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## Mid- to long-term clinical outcomes after press-fit short stem reverse shoulder arthroplasty



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**Background:** To date, a limited number of studies report mid- to long-term outcomes of press-fit short stem shoulder arthroplasty. The purpose of this study was to report and analyze mid- to long-term outcomes in a series of patients that received press-fit short stem reverse shoulder arthroplasty (RSA). The hypothesis was that press-fit short stem RSA would be a safe and effective treatment with satisfactory mid- to long-term outcomes.

**Methods:** The authors retrospectively reviewed the records of 60 patients that received RSA using press-fit uncemented short humeral stems by two surgeons between March 2014 and December 2015. The absolute Constant Score (CS), age-/sex-adjusted CS, and the American Shoulder and Elbow Surgeons (ASES) score were recorded preoperatively and postoperatively at a minimum follow-up of 6 years. The proportions of patients that achieved a satisfactory outcome after RSA were based on the substantial clinical benefit, as proposed for the absolute CS (net improvement  $\geq 19.1$ ).

**Results:** Of the initial cohort of 60 patients, 9 (15%) died of causes unrelated to RSA, 5 (8%) were revised with partial implant removal, and 4 (7%) were lost to follow-up. This left a final cohort of 42 patients (70%) with complete postoperative CS (absolute and age-/sex-adjusted) and ASES scores at a mean follow-up of  $6.7 \pm 0.5$  years (range, 6.1–7.8). Of the final cohort, 11 (18%) had complications, of which 9 (15%) were treated conservatively, and 2 (3%) required reoperations without implant removal. Net improvements in functional outcomes were  $34.7 \pm 21.2$  for the absolute CS,  $54\% \pm 32\%$  for the age-/sex-adjusted CS, and postoperative ASES scores were  $87.9 \pm 13.7$ . Of the 29 patients who had complete records for absolute CS, 22 (76%) received a substantial clinical benefit (net improvement  $\geq 19.1$ ).

**Conclusions:** Mean net improvements of absolute CS exceeded the substantial clinical benefit after press-fit short stem RSA at a follow-up of 6.1 to 8.6 years. While 5 patients (8%) experienced postoperative instability, none had fracture sequelae, which indicates that offset or angular adjustments may be required even in patients with normal bony anatomy. Press-fit short stem RSA is a safe and effective treatment with satisfactory mid- to long-term outcomes, with no stem revisions for aseptic reasons, which compares favorably to the literature that reports high rates of osteolysis and subsequent stem loosening.

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Stemmed humeral components remain the gold standard in total shoulder arthroplasty (TSA) and reverse shoulder arthroplasty (RSA).<sup>4</sup> Compared to first-generation implants, manufacturers have

short stems in subsequent generations,<sup>2,13</sup> with the aim to reduce risks of malpositioning, loosening, and periprosthetic fractures.<sup>14</sup> Recent years have seen a rise in the use of uncemented, press-fit short stems, <10 cm long,<sup>9</sup> as their potential benefits include shorter surgery times, better bone stock preservation in cases of revision, and easier access in shoulders with substantial humeral deformity.<sup>1,2,10</sup>

Controversy remains regarding the best method for optimal humeral fixation. Traditionally, cemented fixation was mandatory, but studies have revealed adequate osseointegration for stability in

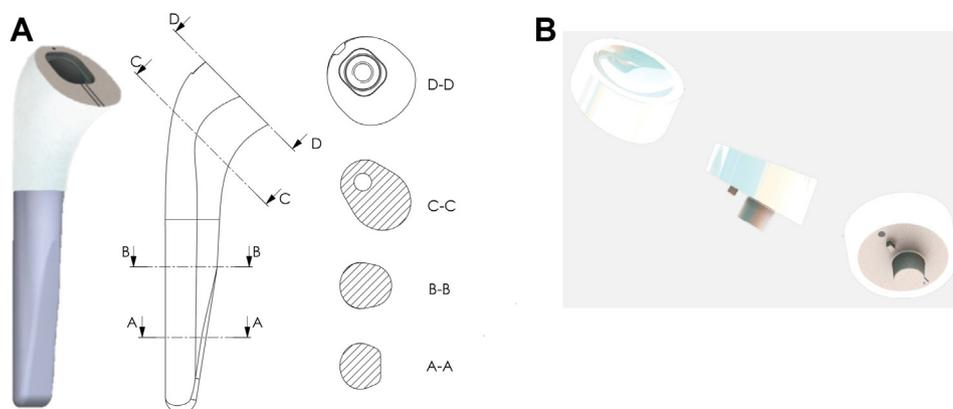
Ramsay Santé Scientific Advisory Board Ethics Committee Institutional Review Board approved this study. Scientific Advisory Board IRB number: IRB00010835. All participants provided informed consent for the use of their data.

