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Short-Term Radiographic Outcomes of Bone Versus Metallic Augmented, Central Screw Type Baseplate in Reverse Total Shoulder Arthroplasty: Matched Case-Control Study

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Abstract

Background: Although glenoid bone grafting and metallic augmented baseplates have demonstrated success in restoring the glenohumeral joint line in the recent literature, there remain no consensus guidelines defining the use of one versus the other.
Methods: Between 2017 and 2020, 15 primary RTSA with screw-in metallically augmented glenoid baseplates were identified and 2:1 matched by age, sex, and body mass index with primary bony-augmented glenoid baseplate patients. Patients with previous glenoid implantation or fracture were excluded. Charts, routine radiographic series (Grashey, Scapula Y, Axillary lateral), and 3-dimensional computed tomography (3D CT) scans were retrospectively reviewed. Structural patient-specific metal or bony augmentation was indicated based on preoperative glenoid morphology as identified by 3D CT. Aseptic failure was identified as hardware breakage and/or shift in glenoid baseplate component position.
Results: There were 45 eligible cases with mean age of 65.7 years (range 44-85 years) and 65.5 years (range 42-82 years) for the metallic-augmented and bone graft group, respectively. Correspondingly, mean follow up was 22.6 months (range 12-53 months), and 27.3 months (range 11-53 months). At latest follow up, there were no baseplate failures in the metallic augment group and 2 baseplate failures (7%) in the bone graft group at a mean of 42.5 months (range 32-53 months) postoperatively. Mean age of the bone failure group was 64.5 years (range 64-65 years).
Conclusion: Contemporary reversed shoulder arthroplasty glenoid baseplate designs appear to have low incidence of failure. Further analysis is necessary to determine if a critical degree of glenoid retroversion or inclination is preferable with a specific form of augmentation.
Level of Evidence: III; Retrospective Cohort Comparison.

Keywords
reverse total shoulder arthroplasty, glenoid augmentation, glenoid bone loss, baseplate augmentation, Bio-RSA, radiographic outcome

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Introduction

While reverse total shoulder arthroplasty has become a standard surgical procedure for complex shoulder pathologies, severe glenoid bone loss still presents a unique challenge to surgeons. Due to poor glenoid bone stock, failure to secure the baseplate to the bone and acquire stable baseplate fixation can predispose early loosening, and early mechanical failure of the baseplate.[1–4]

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Today, glenoid deficiencies of various degrees have been reported in up to 50% of primary RTSA patients, with different wear patterns being more prevalent than others.[5] Two main options for treatment include preferential reaming or glenoid augmentation. Reaming can address the erosion; however, it can lead to medialization of the joint line[6] and poor soft tissue balancing. The alternative is to restore the glenohumeral joint line via glenoid augmentation. The most common methods of augmentation include humeral head autograft or metallic augmented implants.[7] There are concerns that arise for both techniques, including the potential for nonunion or bone graft resorption with bony augmentation, and the lack of customizability with metallic augmentation.[8]

As of current, no consensus treatment has been defined between the use of bony or metallic augmentation for RTSA patients.[9] The aim of the present study was to compare the rate of baseplate failure and other associated radiographic complications in matched cohorts of patients who underwent primary RTSA with either metallic or bony augmentation.

Methods

Study Design and Data Collection

Between January 2017 and January 2021, 15 patients who underwent primary RTSA with metallic augmented centrally threaded baseplates (Perform glenoid baseplate, Stryker Tornier, Kalamazoo, MI) were identified. These cases were 2:1 matched by age (±5 years), sex, and body mass index (BMI; ±5 kg/m^2) via MedCalc software program to 30 patients who underwent primary RTSA with bony-augmented (bony increased offset-reversed shoulder arthroplasty, Bio-RSA) centrally threaded baseplates (Reverse threaded post glenoid baseplate, Stryker Tornier). Inclusion criteria included severe glenoid wear (Walch A2, B2, B3, C2, C3 and Favard E2, E3, and E4 glenoid) requiring glenoid reconstruction. Patients with native glenoid, but previous hemiarthroplasty or with septic arthropathy status postirrigation, debridement, and antibiotic spacer placement were also included. Exclusion criteria included patients with scapula fracture, glenoid fracture, or previous glenoid implantations (ie, anatomic total shoulder arthroplasty or reverse total shoulder arthroplasty).

