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Corresponding Author	Family Name	**Petrillo**
	Particle	
	Given Name	**S.**
	Suffix	
	Division	Department of Orthopaedic and Trauma Surgery
	Organization	Campus Bio-Medico University
	Address	Via Alvaro del Portillo 200, Trigoria, 00128, Rome, Italy
	Division	Centro Integrato di Ricerca (CIR)
	Organization	Campus Bio-Medico University
	Address	Via Alvaro del Portillo 21, 00128, Rome, Italy
	Phone	+ 39 0622 54 11
	Fax	
	Email	s.petrillo@unicampus.it
	URL	
	ORCID	
Author	Family Name	**Longo**
	Particle	
	Given Name	**U. G.**
	Suffix	
	Division	Department of Orthopaedic and Trauma Surgery
	Organization	Campus Bio-Medico University
	Address	Via Alvaro del Portillo 200, Trigoria, 00128, Rome, Italy
	Division	Centro Integrato di Ricerca (CIR)
	Organization	Campus Bio-Medico University
	Address	Via Alvaro del Portillo 21, 00128, Rome, Italy
	Phone	
	Fax	
	Email	
	URL	
	ORCID	
Author	Family Name	**Papalia**
	Particle	
	Given Name	**R.**
	Suffix	
	Division	Department of Orthopaedic and Trauma Surgery

	Organization	Campus Bio-Medico University
	Address	Via Alvaro del Portillo 200, Trigoria, 00128, Rome, Italy
	Division	Centro Integrato di Ricerca (CIR)
	Organization	Campus Bio-Medico University
	Address	Via Alvaro del Portillo 21, 00128, Rome, Italy
	Phone	
	Fax	
	Email	
	URL	
	ORCID	
Author	Family Name	**Denaro**
	Particle	
	Given Name	**V.**
	Suffix	
	Division	Department of Orthopaedic and Trauma Surgery
	Organization	Campus Bio-Medico University
	Address	Via Alvaro del Portillo 200, Trigoria, 00128, Rome, Italy
	Division	Centro Integrato di Ricerca (CIR)
	Organization	Campus Bio-Medico University
	Address	Via Alvaro del Portillo 21, 00128, Rome, Italy
	Phone	
	Fax	
	Email	
	URL	
	ORCID	

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Abstract

Purpose:
To report the outcomes and complications of reverse shoulder arthroplasty (RSA) in massive irreparable rotator cuff tears (MIRCT) and cuff tear arthropathy (CTA).

Methods:
A systematic review of the literature contained in Medline, Cochrane, EMBASE, Google Scholar and Ovid databases was conducted on May 1, 2016, according to PRISMA guidelines. The key words "reverse total shoulder arthroplasty" or "reverse total shoulder prostheses" with "rotator cuff tears"; "failed rotator cuff surgery"; "massive rotator cuff tears"; "irreparable rotator cuff tears"; "cuff tear arthropathy"; "outcomes"; "complications" were matched. All articles reporting outcomes and complications of RSA for the management of MIRCT or CTA were included. The comparison between preoperative and postoperative clinical scores, as well as range of motion (ROM), was performed using the Wilcoxon–Mann–Whitney test. *P* values lower than 0.05 were considered statistically significant.

Results:
Seven articles were included in our qualitative synthesis. A statistically significant improvement in all clinical scores and ROM was found comparing the preoperative value with the postoperative value. The degrees of retroversion of the humeral stem of the RSA do not influence the functional outcomes in a statistically significant fashion. There were 17.4% of complications. The most frequent was heterotopic ossification, occurring in 6.6% of patients. Revision surgery was necessary in 7.3% of patients.

Conclusions:
RSA restores pain-free ROM and improves function of the shoulder in patients with MIRCT or CTA. However, complications occur in a high percentage of patients. The lack of level I studies limits the real understanding of the potentials and limitations of RSA for the management of MIRCT and CTA.

Keywords (separated by '-')	Reverse total shoulder arthroplasty - Massive rotator cuff tears - Cuff tear arthropathy - Outcomes - Complications
Footnote Information	

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REVIEW

Reverse shoulder arthroplasty for massive irreparable rotator cuff tears and cuff tear arthropathy: a systematic review

S. Petrillo[1,2] · U. G. Longo[1,2] · R. Papalia[1,2] · V. Denaro[1,2]

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Abstract

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Results Seven articles were included in our qualitative synthesis. A statistically significant improvement in all clinical scores and ROM was found comparing the preoperative value with the postoperative value. The degrees of retroversion of the humeral stem of the RSA do not influence the functional outcomes in a statistically significant fashion. There were 17.4% of complications. The most frequent was heterotopic ossification, occurring in 6.6% of patients. Revision surgery was necessary in 7.3% of patients.

