaches, and concomitant procedures such as acromioplasty and bone grafts.

Preoperative and postoperative outcome data were extracted, including the range of motion, strength, percentage of very satisfied/satisfied and unsatisfied patients, subjective shoulder value (SSV), Constant-Murley scores and its subscores for activities of daily living and functional use of the arm, American Shoulder and Elbow Surgeons (ASES) scores, and all problems, complications, reoperations, and revisions. Also included in the study was appropriate additional relevant information such as specific postoperative course or information obtained from the postoperative radiographic images.

**Selection bias**

Because the studies were case series, we set out strict inclusion and exclusion criteria to provide as much homogeneity as possible and to limit the potential for selection bias. The inclusion criteria were the performance of an implantation of an RSA with a minimum mean clinical and radiographic follow-up of 24 months. There was no randomization in any of the trials, but the studies that were included in the final analysis had similar mean ages and percentages of female patients. Studies reporting previously published data, or earlier data on a cohort of patients that was later reported again with longer follow-up, were excluded to avoid duplication.

**Exclusion bias**

All studies in the final analysis had more than 80% follow-up and a mean duration of follow-up of 24 months. Thus, there is only minor potential for exclusion bias in this review.

**Results**

**Literature search**

We identified 84 articles in English, French, German, and Spanish involving human subjects. The abstracts of these 84 studies were reviewed to determine the applicability to the present study as determined by the inclusion and exclusion criteria, including a worksheet adapted from evidence-based guides. We rejected 63 articles because of follow-up of less than 24 months, absence of complication data in the study, publication in another language than the reported and a second longer follow-up study of the same cohort by the same group. Also excluded were abstracts case reports, and articles and reviews without original patient data. The studies by Baulot and Grammont, Middernacht et al, Walch et al, Boileau et al, Mottier et al, Neyton et al, and Wall and Walch, were not included in the analysis because parts of them...
were the same cohort as in other published studies.3,10,40,41,95 Twenty-one cohort studies were appropriate for the analysis.

Demographic data

Study design, level of evidence, total number of patients, follow-up, and age and gender of the patients were included in the analysis and are reported in Table I. The review included 782 RSAs in 761 patients with a minimum average follow-up of 24 months. The indications are summarized in Table II. No randomized controlled trials (level I), 3 prospective cohort studies (level II),10,37,95 and 18 therapeutic studies (level IV) were included.

Surgical technique and concomitant procedures

The reverse prosthesis was implanted with a deltapectoral approach in 15 studies containing 617 cases (79%), with a superolateral approach in 8 studies containing 137 cases (17.5%), with a transacromial approach in 4 studies containing 23 cases (2.9%), and in 1 study containing 5 cases (0.6%) with an osteotomy of the clavicle. A Delta prosthesis (De Puy, France) was used in 525 cases (67.1%), an Aequalis Reversed prosthesis (Tornier, France) in 31 cases (4%), and an Encore Reversed Shoulder Prosthesis (Encore Medical Corporation, Austin, TX) in 226 cases (28.9%). The subscapularis was reattached in 42.1% of the studies. Additional concomitant procedures in 13.5% of the cases in 7 studies included acromioplasty in 29 cases,82 a humeral window during revision arthroplasty in 34,37 a bone graft at the humeral or glenoid side in 19 (8 glenoid, 11 humerus),22,23,27,57,58,82 and a spacer removal in 18.22,57

Rehabilitation protocol

If indicated, the arm was placed in a sling in internal rotation in 10 studies (63%), in a brace in abduction and neutral rotation in 4 studies (25%), especially in revisions cases, and without any sling or brace in 2 studies (13%). Sling or brace use was discontinued between 3 and 6 weeks. All postoperative rehabilitation protocols started with unrestricted passive motion between the first and third postoperative week, without any bracing. The patients began active shoulder range of motion exercises as early as 2 weeks and as late as 6 weeks after surgery. Strengthening was initiated between 3 and 12 weeks.

