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Simultaneous bilateral total shoulder arthroplasty with contralateral autograft transfer for glenoid deficiency

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Simultaneous bilateral arthroplasties have been studied extensively in the hip and knee literature.[7,27,28,33] Reports of single-stage bilateral total shoulder arthroplasty (TSA) in the literature to date consist of 2 case series[1,16] and 2 case reports involving proximal humerus fractures.[3,21] The advantages of single-stage bilateral shoulder arthroplasty include reduction in the duration of disability, the total time to recovery, the number of admissions, and episodes of anesthesia as well as the cost of treatment. An addition potential advantage is the use of autograft from the contralateral humerus to reconstruct bone defects in revision shoulder arthroplasties. The case series in the literature comparing single-stage and staged bilateral TSAs demonstrated no difference in complication rates and similar blood loss in case of simultaneous bilateral shoulder arthroplasty. Anyway, given the increased invasiveness of the procedure, the increased surgical time and the more demanding rehabilitation, the indication should be formulated based on each individual patient's health, needs, concerns, and social support system.

The number of TSAs has been increasing rapidly over the past few years. In 2017, an estimated 823,361 patients were living in the United States with a shoulder replacement with a prevalence of 0.258%, increasing markedly from 1995 (0.031%) and 2005 (0.083%).[14] Because of this significant rise in prevalence, shoulder surgeons can expect to increasingly face revisions with concomitant bone defects, which in some cases may be severe. Glenoid component loosening is a common reason for implant failure and a common indication for revision surgery following TSA.[5,9,10,15,41] This complication is commonly associated with progressive glenoid wear which can lead to significant glenoid defects at the time of revision arthroplasty. Large bone loss presents a surgical challenge for revision arthroplasty and several methods are used to address this problem.

This case report describes a revision shoulder arthroplasty for aseptic glenoid component loosening with severe bone loss with significant medialization. A 1-stage revision of stemless endoprosthesis to a bony increased offset-reverse shoulder arthroplasty (BIO-RSA) was performed using autograft from the head of the humerus of the contralateral shoulder, where a reverse shoulder arthroplasty (RSA) was implanted in the same surgery. Consent was obtained for the publication of case material.

Case report

Clinical data

Due to primary glenohumeral osteoarthritis, a 76-year-old woman underwent stemless TSA (screw fixation design) implantation to the left shoulder through a deltopectoral approach. Eight years later, the patient reported progressive restrictions in her daily life because of movement-dependent pain and limited range of motion. She required regular analgesics for pain modulation. Her major comorbidities included arterial hypertension.

Physical examination of the right shoulder revealed absence of irritation, redness, swelling, or hyperthermia. Acromioclavicular

Institutional review board approval was not required for this case report.

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Table I
Active and passive ROM testing of both shoulders.

Preoperative ROM	Right shoulder	Left shoulder
Active flexion	90°	90°
Active abduction	100°	90°
Active external rotation	30°	30°
Active internal rotation	L1	L1
Passive flexion	70°	60°
Active abduction	70°	50°
Active external rotation	50°	50°

ROM, range of motion.

joint and *sulcus intertubercularis* were indolent. Active and passive range of motion testing of both shoulders is summarized in the Table I. Hornblower sign was negative; Jobe test was positive with decreased strength. Strength was good for external/internal rotation. There were no lag signs. The neurovascular examination was normal.

Physical examination of the left shoulder revealed a well-healed deltopectoral scar. There was no tenderness to palpation, no redness, swelling, or hyperthermia. Acromioclavicular joint and *sulcus intertubercularis* were indolent. Hornblower sign was negative; Jobe test was positive with decreased strength. Strength was good for external/internal rotation. There were no lag signs. The neurovascular examination was normal.

