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EVALUATION AND MANAGEMENT OF GLENOID BONE DEFECTS IN REVERSE SHOULDER ARTHROPLASTY

Olivier Verborgt[1,2]
Laurent Willemot[3]
[1]Department of Orthopaedic Surgery and Traumatology, AZ Monica, Antwerp, Belgium
[2]Faculty of Medicine and Health Sciences, University of Antwerp, Antwerp, Belgium
[3]Department of Orthopedic Surgery and Traumatology, Ghent University, Ghent, Belgium

SUMMARY
Traumatic shoulder instability can be complicated by the presence of cartilage injury, glenoid and/or humeral bone defects, rotator cuff injuries and nerve lesions. A high index of suspicion is required in the diagnosis of complex shoulder instability. Patients presenting with continued pain and dysfunction two to three weeks after the initial event should be investigated further. Older patients have a higher risk of associated injuries, but presentation in younger patients is frequent and may lead to devastating outcomes when missed. Correct recognition and treatment of the concomitant injuries is imperative in order to adequately stabilize the glenohumeral joint and avoid long-term dysfunction and degenerative changes. Shoulder instability can also be complicated by prior failed stabilization procedures. Failures are mostly caused by renewed traumatic events, misdiagnosis of the initial pathology or technical errors during the surgery. Type of previous surgical treatment and type of failure will influence the subsequent therapeutic strategy. Surgical history needs to be considered along with patient characteristics, anatomical lesions and functional demands. Clear guidelines in the setting of revision stabilization surgery are not available and treatment should be selected after a thorough case-by-case analysis.

OCENA I POSTĘPOWANIE W PRZYPADKU UBYTKU KOSTNEGO PANEWKI W ODWRÓCONEJ ENDOPROTEZOPLASTYCE STAWU RAMIENNEGO

Olivier Verborgt[1,2]
Laurent Willemot[3]
[1]Department of Orthopaedic Surgery and Traumatology, AZ Monica, Antwerp, Belgia
[2]Faculty of Medicine and Health Sciences, University of Antwerp, Antwerp, Belgia
[3]Department of Orthopedic Surgery and Traumatology, Ghent University, Ghent, Belgia

STRESZCZENIE
Odwrócona endoprotezoplastyka stawu ramiennego (RSA) jest skuteczną metodą leczenia artropatii pierścienia rotatorów u starszych pacjentów. Ze względu na powodzenie, wskazania do RSA rozszerzyły się poza artropatię pierścienia rotatorów. Uwzględniają one bardziej wymagające przypadki od umiarkowanego do znacznego stopnia ubytku panewki w przypadkach operacji pierwotnych jak i rewizyjnych. Przeoczenie ubytku panewki podczas RSA może prowadzić do niewłaściwego pozycjonowania płyty podstawowej i wczesnego niepowodzenia lub komplikacji leczenia, takich jak zwichnięcie protezy lub konflikt z łopatką. Autorzy przedstawiają przegląd aktualnej literatury oraz zalecane klasyfikowanie rodzajów ubytku panewki i preferowane techniki operacyjne.

Keywords: glenoid bone defects, reverse shoulder arthroplasty, bone grafting

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Introduction

Reverse shoulder arthroplasty (RSA) has been proven to be a successful treatment for end stage cuff tear arthropathy in the elderly patient (Werner *et al.,* 2005; Guery *et al.,* 2006; Favard *et al.,* 2012). The correct positioning and fixation of the glenoid component remains however one of the most important challenges of the procedure that will dictate early and long-term results (Guery *et al.,* 2006; Codsi and Iannotti, 2008; Favre *et al.,* 2008; Humphrey *et al.*, 2008; Levigne *et al.,* 2008; Gutierrez *et al.,* 2011). In primary shoulder cases that need a reverse arthroplasty, Frankle *et al.* (2009) have demonstrated that in 40% of the patients there is an abnormal morphology of the glenoid. These numbers could even increase since the reversed prosthesis is being used more and more often in complex and revision cases as the only surgical option left (Affonso, 2012).

