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A narrative review of treatment strategies for major glenoid defects during primary reverse shoulder arthroplasty, with a focus on the use of structural bone graft

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- Structural glenoid defects are common during primary reverse shoulder arthroplasty (RSA) and are often associated with poor outcomes.
- The lack of pre-operative imaging protocols for determining the depth and degree of glenoid wear hinders our ability to accurately plan and correct these defects.
- Although bone grafting has been reported to be effective in reducing glenoid wear during RSA, there is limited information on when to utilise it and how to prepare the graft.
- We conducted this review to assess the evidence for the management of glenoid defects, with an emphasis on bone grafts to treat structural glenoid bone loss in primary RSA patients.

Keywords

- structural glenoid defects
- bone graft
- reverse shoulder arthroplasty

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Introduction

Registry reports have shown an increase in the use of RSA to manage various conditions of the shoulder (1). Glenoid bone defects and erosions are common, with a reported rate of 37.5% on CT scan pictures of shoulders having primary RSA. These are commoner in individuals with rotator cuff arthropathy, with a 50% prevalence reported in this group (2, 3). They may be challenging to manage during the procedure, possibly resulting in an early failure.

On the basis of size, glenoid defects are divided into three categories: mild (affecting less than one-third of the glenoid rim or surface), moderate (affecting one-third to two-thirds of the glenoid rim or surface), and severe (involving more than two-thirds of the glenoid rim or surface). The defect may become uncontained if the glenoid rim or vault is absent (4) Clinical and surgical decision-making while planning for reverse shoulder arthroplasty (RSA) in the presence of major glenoid bone loss is difficult and reconstruction of defects is associated with poor clinical outcomes, compromised implant survivorship, and high risk of complications due to risk of component malposition and inability to achieve component stability due to inadequate bone stock (5, 6). Baseplate component loosening accounts for 11.5% to 40% failure rates in primary RSA (7, 8, 9).

The literature describes several strategies for dealing with glenoid bone loss during RSA. Most surgeons consider bone grafting to be a low-cost and easily accessible solution. The purpose of this article is to present a literature review on the management of glenoid bone loss in primary RSA. This review focuses on the preoperative assessment of glenoid wear, intraoperative strategies for addressing major defects to ensure baseplate stability, and specifically examines the outcomes associated with the use of structural bone grafts.

Methods

Rationale and search methods

The rationale for conducting this review was to critique the available literature to answer the following clinical questions to identify evidence guiding clinical and surgical decision-making processes in patients with a structural glenoid defect undergoing primary RSA.

1. How to accurately determine the size and position of glenoid bone defects?

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2. When to consider structural glenoid bone graft?
3. What influence the choice of structural bone graft and does it have an impact on the outcomes of the procedure?
4. How to prepare the bone graft to accurately fit the dimensions of the defect corrected?
5. How to fixate the bone graft?
6. How to determine bone graft healing and incorporation?
7. When to consider two-stage glenoid reconstruction?

We conducted a web-based search of relevant evidence using Google Scholar, PubMed, and Scopus search engines for studies relating to imaging, pre-operative planning, and management of glenoid bone defects with bone grafts in patients undergoing primary RSA.

Our search included basic science studies, randomised and non-randomised clinical studies, systematic reviews, and narrative reviews. We limited our search to English-language evidence published between 1999 and 2021, and we included a review of possible cornerstone references from these publications. The keywords used were shoulder, reverse, arthroplasty, replacement, glenoid, defects, version, inclination, bone graft, complications, and notching. Words were searched in combinations. The size and pattern of glenoid bone loss have an impact on the strategies of reconstruction and the outcomes of RSA. Based on whether the glenoid rim and vault are present, glenoid bone defects can be classified as (i) contained defects (intact glenoid rim and vault), (ii) uncontained defects (glenoid rim absent), or (iii) uncontainable defects (absent rim and vault). They are further divided into three categories: combined, peripheral, and central, depending on where the defect is located (4, 10). Severe bone loss is described as an uncontained defect with >20° version or 50% loss of anteroposterior glenoid width, a defect resulting in the loss of >10 mm medialisation or <10 mm remaining vault during revision surgery (11). Patterns of glenoid bone loss are depicted, along with severity grading categories, in Fig. 1. This review manuscript provides a comprehensive overview of the management of glenoid bone loss during primary RSA, with a particular emphasis on planning, operative techniques, and the outcomes of defects reconstruction with structural bone grafts.