Radiographs in the antero-posterior, axial, and Neer projections showed on the right side advanced glenohumeral osteoarthritis with abolished joint space, pronounced osteophyte attachments, and no humeral head elevation (Fig. 1). On the left side, the same projections showed glenoid component loosening with glenoid defect and cystic changes in the glenoid. Humeral head was elevated (Fig. 2). A computed tomography (CT) scan of both shoulders was performed to better understand the version and inclination of the glenoid on the right side and to characterize the 3-dimensional extent of glenoid bone loss on the left side. CT scan of the right shoulder showed large osteophytes on the humeral head, a completely obliterated joint space, a slight posterior subluxation of the humeral head, a monoconcave dorsal glenoid erosion, and multiple ossified joint bodies. CT scan of the left shoulder allowed for better visualization of the dorsal erosion of the glenoid and retroversion of the glenoid (approximately 37°) (Fig. 3). It also showed significant bone stock osteopenia around the humeral component, with cortical thinning and notching at the calcar.

To address these findings, we planned for a revision TSA on the right and concurrent 1-stage BIO-RSA on the left using the humeral autograft from the opposite side. The indication for the rTSA was given based on the patient's age (83 years at the time of the surgery described in this case) and the findings of the clinical examination.

An infectious work-up was negative including erythrocyte sedimentation rate, C-reactive protein, complete blood count, and imaging. This allowed the correct diagnosis to be made and the appropriate strategy to be planned.

Surgical procedure

The patient was placed in beach-chair position. Meticulous positioning was performed, with the lines and tubes attached to the lower limbs and directed away from the surgical field.

A deltopectoral approach with sparing of the cephalic vein was performed in the right shoulder. The subscapularis tendon was detached and reinforced with 3 FiberWire (Arthrex, Naples, FL, USA) sutures. The humeral head was sclerotic and flattened and showed pronounced osteophytes. The biceps tendon was already ruptured. After humeral dislocation and removal of the osteophytes, the humeral head was resected in the anatomical neck and the head was stored in a moist substrate as a graft for the opposite side. The metaphysis was prepared until a good fit was obtained, and the cut protector was placed. After glenoid preparation, a 25+3 mm lateralizing screw base plate with a 30 mm 6.5 mm compression screw was inserted. Additional fixation was performed with a ventral and a dorsal compression screw and a cranial and a caudal multidirectional locking head screw. A glenosphere 36+2 mm was impacted eccentrically. To fill the voids around and prevent dead space, the glenoid was injected dorsally with a hemostatic collagen sponge that contains gentamicin sulphate. After humeral dislocation, a 3B stem was impacted with tray 3.5. A polyethylene +6 was impacted and the humerus was reduced. After the implantation of the RSA, a highly stable fit with good glenohumeral rotation and abduction was tested. Subscapularis repair and wound closure were performed and a redon drain was inserted.

Figure 1 Preoperative anteroposterior radiograph of the right shoulder showing an advanced glenohumeral osteoarthritis.

After finishing the procedure on the right, the patient was repositioned. On the left shoulder, as with the first surgical procedure, a deltopectoral approach was used over the old incision. A preparation of the deltopectoral interval sparing the cephalic vein was performed. Significant scarring between the deltoid muscle and the proximal humerus was found. Free suture material was removed and sent in for microbiological workup. The subscapularis tendon was detached and was found to be massively thinned out. The diagnosis of glenoid component loosening with component fracture and secondary glenoid wear was confirmed. The head was dislocated, removed, and sent for sonication. The coated head also showed abrasion, so that the anterosuperior coating was missing. The central screw was released and sent for sonication. Intraosseous material was taken and sent for microbiological and histopathological examination to exclude a low-grade infection. The glenoid was massively medialized; the 2 pegs were still

Figure 2 Prerevision anteroposterior radiograph of the left shoulder.