Table I  Details of demographic data, including study design and level of evidence of the analyzed studies

<table>
<thead>
<tr>
<th>First author</th>
<th>Year</th>
<th>Etiologies</th>
<th>Level of evidence</th>
<th>Total cases (No.)</th>
<th>Patients (No.)</th>
<th>Follow-up (mon)</th>
<th>Range Age (y)</th>
<th>Gender, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DeWilde25</td>
<td>2001</td>
<td>CTA, FS, FX</td>
<td>IV</td>
<td>5</td>
<td>4</td>
<td>30</td>
<td>23-39</td>
<td>54, 34-73, 1, 3</td>
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<td>Jacobs5</td>
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<td>CTA</td>
<td>IV</td>
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<td>7</td>
<td>26</td>
<td>16-37</td>
<td>72, 54-80, 7, 0</td>
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<tr>
<td>Rittmeister74</td>
<td>2001</td>
<td>RA</td>
<td>IV</td>
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<td>7</td>
<td>54.3</td>
<td>48-73</td>
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<td>Valenti90</td>
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<td>CTA</td>
<td>IV</td>
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<td>39</td>
<td>84</td>
<td>60-108</td>
<td>70, 55-87, 29, 10</td>
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<td>Boulahia12</td>
<td>2002</td>
<td>CTA, MRCT, FS</td>
<td>IV</td>
<td>16</td>
<td>16</td>
<td>35</td>
<td>24-65</td>
<td>72, 66-80, 14, 2</td>
</tr>
<tr>
<td>Delloye29</td>
<td>2002</td>
<td>CTA, REV</td>
<td>IV</td>
<td>5</td>
<td>5</td>
<td>81</td>
<td>66-96</td>
<td>73, 67-79, N/S, N/S</td>
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<tr>
<td>Woodruff103</td>
<td>2003</td>
<td>RA</td>
<td>IV</td>
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<td>11</td>
<td>87</td>
<td>60-110</td>
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<td>Sirveaux83</td>
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<td>80</td>
<td>77</td>
<td>44.5</td>
<td>24-97</td>
<td>72.8, 60-86, 63, 14</td>
</tr>
<tr>
<td>Vanhoeye104</td>
<td>2004</td>
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<td>IV</td>
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<td>14</td>
<td>29.5</td>
<td>11-50</td>
<td>72, 55-85, 12, 2</td>
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<tr>
<td>De Wilde27</td>
<td>2005</td>
<td>T</td>
<td>IV</td>
<td>4</td>
<td>4</td>
<td>38</td>
<td>24-60</td>
<td>42, 23-51, N/S, N/S</td>
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<tr>
<td>Frankle14</td>
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<td>60</td>
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<td>24-68</td>
<td>71, 34-86, 41, 19</td>
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<td>Werner101</td>
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<td>58</td>
<td>38</td>
<td>min 24</td>
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<td>Boileau10</td>
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<td>CTA, FS, REV</td>
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<td>II</td>
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<td>II</td>
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<td>34</td>
<td>31.5</td>
<td>12-59</td>
<td>68, N/S, 29, 5</td>
</tr>
<tr>
<td>Levy58</td>
<td>2007</td>
<td>REV</td>
<td>IV</td>
<td>29</td>
<td>29</td>
<td>35</td>
<td>min 24</td>
<td>69, 42-80, 25, 4</td>
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<tr>
<td>Levy49</td>
<td>2007</td>
<td>REV</td>
<td>IV</td>
<td>19</td>
<td>18</td>
<td>44</td>
<td>24-89</td>
<td>72, 56-83, 11, 7</td>
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<tr>
<td>Wall67</td>
<td>2007</td>
<td>CTA, MRCT, FS, REV</td>
<td>II</td>
<td>196</td>
<td>186</td>
<td>39.9</td>
<td>24-118</td>
<td>75.3, 26-89, 145, 41</td>
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<tr>
<td>Cuff22</td>
<td>2008</td>
<td>MRCT, FS, REV</td>
<td>IV</td>
<td>96</td>
<td>94</td>
<td>27.5</td>
<td>24-38</td>
<td>72, 52-88, 64, 32</td>
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<tr>
<td>Cuff23</td>
<td>2008</td>
<td>REV</td>
<td>IV</td>
<td>22</td>
<td>21</td>
<td>43</td>
<td>25-66</td>
<td>67, 43-83, 11, 10</td>
</tr>
<tr>
<td>Total (%)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>782</td>
<td>761</td>
<td>42</td>
<td>...</td>
<td>68, ... , 558 (77), 178 (23)</td>
</tr>
</tbody>
</table>

