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Scapular spine load-bearing strut in custom-made reverse shoulder arthroplasty - clinical and radiological follow-up of an index case

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Abstract
Reverse shoulder arthroplasty allows surgeons to effectively treat complex primary and salvage cases that were previously difficult to manage. Revision shoulder arthroplasty provides a unique challenging environment to both surgeon and patient alike, with the variability of bone stock in the shoulder girdle offering unique tests to existing surgical methods and techniques.
Following severe glenoid erosion, custom-made implants have a role in restoring optimal anatomy for the shoulder arthroplasty to be effective. The case described illustrates the challenges of reconstructing a glenoid with significant bone loss. Currently, there is no evidence concerning the outcomes of specific scapular spine strut supports in custom-made glenoid implants.
The authors highlight an innovative design for the custom glenoid baseplate with the addition of a strut which allows for supplementary load-bearing through the scapular spine. Implant stability, as well as the satisfactory medium-term clinical and radiological outcomes of such a construct, are also demonstrated.

Keywords: reverse shoulder arthroplasty; custom-made; scapular spine strut

Introduction
Reverse Shoulder Arthroplasty (RSA) has allowed surgeons to effectively treat complex primary and salvage cases that were previously difficult to manage. RSA has been utilised in the surgical treatment of cuff tear arthropathy and cases of significant bone loss. However, revision shoulder arthroplasty provides a unique challenging environment to both surgeon and patient alike. The variability of bone stock in the shoulder girdle offers unique tests to existing surgical methods and techniques. Historically, significant bone deficiencies have been a contraindication towards anatomic or reverse arthroplasty [1]. However, current strategies to reconstruct the glenoid bone loss have involved bone grafting (both autologous and allograft) and metallic augmentation [2].
When significant glenoid erosion is present, coracoid-bearing implants are created to supplement fixation and distribute the reactive forces to the remaining shoulder girdle. When coexisting significant glenoid or coracoid erosion is present, such coracoid-bearing implants may not provide sufficient structural stability against vertical shear forces. In such situations with extreme unconfined glenoid defects, implants using a scapular spine load bearing strut have been postulated. Currently there is no evidence regarding the outcomes of specific scapular spine strut support in custom made glenoid implants. This case report describes the clinical and radiological outcomes of a patient following implantation of such an implant at 30 months post-procedure.

Case Report
A 77-year-old, right hand dominant female presented with pain following a reverse geometry total shoulder arthroplasty. The RSA was performed 2 years prior to referral for rotator cuff arthropathy. Post-operatively she had experienced no subsequent complications or trauma and had received no antibiotics. She had swiftly achieved a pain free range of abduction up to 90 degrees. However, from 3 months post-operatively, she described an insidious generalised discomfort radiating anterolaterally down the upper arm, which progressively worsened leading up to her tertiary outpatient appointment at our unit. This was accompanied by clicking in the shoulder and a progressive loss of movement around her shoulder joint. At presentation, she struggled with activities of daily living being unable to wash her hair and reach behind her back and was becoming increasingly more frustrated with

her shoulder. She was otherwise fit and healthy without any significant past medical history. On examination there was a well healed surgical scar with no overt signs of infection. She was able to achieve 90 degrees of abduction but with pain throughout the terminal phase.

Plain radiographs illustrated glenoid loosening with significant bone loss and a broken screw (Fig. 1 and 2).

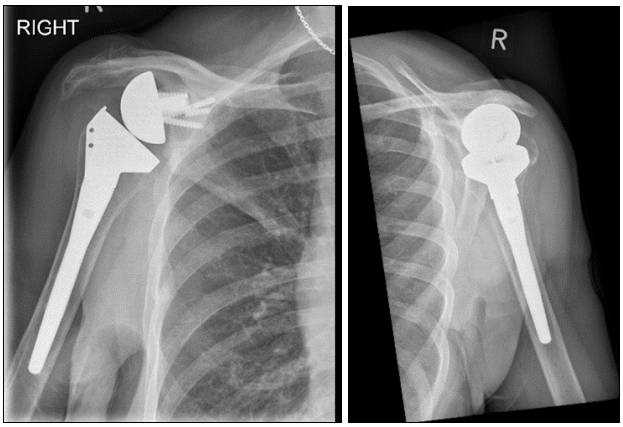

Fig 1, 2: Initial plain radiographs illustrating a loose and migrated glenoid component with broken metalwork.