intraosseous and could be recovered. The polyethylene contact surface could not be found intra-articularly but was found dislocated postero-inferiorly. After release, it could be recovered (Fig. 4*A*). Apparently, during the time after implantation, the pegs broken, and the polyethylene was dislocated dorsally. Subsequently, posterior glenoid consumption increased. The glenoid was freed from residual cement. The glenoid defect was classified as grade 4 according to Gohlke and Werner:[17] a severe bone defect with significant medialization below the base of the coracoid but with bone still in the native subchondral surface and with the glenoid vault intact (Fig. 4*B*). A central pin was inserted and the glenoid was carefully reamed until bleeding from the contact surface occurred. The head of the opposite side was prepared and a fully cancellous disc with a thickness of about 1 cm was prepared. The bone graft was not flat but had a slope: it was thicker superiorly and posteriorly to correct glenoid wear. This disc was inserted along the lengthened central peg of a 25 mm baseplate (Fig. 4*C*). Subsequently, the central pin was overdrilled in steps down to 8.0 mm. Uneven portions of the glenoid were filled with additional bone material from the autograft. The baseplate was then impacted with the long post and the BIO-RSA graft (Fig. 4*D*). Dorsal fixation was provided with a compression screw, cranial and caudal fixation with a multidirectional locking head screw. A glenosphere 36+2 mm eccentric was impacted. To prevent dead space, the glenosphere was inoculated dorsally with a hemostatic collagen sponge that contains gentamicin sulphate. The meta-diaphysis was prepared, and a 9 mm cementless metaphysis stem was inserted. A +9 trial polyethylene was positioned. Highly stable fit, no impingement, and no notching were achieved. The definitive components were impacted in approximately 20° retrotorsion. After irrigation and reduction, 2 redon drains were inserted. Wound was closed and final X-ray control was performed.

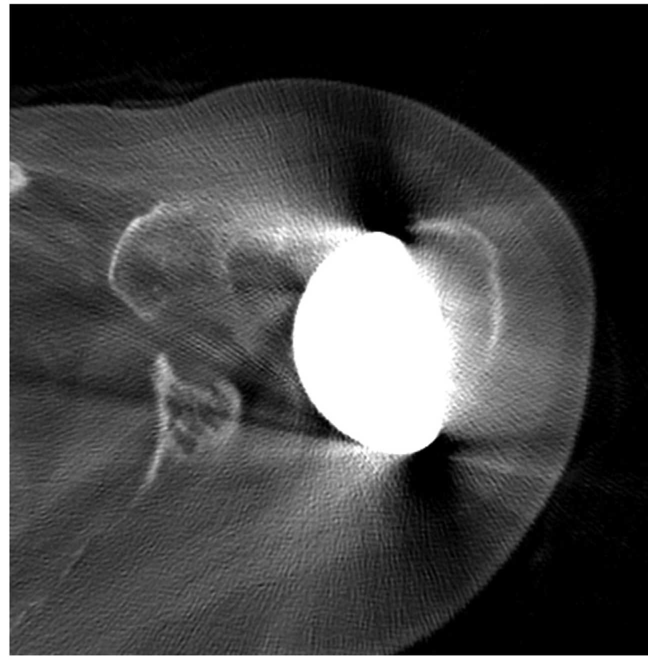

Figure 3 Prerevision axial CT slice of the left shoulder demonstrating severe glenoid bone loss. *CT*, computed tomography.

Postoperative course

Redon drains were removed after 24 hours. Thrombosis prophylaxis was administered. The postoperative course was complicated by hyponatremia and hypokalemia (treated with electrolyte balance) and postoperative anemia (treated with transfusion of 2 red blood cells units).

A shoulder immobilization support for positioning in internal rotation was prescribed for the right shoulder to be worn overnight. A shoulder immobilization support for positioning in internal rotation was prescribed for the left shoulder to be worn for 4 weeks, with a ban on active internal rotation against resistance. The rehabilitation protocol was different for the 2 shoulders, depending on whether the subscapularis was repaired (Table II).