Failure to appreciate and address glenoid bone loss during RSA can lead to improper baseplate positioning and early failure or complications such as dislocation or scapular notching (Affonso, 2012; Codsi and Iannotti, 2008; Favre *et al.,* 2008; Levigne *et al.,* 2008; Gutierrez *et al.,* 2011; Hendel *et al.,* 2012). Therefore, bone grafting techniques and specific prosthetic implants need to be considered in selected cases.

Aim

This research report reviews and presents own experiences of Authors in accurate pre-operative assessment of glenoid bone stock, the use of 3D technology and appropriate surgical solutions for moderate and severe glenoid bone loss in reverse shoulder arthroplasty.

Słowa kluczowe: ubytek panewki, odwrócona endoprotezoplastyka stawu ramiennego, przeszczepy kostne

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Material, methods and results

PRE-OPERATIVE ASSESSMENT OF GLENOID BONE STOCK

Pre-operative planning is cardinal for proper characterization of glenoid bone loss and to determine the correct implant and need for a bone graft. Furthermore, precise measurement of glenoid version, inclination, and depth of defects can aid in glenoid surface preparation and bone graft selection. Imaging should be used to plan positioning of the central guide pin, the position and size of the central post, and the orientation and length of fixation screws based on patient's anatomy, remaining bone stock and surrounding neurovascular structures.

Standard Imaging

Plain radiographs are essential and include a true anteroposterior view, an axillary view, and a scapular Y view. Advanced imaging is necessary in most cases of glenoid bone loss or revisions for adequate preoperative planning, with computed tomography (CT) being the modality of choice due to its accuracy in assessing glenoid morphology (Nyffeler *et al.,* 2003). It is imperative that CT images be in the scapular plane and perpendicular to the scapular plane for accurate characterization of the glenoid. Additional three-dimensional (3D) CT images can provide a global view of the bone loss and are used frequently by many shoulder surgeons.

The standard method of measuring glenoid version, inclination and bone defects is done on CT. Assessment of version involves the use of Friedman's line and the intermediate glenoid line (Friedman *et al.,* 1992; Rouleau *et al.,* 2010). The maximum depth of the horizontal plane bone defect can be measured using the method adapted from Hill and Norris (Hill and Norris, 2001). Measurement of inclination can be performed using the ß angle described by Maurer *et al* (Maurer *et al.,* 2012) and later validated by Van Haver *et al.* for standard radiographs and CT-based 3D models (2016).

3D Pre-operative Planning Software

The use of 2D imaging and currently available surgical instruments has been shown to be imprecise for the correction of severe glenoid deformity (Verborgt *et al.,* 2011; Hendel *et al.,* 2012; Heylen *et al.,* 2016). Several authors have reported better accuracy of glenoid component positioning using 3D imaging and patient-specific instrumentation in cadaveric and clinical studies (Verborgt *et al.,* 2011; Hendel *et al.,* 2012; Verborgt *et al.,* 2014 Throckmorton *et al.,* 2015; Gauci *et al.,* 2016; Heylen *et al.,* 2016). Currently, 3D preoperative planning software and patient-specific instruments are becoming gradually commercially available for guidance in the insertion of the glenoid component in anatomic and RSA. The process involves the use of standard preoperative CT scan images of the patient's scapula that are then uploaded and used to create a 3D model of the patient's glenoid. Manufacturer specific algorithms are then applied to the model and glenoid component positioning is determined. The surgeon then reviews, adjusts where necessary, and approves the proposed plan using 3D planning software. The disposable, patient-specific drill guides and a bone model of the glenoid are then produced using rapid prototyping technology and are delivered for the surgical procedure. Depending on the manufacturer, different types of guides are available to determine the insertion point and orientation of the central guide pin on the glenoid surface, as well as further guidance of the reaming depth and angle. For RSA, the rotation of the baseplate and the length and orientation of the screws can be accurately guided as well optimizing the final implantation of the glenoid component.