Conclusions RSA restores pain-free ROM and improves function of the shoulder in patients with MIRCT or CTA. However, complications occur in a high percentage of patients. The lack of level I studies limits the real understanding of the potentials and limitations of RSA for the management of MIRCT and CTA.

Keywords Reverse total shoulder arthroplasty · Massive rotator cuff tears · Cuff tear arthropathy · Outcomes · Complications

Introduction

Massive irreparable rotator cuff tears (MIRCT) and cuff tear arthropathy (CTA) are two main problems in orthopedics [1]. Any rotator cuff (RC) lesions larger than 5 cm were defined MIRCT by Coefield [2]. However, other authors suggested that if the remnant of the RC tendons cannot be anchored to bony trough even though the arm is abducted at 60°, the tear should be considered massive and irreparable [3]. On the other hand, CTA is a well-defined pathology. It was firstly described by Neer et al. [4] as a pathological condition of the shoulder characterized by the association of massive RC tear and gleno-humeral joint degeneration, often accompanied by an antero-superior migration of the humeral head.

The treatment of both pathologies represents a challenge, and patients suffering from one of these conditions often reported a reduction in their quality of life due to

✉ S. Petrillo
s.petrillo@unicampus.it

[1] Department of Orthopaedic and Trauma Surgery, Campus Bio-Medico University, Via Alvaro del Portillo 200, Trigoria, 00128 Rome, Italy

[2] Centro Integrato di Ricerca (CIR), Campus Bio-Medico University, Via Alvaro del Portillo 21, 00128 Rome, Italy

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severe impairment to perform several activities of daily living requiring shoulder function [5, 6].

Reverse shoulder arthroplasty (RSA) was considered a useful solution in these patients to improve their quality of life, restoring pain-free ROM, function and strength of the shoulder [7–12]. RSA lowers the humeral head and medializes the center of rotation (COR) of the shoulder, improving the deltoid lever arm which supplies the RC deficiency [8, 13–17]. However, various unsatisfactory outcomes were reported after RSA. Several studies showed a limited external rotation ROM, while other studies reported a high percentage of scapular notching ad impingement against the acromion, scapular pillar or coracoid process. Moreover, as any other joint replacement procedure, RSA can be associated with important intraoperative and postoperative complications [18].

The purpose of this systematic review was to evaluate the clinical and functional outcomes, as well as complications and revisions rate, of RSA in patients with MIRCT or CTA.

Materials and methods

AQ3 We have performed a systematic review of the literature according to the PRISMA guidelines. Two independent reviewers (S.P. and U.G.L.) conducted a blind search. The search was performed on May 1, 2016, on Medline, Cochrane, EMBASE, Google Scholar and Ovid databases. We matched the following key words: "reverse total shoulder arthroplasty" or "reverse total shoulder prostheses" with "rotator cuff tears"; "failed rotator cuff surgery"; "massive rotator cuff tears"; "irreparable rotator cuff tears"; "cuff tear arthropathy"; "outcomes"; "complications." Only clinical trials in English language which were published in peer-review journals were evaluated.

Inclusion and exclusion criteria are shown in Table 1. Articles title and abstract were firstly evaluated. Articles without an abstract were excluded, while full-text article was retrieved if the abstract did not allow the investigators to assess the compliance with the inclusion and exclusion criteria. All clinical trials reporting outcomes and complications of RSA performed for the management of MIRCT or CTA were included.

Statistical analysis

All the statistical analyses were performed using SPSS for Mac (IBM SPSS Statistics Desktop version 22.0; Chicago, Illinois). The comparison between preoperative and postoperative clinical scores as well as the degrees of anterior elevation, abduction, external rotation and internal rotation ROM was carried out using the Wilcoxon–Mann–Whitney test. *P* values lower than 0.05 were considered statistically significant.

In all studies, *P* values <0.5 were considered statistically significant.

Results

Twenty-four articles [19–42] were eligible for the present study. However, only seven [20, 36–41] articles were compliant with the inclusion/exclusion criteria (Fig. 1). AQ4 The exclusion reasons of the other 17 articles are explained in Table 2.