Results

A total of 119 articles found through our search were used for a narrative literature review. After eliminating duplicates and screening titles and abstracts, the PubMed search turned up 86 articles, and the Scopus search turned up 55 articles that could be read in full. There were 34 legible articles for evidence synthesis. Eighty-five additional articles were found by hand-searching Google Scholar to assist in addressing the general questions raised in this review.

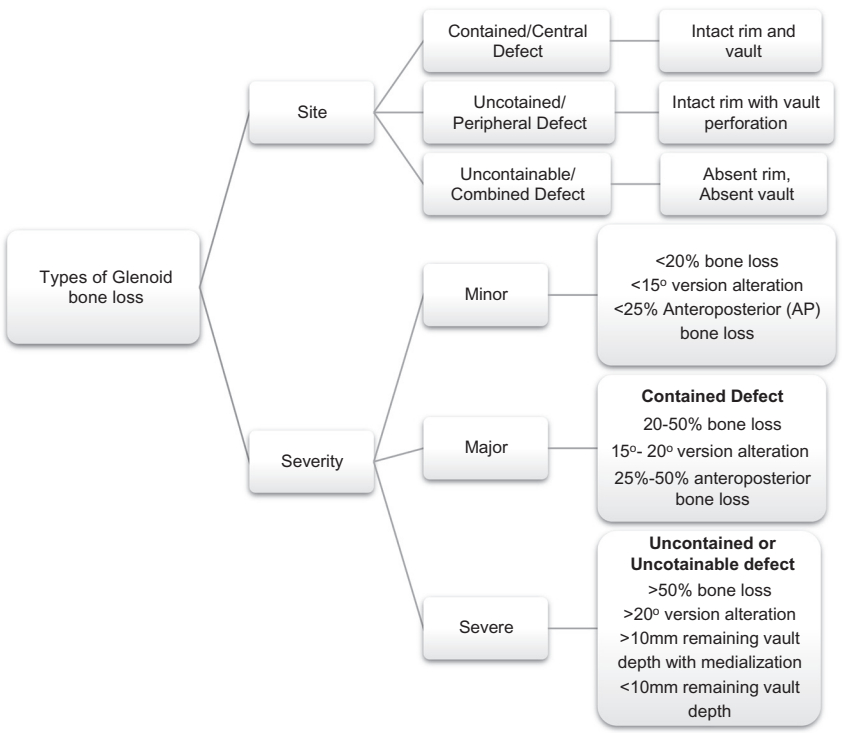

Figure 1
A chart demonstrating types of glenoid bone loss.

Discussion

Introduction

Glenoid wear and structural defects usually follow a predictable pattern depending on the underlying disease. These defects affect glenoid version and/or inclination, which may need to be corrected during surgery. Failure to recognise this during the planning process may result in the procedure failing prematurely. This is covered in greater detail below.

Glenoid morphology and patterns of glenoid wear

Various patterns of glenoid wear are observed in an arthritic shoulder, often related to a primary cause. Central glenoid wear is observed commonly seen in patients with inflammatory conditions, superior wear in those with rotator cuff arthropathy, and those with glenohumeral joint osteoarthritis (GHJOA) will usually have posterior wear (12). Walch *et al.* first introduced a description and classification of glenoid morphological changes in 1999, based on observations on 2D CT scan images of patients with GHJOA (13). However, this classification was limited by the ability of 2D CT scan to identify inferior glenoid morphology and low inter-observer reliability (14). The modification of this classification system was introduced in 3D image reconstruction (Table 1) (15). Type A glenoids are characterised by concentric glenoid wear with the humeral head centred. Humeral head subluxation associated with posterior glenoid wear is characteristic of type B glenoid. The new modification redefined A-2 glenoids as a central erosion with humeral head medialisation such that a line drawn from the anterior rim to the posterior rim of the native glenoid will transect the humeral head. A monoconcave B-3 glenoid and type D glenoid were also recognised (13, 15) Favard described a classification for glenoid wear in rotator cuff arthropathy (16).