SURGICAL TECHNIQUE

Moderate glenoid bone loss; standard peg, no graft

There are situations with glenoid bone loss or deformity that can be addressed with asymmetric reaming alone. A modified reaming technique for version and inclination correction can allow for stable baseplate fixation (Hill and Norris, 2001). This involves using a cannulated system with the central screw oriented in the axis of the scapular spine, passed from the center of the glenoid surface to the junction where the scapular spine joins the body of the scapula. Reaming in this orientation is then performed followed by assessment of the baseplate – glenoid contact. In cases with greater than 80% of bony coverage, a baseplate with standard peg can be implanted without the need for a bone graft. The use of 3D planning software and peroperative PSI guides can be extremely helpful when performing this technique (Figure 1).

A standard deltopectoral approach is used and the humerus is prepared using standard techniques. After glenoid exposure, a 3D printed bone model serves as a reference for the native glenoidal anatomy and the position of the first pin guide (Figure 2A). Then four PSI guides can be used to execute the pre-operative planning for glenoid component implantation – 1. pin guide: for insertion of the central pin in the corrected version and inclination (Figure 2B); 2. ream guide: sets the reaming angle and depth (Figure 2C); 3. roll guide: for guidance of component rotation orientation and screw entry points (Figure 2D); 4. screw guide provides the drill direction to achieve planned screw orientation and length (Figure 2E). Final fixation of the baseplate with locking screws and caps (Figure 2F).

Severe primary glenoid bone loss; long peg, humeral head autograft

In cases with severe glenoid bone loss or deformity such as a type C glenoid, a combination of corrective reaming and bone

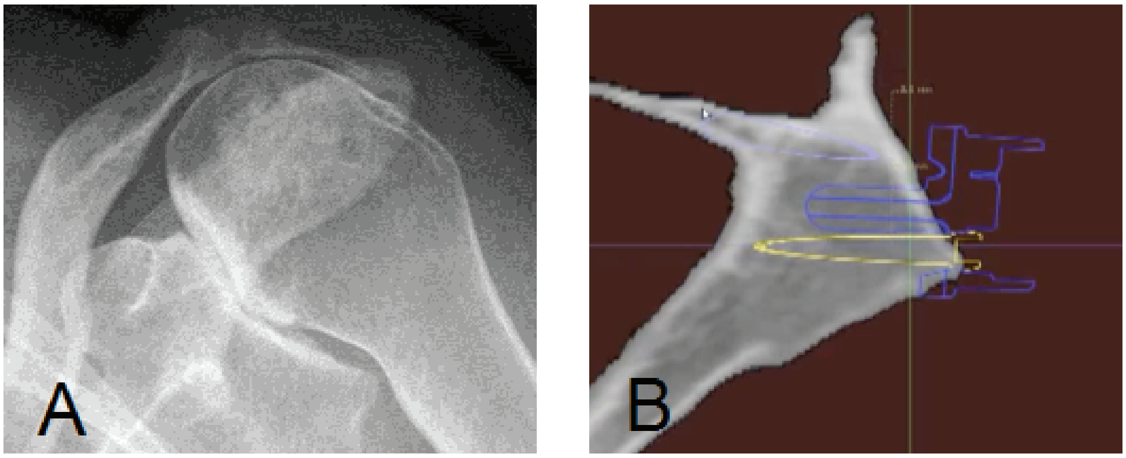

Figure 1. (A) Favard Type E2 glenoid deformity with superior bone loss and superior inclination of the glenoid surface. (B) Planning of corrective reaming and positioning of a standard baseplate using 3D software.

grafting will be necessary to achieve a stable fixation of the glenoid component. This technique has been referred to as the "angled Bio RSA technique" by P. Boileau (Boileau *et al.,* 2011) (Figure 3).