Subsequent inflammatory markers revealed a CRP of <4 and ESR of 6. A CT scan showed significant glenoid bone loss, especially postero-superiorly, with broken glenoid screws as well as a migrated glenosphere. Following multidisciplinary discussion, further leucocyte bone scans were performed to exclude possible infection, which were normal. A decision to perform a 2-stage revision procedure was made. The patient underwent 1st stage revision surgery with implant removal, debridement, multiple biopsies and antibiotic-loaded cement spacer insertion. She received 2 weeks IV antibiotics (Teicoplanin + Ciprofloxacin) whilst awaiting cultures. She had a growth of coliform on a single extended culture and received a further 4 weeks of Ciprofloxacin. She remained systemically well and continued to improve post-operatively. She completed the antibiotic regime without issue.

At 6 weeks, a further CT scan was performed to assess the resultant glenoid bone stock available for reconstruction. This revealed a large cystic lesion in the posterosuperior aspect of the glenoid along with osteolytic changes in the acromial process of the scapula. These lytic changes corresponded to the area of impingement by the dislodged glenosphere (Fig. 3, 4, 5). As a result, a custom-made glenoid component was proposed and manufactured for a 2nd stage reconstruction.

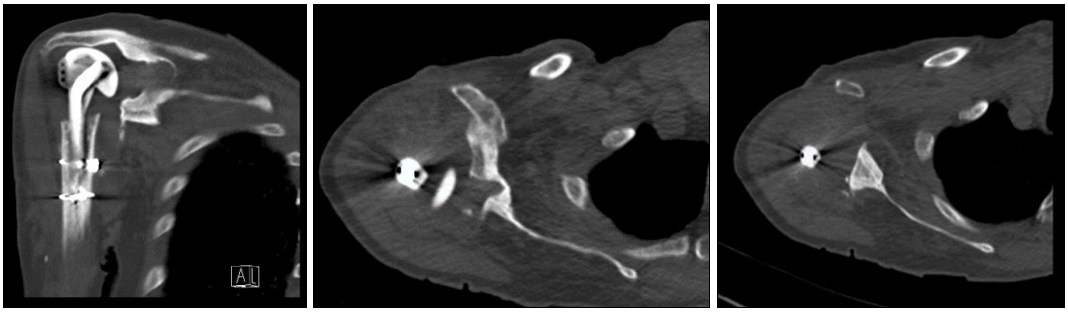

Fig 3, 4, 5: CT highlighting glenoid bone loss following 1st stage revision.

The custom-made revision reverse geometry was performed in 4 months later. This Lima Promade prosthesis allowed for the significant scapula bone loss following erosion of posterosuperior aspect of the glenoid. It utilized scapula and coracoid fixation with an additional scapular spine load-bearing strut to supplement fixation (Fig. 6 and 7). As per our understanding, this was the first use of such an implant to supplement advanced glenoid bone loss.

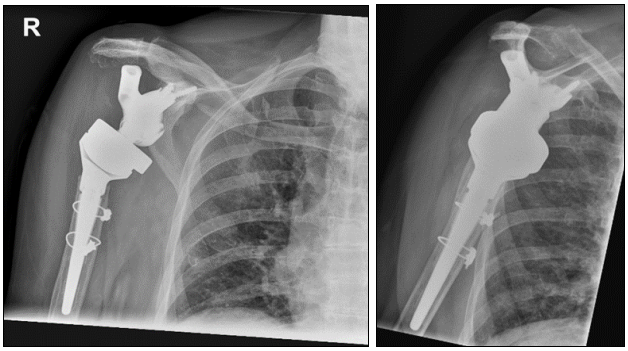

Fig 6, 7: Radiographs showing post-operative images of custom-made revision implant.

The patient made good post-operative progress, swiftly becoming pain free with an improving range of movement. Unfortunately, she was troubled by subsequent trauma 4 weeks following second stage revision, where she fell and sustained an ipsilateral midshaft clavicle fracture and pubic ramus fracture. Despite this, the revision shoulder implant remained well positioned in-situ and well fixed. She went on to achieve a good functional outcome and range of movement, in addition to radiographical union at the clavicle fracture site.

At 30 months, she is pain-free with no deficit on function or daily activities (Fig. 8 and 9). She could achieve 100º flexion and abduction and 60º external rotation. Her latest Oxford shoulder score is 27 and she is happy with the outcome of her surgery. A repeat post-op CT scan illustrated good integration of the glenoid baseplate and a well fixed, well positioned implant. The pre-existing cystic lesion seen in the acromial area had healed completely.