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**Figure 1** Graphical presentation of the humeral assembly of the press-fit short stem RSA system. RSA, reverse shoulder arthroplasty.

second- and third-generation implants yielding good short-term function and lower complication rates.<sup>13,16</sup> Proximally coated short stems have been reported to demonstrate a loosening rate ranging from 0% to 8% that is mostly associated with infection.<sup>2</sup> Other potential complications include component malalignment and higher rates of mechanical failure.<sup>2</sup>

To date, a limited number of studies report mid- to long-term outcomes of press-fit short stem shoulder arthroplasty.<sup>1,10</sup> The purpose of this study was to report and analyze mid- to long-term outcomes in a series of patients that received press-fit short stem RSA. RSA has been shown to be an effective treatment for patients with a variety of conditions including cuff tear arthropathy, massive rotator cuff tear, osteoarthritis, and rheumatoid arthritis.<sup>6</sup> The hypothesis was therefore that press-fit short stem RSA would be a safe and effective treatment with satisfactory mid- to long-term outcomes.

## Materials and methods

### Cohort

The authors retrospectively reviewed the records of 60 patients that received RSA using press-fit uncemented short humeral stems (Humeris Reversible, FX Solutions, Viriat, France) by two surgeons (GN and EL) between March 2014 and December 2015. The indications for RSA were cuff tear arthropathy ( $n = 35$ ), primary osteoarthritis ( $n = 13$ ), massive rotator cuff tear ( $n = 7$ ), and trauma sequelae ( $n = 5$ ). Contraindications for RSA were slightly dislocated or nondislocated fractures, dislocation fractures in elderly patients, severe muscular, neurological or vascular deficiencies affecting the joint, bone destruction or poor bone quality.

### Implant design

The humeral stem, manufactured from Ti6Al4V ELI, has a stem length of 100 mm which was available in 4 diameters of 8, 10, 12, and 14 mm. The distal end of the stem is tapered medially to create a trapezoidal shape which facilitates insertion and reduces stress shielding on the lateral side (Fig. 1). The proximal surface has a layer of plasma-sprayed titanium coated with plasma-sprayed hydroxyapatite (Ti+HA). The humeral cup attaches to the stem by means of a 10 mm male taper, and consists of ultra-high molecular weight polyethylene (UHMWPE) net-shaped molded within a Ti6Al4V alloy disc. The asymmetric cups are offered in 2 diameters of 36 or 40 mm, and 3 thicknesses of 3, 6, or 9 mm, to obtain a reversed configuration at 145°.

A glenoid baseplate of 24 mm diameter, manufactured from Ti6Al4V ELI, has a 17 mm central tapered post which can be extended by 6 or 10 mm. Fixation is established by locking and/or compressing screws which have a  $\pm 12^\circ$  angular tolerance. The screw at the top position has a fixed  $10^\circ$  angular offset. The glenospheres attach to the baseplate by a screw mechanism and peripheral taper, and are manufactured from cobalt chromium (CoCr). The glenospheres are 36 or 40 mm diameter, and are offered in a centered or eccentric option. All glenospheres are lateralized by 3.5 mm, and the articular surface extends  $10^\circ$  beyond the equator which lateralizes the center of rotation to help reduce the potential of scapular notching by the humeral cup.