A standard deltopectoral approach is used. After exposure of the proximal humerus a symmetrical graft from the humeral head is harvested (Figure 4A) and further standard preparation of the humerus is performed. Excellent glenoid exposure is essential for successful implant and graft placement. Once the glenoid is exposed, a threaded guide wire is inserted into the glenoid vault using standard techniques or preferably a PSI guide (Figure 4B). Limited corrective reaming using a small reamer and PSI reaming guide is used to abrade the glenoid until the subchondral plate is reached (Figure 4C). In cases of severe glenoid bone deficiency or deformity, the circular reamer will often not be flush with the glenoid and unreamed areas are abraded with a burr (Figure 4D). The central peg hole is then drilled and small peripheral drill holes are made using the threaded guide wire to obtain a complete bleeding bone surface. The goal of the glenoid preparation is to reach

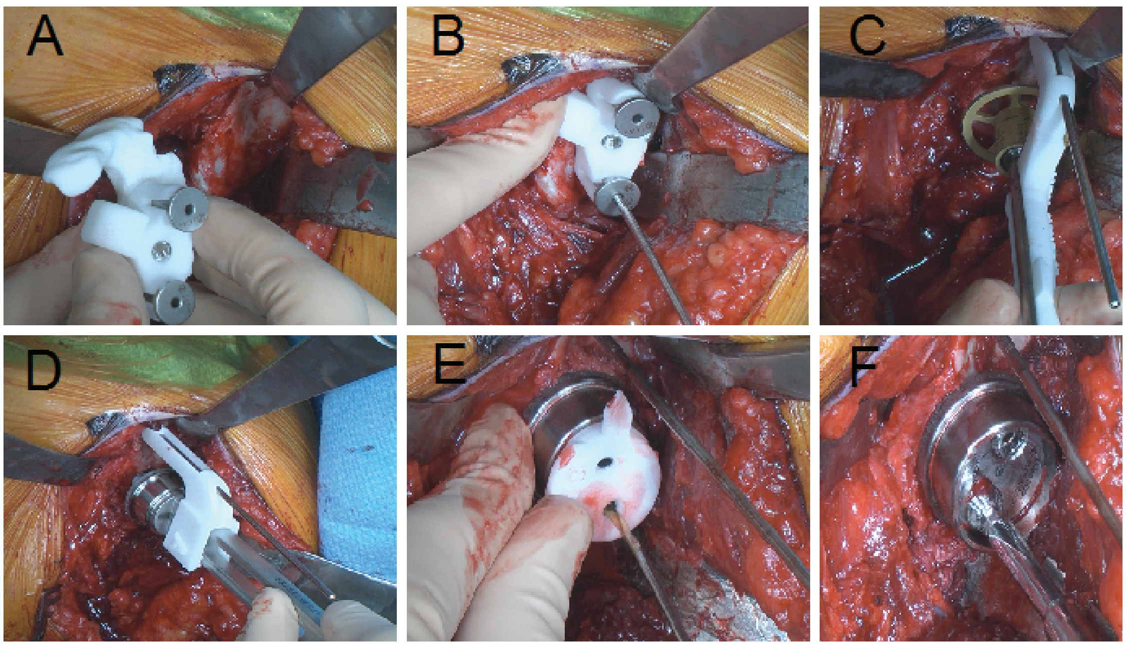

Figure 2. Further explanations in the text.