No level I studies were included. We found three retrospective level IV studies [20, 36, 38], one prospective level IV study [39, 41], one retrospective level III study [20], one prospective level III study [37] and one prospective level II study [40].

Table 1 Inclusion and exclusion criteria

Databases screened	Medline, Cochrane, EMBASE, Google Scholar and Ovid
Date of source	May 1, 2016
Language accepted	English
Key words matched	"Reverse total shoulder arthroplasty" or "reverse total shoulder prostheses" with "rotator cuff tears"; "failed rotator cuff surgery"; "massive rotator cuff tears"; "irreparable rotator cuff tears"; "cuff tear arthropathy"; "outcomes"; "complications"
Type of articles excluded	Reviews, case reports, animal studies, cadavers studies, biomechanical studies, tumoral studies
Inclusion criteria	RSA implanted as primary surgery; RSA for revision surgery of failed RC repair; description of the surgical approach; description of the version of the humeral stem of RSA; preoperative and postoperative information on clinical condition of the patients (using outcomes scores, measuring ROM); description of the follow-up period; detailed information of the complications and their management
Exclusion criteria	Studies on failed RSA, RSA in fractures, RSA in instability or failed RSA; follow-up period shorter than 12 months; no information on surgical intervention, complications, clinical outcomes, radiographic outcomes and statistical analysis pf the relative results

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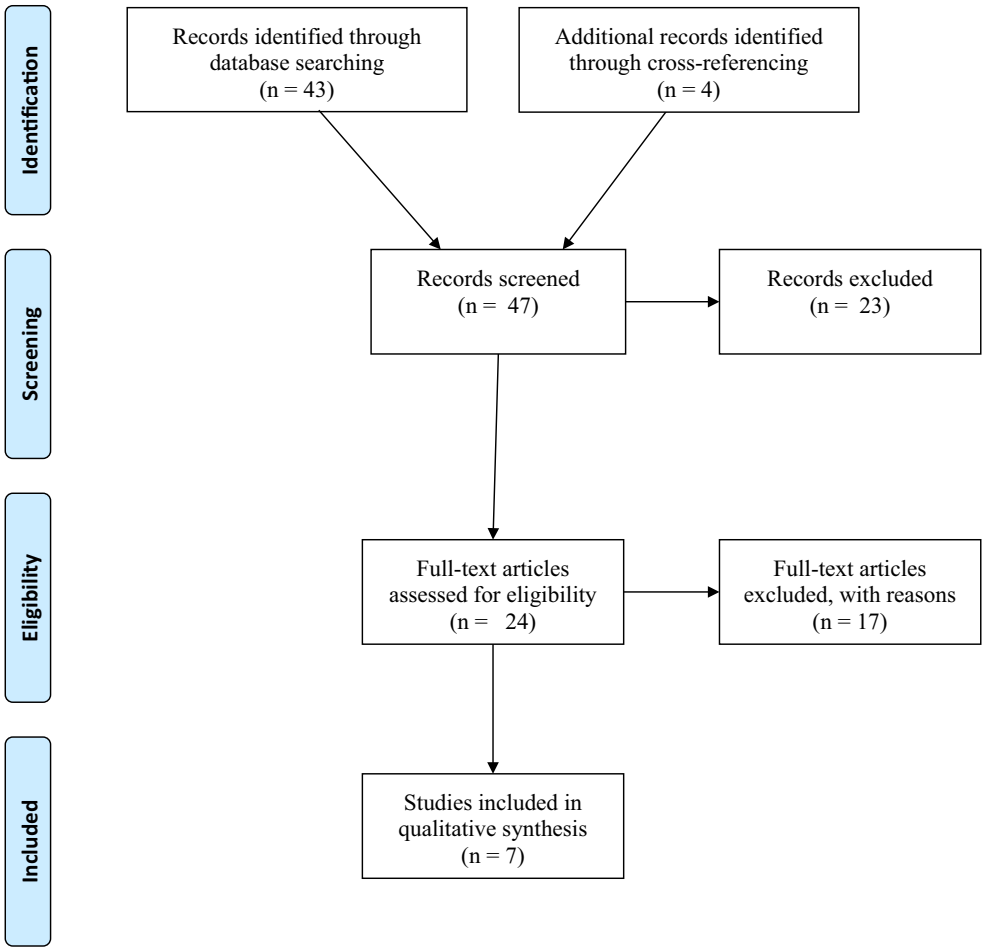

Fig. 1 PRISMA flow diagram

Demographics

Overall, 408 shoulders in 396 patients presenting MIRCT or CTA were managed with RSA. There were 125 (31.5%) male and 271 (68.5%) female patients. The male/female ratio was 0.46.