The patient returned for a first follow-up at 4 weeks and a second follow-up with X-rays at 8 weeks. Postoperative radiographs demonstrate well-aligned, well-fixed arthroplasties on both the left and right sides (Fig. 5). The clinical outcome was good: at the 8-week follow-up, she achieved with both shoulders elevation to 100°, abduction also up to 100°, external rotation 30°, and internal rotation to lumbar spine (Fig. 6).

Discussion

End-stage shoulder disease can be a bilateral process and the need to appropriately manage patients with this condition is becoming increasingly relevant to shoulder surgeons. Numerous studies have already shown the feasibility of a staged bilateral shoulder arthroplasty, reporting mostly favorable outcomes.[4,13,18,25,26,29,30,36,38,40] The limited literature published on simultaneous bilateral shoulder arthroplasty[1,16] suggests that this procedure in selected patients can be a safe and effective option, with results that appear comparable to single-sided procedures. Gerber et al[16] demonstrated improved motion (active elevation and

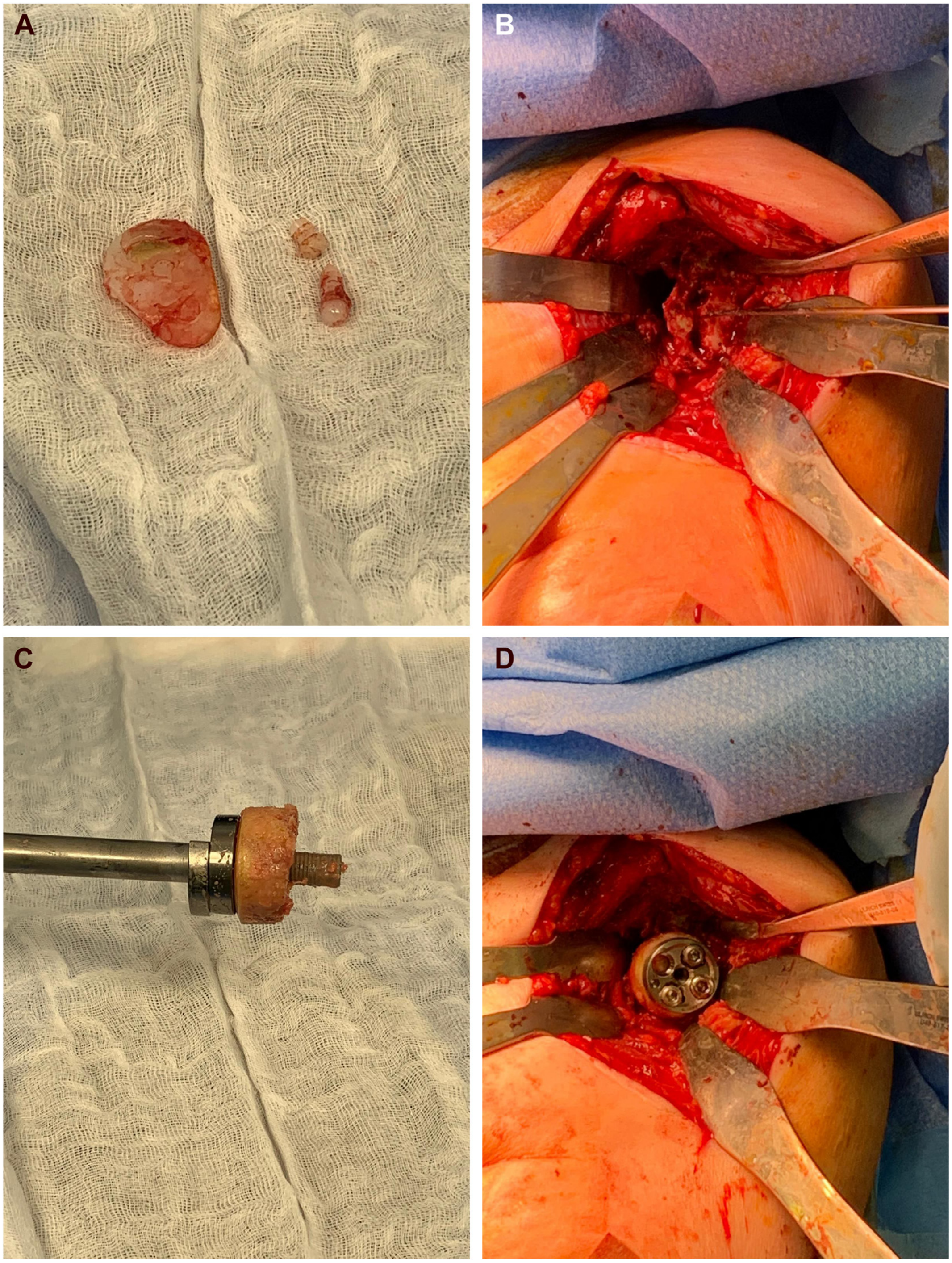

Figure 4 Intraoperative photographs. (**A**) The removed polyethylene glenoid component and the pegs showing macroscopic structural damage and polyethylene wear. (**B**) The resultant glenoid bone loss after removal of the polyethylene glenoid component. (**C**) The prepared graft/baseplate construct ready for implantation. (**D**) Graft/baseplate construct impacted and fixated on the glenoid.

Table II
Active and passive ROM testing of both shoulders.

Week	Rehabilitation right shoulder	Rehabilitation left shoulder
1-2	Active mobilization of the shoulder within field of view. Free passive ROM in flexion/abduction and external rotation, internal rotation to abdomen.	Passive flexion/abduction of the shoulder 45° in internal rotation, external rotation 0°, and internal rotation to abdomen.
3-4	Active ROM is increased.	Active-assisted flexion/abduction 60° in internal rotation, external rotation 0°, and internal rotation to abdomen.
5	Active strengthening.	Active flexion/abduction 90° in internal rotation, external rotation 0°, and internal rotation free

ROM, range of motion.