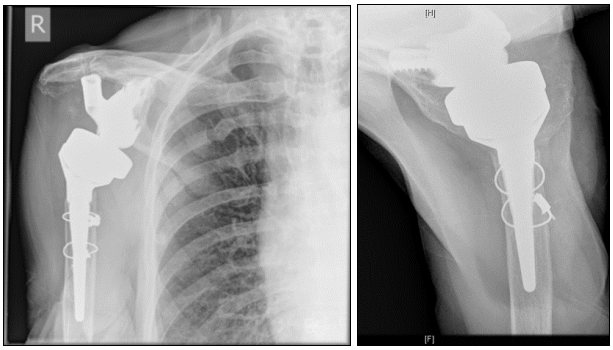

Fig 8, 9: Radiographs at 30 months follow up.

Discussion

This case illustrates the challenges of reconstructing a glenoid with significant bone loss. When severe erosion has taken place then custom-made implants have a role in restoring optimal anatomy for the shoulder arthroplasty to be effective. The addition of the scapular spine strut to the custom glenoid baseplate has the advantage of allowing supplementary loading via good quality bone. In this index case, an osteolytic area within the acromion was also present, which had a risk of subsequent stress fracture following implantation of the RSA. We believe that the addition of a strategically placed scapular spine strut medial to this lesion allowed for the load sharing over a larger area, subsequently allowing for the cystic lesion to heal completely on subsequent CT scan. This allows a further point of fixation around the shoulder girdle, which the authors believe has not been seen before.

Glenoid bone loss is of paramount concern in shoulder arthroplasty and must be corrected to avoid prosthetic instability, in addition to notching, and promote maximal clinical outcome and implant longevity [3]. Boileau has shown encouraging results with the BIO-RSA, using autologous bone graft to correct multiplanar glenoid deficiencies. He was able to show predictable graft incorporation through a variety of glenoid morphologies. Tricortical iliac crest bone grafts have been shown to restore a stable glenoid platform in conjunction with long glenoid post fixation of RSA [4]. However, other exponents of bone grafting have not been able to show such reliable results with increasing rates of graft loosening [5].

The majority of glenoid wear is thought to be posteriorly with up to 40% showing retroversion [1]. Scoring systems have sought to ascertain the location and severity of bone loss as a guide to reconstructive management with impaction bone grafting [6]. Central 'contained' defects can be managed effectively with impaction bone grafting [6]. Peripheral defects are more challenging. With respect to RSA, the depth and volume of the glenoid vault are crucial to incorporate the central peg and screw configuration of the baseplate [1]. Boileau suggested the minimum peg depth required was 8mm and others 10mm, therefore a matching vault depth is required [1, 3].

The increasing proportion of osteoporosis in this cohort of patients provides additional dilemmas with questions over efficacy of bone graft integration. If a stable glenoid-graft-implant construct if not achievable then alternatives should be sought. Metallic augmentation negates this concern and allows reconstruction of bony defects with the aim of restoring optimal anatomy and centre of rotation of the prosthesis [1]. This is commonly seen in simple retroversion such as a Walch type B2 glenoid with a half-wedged or stepped augment built into the glenoid component [7, 8]. This enables any reaming of existing anatomy to be minimized and supplemented to restore optimal mechanics [9, 10]. These augments are additionally available as full wedge implants or more significant examples to help with more complex wear.

Despite these difficulties, accurate glenoid placement remains crucial for the best outcome. Mal-positioned implants can be related to dislocation, increased loosening, wear and potential early failure [11]. Custom-made prostheses allows this reconstruction to be specified for individual patients [12]. The bone loss and defects are mapped using CT reformatting and a unique prosthesis is customised to allow large bone voids to be managed effectively. Much of the literature regarding custom-made prostheses relates to tumour endoprostheses and are as such linked with a poorer outcome [1, 12]. However, the evidence behind customized total hip replacements in patients with massive acetabular loss is more encouraging and therefore subtended towards similar cases in the shoulder.

As the frequency of implanted primary RSAs increases, the necessity for accomplished revision techniques will be driven forward. Complex cases such as the case described, involving significant glenoid loss, require sufficient planning and may require custom-made implants to give a reliable outcome. This case demonstrates good clinical and functional outcomes approaching 3 years. Imaging has also demonstrated good integration and positioning at this time. The additional trauma to the ipsilateral shoulder leading to a clavicle fracture serves to highlight the stability of this implant above that of standard demands. This is especially dramatic given the proximity to the prosthesis to the site of injury, the position of which remained unchanged despite the injury occurring 4 weeks following surgery.

In this case report, the authors have highlighted an innovative design for the custom glenoid baseplate that allows for supplementary load-bearing through the scapular spine. The case illustrates the stability of initial fixation, tested serendipitously by a traumatic clavicular fracture in the early post-operative period. The case also demonstrates the satisfactory medium-term clinical and radiological outcomes of such a construct.

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