### Surgical technique

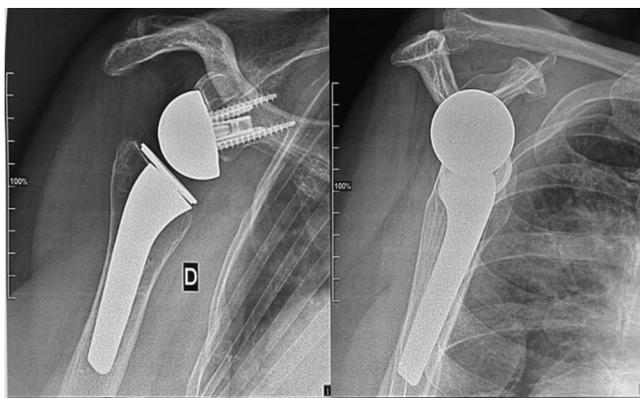
All patients were operated under general anesthesia in a beach chair position or prone position (surgeon choice) following a deltopectoral approach. The baseplate was impacted and screwed to the glenoid by compressive or locking screws depending on bone quality and surgeon experience. The glenosphere was then impacted and screwed to the baseplate. The humeral stem was impacted and positioned to respect the native retroversion of the humerus (Fig. 2).

### Rehabilitation

The patients' shoulders were immobilized in either internal or neutral rotation using a sling. Passive range of motion exercises were initiated on the first postoperative day. Depending on surgeon assessment, active range of motion exercises started after 4 to 6 weeks, under the supervision of physiotherapists.

### Functional outcomes

The primary functional outcomes were the absolute Constant Score (CS), age-/sex-adjusted CS, and the American Shoulder and Elbow Surgeons (ASES) score. Functional outcomes were recorded preoperatively and postoperatively at a minimum follow-up of 6 years. The proportions of patients that achieved a satisfactory outcome after RSA were based on the substantial clinical benefit, as proposed for the absolute CS (net improvement  $\geq 19.1$ ).<sup>18</sup> In addition, complications related to RSA as well as requirement for revision were also recorded. Patients were routinely followed-up at 1 and 12 months after surgery and exceptionally at the final follow-up for the study.



**Figure 2** Radiograph illustrating postoperative implant positioning at 8 years follow-up.

### Informed consent

This study was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki, and approved by the institutional review board (Ref: COS-RGDS-2022-02-006-NOURISSAT-G). All participants provided informed consent for the use of their data.

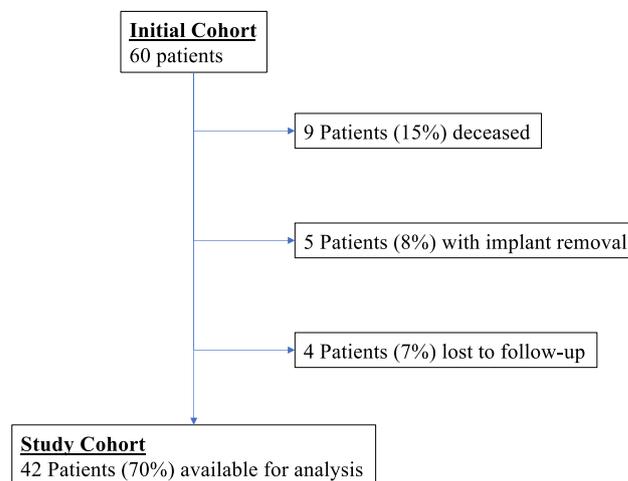
### Statistical analysis

The cohort characteristics were summarized using descriptive statistics. For continuous variables, the mean, standard deviation, range, median and interquartile range were reported, and for categorical variables, the number and proportion were reported. Boxplots were used to visually compare medians and interquartile ranges of postoperative functional outcomes among patients: 1) different indications for surgery. Finally, Shapiro–Wilk tests were used to assess the normality of distributions. Differences between normally distributed groups were assessed using the student's *t* test, whereas differences between skewed groups were evaluated using the Wilcoxon rank sum test (Mann–Whitney *U* test). A *P* value < .05 was considered statistically significant. All analyses were performed using R version 4.1.0 (R Foundation for Statistical Computing, Vienna, Austria).