CTA, cuff tear arthropathy; F, female; FS, posttraumatic fracture sequela; FX, acute fracture; M, male; MRCT, massive rotator cuff tear; N/S, not stated; RA, rheumatoid arthritis; REV, revision of a previous hemi or total shoulder arthroplasty; T, tumor.
Problems, complications, reoperations, and revisions

Problems and complications
There were 347 problems and 188 complications, representing a global problem rate of 44% and a complication rate of 24% (Table III). Two intraoperative and 345 postoperative problems were reported. The complications occurred in 24 cases intraoperatively and in 164 cases postoperatively. The most common problem was radiographic scapular notching in 277 cases, followed by radiographic glenoid lucent lines in 29 and hematomas in 20. The most common complication was instability, which occurred in 37 cases (4.7%), followed by infection in 30 cases (4%).

The problem and complication rates differed among the different etiologies (Table IV) and were both twice as frequent in the REV patients as in the combined primary arthroplasty group (CTA, MRCT, FS, OA, RA, FX, and T), at 12.5% vs 6.0%, and 33.3% vs 13.4%. A detailed analysis showed the REV group had average higher rates than the primary arthroplasty groups for intraoperative (7.4% vs 1.4%) and postoperative complications (23.6% vs 13.3%). Although problems and complications in the RA and the FX groups could be as high as in the REV group, both groups had only small numbers of patients and their adverse effects were mainly related to the transacromial approach.73

The highest incidence of problems and complications directly related to the surgical approach was in the group with an osteotomy of the clavicle, with 6 problems and complications in 3 of the 5 patients,25 followed by the transacromial approach, with 5 problems and complications in 23 patients. 3,40,73 The deltopectoral approach group had higher mean rates than in the superolateral approach group for problems (9.8% vs 7.1%), complications (23.5% vs 18.7%), reoperations (3.6% vs 0.6%), and revisions (9.5% vs 5.8%).

Intraoperative problems and complications (26 cases)
The 2 intraoperative problems reported were a cement extravasation57 and an intraoperative dislocation during wound closure, which was immediately reduced. All intraoperative complications were fractures, comprising 16 humeral fractures, 7 glenoid fractures, and 1 fracture of the acromion. Intraoperative humeral fractures10,29,40,51,95 occurred mainly during removal of the primary humeral stem or cement mantle in revision surgery in up to 24.1% of all revisions.97 These events influenced the final outcome.10 Intraoperative glenoid fractures10,88,95,100 were rare and related to the initial reaming or fixation technique. However, they may have a pejorative effect on the functional outcome.10 Therefore, everything should be done to improve the initial fixation of the meta-glenoid on the remaining bone stock. The intraoperative fracture of the
acromion was associated with the transacromial approach.3,40

Postoperative problems and complications (230 cases)
The 345 postoperative problems and 164 postoperative complications represented an overall problem and complication rate of 44% and 20.7%.

The most common postoperative problem was radiographic scapular notching, which was present in 277 cases (35%). Notching was present in almost half of the cases using the Grammont reverse shoulder system (49.8%), but no cases of notching were reported using the Encore shoulder system. The Sirveaux classification of scapular notching82 was available for 172 cases (62%); of these, 116 were stage 1 or 2 (67%) and 56 were stage 3 or 4 (33%).

According to approach, 77% (66 of 86 shoulders) were in the anterosuperior group and 49% (168 of 342 shoulders) were in the deltopectoral group. However, there was no precise information of the notching incidences in the subgroups of the etiologies in the studies.

The next most frequent postoperative problems were lucent lines around the glenoid component without clinical effect (23 cases) and hematomas (20 cases). Lucent lines around the glenoid were rare in the Grammont reverse shoulder system (14 of 556 cases, mean incidence of 2.5%),29,82,88,95,100 and were almost twice as frequent in the Encore shoulder system (9 of 226 cases, mean incidence of 4%).22,23,33,57,58 in which they were up to 11.1%.58 Postoperative hematomas occurred in 20 cases and were reported with a wide range (1% to 21%) and necessitated a surgical intervention in 9 cases and an aspiration in 5,10,12,22,23,25,58,98

No subsequent infections or adverse clinical outcomes were reported in the patients who had hematomas.