Table 1 Modified Walch classification of glenoid morphologic changes in GHJOA (15).

Classification	Description
Type-A glenoid	Centred humeral head
	A-1: minor erosions
	A-2: major central erosion
Type-B glenoid	Posterior humeral head subluxation
	B-1: no erosion
	B-2: posterior erosion, biconcave
	B-3: posterior erosion, mono-concave (15° or more retroversion or minimum 70% posterior humeral head subluxation, or both)
Type-C glenoid	Dysplastic glenoid with >25° retroversion
Type-D glenoid	Anterior humeral head subluxation of <40% or any glenoid anteversion

Evaluation of glenoid wear

Preoperative planning and accurate assessment of glenoid wear are pivotal to a successful RSA. Plain x-rays with Grashey views are the first imaging modality in patients undergoing RSA (3). They may show the presence of glenoid wear, but it is difficult to accurately determine the depth and degree of glenoid morphological changes on plain radiographs alone (2, 3). Nyfeller *et al.* have shown that plain x-ray axillary views tend to overestimate the degree of glenoid retroversion in 86% of patients (17).

Studies reporting on 2D and 3D CT scans have reported improved sensitivity and specificity in the diagnosis and description of glenoid version and inclination alterations and depth of bone defects (17, 18). Accurate analysis of the images and quantification of the defects is dependent on multiple factors. Chalmers *et al.* observed variations in the magnitude of glenoid retroversion with alteration in the direction of the gantry during the CT imaging process. Retroversion measurements also varied when the images showed less than 50% of the scapula width. However, retroversion measurements were accurate if a minimum of 8 cm of the scapula width was imaged (19). Conversely, Bokor *et al.* observed a 15° alteration in the glenoid version when the scapula was rotated by 10° during the CT imaging process (20). Localised erosions can be missed on 2D slices due to a lack of comparison with other sliced planes. The 3D images have better sensitivity for localised erosions diagnosis (2). The glenoid version measurements are also influenced by the thickness of image slices and this in turn may influence 3D image reconstruction (21). The use of MR imaging for the determination of glenoid wear has not been proven to be superior to CT assessment (21, 22). The study comparing the accuracy of glenoid bone loss measurement in patients with anterior shoulder instability found MRI to have 25% inaccurate predictions compared to 4.8% of CT measurements (23).

The challenge in clinical practice is finding a reliable reference point for glenoid defect, version, and tilt measurements. Various techniques are described with varying reliability reported in the literature (24, 25) Friedman *et al.* (1992) introduced the scapular axis method for measuring glenoid version on axial 2D CT images with 2.5 mm thickness of the slices, measured 10 mm inferior to the coracoid process (26). This method is considered reliable, but various studies reported variable results (18, 27). Additionally, the introduction of 3D images has exposed the ability to accurately determine the centre of the glenoid on 2D axial slices (20, 27, 28). It is important to note that the version is not the same throughout the whole glenoid, and using the scapular axis may not be representative of the entire glenoid (29, 30). The use of 3D reconstructed images was introduced with reported improved reliability (18). These reconstructions are not immune to problems encountered in 2D images. Moroder

et al. observed alteration in defect measurements relative to imprecise scapula positioning when using the best-fitting method for measuring anterior glenoid bone loss on the en-face view of 3D images (31). Similarly, Bryce *et al.* noted that scapula alteration of >1° resulted in a significant alteration of version measurements on 3D reconstructed images (32).

The use of 3D computer-based planning systems and patient-specific guides has been reported to aid surgeons with accurate glenoid morphological measurements and accurate placement of glenoid components (33, 34). Levy *et al.* showed patient-specific guided glenoid baseplate to be accurate in a cadaver study with a 2.6° deviation of planned version (35). Studies have, however, demonstrated variability of measurements between CT scan manual native glenoid measurements and those provided by automated and semi-automated 3D pre-operative planning tools (36, 37). Comparison of the planning tools has also shown significant variability in determining glenoid version, inclination, and defect size (38, 39). Surgeons should be aware of these limitations and be willing to alter their planning within limits during the intra-operative period.