### Results

Of the initial cohort of 60 patients, 9 (15%) died of causes unrelated to RSA, 2 (3%) had revision for infection with the removal of all components, 3 (5%) had revision of the glenoid component for dislocation, and 4 (7%) were lost to follow-up (Fig. 3, Table I). This left a final cohort of 42 patients (70%) with complete postoperative CS (absolute and age-/sex-adjusted) and ASES scores at a mean follow-up of  $6.7 \pm 0.5$  years (range, 6.1 to 7.8). It is worth noting that of the final cohort, 11 (18%) had complications, 9 (15%) of which were treated conservatively, and 2 (3%) required reoperations without implant removal (Table II). It was not possible to determine factors that could have led to instability in 5 patients due to small sample size and skewed distributions.

Net improvements in functional outcomes were  $34.7 \pm 21.2$  for the absolute CS,  $54 \pm 32$  for the age-/sex-adjusted CS, and postoperative ASES scores were  $87.9 \pm 13.7$  (Table III). Patients indicated for surgery due to trauma sequelae had lower CS (absolute and age-/sex-adjusted) compared to patients indicated for surgery due to cuff tear arthropathy, primary osteoarthritis, or massive rotator cuff tear, but the differences did not reach statistical



**Figure 3** Flowchart of the case series.

significance (Fig. 4, Table IV). Of the 29 patients who had complete records for absolute CS, 22 (76%) received a substantial clinical benefit (net improvement  $\geq 19.1$ ), whereas 7 patients, 3 treated for trauma sequelae and 4 treated for cuff tear arthropathy, did not receive a substantial clinical benefit (Table V). Two of the 3 patients (women aged 76, 80, and 81 years) that were treated for trauma sequelae had postoperative fractures. Of the 4 patients (3 women aged 69, 77, and 81 years and 1 man aged 69 years) that were treated for cuff tear arthropathy 1 received a bursectomy for bursitis and 1 had a postoperative fracture.

### Discussion

The main finding of the present study was that at a follow-up of 6.1 to 8.6 years after press-fit short stem RSA, mean net improvements of absolute CS exceeded the substantial clinical benefit; however, 2 (3%) had revision for infection with the removal of all components, 3 (5%) had revision for dislocation with the removal of the glenoid component only, and 2 patients (3%) required reoperation without implant removal. The findings of this study revealed press-fit short stem RSA to be effective in patients treated for cuff tear arthropathy, massive rotator cuff tear, and primary osteoarthritis, but less effective in patients treated for trauma sequelae. It is also worth noting that 5 patients (8%) experienced postoperative dislocation or subluxation, none of which had fracture sequelae, which indicates that instability could occur even in shoulders without anatomic deformities. Of those 5 patients, only 3 required glenosphere revision without stem removal, while the other 2 were treated by manipulation under anesthesia or physiotherapy, which confirms that the stem position was not a contributing factor for revision. These findings therefore partly support the hypothesis that press-fit short stem RSA is a safe and effective treatment with satisfactory mid- to long-term outcomes, with no stem revisions for aseptic reasons.

The popularity of RSA has increased in recent decades,<sup>10</sup> and the most common primary indications are osteoarthritis (45%), followed by rotator cuff arthropathy (35%) and fracture (15%).<sup>5</sup> While early studies on RSA showed relatively high rates of complications, better outcomes have been reported with newer designs and improved surgical technique<sup>11</sup>; however, complication rates could still range from 1% to 28%.<sup>10,15</sup> The complication rate in the present series was 18%, of which 8% were serious requiring implant removal due to dislocation ( $n = 3$ ) or infection ( $n = 2$ ).