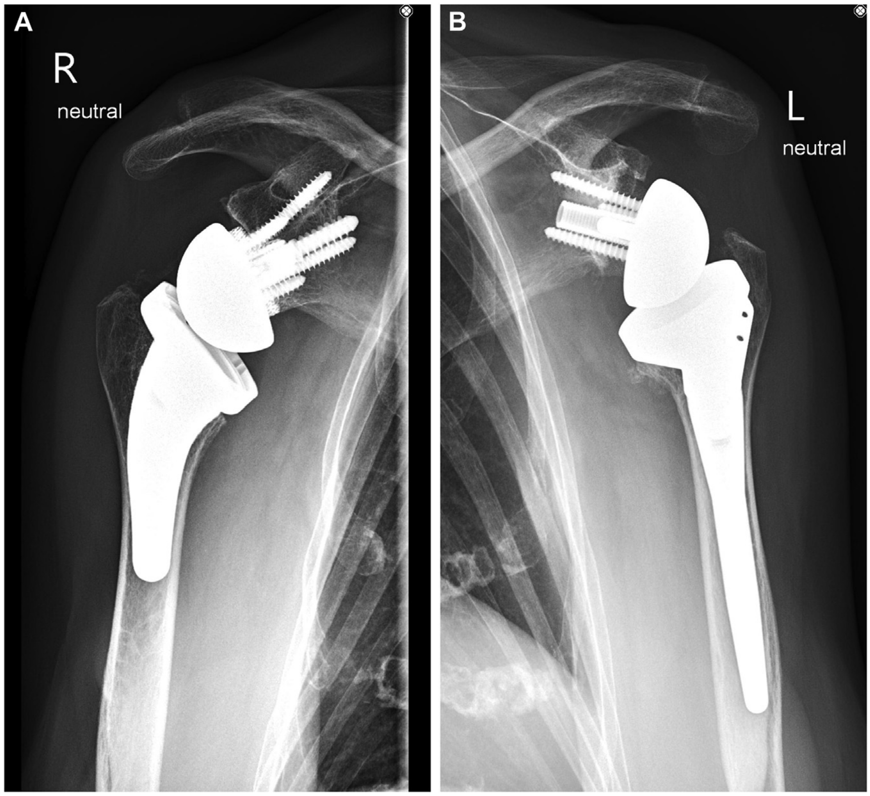

Figure 5 Anteroposterior radiograph of the (**A**) right shoulder and the (**B**) left shoulder obtained at the 8-week office follow-up showing consolidation of the glenoid bone graft with well-positioned humeral and glenoid implants.

Figure 6 Eight weeks after the surgery the patient demonstrated excellent active ROM of both shoulders. *ROM*, range of motion.

abduction) and overall function and shorter hospitalization with single-stage bilateral TSA when compared to a cohort of staged replacements. In a case series, Ajibade et al[1] examined the safety and postoperative complication profile of simultaneous bilateral TSA and demonstrated the short-term safety of this procedure. Our presented case adds to the literature the potential advantage of using contralateral autograft for glenoid reconstruction when performing staged arthroplasties: the possibility to harvest an autograft from the humeral head of the side where the primary TSA is implanted to fill the contralateral bone loss and lateralize the implant.

The problem of glenoid bone loss in revision arthroplasty can be addressed through various treatment options, including glenoid component removal with or without cortico-cancellous grafting, bone grafting without prosthetic glenoid reimplantation, glenoid component reimplantation, and revision arthroplasty.[2,8] In the presented case, the patient had a large and deep glenoid bone defect with pronounced glenoid retroversion associated with rotator cuff insufficiency. Humeral bone loss was also present in addition to the glenoid component failure. Therefore, a revision RSA with a structural bone graft was indicated. Revision of a TSA to a RSA in the presence of glenoid bone loss is challenging.[12,24] Many solutions like bone grafting with an autograft or allograft,[19,20,31,32,35,37,39] augmented glenoid baseplates,[23,34] patient-specific instrumentations,[11] and custom-made implants[22] are available to tackle bone loss. The BIO-RSA technique described by Boileau et al[6] uses a cylinder of autologous bone graft harvested from the humeral head to lateralize the prosthesis without increasing torque or shear force applied to the baseplate-glenoid interface. However, normally in revision surgery, the humeral head is absent, and an alternate source of bone graft is needed. In such cases, alternatives such as autologous iliac crest graft, allograft, and metal augmentation are useful reconstructive options. In the case described, the patient also had contralateral glenohumeral osteoarthritis and rotator cuff insufficiency, resulting in a significant functional impairment; therefore, the opportunity to use contralateral humerus autograft in a BIO-RSA was considered a fruitful solution, although challenging and technically demanding.

Conclusion

To our knowledge, this is the first report to use contralateral humerus autograft in a revision arthroplasty. The use of a BIO-RSA in revision surgery has made it possible to restore the glenoid bone stock and obtain correct alignment of the implant with minimal morbidity. The use of a 1-stage surgery and a simultaneous bilateral procedure resulted in an optimal clinical outcome with 1 episode of anesthesia and shorter hospitalization and rehabilitation compared to a staged replacement. However, it should be noted that minor complications occurred in the described case: electrolyte imbalance and postoperative anemia. Most shoulder arthroplasty patients are not good candidates for the single-stage procedure because of medical comorbidities, decreased social support system, or the unwillingness to tolerate recovery from both procedures. Therefore, mutual decision-making must be employed to identify proper candidates for a simultaneous procedure. Larger studies are required to best identify and indicate appropriate patients.

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Conflicts of interest: Markus Scheibel is a consultant for Stryker company. The other author, his immediate family, and any research foundation with which he is affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.
Patient consent: Patient consent has been obtained to publish case details, personal information in an anonymous form, and images.

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