Glenoid component placement

Grammont component is based on medialising centre of rotation (COR) offset, hence reducing component torque and recruiting more deltoid muscle fibres for arm elevation (40). Baseplate micromotion of <150 μm is generally acceptable to allow bone ingrowth (41). Virani *et al.* demonstrated no increase in micromotion when the baseplate was implanted at 0 mm and 10 mm COR offset (42). Excessive component medialisation is associated with loss of adduction and internal rotation movements, increased scapular notching, and joint instability (43, 44). Li *et al.* demonstrated poor ranges of movement and a high rate of scapular notching when the component was medialised by 5 mm on a virtual computer simulation (45). In a clinical study, Jobin *et al.* reported 68% scapular notching in patients with component medialisation of 18mm (±8) (46). Simovitch *et al.* found scapular notching to be highly associated with craniocaudal glenosphere positioning and the angular relationship between the scapular neck and glenosphere (44).

Component lateralisation has been reported to improve deltoid wrapping angle and ranges of motion compared to standard component placement (47, 48, 49, 50). However, Nunes *et al.* (2021) could not find a significant difference in outcomes and ranges of motion between standard RSA (s-RSA) and lateralised RSA in a systematic literature review (51). Over lateralising the COR may result in an increase in torsional forces at the component–bone interface and result in an increase in deltoid elevation force with resultant early component loosening and scapular stress fractures (52, 53). Gutiérrez *et al.* found a component lateral eccentric placement, concentric placement with inferior tilt, and inferior eccentric placement with a neutral tilt to be associated with reduced 'rocking horse phenomenon' and forces across the baseplate-bone interval in a computer simulation study. Superior tilt was associated with increased forces regardless of component placement (54). Similar results were reported by other authors (45, 55). Li *et al.* found component placement with 10 mm lateralisation, 6 mm inferior translation, and placement with 15°–30° inferior tilt to be associated with improved internal and external rotation of the shoulder without increasing shear forces at the baseplate-bone interval (45).

Management of glenoid bone defects

Various strategies exist in the literature for addressing glenoid defects based on the defect size, site, and shape.

Strategies for managing minor glenoid defects

Minor glenoid defects can be managed with the following strategies: (i) the use of a small baseplate, (ii) excessive concentric glenoid reaming, and (iii) preferential reaming techniques depending on the type and size of the defect. These strategies are described below.

Small-diameter baseplate selection

Component to native bone contact of 30–50% with 10–15 mm centre peg penetration or 50% of long peg penetration into native bone and a minimum of two bicortical screws is required to achieve absolute component stability (56, 57, 58). A smaller baseplate may be used in cases of glenoid bone loss to achieve maximal contact with bone and component stability (59). The standard baseplate has a diameter of 27–29 mm and those sized 25 mm and below are referred to as small-diameter baseplates (59). Chae *et al.* was able to demonstrate component stability when using a 25 mm baseplate in a computer simulation study of 14 scapulae of fresh cadavers (60). Athwal *et al.* reported comparable good results in patients who underwent s-RSA versus bony-increased offset (BIO)–RSA for rotator cuff arthropathy using a 25 mm baseplate with 36 mm glenosphere. He, however, noted 62% scapular notching in s-RSA group compared to 46% in the BIO–RSA group (61).

Excessive concentric glenoid reaming

The challenge during surgery is to identify reliable landmarks for glenoid reconstruction and component

placement (62). Ott *et al.* reported the base of the coracoid to be a reliable anatomical landmark for glenoid reconstruction during RSA in a CT analysis study of 131 images of people aged 19–88 years (63). Excessive reaming may result in volumetric bone loss and excessive medialisation. Sutton *et al.* observed a linear reduction in total glenoid surface area for baseplate support with an increment of reaming. Glenoid reaming of 5 mm depth resulted in a 28% reduction in total surface area and 57% loss of cortical support (64). Reaming subchondral bone off may have been suggested to compromise component stability in cases of total shoulder arthroplasty (TSA) (65, 66). Medialised centre of rotation may recruit more deltoid muscle fibres for arm elevation strength, at the expense of range of motion loss, risk of scapular notching, and risk of joint instability (48, 55, 67).

Minor version alteration

Component placement in ≤10° retroversion has been reported not to increase baseplate micromotion or compromise joint stability by the biomechanics studies and it is therefore acceptable (42, 68, 69). Therefore, component placement in retroversion of 0°–10° has been accepted by some authors when neutral version cannot be obtained during RSA (70).