The mean age of the patients at the time of surgery was 71.9 ± 3.2 years (range 34–95 years). In 102 (70.3%) of 145 (35.5%) patients, the pathology involved the dominant shoulder.

The mean follow-up period was 35.3 ± 12.3 months (range 12–101 months). Only two (0.05%) patients were lost at the final follow-up.

Imaging assessment

A preoperative and postoperative standard radiographic evaluation of the shoulder was performed in all patients. Radiographs in antero-posterior view with the arm in neutral position and axillary view were performed in 312 (76.4%) shoulders. The radiographic scapular-Y lateral view was performed in 244 (59.8%) shoulders and the Grashey view in 131 (32.1%) shoulders.

Preoperative computed tomography (CT) scans were performed in 60 (14.8%) shoulders while preoperative magnetic resonance imaging (MRI) was performed in another 76 (18.6%) shoulders.

Surgical approach, type of prostheses and humeral component retroversion

RSA was implanted using the delto-pectoral approach in 272 (66.6%) shoulders, the superolateral approach in 76 (18.6%) shoulders and the delto-pectoral extended approach in 60 (14.8%) shoulders.

The Delta III® reverse shoulder prostheses (DePuy Orthopaedics, Warsaw, IN, USA) was implanted in 206 (50.5%) shoulders, the Arrow® reverse shoulder prosthesis (FhOrthopaedics, Mulhouse, France) in 76 (18.6%) shoulders, the RSP® (RSP; DJO Surgical, Austin, Texas) in 60 (14.8%) shoulders, the Zimmer® anatomical shoulder reversed prostheses (Zimmer, Warsaw, IN, USA) in 27

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Table 2 Reasons of exclusion of the studies

References	Reason of exclusion
Werner et al. [19]	The study includes revisions of hemiarthroplasty/total anatomical arthroplasty
Frankle et al. [42]	The study not describes the surgical technique
Guery et al. [21]	It includes fractures and rheumatoid arthritis
Simovitich et al. [23]	The study not evaluates ROM and clinical outcomes
Simovitich et al. [22]	The study not reports radiographic result
Grassi et al. [24]	The study includes fractures, instability and revisions
Young et al. [25]	The study includes fractures, instability and revisions
Boileau et al. [26]	The study includes fractures
Favard et al. [27]	The study not reports radiographic outcomes and information on surgical approach;
Bries et al. [28]	The study not reports evaluation of ROM and clinical outcomes
Coe et al. [29]	The study not evaluates ROM, clinical and radiographic outcomes
Day et al. [30]	The study includes revisions of hemiarthroplasty
Lawrence et al. [56]	The study includes fractures
Wiater et al. [35]	The study includes failed hemiarthroplasty and rheumatoid arthritis
Ek et al. [32]	The study includes tendon transfer associated with RTSA
Ji et al. [33]	The study includes fractures
Young et al. [34]	The study not reports radiographic outcomes

RC rotator cuff, *RTSA* reverse total shoulder arthroplasty, *ROM* range of motion

(6.6%) shoulders and the Aequalis® reverse prostheses (Tornier SAS, Montbonnot, France) in 3 shoulders (0.7%). In another 36 (8.8%) shoulders of 32 (8.1%) patients, the type of RSA implanted was not reported.

The humeral stem retroversion was 30° in 131 (32.1%) shoulders, 20° in 76 (18.6%) shoulders and from 10° to 20° in 141 (34.5%) shoulders. A RSA with a lateralized COR was implanted in 60 (14.8%) shoulders [36].

Immobilization and rehabilitation period

The length of the postoperative immobilization period was not reported in 113 (17.4%) patients, and in the other 283 (82.6%) patients it averaged 4.6 ± 2.5 weeks (range 3–6 weeks). The same group of patients (82.6%) started passive motion exercises at an average time from surgery of 1.8 ± 1.1 days (range 1–3 days), while active exercises started at an average time from surgery of 38.2 ± 29.3 days (range 9–77 days).