Patient demographic data and medical history were found in the electronic medical records system. Retrospective chart review was performed to record patient demographics, comorbidities, surgical history, and indications. All patient indications were reported. Preoperative routine radiographs including Grashey, Scapula Y, and axillary lateral views were obtained for every patient. In cases with previous implantation, infection serology labs (complete blood count, C reactive protein, and sedimentation rate) were obtained to rule out subtle infections and nerve conduction studies were obtained to rule out associated nerve injuries. The same radiographs were obtained for postoperative follow up and the most recent radiograph at the minimum of 1-year was recorded. All radiographs were independently reviewed by a fellowship-trained shoulder and elbow surgeon (EYL) (Figures 1 and 2).

The primary outcome of interest was baseplate failure. Secondary radiographic outcomes of interest were complications such as dislocation, periprosthetic fracture, humeral loosening, and scapular notching.

Statistical Analysis

The statistical analysis portion of this paper is comprised of 2 types of analyses: descriptive and bivariate. For the descriptive analysis, sample statistics such as mean and standard deviation (if the variable follows a normal distribution), median and interquartile range (if the variable is skewed), minimum, maximum, first quartile, and third quartile were calculated for variables of a continuous type. For variables of a binary or categorical type, frequencies and percentages were calculated. For this specific project, the bivariate analysis calls for the use of the Wilcoxon Rank Sum due to skewness detected individually for the variables of interest being compared. Using a statistical significance threshold of 0.05 to determine if the tests used were statistically significant, all analyses were calculated in SAS, version 9.4.

Surgical Techniques

All surgeries were performed by the senior surgeon (SGK) in a tertiary care hospital setting. All primary RTSA surgeries were conducted in the anterosuperior approach, as previously described.[10] All revision RTSA surgeries were performed in the deltopectoral approach.[11] Patients were positioned in the beach chair position. Preoperative planning included 3-dimensional computed tomography (3D CT) evaluation of the glenoid defect. The glenoid defect was measured to prepare for intraoperative reconstruction.

In a primary RTSA setting, the humeral head is available for autograft harvesting so a threaded baseplate with central screw is selected. Once the proximal humerus is exposed, a Kirschner wire is inserted into the humeral head and a circular saw is used to harvest a cylindrical bone graft. Using a cutting jig, a precisely measured bone graft is fashioned with an oscillating saw. The humeral head autograft is then placed on the back of the threaded baseplate, threaded over the central screw and dialed to match the size and orientation of the glenoid deficiency.[2] All 4 locking screws are inserted. Finally, an appropriately sized glenosphere is selected, impacted over the baseplate, and secured with a set screw.

In the revision setting, as there is no humeral head available for autograft, a metallic augmented glenoid baseplate is used for augmentation. Once the glenoid is exposed, an osteotome is used to debride the fibrous tissue of its