Instability (37 cases)10,15,22,23,25,37,57,95,98 was the most common postoperative complication, with a mean incidence of 4.7%. The deltopectoral approach was used in 97.3% of the shoulders with subsequent instability. Instability was more frequent in the REV group (9.4%) than in the primary arthroplasty group (4.1%).10,22,23,37,57,95,98 A reoperation was necessary in 87.5%,10,37,57,98 consisting of open reduction and exchange of the polyethylene liner alone, or combined with the addition of a metallic humeral spacer to improve tension of the deltoid.98 If the patient’s general health allowed a reoperation, there was no negative effect on the final functional outcome.10,57,98

Infections (30 cases) were reported in 14 studies.3 The incidence of deep infection after RSA was 3.8%, which was comparable with anatomic arthroplasties but higher than in other shoulder surgeries.21 A revision with debridement, polyethylene, or component exchange, or both, with

<table>
<thead>
<tr>
<th>Table III</th>
<th>Incidences of problems and complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Cases (No.)</td>
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<tr>
<td>Intraoperative problems</td>
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<tr>
<td>Miscellaneous</td>
<td>24</td>
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<tr>
<td>Intraoperative complications, total</td>
<td>245</td>
</tr>
<tr>
<td>Humeral fractures</td>
<td>7</td>
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<tr>
<td>Glenoid fractures</td>
<td>7</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1</td>
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<tr>
<td>Postoperative problems, total</td>
<td>345</td>
</tr>
<tr>
<td>Scapular notching</td>
<td>277</td>
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<tr>
<td>Lucent lines around the glenoid</td>
<td>23</td>
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<tr>
<td>Hematomas</td>
<td>20</td>
</tr>
<tr>
<td>Problems with acromion osteosynthesis</td>
<td>7</td>
</tr>
<tr>
<td>Heterotopic ossifications</td>
<td>6</td>
</tr>
<tr>
<td>Algodystrophic + phlebitis</td>
<td>4</td>
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<tr>
<td>Miscellaneous</td>
<td>8</td>
</tr>
<tr>
<td>Postoperative complications, total</td>
<td>164</td>
</tr>
<tr>
<td>Instability</td>
<td>37</td>
</tr>
<tr>
<td>Infection</td>
<td>30</td>
</tr>
<tr>
<td>Aseptic glenoid loosening</td>
<td>27</td>
</tr>
<tr>
<td>Acromion and scapular spine fractures</td>
<td>12</td>
</tr>
<tr>
<td>Glenoid disassembly</td>
<td>12</td>
</tr>
<tr>
<td>Humeral disassembly, polyethylene dislocation</td>
<td>12</td>
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<tr>
<td>Humeral fracture</td>
<td>11</td>
</tr>
<tr>
<td>Humeral loosening</td>
<td>10</td>
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<tr>
<td>Neurologic complications (axillary, radial)</td>
<td>9</td>
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<tr>
<td>Miscellaneous</td>
<td>4</td>
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</table>

References 4, 10, 15, 22, 25, 34, 37, 40, 57, 58, 73, 82, 88, 98
postoperative antibiotics, was performed in 29 of the 30 infected RSAs. There was an increased rate of infection in the revision group compared with the primary group (5.8% vs 2.9%). As in other shoulder surgeries, low-virulence organisms, such as Propionibacterium acnes and Staphylococcus epidermidis, were frequently implicated in RSA infections.10,95,98

Aseptic glenoid loosening (27 cases) was not reported as being related to a progression of inferior scapular notching. Like postoperative glenoid lucent lines, aseptic glenoid loosening is twice as frequent in the studies using the Encore shoulder system22,23,33,57,58 than in the studies using the Grammont reverse shoulder arthroplasty system10,12,29,73,82,92,95,98 (5.8% vs 2.5%; P = .025). In one study,34 there was no osseous ingrowth in any of the 7 revised shoulders. However, when 5 shoulders with loose glenoid components were revised with another RSA, the clinical outcome was excellent in 4 and good in 1.

Postoperative fractures of the acromion and scapular spine10,22,23,34,98 (12 shoulders) are rare (1.5% incidence). In the case of conservative treatment of an acromion fracture with immobilization, there was no influence on the final outcome reported. However, fractures of the scapular spine may require osteosynthesis and compromise the final outcome.