Several studies report a high rate of bone resorption after press fit fixation in RSA,<sup>9</sup> and bone remodeling still remains a

**Table I**  
Cohort characteristics.

	Baseline characteristics (n = 60)		Study cohort characteristics (42)		P value
	Mean ± SD n (%)	(Range)	Mean ± SD n (%)	(Range)	
Age (y)	74.1 ± 8.2	(44-90)	73.8 ± 7.7	(58-87)	n.s.
BMI (kg/m <sup>2</sup> )	28.6 ± 6.0	(20-49)	28.6 ± 6.0	(20-49)	n.s.
Sex (women)	46 (77)		35 (83)		n.s.
Indications					
Cuff tear arthropathy	35 (58)		26 (62)		n.s.
Primary OA	13 (22)		8 (19)		n.s.
Massive rotator cuff tear	7 (12)		4 (10)		n.s.
Trauma sequelae	5 (8)		4 (10)		n.s.
Risk factors					
Overweight (BMI>25)	31 (52)		19 (45)		n.s.
Diabetes	3 (5)		3 (7)		n.s.
Hypertensive	24 (40)		17 (40)		n.s.
Dyslipidemia	5 (8)		4 (10)		n.s.
Osteoporosis	1 (2)		1 (2)		n.s.
Cardiovascular	5 (8)		2 (5)		n.s.
Musculoskeletal	1 (2)		1 (2)		n.s.

BMI, body mass index; OA, osteoarthritis; SD, standard deviation.

**Table II**  
Complications, reoperations, and revisions.

Complication	Reoperation	Treatment	Implant removed
Fracture			
Acromion	No	Conservative	
Acromion	No	Conservative	
Acromion	No	Conservative	
Acromion, humerus, and scapula	No	Conservative	
Clavicle	No	Conservative	
Infection	Yes	Implant removal	Stem and glenosphere
Infection	Yes	Implant removal	Stem and glenosphere
Infection	Yes	Lavage	
Instability			
Dislocation	Yes	Implant removal	Glenosphere
Dislocation	Yes	Implant removal	Glenosphere
Dislocation	Yes	Implant removal	Glenosphere
Dislocation	No	MUA	
Subluxation	No	Physiotherapy	
Other			
Axillary nerveneurapraxia with partial deltoid palsy	No	Physiotherapy	
Bursitis pain	Yes	Bursectomy	
Urinary tract infection	No	Conservative	

MUA, manipulation under anesthesia.

**Table III**  
Functional outcomes of the study cohort (n = 42).

	Mean ± SD n (%)	(Range)	Median	(IQR)
Follow-up (years)	6.7 ± 0.5	(6.1-7.8)		
Absolute CS				
Preoperative*	32.0 ± 8.5	(18.5-50.0)	32.0	(24.0-36.0)
Postoperative	66.3 ± 22.4	(19.0-94.0)	71.2	(57.0-82.5)
Net improvement*	34.7 ± 21.2	(-9.0-68.5)	37.0	(23.0-48.0)
Substantial clinical benefit	22 (76%)			
Age-/sex-adjusted CS				
Preoperative*	45% ± 12%	(27%-71%)	43.4	(37.0-50.0)
Postoperative	100% ± 33%	(30%-147%)	108.0	(85.7-122.0)
Net improvement*	54% ± 32%	(-14%-109%)	54.7	(40.7-77.4)
ASES score				
Preoperative†	39.3 ± 6.9	(31.7-55.0)	39.2	(34.6-41.2)
Postoperative	87.9 ± 13.7	(55.0-100.0)	93.3	(81.2-98.3)

CS, Constant Score; ASES, American Shoulder and Elbow Surgeons; SD, standard deviation; IQR, interquartile range.

\*Complete preoperative records for only 29 patients.

†Complete preoperative records for only 10 patients (ASES was not systematically collected preoperatively).

hypothetical weakness of short stem designs.<sup>12</sup> Short stems potentially protect proximal humeral bone stock by shifting the location of humeral fixation from the diaphysis to the metaphysis

which could prevent stress shielding, subsidence, and loosening.<sup>1,12</sup> The findings of the present study are therefore encouraging as there were no symptoms of humeral stem loosening, although