Outcomes assessment

AQ5 Preoperative and postoperative clinical outcomes were assessed using the visual analog scale (VAS) in 268 (65.7%) patients, the American shoulder and elbow surgeons score (ASES) [43] in 228 (57.6%) patients, the Constant–Murley shoulder score [43] in 215 (54.3%) patients, the subjective shoulder value (SSV) [43] in 71 (17.9%) patients, the Oxford shoulder score (OSS) [43] in 68 (17.2%) patients, the University of California Los Angeles shoulder score (UCLA) [43] in 68 patients (17.2%), the SF-36 [43] in 60 (15.2%) patients, the simple shoulder test (SST) [43] in 37 (9.3%) patients and the Shoulder Pain and Disability Index (SPADI) [43] in 36 (9.1%) patients. The disability of arm shoulder and hand score (DASH) [44] was administered to 68 (17.2%) patients only postoperatively.

Functional outcomes were assessed preoperatively and postoperatively measuring active ROM of the operated shoulder in all patients. Active anterior elevation and external rotation with the arm in adduction were measured in all patients, active abduction was measured in 188 (46.1%) shoulders, active external rotation with the arm at 90° of abduction was measured in 113 (27.7%) shoulders, and active internal rotation was measured in 203 (53.8%) shoulders.

Clinical and functional outcomes

All clinical scores improved after surgery in a statistically significant fashion (Table 3). At the same time, we found a statistically significant improvement in the degrees of anterior elevation, abduction and external rotation ROM when comparing the preoperative value with the postoperative value (Table 4). Also internal rotation ROM improved after surgery. However, it was not possible to perform a statistical comparison of the preoperative and postoperative values due to inhomogeneity of reporting this information.

We found that the degrees of retroversion of the humeral stem of the RSA do not influence the functional outcomes of RSA (Table 5). AQ6

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Table 3 Comparison between preoperative and postoperative clinical scores

Clinical score	N° shoulders (%)	Preoperative	Postoperative	P value
VAS	268 (65.7%)			
Pain		6.5 ± 0.4 (6.3–7)	1.8 ± 0.4 (1.4–2.2)	$P < 0.05$
Function		3 ± 1.7 (2.7–3.2)	6.5 ± 3.9 (6–7.1)	$P < 0.05$
ASES	228 (57.6%)	29.4 ± 5.2 (24–34.3)	72.2 ± 4.1 (68.2–76.1)	$P < 0.05$
Pain	120	18.1 ± 0.07 (18.1–18.2)	40 ± 18.5 (38.7–41.3)	$P < 0.05$
Function	120	15.7 ± 0.6 (15.3–6.1)	31.8 ± 14.8 (29.4–34.2)	$P < 0.05$
CONSTANT	215 (54.3%)	31.4 ± 7.5 (24–41.4)	60.3 ± 1.2 (59–61.8)	$P < 0.05$
SSV	71 (17.9%)	23	76.9	$P < 0.05$
OSS	68 (17.2%)	21.8 ± 0.4 (21.5–22)	40.6 ± 0.2 (40.5–40.8)	$P < 0.05$
UCLA	68 (17.2%)	15.2 ± 0.1 (15.1–15.2)	26.9 ± 0.8 (26.3–27.7)	$P < 0.05$
SF-36	60 (15.2%)			
Physical		31.8	41.6	$P < 0.05$
Mental		36.8	47.4	$P < 0.05$
SST	37 (9.3%)	2	7.5	$P < 0.05$
SPADI	36 (9.1%)	77	34	$P < 0.05$
DASH	68 (17.2%)	N.R.	32.2	$P < 0.05$

VAS visual analogue scale, *ASES* American shoulder and elbow surgeons score, *CONSTANT* Constant–Murley shoulder score, *SSV* subjective shoulder value, *OSS* Oxford shoulder score, *UCLA* University of California, Los Angeles shoulder score, *SF-36* Short form SF-36, *SST* subjective shoulder test, SPADI, *DASH* disability of arm shoulder and hand score, *NR* not reported; *P* value: result of the Wilcoxon–Mann–Whitney test