Glenoid disassembly (12 cases) occurred only in the first series of the Grammont shoulder system and decreased after introducing a modified Morse taper fixation system for the glenosphere on the metaglene.82

Humeral stem disassembly (4 cases) and polyethylene disassociations (8 cases) was also a rare complication in different studies. Humeral stem disassembly did not always need reintervention, and disassociated polyethylene components were revised without clinical impact.34,37,58,98

All postoperative humeral fractures10,22,37,40,57,58,92 (11 cases) were associated with a traumatic event. One fracture was treated conservatively with an excellent result at follow up.23 The remaining shoulders were revised with a long stem and open reduction and internal fixation with plates or cerclages. Postoperative humeral fractures had a negative impact on the clinical outcome.

Humeral subsidence (loosening)10,23,58,73,82,98 (10 cases) was reported in 7 different studies. They were only revised in case of clinical impact.10,57,82

Neurologic complications were reported in 9 cases10,23,57,98 and included axillary (2 cases), radial (6 cases) and musculocutaneous (1 case) nerve palsies. Whereas axillary nerve palsies were immediate postoperative complications, radial nerve palsies were often subsequent to a humeral shaft fracture during follow-up.23,37,57 In 1 shoulder, the axillary lesion resolved completely without any effect on the functional outcome and the other shoulder had only partial recovery, with inferior outcome.

Glenoid screw problems (2 cases) were rarely reported and occurred with the inferior screws, which were too long and penetrated the lateral scapular border.3

Reoperations and revisions

Eighty-four patients underwent 26 reoperations and 79 revisions, representing rates of 3.3% and 10.1%, respectively. A detailed analysis of the revisions showed there were 23 less “aggressive” cases in which the glenosphere was rescrewed, the polyethylene was exchanged, or a metallic humeral spacer was implanted.10,15,22,23,34,38,57,58,73,98 The remaining 56 cases were removals or exchanges of the baseplate, the humeral stem or both.** Although the incidence of reoperation was nearly equal in the REV and the primary arthroplasty groups (4.2% vs 3.0%), revisions were more than twice as

** References 3, 10, 12, 15, 22, 23, 29, 34, 38, 57, 58, 73, 82, 88, 98.

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Table IV  Summarized and detailed incidences of problems, complications, reoperations, and revisions in patients treated with reverse shoulder arthroplasty

<table>
<thead>
<tr>
<th>Etiology</th>
<th>No. (n = 70)</th>
<th>Problems</th>
<th>Complications</th>
<th>Reinterventions (n = 105)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(n = 188)</td>
<td>Reoperations (n = 26)</td>
</tr>
<tr>
<td>Total</td>
<td>782</td>
<td>44%</td>
<td>24%</td>
<td>3.3%</td>
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<tr>
<td>Primary arthroplasty group</td>
<td>566</td>
<td>6.0%</td>
<td>13.4%</td>
<td>3.0%</td>
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<tr>
<td>Cuff tear arthropathy</td>
<td>318</td>
<td>6.9%</td>
<td>19.5%</td>
<td>11.9%</td>
</tr>
<tr>
<td>Fracture sequela</td>
<td>41</td>
<td>N/S</td>
<td>5%</td>
<td>4.9%</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>23</td>
<td>21.7%*</td>
<td>45%*</td>
<td>26.1%</td>
</tr>
<tr>
<td>Acute fracture</td>
<td>18</td>
<td>(11.1%)</td>
<td>(36%)†</td>
<td>(6.3%)†</td>
</tr>
<tr>
<td>Tumor</td>
<td>6</td>
<td>N/S</td>
<td>N/S</td>
<td>N/S</td>
</tr>
<tr>
<td>N/S</td>
<td>160</td>
<td>N/S</td>
<td>N/S</td>
<td>N/S</td>
</tr>
<tr>
<td>Revision</td>
<td>216</td>
<td>12.5%</td>
<td>33.3%</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

N/S, No clear statement among the different etiologies reported.
* Only cited in 2 studies with problems related to the approach74
† Only cited in 1 study86
frequent in the REV group (15.7% vs 6.3%; Table IV). Prosthesis removals were necessary in 5 cases and all were treated with resection arthroplasty.\textsuperscript{10,40,73,88,98} No removal treated with an arthrodesis was reported. Nine prostheses were converted to hemiarthroplasty.\textsuperscript{10,34,98}