Eccentric glenoid reaming

Asymmetric reaming is a simple anterior preferential reaming technique, commonly described in the management of B2 glenoid during anatomic TSA (71). Biomechanical and clinical studies have demonstrated that eccentric reaming can correct glenoid retroversion of 10°–5° and defects of 5–8 mm without compromising component position and contact with native bone (5, 37, 57, 72). Conversely, Yongpravat *et al.* found that 5 mm reaming was inadequate to correct 10° retroversion in a computer simulation study of 10 CT scans of patients with GHJOA (66). The concern with this technique is the amount of bone reamed off to restore the neutral version. Gillespie *et al.* demonstrated that eccentric reaming of a glenoid with >10° retroversion resulted in a reduction of glenoid anteroposterior width and 15° retroversion had a 50% chance of successful correction through eccentric reaming during TSA in a cadaveric study (73). Evidence for the use of eccentric reaming in RSA is still limited, but this technique may be considered in minor B2 glenoids with less than 15° retroversion. Martin *et al.* reported significant medialisation and increased scapular notching in 10 B2 glenoids with more than 15° retroversion treated with eccentric reaming during RSA (74, 75). Generally, the glenoid version of 15°–20° results in excessive medialisation when treated with eccentric reaming (73, 75).

Off-axis reaming

Superior glenoid defects are encountered in 9% of the shoulders undergoing RSA (76). Failure to correct superior tilt has been shown to be associated with scapular notching, component instability, and early failure (77). Off-axis reaming is recommended for correction of 5°–10° superior tilt in glenoids with superior defects and augments or bone graft can be added for those with 10°–15° tilt without compromise in centre peg penetration (76).

Accuracy of glenoid reaming and component placement

Correct glenoid component placement has an impact on long-term survival of the prosthesis, functional outcome, and risk of scapular notching in patients undergoing RSA (41, 78, 79). There are no definite intra-operative reaming landmarks to guide accurate placement. The accuracy of manual glenoid reaming and component placement has been reported to be less precise in the literature. The use of intra-operative fluoroscopy has been suggested with improved accuracy of TSA glenoid component placement (80). Patient-specific instruments (PSI) have been reported to improve the accuracy of glenoid component placement during shoulder arthroplasty (62, 81, 82). Throckmorton *et al.* reported a 7° intended inclination deviation in manual guide wire placement compared to 3° when using PSI in a cadaveric study. Starting point and version deviations were not significant between the two methods (83). Verborgt *et al.* were able to reproduce precise 3D pre-operative measurements when using a PSI in 32 RSA procedures with a 4.4° mean deviation from the planned version and a 5° mean deviation from the planned inclination (84).

Structural bone graft for managing major glenoid defects

When to consider structural glenoid bone graft for glenoid defects

Structural bone graft has yielded promising results with lower baseplate loosening rates and joint instability in the management of severe glenoid bone defects (85, 86). It is recommended that glenoid defects extending medial to the base of the coracoid are managed with structural bone graft during RSA (56). Excessive preoperative glenoid retroversion of >27° or >80% humeral head subluxation and post-reaming glenoid retroversion of greater than 10° are associated with compromised joint stability and high rates of component loosening for both RSA and TSA (5, 13, 69).

Inability to achieve 50% baseplate coverage by native bone has been defined as the threshold to consider

structural bone graft during RSA (87). Recommended algorithm guides that defects with baseplate coverage of 50–80% can be treated with morselized graft, whereas structural bone grafting or glenoid augments should be considered when 30–50% baseplate coverage cannot be achieved (88). In a study of 26 patients treated with RSA for proximal humerus fractures and glenoid fractures, Gorofalo *et al.* compared glenoid width to the contralateral uninjured shoulder on the CT scan. Their results demonstrated that anterior glenoid rim defects compromising less than 30% anteroposterior diameter can be successfully treated with single-stage bone grafting during RSA (89). The location of a defect is also important in the choice of graft. Concentric central defects are generally contained, and structural bone graft is indicated when 30% baseplate contact with bone cannot be obtained (90, 91). A CT image reconstruction of structural anteroinferior glenoid wear in a patient with chronic shoulder dislocation is shown in Fig. 2.