Table 4 Comparison between preoperative and postoperative range of motion

ROM	N° shoulders	Preoperative	Postoperative	P value
Anterior elevation	408 (100%)	51 ± 13.2 (34–66)	124.4 ± 11.9 (105.1–144)	$P < 0.05$
Abduction	188 (46.1%)	41.1 ± 5.7 (36–49)	115.4 ± 9.8 (101.8–125)	$P < 0.05$
External rotation with the arm in adduction	408 (100%)	17.1 ± 6.9 (11–29)	27.7 ± 13.8 (13.9–51)	$P < 0.05$
External rotation with the arm at 90° of abduction	113 (27.7%)	18.5 ± 0.7 (18–19)	47 ± 4.2 (44–50)	$P < 0.05$

ROM range of motion; *P* value: result of the Wilcoxon–Mann–Whitney test; Mean ± SD (Range)

Complications

Clinical and radiographic complications were reported in all studies. We found 71 (17.4%) complications, resulting in a total of 30 (7.3%) revision surgeries. The different types of complications are listed in (Table 6).

Discussion

In this systematic review, we have evaluated the outcomes of RSA for the management of MIRCT and CTA. Strict inclusion and exclusion criteria were applied in the article selection process. For this reason, we could include only seven articles in our qualitative synthesis, but no one of them was a level I clinical trial.

As shown in the demographic results of our study, the implantation of RSA is more common in women than in men (68.5 vs 31.5%), usually in their sixth or seventh decade of life, involving the dominant arm in approximately 70% of the cases. These findings demonstrate that both MIRCT and CTA produce a negative impact on patient's quality of life.

RSA is a valuable surgical option to manage MIRCT or CTA. It showed the capacity to restore pain-free ROM, ameliorating the clinical condition of the patients. Indeed, all the clinical scores improved in a statistically significant fashion after surgery. Moreover, active internal rotation

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Table 5 Comparison of ROM between RTSA with 30° of humeral stem retroversion and 10°–20° of humeral stem retroversion

Range of motion	30° of humeral stem retroversion	10°–20° of humeral stem retroversion	*P* value
Anterior elevation	113.2 ± 8.1 (105.1–121.3)	127 ± 9.9 (113–144)	$P > 0.05$
Abduction	101.8 (NR)	117.5 ± 0.5 (117–118)	$P > 0.05$
External rotation with the arm in adduction	27.8 ± 13.2 (14.6–41.1)	22.8 ± 7.9 (13.9–33)	$P > 0.05$

Mean ± standard deviation (range)

NR not reported

Table 6 Complications and revision rate

Complication	*N*° (%)	Revisions (%)
Transitory nerve injury	3 (0.7%)	0
Deep venous thrombosis	2 (0.4%)	0
Hematoma	1 (0.2%)	0
Infection	4 (0.9%)	3 (75%)
Pneumonia	1 (0.2%)	0
Humeral fracture	3 (0.7%)	0
Scapular fracture	3 (0.7%)	0
Acromion fracture	11 (2.7%)	0
Coracoid fracture	1 (0.4%)	0
Humeral stem loosening	3 (0.7%)	3 (100%)
Failed baseplate	9 (2.2%)	9 (100%)
Center screw breakage	3 (0.7%)	0
Mechanical failure	10 (2.4%)	10 (100%)
Metaglene loosening	2 (0.4%)	0
Glenoid luxation	4 (0.9%)	4 (100%)
Glenoid radiolucency	12 (2.9%)	0
Dislocation	5 (1.2%)	1 (20%)
Heterotopic ossification	27 (6.6%)	0

ROM improved after RSA. However, we were unable to perform a statistical evaluation of the improvement in active internal rotation, because in some studies it was reported as degrees of internal rotation in the scapular plane, while in other studies it was reported as the vertebra that the patient can reach with the hand keeping the elbow flexed to 90°.

Active anterior elevation, abduction and external rotation ROM improved after RSA in a statistically significant fashion when comparing the preoperative with the postoperative value. The mean improvement in active anterior elevation and abduction ROM was 73.4° and 74.3°, respectively. The mean improvement in active external rotation with the arm adducted was only 10.6° and 28.5° with the arm at 90° of abduction. Although the improvement in active external rotation was lower than the improvement in other ROM considered, this resulted statistically significant.