In contrast to problems and reoperations,\textsuperscript{10,34,98} most complications and revisions had an effect on the final outcome. In 7 studies, a more inferior average Constant-Murley or ASES score was reported with complications than without (32 vs 68 points, and 60 vs 69 points, respectively).\textsuperscript{22,23,27,29,51,73,92} Because complications were not separated into problems and complications in the study of Werner et al.\textsuperscript{98} a complication had an effect on the final outcome only in 18.2% of the cases. In 3 studies in which the effect of a revision on the clinical result was reported, the clinical outcome measured by the Constant-Murley score was also inferior after revision compared with without (54 vs 62 points).\textsuperscript{51,95,98}

**Discussion**

Treatment of the rotator cuff deficient shoulder has evolved during the last 2 decades, and today RSA is a commonly performed procedure in Europe and all over the world. There has been growing interest in using RSA and indications continue to expand. However, high rates of problems, complications, reoperations, and revisions have been reported with the procedure.

On the basis of the present study, the global rates for problems, complications, reoperations, and revisions after RSA were 44%, 24%, 3.5%, and 10%, respectively. However, wide variations were noted among the studies and occurred for several possible reasons. The definition of a problem or complication differs significantly among the studies. Whereas some authors included and reported all intraoperative or postoperative problems and complications during revisions, others did not because they were related to the revision procedure itself and not to the RSA implantation.\textsuperscript{95} Also, some series included radiographic changes around the humeral or glenoid components as complications, whereas others considered these separately as radiographic findings.

The complication and reoperation rates were much higher after revision RSA than after primary RSA. Although the values in the RA and in the FX groups are as high as in the REV group, they may be overestimated because of the problem and complication rates of the transacromial approach in 1 study.\textsuperscript{73} However, surgeons should be aware of the possible problems and complications in RA or FX situations. The results of this review are comparable with a previous French multicenter study\textsuperscript{84} that found a similar overall complication rate and an almost 4-fold increase in complications in the revision RSA group. The initial pathology in shoulders that are subsequently revised has a significant influence on subsequent complications.\textsuperscript{10,95,98} Several series have reported lower complication rates; however, these series excluded revision cases.\textsuperscript{33,34} The higher complication rate in revision shoulder arthroplasty was mainly related to the revision surgery and not to the reverse prosthesis itself.

Scapular notching was by far the most frequently reported problem after RSA. It was present in almost half of all the Grammont prostheses in our series, which is similar to the published rates in the literature on scapular notching using this reverse shoulder design.\textsuperscript{56} The relative medialization of the center of rotation in the Grammont design is thought to predispose to impingement of the humeral component against the scapular neck in adduction.\textsuperscript{56,69} A biomechanical study by Nyffeler et al.\textsuperscript{69} showed that the most important factor in preventing notching is inferior placement of the glenosphere. In contrast to the Grammont design, the Encore prosthesis features a lateralized center of rotation. This design seems to be effective in preventing notching, because no notching was observed in the Encore prostheses in our study. The approach seems to influence the incidence of notching in the studies. Simovitch et al.\textsuperscript{80,81} reported the importance of the prosthetic scapular neck angle and the inferior positioning of the glenoid component in avoiding notching. In their report, notching can be prevented by optimal positioning of the glenoid component, with a sensitivity and specificity of 90% using the notching index calculation. The inferior positioning of the glenoid component is assumed to be more difficult through a superior approach because the clear exposure of the inferior glenoid rim is difficult to achieve.

The clinical significance of scapular notching is a matter of some controversy. Although some studies have implicated scapular notching as a cause of glenoid component loosening\textsuperscript{7,12,25,82,88} and negative impact on clinical outcome scores,\textsuperscript{81,82} the largest and most comprehensive study on the subject found no clinical effect and only 1 case of progressive notching leading to loosening at 114 months postoperatively.\textsuperscript{56}

Lucent lines around the glenoid component, which was the most frequently documented postoperative problem, did not have any clinical effect reported. To prevent lucent lines of the glenoid, the consensus in other studies is that that the central peg of the base plate is thought to be the critical point for glenoid component stability and should be fixed in native bone stock.\textsuperscript{70,54} The lateralization of the center of rotation in the Encore shoulder system, compared with the Grammont shoulder system, theoretically increases the torque forces at the glenosphere-baseplate interface. This could be the reason for the more frequently reported lucent lines and glenoid loosening (5.8% vs 2.5%; \( P = .025 \)) in this reverse shoulder system.