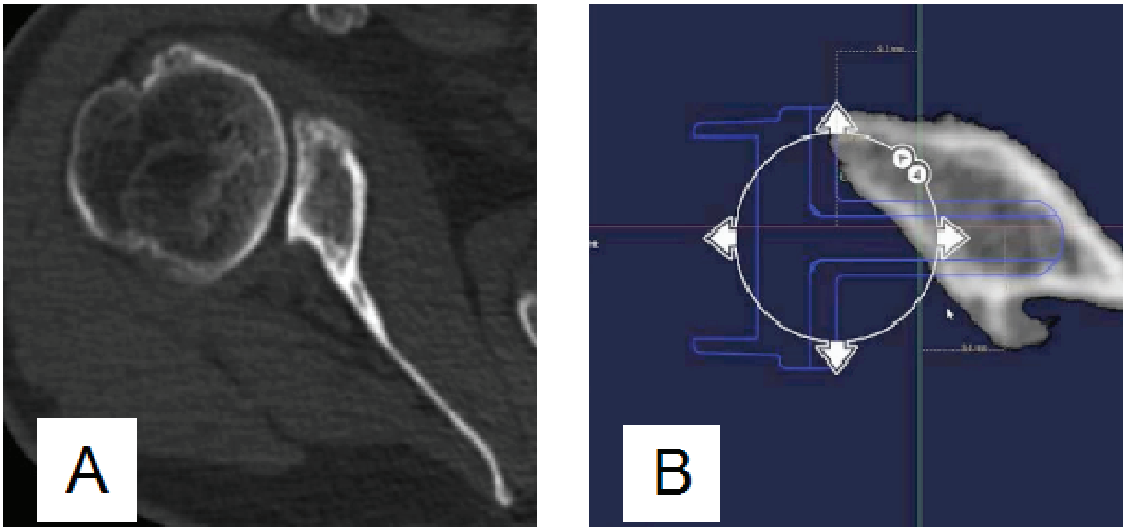

Figure 3. (A) Walch Type C glenoid deformity. (B) Measurement of posterior deformity and positioning of the glenoid baseplate with long post using 3D planning.

cancellous bleeding bone to provide an environment for bone graft incorporation and healing. After preparation of the graft (Figure 4E), the baseplate with long post and angled bone graft are then impacted into the center hole, with care taken to orient the bone graft appropriately with the defect (Figure 4F). The central post should pass 50% of the graft and 50% of the native glenoid bone. Baseplate fixation is then performed using postaxial locking screws. Figure 4G and 4H present principles.

Revision with long peg and iliac crest autograft or allograft

In revision cases where anatomical or reversed glenoid components are loose or malpositioned, often important bone defects need to be addressed. These defects need to be addressed in 1 or 2 stage procedures depending on the primary stability of the graft and new component (Figure 5). Choices between iliac crest autograft or structural allografts need to be made. The strategies and surgical techniques for preparing, contouring, and implanting allograft with the baseplate are similar to those described above with autograft. When selecting allograft, the authors' current preference is to use femoral neck because it has dimensions that mimic the native glenoid.

Discussion and conclusions

Glenoid bone loss is a challenging problem that is frequently encountered during RSA. Failure to identify and address glenoid bone loss can lead to improper baseplate positioning and predispose patients to complications and failure of RSA. Surgeons performing RSA should feel comfortable with the preoperative assessment of glenoid bone loss and be familiar with the surgical strategies to address the bone loss at the time of RSA.