Choice of bone graft

There is no ideal bone grafting technique for reconstruction of major glenoid defects, and current evidence is limited to low-quality evidence. Resected humeral head autograft can easily be harvested with no donor site morbidity and has been reported to have high graft incorporation rates (40, 92, 93). The evidence on iliac crest bone graft (ICBG) in primary RSA is scarce, but it has shown good results in both primary and revision cases (3, 94). ICBG harvest is associated with 15% donor site morbidity (95).

Allografts are reported to have lower incorporation rates and higher complications compared to humeral head autograft (76). The use of allografts had a lower graft incorporation rate (66%) compared to those who had humeral head autografts (86%) in a cohort of 44 patients with structural glenoid defects. However, clinical results were not different between the two groups; only one patient from each group had a failure and required revision (17, 92).

Bateman *et al.* described a hybrid technique of reconstructing massive uncontained glenoid defects using a combination of peripherally seated cortical femoral neck allograft and centrally impacted iliac crest corticocancellous autograft in ten shoulders. None of the 5 patients with 13–36 months' follow-up had component loosening, joint instability, or infection. CT imaging at 6 months showed graft incorporation (96). Malhas *et al.* reported on the results of 29 RSA and 10 TSA treated with the use of a metal baseplate with a trabecular titanium surface in conjunction with an autologous bone graft. They observed a 93% graft incorporation rate and a 16% complication rate (11). In a patient with chronic anterior shoulder dislocation and anterior bone loss, glenoid reconstruction with humeral head autograft is shown in Fig. 3. Prior to glenoid reaming, the graft was secured with screws.

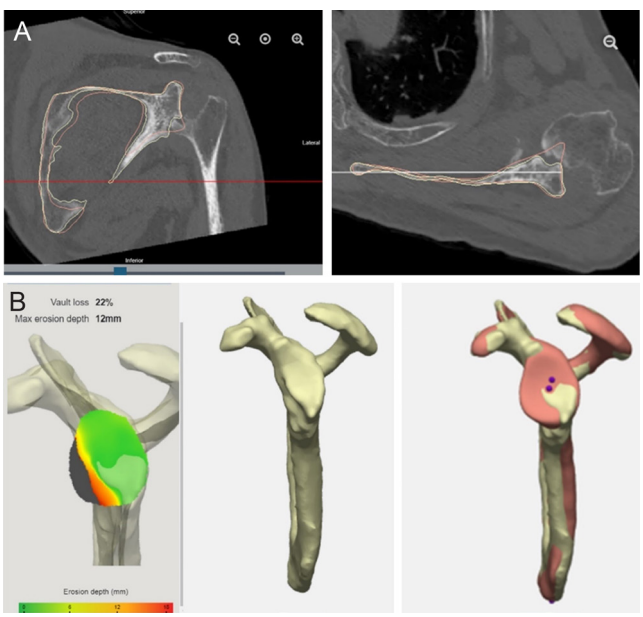

Figure 2
2D (A) and 3D CT (B) scan images of a glenoid with eccentric anteroinferior bone loss in a patient with ancient type chronic shoulder dislocation and premorbid glenoid images reconstructed through Materialise SurgiCase TruMatch® system.

Bone graft preparation and fixation

Pre-operative planning using CT and computer software combined with intra-operative post-reaming glenoid measurements have been reported to accurately guide on graft shape and size (18, 90, 97). Various techniques of graft preparation are described in the literature, and there seems to be no consensus on an ideal technique. In principle, Walch type A2 defects are contained and can be successfully managed with a trapezoidal graft compressed with a mallet to baseplate impaction without the use of screws. Peripheral defects (B2) may be uncontained and screw fixation of the graft may be necessary (3, 88).

Hussain *et al.* described a technique which involves humeral head harvest and preparation and shaping at the back table using a saw and a burr following pre- and intraoperative templating. In their series, grafts were fixated with headless cannulated screws to achieve compression (90). Sebasan *et al.* reported good results with trapezoidal shaped grafts with a middle step to prevent medial migration in the management of severe retroversion during anatomic shoulder arthroplasty. Graft compression was achieved with screws prior to component implantation (98).