Clinical outcomes by indication

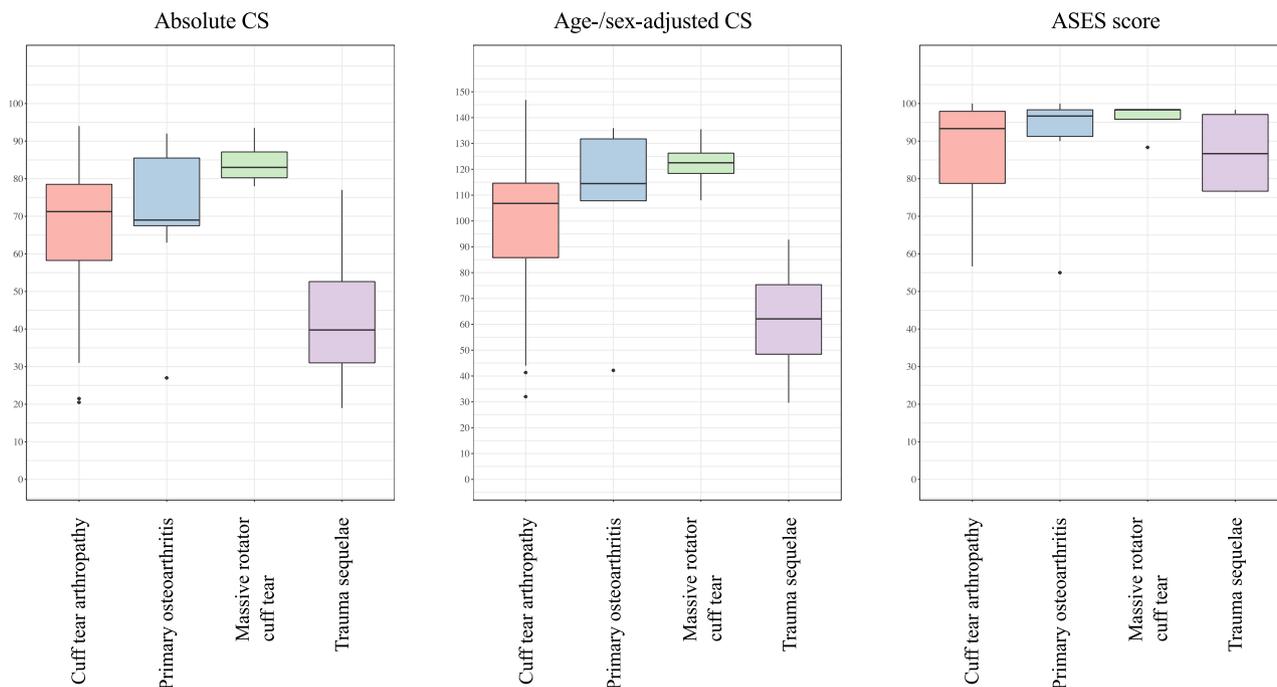


Figure 4 Comparison of clinical outcomes by indications for surgery. CS, Constant Score; ASES, American Shoulder and Elbow Surgeons.

Table IV Functional outcomes of the study cohort according to indication.

	CTA (n = 26)	Primary OA (n = 8)	Massive RCT (n = 4)	Trauma sequelae (n = 4)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Absolute CS				
Preoperative	34.3 ± 7.7	24.9 ± 6.7	32.5 ± 12.4	31.1 ± 6.4
Postoperative	65.7 ± 22.2	70.1 ± 20.4	84.4 ± 6.7	43.9 ± 24.5
Net improvement	30.8 ± 19.5	50.9 ± 14.2	34.7 ± 21.2	34.7 ± 21.2
Age-/sex-adjusted CS				
Preoperative	47% ± 12%	36% ± 10%	45% ± 19%	43% ± 9%
Postoperative	99% ± 32%	111% ± 30%	122% ± 11%	62% ± 26%
Net improvement	48% ± 29%	82% ± 22%	54% ± 32%	54% ± 32%

CTA, cuff tear arthropathy; OA, osteoarthritis; RCT, rotator cuff tear; CS, Constant Score; SD, standard deviation.

radiographs would be needed to ascertain the quality of implant fixation in the long term.