Several studies showed that RSA fails the restoration of external rotation ROM [22, 45, 46]. The loss of the external rotation may be a major problem for patients using the arm in abduction, as the gain in elevation could be not sufficient to supply their impairment [22]. The deltoid is able to restore anterior elevation and abduction ROM, but it cannot provide external rotation alone. Usually, in patients with MIRCT or CTA in which the postero-superior aspect of the RC is deficient, the only external rotator muscle available is the teres minor (TM) [47]. Accordingly, the active external rotation ROM achieved after RSA depends on the condition of the TM. Especially in the elderly population, it can be retracted, atrophied or fatty infiltrated [48]. Probably, a preoperative accurate MRI evaluation of the TM could be useful to predict the capacity to externally rotate the arm in patients with MIRCT or CTA undergoing RSA [22], offering also the possibility to plan a tendon transfer procedure in association with RSA [49]. Some authors [45, 50, 51] proposed to improve humeral retroversion to increase active external rotation ROM. In several biomechanical studies, it was reported that placing the humeral component retroversion at 20° [52] or from 20° to 40° [53] increases the degrees of external rotation and impingement free ROM, reducing scapular notching. On the other hand, better internal rotation ROM can be obtained improving the humeral stem anteversion [45, 50, 51]. We have compared the functional results of patients underwent RSA with the humeral stem placed at 30° of retroversion with those underwent RSA with humeral stem placed at 10°–20° of retroversion. No statistically significant differences were found, although active anterior elevation and abduction ROM were better in patients with the humeral stem placed at 10°–20° of retroversion, while external rotation ROM was better in patients with the humeral stem placed at 30° of retroversion. These findings support the theory of Grammont and Baulot [50], Grammont et al. [51] and Boileau et al. [45], while they are in contrast with the results of the biomechanical study of Henninger et al. [54]. Probably, the discrepancies of the results could be related to the different nature of these studies.

RSA medializes the COR and lowers the humeral head, improving deltoid level arm [19, 55]. Nevertheless, various complications may result from the non-anatomical design of the RSA. Anterior impingement is responsible for limited internal rotation, while posterior impingement limits external rotation ROM. Infero-medial impingement

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produces inferior scapular notching during rotation and adduction ROM. Polyethylene wear and bone erosions were found in patients with infero-medial impingement [45]. Impingement of the great tuberosity against the acromion, coracoid process and scapular spine was also described. The first limits abduction and anterior elevation ROM, while the second and third limit internal and external rotation ROM, respectively. Poor soft tissue tension could result from the medialization of the COR producing prosthetic instability because of gleno-humeral impingement [45]. In our study, we found 17.4% of complications. The most frequent was heterotopic ossification, occurring in 6.6% of patients. Infection was also common. In 7.6% of patients, revision surgery was necessary. The majority of revision surgeries were necessary because of prostheses component loosening, mechanical failure and dislocations.

The most important strength of our study is that it was conducted following the PRISMA guidelines. As shown in our previous study [43], this method of articles selection, data extraction and analysis of the results improves the quality of the information obtained. Moreover, two independent reviewers evaluated the same information from the selected articles in a blinded fashion. Furthermore, we have included only articles reporting preoperative and postoperative outcomes and complication of RSA in patients with MIRCT or CTA at a minimum follow-up period from surgery of 12 months.

The major limitation of our systematic review is represented by the lack of high-quality clinical trials included in the qualitative synthesis, because no level I studies were found about the topic. Another important limitation is represented by the nature of our study. Thirdly, we included articles reporting about RSA performed as primary surgery or revision surgery of failed RC repair. However, Sadoghi et al. [37] found no functional or clinical differences between patients presenting with failed RC surgery and patients with MIRCT who are managed with RSA. Finally, we could include only seven studies [20, 36–41] reporting outcomes about 408 shoulders affected by MIRCT or CTA and managed with RSA. This sample of patients is not enough robust to reach definitive conclusions about the potentials and limits of RSA in patients with MIRCT and CTA.

Conclusions

RSA is a safe and effective surgical option for the management of patients with MIRCT or CTA. It relieves pain and improves the function of the shoulder, restoring the capacity to perform several activities of daily living. Statistically significant improvement in all clinical scores and ROM was found after RSA. Despite the improvement in active external rotation ROM resulted statistically significant, it remains limited, and it is better in patients who underwent RSA with the humeral stem placed at 30° of retroversion than in patients who underwent RSA with the humeral stem placed at 10°–20° of retroversion. Furthermore, intraoperative and perioperative complications occur in a high percentage of patients, resulting in high revision rate.

Taking into account the nature of the present study, the lack of level I clinical trials included in our qualitative synthesis represents an important limitation for the real understanding of the issue. Further level I studies are required to better understand the results, complications, potentials and limitations of RSA for the management of MIRCT and CTA.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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