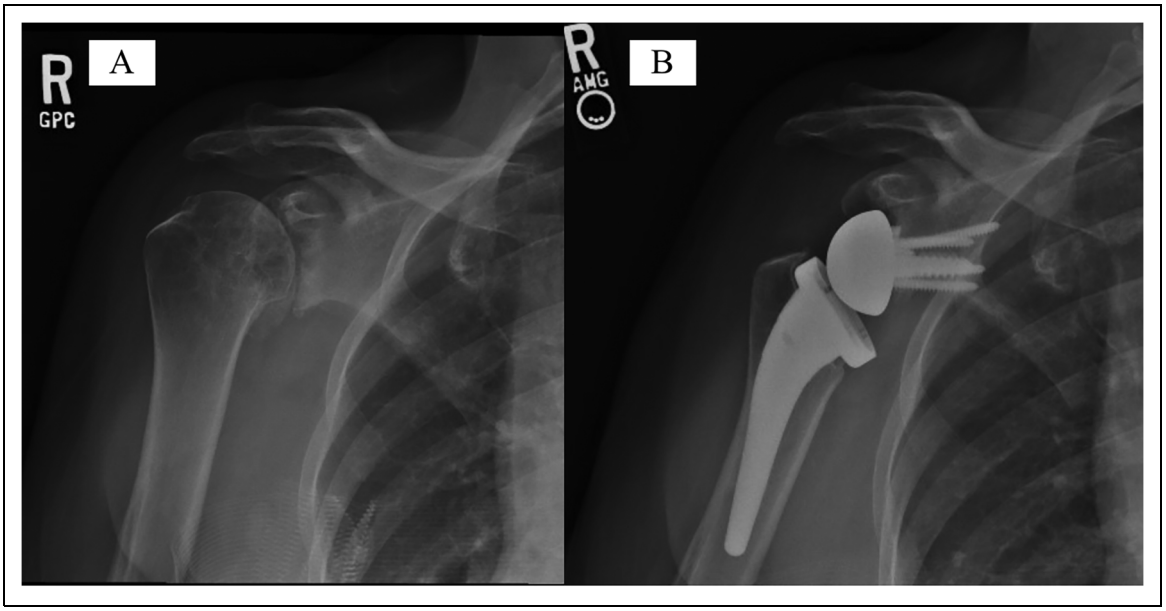

Figure 1. (A) Preoperative and (B) postoperative radiographs of a 67-year-old woman treated with RTSA using a metallic augment baseplate.

surface. As the glenoid wear pattern is confirmed by visualization, a lateralized (+3 or +6) baseplate is used if there is a symmetric, central glenoid defect, and a wedge (half or full) baseplate is used if there is an asymmetric glenoid defect. A guidewire is inserted over the center point of the glenoid and minimal reaming is performed. The augmented baseplate with a central screw is then inserted until seated. All 4 locking and nonlocking screws are inserted. Finally, an appropriately sized glenosphere is also selected, impacted over the baseplate, and secured with a set screw.

After glenoid implantation is completed, humeral implantation is performed per revision shoulder reconstruction protocol.[12] Humeral stem type is selected based on the available humeral bone for reconstruction. Trial reduction is completed to ensure proper stability of the joint. Subscapularis tendon and other rotator cuff tendons are repaired whenever possible.

Results

Both metallic augment (MA) and bone augment (BA) groups completed a mean follow up of 22.6 and 27.3 months, respectively. As both groups were matched, patient characteristics showed no significant differences in regard to age, sex, or BMI. The MA cohort showed more patients with type E glenoid morphologies, while the BA cohort had more patients in the type B glenoid morphology groups (Table 1). Surgical indications for the MA and BA cohort were listed in Table 2. While there were more patients with previous infections and previous hemiarthroplasty in the MA group, the BA group had primarily rotator cuff arthropathy patients. The 2 groups had similar patient comorbidities except for prior hemiarthroplasty (Table 3).

At short-term radiographic follow up, baseplate failure was not seen in the MA group and occurred in 2 cases (7%) in the BA group, which was not statistically significant (Table 4). In terms of radiographic complications, the MA cohort had 3 cases of humeral loosening (20%), 1 case of dislocation (3%), and 1 case of periprosthetic fracture (3%). The BA cohort had 1 case (3%) of scapular notching (Table 4). Only humeral loosening had a statistically significant difference among the 2 groups.

Discussion

As the number of primary RTSAs increases per year, a parallel increase in the incidence of glenoid deficiencies should be anticipated.[1,13] To achieve adequate baseplate fixation, $>80\%$ of native glenoid fixation is desired.[14] Glenoid augmentation with metallic implants or bone graft are the most common techniques to optimize fixation in the setting of glenoid deficiency. However, in the current published literature, there has been no defined gold standard treatment for these patients.

Theoretically, humeral head autograft is an attractive option for patients because the humeral head is always available in primary arthroplasty. It allows for precise patient-specific reconstruction of the glenoid defect and can restore glenoid bone stock biologically for future revision surgeries.[3,15] However, it is technically more difficult and the glenoid bone resorption has been previously reported.[16] Alternatively, metallic augment utilizes off the shelf implants to match the glenoid deficiencies. It can be technically straightforward, and the metal is reliable with no risk of