The postoperative absolute CS (66.3) reported for the present series at a mean follow-up of 6.7 years compare favorably to those reported by other studies. Dukan et al<sup>10</sup> reported a mean score of 87.9 at a mean follow-up of 3.2 years. Atoun et al<sup>3</sup> reported a mean score of 56.2 at a mean follow-up of 3 years. Finally, Levy et al<sup>17</sup> reported a mean score of 59 at a mean follow-up of 4.2 years. The present study also revealed that patients with indication of trauma sequelae for RSA had lower absolute and age-/sex-adjusted CS compared to patients with indications of cuff tear arthropathy, massive rotator cuff tear, and primary osteoarthritis. Interestingly, Cowling et al<sup>8</sup> found that patients undergoing RSA for trauma sequelae had higher risks for intraoperative complications, while Cho et al<sup>7</sup> found higher risks for acromial fracture after RSA in patients that had prior surgery. It is noteworthy that 3 of the 7 patients that did not receive a substantial clinical benefit were treated for trauma sequelae after failed previous interventions, and 2 of the 3 also had postoperative fractures, one of the acromion and the other of the scapula. These findings suggest that surgeons

should carefully consider treatment by RSA in this group of patients, which warrants future investigations to identify specific factors that could lead to suboptimal outcomes.

The present study revealed encouraging results at mid- to long-term after press-fit short stem RSA, but these findings should be interpreted with the following limitations in mind. First, this was a retrospective analysis of clinical outcomes after RSA at mid- to long-term. Pooling of demographics, surgical data, and functional outcomes could be subject to high levels of heterogeneity. Second, the purpose of this study was to only report on mid- to long-term outcomes in a series of patients who received press-fit short stem RSA, and the study might not be adequately powered to draw any definitive conclusions from the comparisons made in terms of indications for surgery. Third, there were no preoperative or postoperative radiographs available to assess implant position, alignment, or signs of osteolysis. The final follow-up occurred during the COVID-19 pandemic, and it was inappropriate to recall asymptomatic elderly patients for radiographic follow-up, to avoid exposure to the disease as per national guidelines.

**Table V**  
Demographics of patients who did not achieve the substantial clinical benefit for absolute CS.

Sex	Age, years	Previous surgery	Risk factors				Complications		Follow-up, years	Absolute CS			Age-/sex-adjusted CS			
			BMI >25	Diabetes	Hypertensive	Osteoporosis	# Risk factors	Type		Treatment	Preoperative	Postoperative	Net improvement	Preoperative (%)	Postoperative (%)	Net improvement (%)
Trauma sequelae																
Woman	81	Failure of previous treatment for trauma using pin/nail					0			7.4	34	45	11	52	70	17
Woman	76	Failure due to necrosis following synthesis for treatment of proximal humeral fracture	Yes			Yes	2	Fracture: acromion humerus and scapula	Conservative	6.2	32	35	3	46	55	8
Woman	80	Failure of orthopedic treatment - malunion and pseudarthrosis	Yes				1	Fracture: clavicle	Conservative	6.2	22	19	-3	32	30	-2
Cuff tear arthropathy																
Man	69		Yes		Yes		2			6.2	40	33	-7	48	44	-4
Woman	77				Yes		1	Bursitis pain	Bursectomy	6.8	28	38	10	40	59	19
Woman	69			Yes	Yes		2			6.2	50	69	19	71	100	29
Woman	81		Yes		Yes		2	Fracture: acromion	Conservative	6.8	40	31	-9	63	48	-14

CS, Constant Score; ASES, American Shoulder and Elbow Surgeons; BMI, body mass index.

## Conclusion

Mean net improvements of absolute CS exceeded the substantial clinical benefit after press-fit short stem RSA at a follow-up of 6.1 to 8.6 years. While 5 patients (8%) experienced postoperative instability, none had fracture sequelae, which indicates that offset or angular adjustments may be required even in patients with normal bony anatomy. Press-fit short stem RSA is a safe and effective treatment with satisfactory mid- to long-term outcomes, with no stem revisions, which compares favorably to the literature.

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