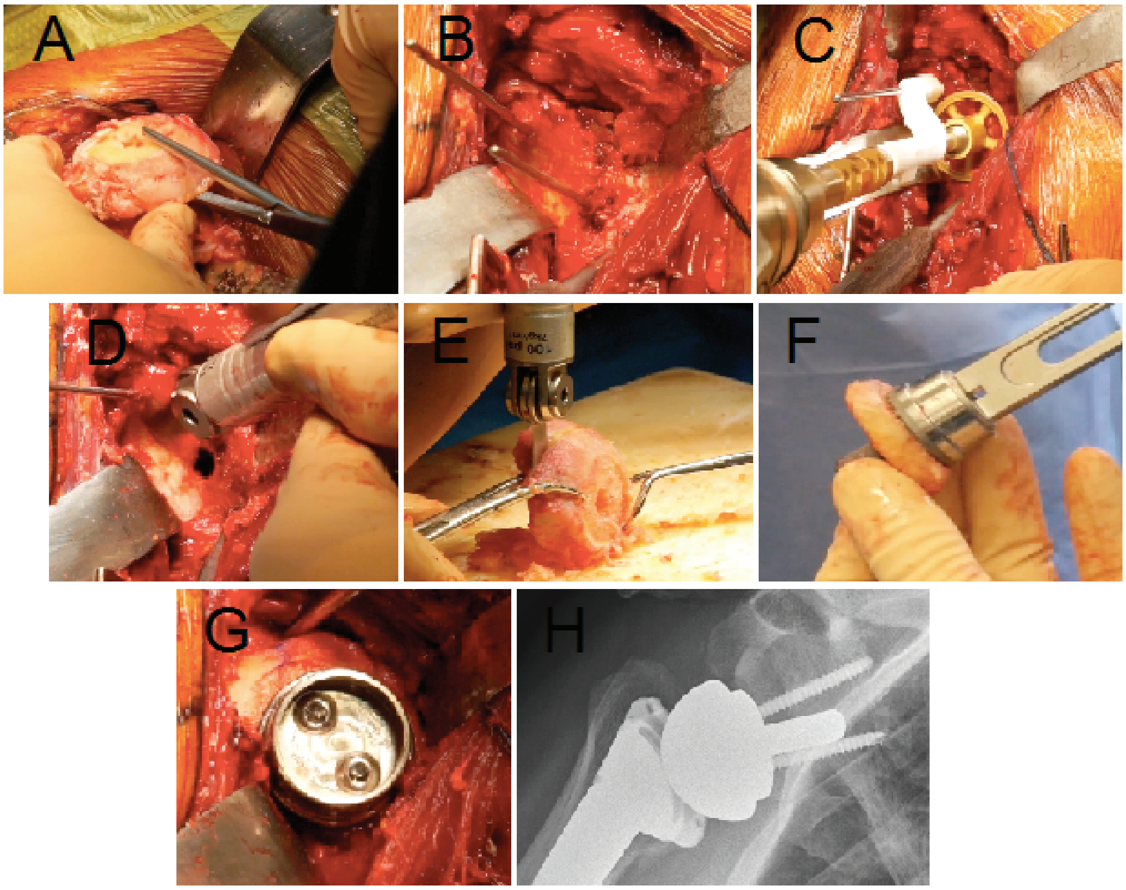

Figure 4. Further explanations in the text.

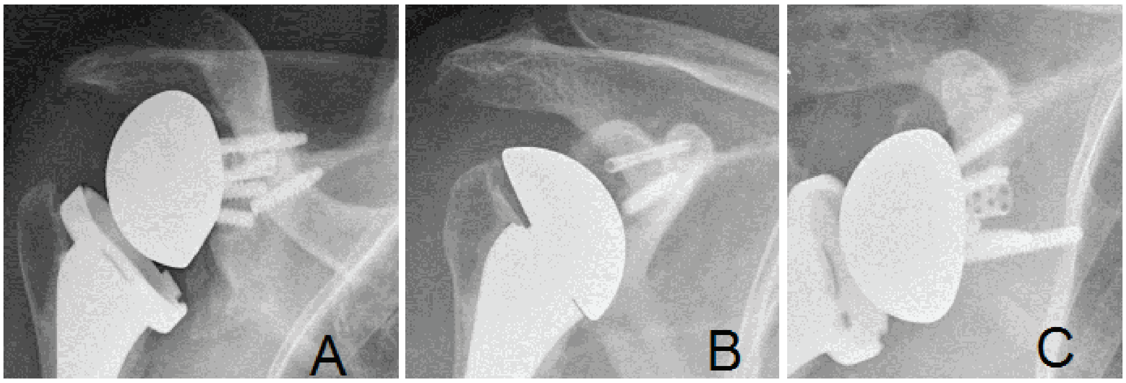

Figure 5. (A) Failed glenoid component after primary RSA. (B) First stage revision with conversion to a hemiarthroplasty and bone grafting of the glenoid. (C) Second stage revision with reimplantation of a glenoid component with a long peg.

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Author responsible for correspondence:
Olivier Verborgt
Department of Orthopaedic Surgery and Traumatology, AZ Monica, Antwerp, Belgium
Stevenslei 20 2100 Antwerp – Belgium
olivier.verborgt@azmonica.be
olivier.verborgt@icloud.com

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Autor odpowiedzialny za korespondencję:
Olivier Verborgt
Department of Orthopaedic Surgery and Traumatology, AZ Monica, Antwerp, Belgia
Stevenslei 20 2100 Antwerp – Belgium
olivier.verborgt@azmonica.be
olivier.verborgt@icloud.com