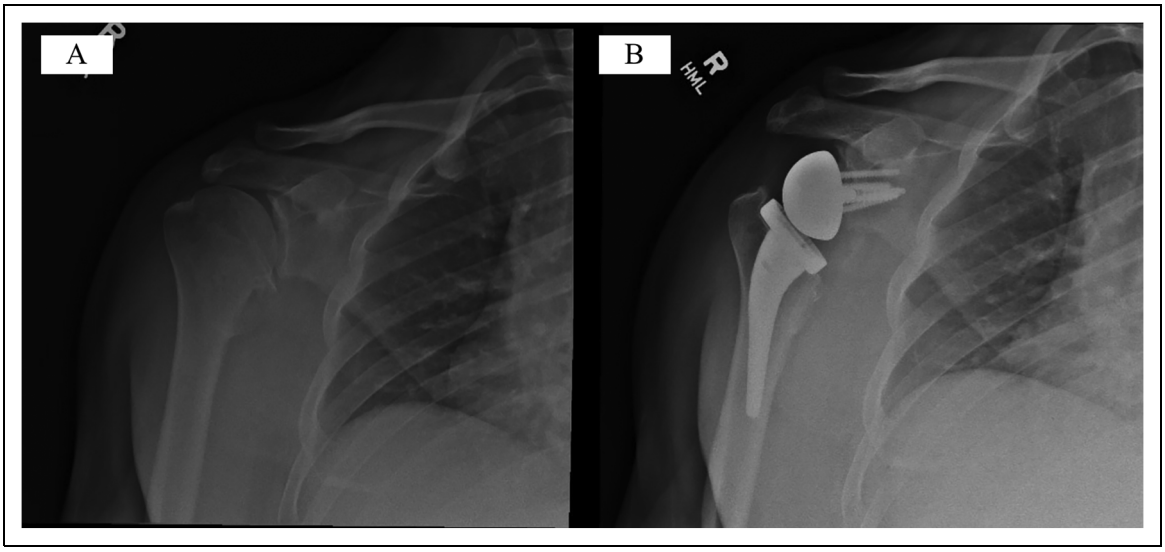

Figure 2. (A) Preoperative and (B) postoperative radiographs of a 42-year-old man treated with RTSA using a bony augment baseplate.

Table 1. Patient Demographics Between Metallic and Bony Augment Groups.

Patient demographics	MA, N = 15	BA, N = 30	*P* value
Mean follow up (months)	22.6	27.3	-
Age, mean ± SD (range)	65.7 ± 11.7 (44-85)	65.5 ± 10.7 (42-82)	.9697
Sex, male:female, N	7:8	14:16	-
BMI, mean ± SD (range)	31.1 ± 4.7 (21.3-40.5)	30.5 ± 4.7 (22.0-43.2)	.6909
Handedness, right: left, N	13:2	27:3	-
Glenoid morphology	5	6	-
A2	0	14	
B2	2	6	
B3	1	0	
D	3	3	
E2	3	1	
E3	1	0	
E4			

Abbreviations: BA, bony augment; BMI, body mass index; MA, metallic augment; N, number of subjects; SD, standard deviation.

Table 2. Indications Between Metallic and Bony Augment Patients.

Indications, n (%)	MA, N = 15	BA, N = 30	*P* value
Septic cuff arthropathy	6 (40)	0 (0)	.0006*
Infection due to failed hemiarthroplasty	3 (20)	0 (0)	.0321*
Rotator cuff arthropathy	2 (13)	28 (93)	<.0001*
Failed hemiarthroplasty	2 (13)	0 (0)	.1061
Proximal humeral bone loss	2 (13)	0 (0)	.1061
Humeral shaft fractures	2 (13)	1 (3)	.1061
Dislocation arthropathy	0 (0)	1 (3)	.6667
Failed ORIF	0 (0)	1 (3)	.6667

Significant *P* values (<.05) are indicated with asterisks (*).
Abbreviations: BA, bony augment; MA, metallic augment; N, number of subjects; ORIF, Open Reduction Internal Fixation.

resorption. However, it can be financially more costly to utilize these specialized glenoid baseplates. At the current time, there have been zero level I randomized clinical trials that directly compare the use of metallic augmentation to bony augmentation. Nabergoj et al[13] compared the use of combined bony and metallic augmentation to use of bony augmentation alone. At 2-year follow up, the bony augmentation group had better clinical outcomes compared to the combined augmentation group; though both groups had similar radiographic failure rates. However, as a retrospective study, the combined augmentation group had more severe glenoid wear, which may account for some of the clinical findings. Van de Kleut et al[9] performed a short-term radiostereometric analysis comparing bony augmentation with a central postbaseplate with a metallic-augmented central screw baseplate. With the primary goal of assessing baseplate migration, the authors noted no statistical significant differences in implant position or clinical outcomes in 2 years. Although the 2 implants are substantially different in design and fixation mechanics, it offered substantial preliminary insights into the bone versus metal debate.