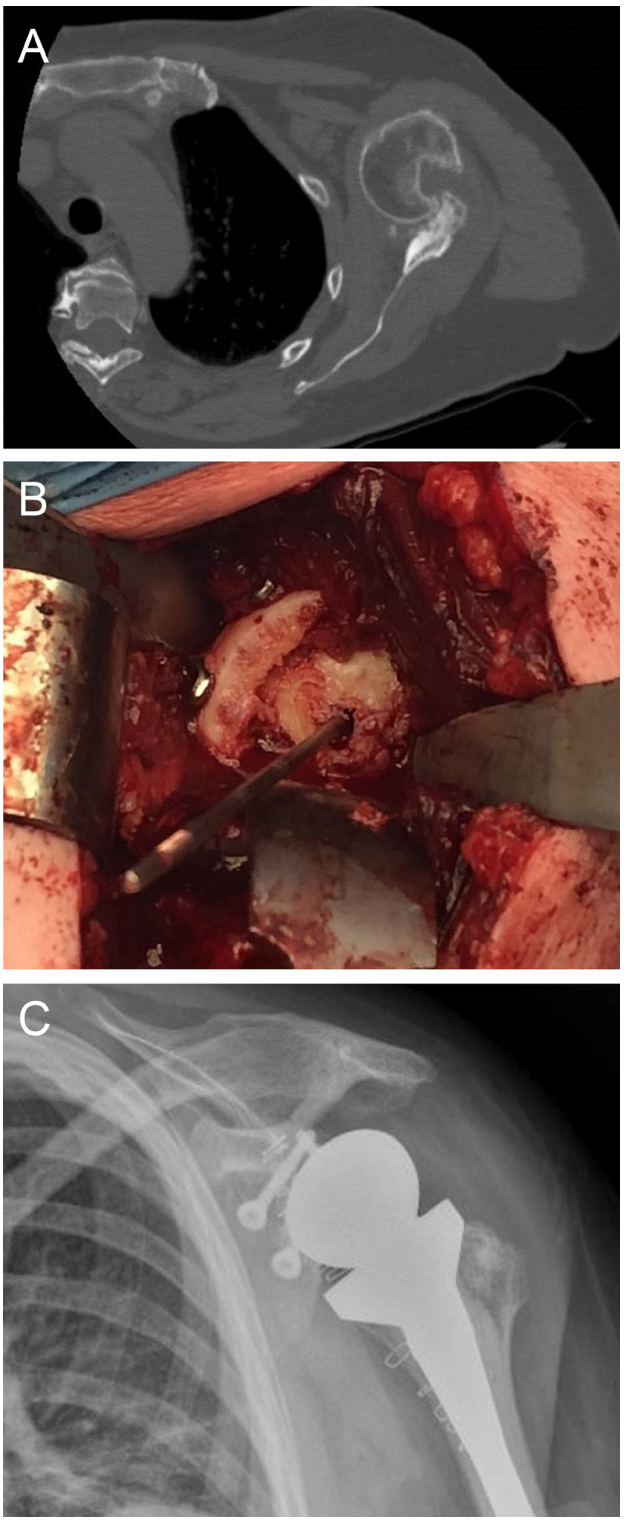

Figure 3

(A) 2D axial CT scan image of a glenoid in a patient with chronic shoulder dislocation with structural anterior glenoid bone loss. (B) Intra-operative image of the glenoid with anterior bone graft using humeral head autograft. (C) Post-operative antero-superior view x-ray.

Graft compression improves healing and minimises the risk of resorption. Graft impaction loading with a baseplate without screw fixation has shown good healing results during RSA (3, 88). The choice of graft shape is difficult, and it is dictated by the defect location and shape. Whichever shape one chooses, it is important to achieve graft compression to enable healing and incorporation. Peripherally placed grafts may need screw fixation as described earlier. According to the abovementioned literature, screw fixation is the best option for eccentrically placed grafts.