The wide variation in rates of postoperative hematoma between studies could be because some authors only included hematomas as a complication if there was a need for a reoperation,\textsuperscript{10} whereas others included all hematomas, even if no reintervention was needed.\textsuperscript{98} The lack of tamponade effect of the rotator cuff results in a large dead
space; therefore, we think the space should be drained with at least 1 drain for 48 hours. Werner et al\textsuperscript{98} suggested a delayed start of the rehabilitation program that might favor hematoma formation in the first days postoperatively.

Postoperative instability subsequent to RSA was the most frequent complication, but it is difficult to analyze the causes because of the variability among the studies. Some have reported that the deltopectoral approach seems to negatively influence the incidence of instability.\textsuperscript{94} Factors such as altered version of the humeral and glenoid components, ruptured, and fatty infiltrated subscapular muscle are present in different approaches, so they cannot be the main reason for increased instability in studies using the deltopectoral approach. However, the complete release of the subscapularis, including the inferior and middle glenohumeral ligaments at the glenoid insertion site, may predispose to weakened anterior restraints in deltopectoral approaches. Therefore, the subscapularis seems to be of tremendous importance and should be repaired and protected whenever possible.\textsuperscript{10,95,98}

Another potential cause of instability is a loss of tension of the deltoid. This could be because of preexisting atrophy or insufficiency of the anterior part of the deltoid, or because of relative humeral shortening compared with the contralateral side. Preoperative deltoid insufficiencies in revision arthroplasty are probably underestimated and were reported to be present in 71% in the Gohlke and Rolf study.\textsuperscript{37} In cases of revision or fracture sequelae, intraoperative assessment of deltoid tension can be difficult (eg, general anesthesia, fibrosis, scar, and retraction of soft tissue), and preoperative templating of the humeral length is essential. In recurrent instability, additional humeral spacers can be implanted with success.\textsuperscript{10,98}

Postoperative infection rates were high both in primary and revision surgery. As in the French multicenter study,\textsuperscript{96} there was a trend toward higher infection rates in revision surgery compared with primary arthroplasty groups. As previously mentioned, the large subacromial dead space, the compromised general health of some patients, and the large surgical dissection, especially in revision cases, may predispose to later infection.

Although the rate of aseptic glenoid loosening is not reported to be a major problem in the Grammont system (2.5%),\textsuperscript{11} it has been reported in up to 11.7%\textsuperscript{34} in the first-generation Encore system, which is comparable to the loosening rate of anatomic shoulder prostheses. Changes in design to the Encore system, including the addition of locking screws and hydroxyapatite coating of the baseplate, seem to have decreased the risk of loosening; a subsequent study using only the updated system had only 1 case of loosening in 96 RSAs.\textsuperscript{22} To avoid loosening, every effort should be made to optimally fix the glenoid component onto good bone stock at the inferior border of the glenoid.\textsuperscript{70,94} Because initial fixation is dependent on the central peg, scapular notching does not seem to predispose to aseptic loosening of the glenoid.\textsuperscript{70} Preoperative assessment of glenoid bone stock and careful planning for optimal positioning of the meta-glenoid may be important in preventing loosening.\textsuperscript{69,81} Lateralization of the baseplate using a glenoid bone graft taken from the osteotomized humeral head may theoretically increase range of motion and lessen impingement of the humerus on the scapula.\textsuperscript{9}

Postoperative fractures of the acromion often occur spontaneously. They can be treated with skilful neglect and are not a contraindication to a reverse prosthesis. Conversely, postoperative fractures of the scapular spine lead to poor functional outcome and may require osteosynthesis, as reported by of Mottier et al.\textsuperscript{56}

Postoperative glenoid disassembly was rare and was a problem related to the design of the Grammont prosthesis used before 1995.\textsuperscript{10} Modification of the Grammont design with a Morse taper central fixation and a new central screw fixation improved the fixation and avoided dissociation of the glenosphere thereafter. Similarly to study by Chuinard et al.\textsuperscript{17} humeral disassembly, loosening, and polyethylene dissociations were minor problems subsequent to the design changes to the Delta III prosthesis, which had had problems with disassembly. These complications may require revision in cases of unstable components. However, in shoulders with thin cortical bone in the proximal humerus and tuberosities, extensive cementing around the prosthesis in the area of the tuberosities to prevent component rotation may be preferable to revision.