In the current study, the authors performed a retrospective study reviewing 2 similar central screw baseplates with bony and metal augmentation. In the absence of a randomized clinical trial with large patient populations, the two cohorts were patient matched with regard to patient age, gender, and BMI.

Table 3. Patient Comorbidities and Surgical History Between Metallic and Bony Augment Groups.

Patient comorbidities, N (%)	MA, N = 15	BA, N = 30	*P* value
Diabetes	0 (0)	3 (10)	.5402
Rheumatoid disease	2 (13)	1 (3)	.2451
Vitamin D deficiency	3 (20)	9 (30)	.5000
Smoking	0 (0)	1 (3)	1.0000
Cardiovascular disease	6 (40)	19 (63)	.1376
Surgical history, N (%)	**MA, N = 15**	**BA, N = 30**	***P* value**
Hemiarthroplasties	5 (33)	0 (0)	.0025*
Steroid injections	5 (33)	13 (43)	.3976
ORIF	0 (0)	1 (3)	1.0000
Soft tissue surgery	3 (20)	7 (23)	.6724
Total number of surgeries, mean ± SD (range)	0.7 ± 1.0 (0–3)	0.3 ± 0.7 (0–2)	.1146

Significant *P* values (<.05) are indicated with asterisks (*).
Abbreviations: BA, bony augment; MA, metallic augment; N, number of subjects; ORIF, Open Reduction Internal Fixation; SD, standard deviation.

Table 4. Radiographic Complications Between Metallic and Bony Augment Patients.

Complications, n(%)	MA, N = 15	BA, N = 30	*P* value
Humeral loosening	3 (20)	0 (0)	.0321*
Dislocation	1 (3)	0 (0)	.3333
Periprosthetic fracture	1 (3)	0 (0)	.3333
Scapular notching	0 (0)	1 (3)	.6667
Baseplate failure	0 (0)	2 (7)	.5455
Revision due to baseplate failure	0 (0)	0 (0)	1.0000

Significant *P* values (<.05) are indicated with asterisks (*).
Abbreviations: BA, bony augment; MA, metallic augment.

Nevertheless, the 2 cohorts had some baseline differences in their indications, with the MA group having more previous humeral hemiarthroplasty. At short-term follow up, there were no statistically significant differences in overall baseplate failure rates between the metal and bony augmentation groups. There was a higher rate of humeral loosening in the metallic group, which is likely due to the higher rates of previous hemiarthroplasty use.

Proponents of the metallic augments argue that the off the shelf is easy to use and has more reliable implant longevity. This study is unable to demonstrate such findings, as the study duration is not long enough to assess bone resorption and demonstrate the difference among groups. On the other hand, the limited shapes and sizes of the metallic augment implants may theoretically limit their overall customizability and generalized use in all types of glenoid wear patterns.[3,5] In the current study, the metallic augment group was utilized for almost all glenoid types. However, there was no radiographic evidence of its superiority.

The strengths of this study include that it was a single surgeon, single institution cohort. There was minimal variation in surgical techniques and the associated postoperative rehabilitation. The study was designed with patient matched groups via age, sex, and BMI to minimize confounders. However, the study design was a retrospective study and the patient matching led to limited patient enrollment in the comparison groups, which limited the power of the study. Furthermore, the short-term follow up of these patients limits the generalizability of these studies to a shorter postoperative time period. Ultimately, a randomized clinical trial with head-to-head comparison of the implant types may be necessary to control patient indications and surgical history. Longer patient follow up and evaluation of functional outcomes may also reveal superiority of one implant versus the other.

Conclusion

At short-term radiographic follow up, both metallic-augmented and bony-augmented primary RTSA patients had similar incidence rate of baseplate failure and radiographic complication rates. Though the differences in patient indications led to higher humeral complications, no difference in glenoid complications were noted.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

Institutional Review Board: Approved by the Baylor Scott & White Research Institute IRB. Study number 017–084.

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