Graft incorporation imaging

Bone graft healing and incorporation are important for implant survival and good clinical results. Plain x-rays are usually used as a first imaging modality to assess post-operative results of shoulder arthroplasty, with reported limitations in assessing component placement and version evaluation post RSA (17, 99, 100). Graft healing and incorporation are difficult to assess on x-ray views alone, but various diagnostic criteria have been described. Jones *et al.* assessed component loosening following RSA on the presence of radiolucent lines on plain x-rays. They defined and graded graft incorporation based on the amount of graft left on the latest x-rays, with graft >75% of the initial size defined as fully incorporated, 25–75% being partial and <25% considered not incorporated (92). Melis *et al.* described x-ray diagnostic criteria of glenoid loosening based on the presence of a radiolucency of ≥2mm wide around the screws and below the baseplate (101). Bacle *et al.* demonstrated loosening on plain x-rays following RSA of 67 shoulders using Melis criteria (101). Metal artefact and scatter may obscure the graft, and they may make it difficult to see graft resorption and osteolysis (103).

CT scan is used for evaluation of graft incorporation, based on the presence of a radiolucent line between the graft and the glenoid, the presence of graft resorption or lysis, and evidence of component loosening with reported accuracy (40, 94). However, Ferreira *et al.* reported a poor sensitivity (38%) and good specificity (88%) for graft resorption gap diagnosis on CT scan (103). Granville-Chapman *et al.* described an evaluation and classification of graft incorporation and centre peg integration in 40 RSA and 16 TSA, using CT scan with metal artefacts reduction sequences on axial, sagittal, and coronal cuts at a maximum 2.3 years follow-up duration (105). Italia *et al.* observed joint line restoration in a retrospective review of post-operative CT images of 21 shoulders that underwent RSA and bone graft, using computer navigation software (MIMICS 21.0; Materialise, Leuven, Belgium) (106). Hochreiter *et al.* outlined shortfalls of x-rays and CT scan to quantify viability and healing of large allografts post

RSA. They demonstrated graft viability, metabolic activity, and fusion at 44-month follow-up on ^{18}F-flouride PET-CT scan. They recommended PET-CT as a practical tool for large grafts assessment (107).

Two-staged glenoid reconstruction

Severe glenoid bone loss with large uncontained defects and inability to achieve minimum 2 bicortical screw fixation, 10 mm peg penetration, or 50% long-peg penetration into native bone is considered a contraindication to single-stage glenoid reconstruction (3, 56, 108). Staged glenoid reconstruction has yielded good results in revision cases of eradicated prosthetic infections (56, 109, 110). Staged glenoid defect reconstructions may also be considered in severe osteoporotic bone (6).

Results of RSA with structural defect reconstruction

The results of bone graft use in structural bone defects have been promising, with good outcomes reported in the literature (86). Boileau *et al.* reported good results in 54 arthritic shoulders treated with BIO–RSA using resected humeral head autograft at a minimum 2 years follow-up. Glenoid loosening was observed in three patients (5%) and they were all successfully treated with ICBG (104).

Similarly, Werner *et al.* reported good results in 19 patients with chronic shoulder dislocation and anterior glenoid rim bone loss. In this trial, bone loss averaged 45%. Graft resorption was observed in two patients, one with 66% loss and the other with 80% loss. The reason for failure in these cases was attributed to the inability to achieve adequate baseplate peg penetration (6). However, complications remain a great concern when reconstructing glenoid defects. Wagner *et al.* reported a 12% complication rate and a 3% reoperation rate at minimum 3-month follow-up period in 137 shoulders that underwent bone grafting in primary RSA (111). More recently, Ho *et al.* reported an 18% revision rate and a 25% graft resorption at a short-term follow-up of 37 primary RSA and bone grafting and 7 revision cases (total, $n = 44$). Glenoid component failure was closely related to a large version correction required at the time of surgery (112).

Conclusion

The glenoid defects are very common during primary RSA. This can make surgery difficult and has been linked to poor outcomes. The use of a bone graft for the management of these defects has improved the procedure's results. However, no clear guidelines on graft preparation, placement, and fixation during RSA are available, and higher complication rates have been reported. X-rays and CT scans are both significant imaging modalities for planning procedures, though they have some limitations because of their lack of specificity. Software planning tools have shown some improvement in glenoid defect management, component placement accuracy, and planning, but their dependability is still up for debate. The body of evidence that governs the management of glenoid defects during primary RSA is based on data from revision cases. The evaluation of graft healing is still debatable. Long-term, multi-centre studies are required in this area.

ICMJE conflict of interest statement
The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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