Postoperative humeral fractures occurred mainly at the distal tip of the stem and were generally treated conservatively.\textsuperscript{77} However, they can have a negative effect on the functional outcome.\textsuperscript{10,37,57,58} Proper cementing technique at the distal tip with correct sizing of the component can decrease stress forces to the bone and may prevent fractures. Neurologic injury is fortunately very rare and had an effect only in case of incomplete recovery.\textsuperscript{10}

Reoperations were mainly related to hematomas\textsuperscript{10,23,34,98} and the transacromial approach\textsuperscript{73} and did not influence the final outcome in most of the cases.\textsuperscript{10,34,98} However, because complications and subsequent reoperations are directly associated with the transacromial approach\textsuperscript{3,40,73} and the osteotomy of the clavicle,\textsuperscript{25} there has been a trend in the last decade to use the deltopectoral or the superolateral approach. Revision procedures and revisions subsequent to RSA have a major impact on the final outcome, so every attempt should be made to avoid complications and revision.

\textbf{Performance bias}

Performance bias may occur if high numbers of concomitant procedures are performed. One study reported 29

\textsuperscript{11} References 3, 10, 12, 15, 25, 27, 29, 37, 51, 73, 82, 88, 92, 95, 100.
acromioplasties (36.3% of all cases in that study). However, we do not believe that this results in a substantive difference leading to performance bias. The 34 patients who had a surgical approach with a humeral window had slightly inferior clinical results. Although these patients represented only 15.7% of all revision cases, their inclusion in the revision group may predispose to underestimation of the clinical outcome in revision procedures.

Detection bias

The Constant-Murley score was used in 16 of the 22 studies, and the ASES score was the primary outcome measure in 5 of the remaining 6 studies. Both scores are well established and validated. There was no appreciable difference between the series in scores and pain. Inferior function was documented in 3 of the 22 studies, with an active forward flexion below 90°. All 3 studies included only or mainly revision cases subsequent to failed hemiarthroplasty. This supports the observation that revisions of RSAs predispose to inferior outcomes.

The present review has weaknesses related to the homogeneity among the groups. After reviewing the literature, no level I studies met the criteria at the time of the literature research. Three studies were prospective cohort studies. This indicates the need for studies of improved quality on the problems, complications, reoperations, and revisions after RSA. A meta-analysis could not be performed because of the lack of homogeneity, and a systematic review was performed instead. However, systematic reviews are qualitatively and quantitatively limited by the quality of the published studies. We therefore analyzed in detail the differences between the different etiologies and attempted to exclude any study with a potential confounding factor, such as less than 24 months of follow-up, absence of complication data, or subsequent longer follow-up of the same cohort. Complication rates may have been influenced by potential confounding factors that were not extractable from the published data. RSA is a complex procedure with a considerable learning curve; however, none of the studies reported the operating surgeon’s experience with the procedure. Similarly, updates have been made in the design of both the Grammont and Encore reverse shoulder systems to address problems with the original design, but it was not always possible to determine whether an original or updated design was used. We were therefore unable to determine whether design changes had an effect on the problem and complication rates.

Conclusions

Problems, complications, reoperations, and revisions after RSA are frequent (44%, 24%, 3.5%, and 10% respectively). Scapular notching is a common problem but is rarely clinically significant. Although reoperations were equal in the REV and primary arthroplasty group, REV arthroplasty as an etiology has an effect, with a higher average problem, complication, and revision rate of 12.5%, 33.3%, and 15.7%, respectively. Instability and infection were the 2 most frequent complications leading to revision.

Disclaimer

This is a systematic review of the literature concerning problems and complications encountered with all types of RSA (Deupuy, Tornier, Encore). Any royalties and/or consultant payments received are not related directly to the subject matter or content of this article. The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References


88. Valenti P, Bouzens D, Nerot C. Delta 3 reversed prosthesis for arthritis with massive rotator cuff tear: long term results (> 5 years).


