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ORIGINAL ARTICLE

How to deal with glenoid type B2 or C? How to prevent mistakes in implantation of glenoid component?

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Abstract
Background Although TSA has been shown to significantly yield better outcomes than hemiarthroplasty, glenoid prosthesis loosening remains the most common complication. Inadequate primary fixation enables the glenoid component to move. In primary glenohumeral osteoarthritis (GHOA), glenoid involvement and proper morphology vary considerably. Postero-inferior glenoid hypoplasia could be associated with some degree of osteoarthritis. According to Walch, 24 % of glenoids in GHOA are type B2 or C (excessive posterior retroversion), which increases the challenge for the glenoid component fixation.
Materials and methods A total of 30 cases of TSR with glenoid type B2 (20 cases) and type C (10 cases) were reviewed. Mean follow-up was 11.2 months. A metal-backed (MB) glenoid component was implanted, with a posterior bone graft reconstruction. Pre- and post-operative clinical evaluation was done using the Constant–Murley score and the SST from Matsen.
Results There is no glenoid loosening, no joint narrowing and no radiolucent line. There was no bone graft osteolysis. With 4 patients revised (4 conversions from TSR to RSR for 3 instabilities and 1 secondary rotator cuff tear), on the overall 30 patients cohort, Constant score pain increased from 1.6 to 13.4, forward flexion from 92° to 146° and Constant score from 27 (36 %) to 70 (95 %). The statistical difference between pre- and post-operative values is greatly significant.
Conclusion Although MB prostheses have been noted to have a higher rate of loosening than full-cemented PE, this is not our experience, even in case of glenoid type B2 or C, where the technical challenge is demanding and most of the time a posterior bone graft is necessary.

Keywords Glenoid dysplasia · Glenoid component · Metal-backed

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Introduction

Glenoid loosening component is the main cause of total shoulder replacement (TSR) failure. Placement of the glenoid component in a specified and anatomic location is important for the proper long-term function of the implant. In TSR, if the glenoid component is abnormally retroverted, anteverted, or inclined superiorly or inferiorly, loads become eccentric, creating the so-called rocking horse effect described by Matsen [1, 2]. Most of the time, abnormal component glenoid version results from technical mistakes with a wrong choice of the glenoid vault center and as a result asymmetrical reaming, since it is difficult during the surgery to identify the landmarks that define the plane of scapula and to orient the glenoid component perpendicular [3, 4].

In addition, significant posterior glenoid bone loss is commonly seen in advanced glenohumeral osteoarthritis (GHOA) (glenoid dysplasia type B2 and C from Walch [5]); thus, proper placement of the glenoid component is made more difficult. Correction of glenoid version can include asymmetric reaming of the anterior glenoid.

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Nevertheless, this technique is limited by the amount of bone available after reaming for proper seating and fixation of the component.

In cases where correction of retroversion is not possible without severe compromise in the bone volume, one option includes placing the glenoid component in more retroversion. This option increases the risk of loosening by eccentric loads and may result in perforation of the anterior glenoid wall with, consequently, risk of fracture. An additional alternative would be to combine reaming the anterior part of the glenoid and buildup of the bone deficient posterior part of the glenoid with bone graft. However, interposing cement between the back of the polyethylene (PE) glenoid component and the posterior bone graft presents a high risk of osteolysis with a not fully seated glenoid component.

So far, treatment guidelines for glenoid bone loss have not been clearly established. As risk of loosening is high and as revision surgery is even more technically demanding than the original surgery scarring, stiffness, poor glenoid exposure, destruction of the bone stock, many surgeons opt not to implant a glenoid component.

The purpose of this paper is to present our experience in order to determine how to prevent mistakes in implantation of glenoid component, especially in case of glenoid dysplasia type B2 or C.

Materials and methods

Overall cohort

A total of 143 cases were operated on between 2003 and 2011.

The clinical analysis included a pre- and post-operative evaluation of the Constant and Murley score, of the active and passive range of motion and of the simple shoulder test from Matsen.

Radiographic preoperative assessment consisted of plain AP radiographs with medial, neutral and lateral rotation, axillary and outlet view under fluoroscopic guidance. A systematic CT scan completed the preoperative radiographic analysis to evaluate the status of the cuff and the glenoid bone stock according to Walch classification [5].

Post-operative radiological study included an AP view with a standardized fluoroscopic technique and the X-ray beam perpendicular to the plane of the joint space. This allowed to detect either a potential narrowing witness of a progressive polyethylene wear or radiolucent lines (RLL) at the subchondral bone–component interface, implying incomplete seating and therefore suboptimal fixation which has been shown to increase rocking forces at the component edge.

Operative protocol

All the procedures have been performed by two shoulder surgeons since 2003.

A metal-backed glenoid implant (MB) of the Universal Shoulder Arthroplasty System ARROW (FH orthopedics, 3 rue de la Forêt 68990-Heimsbrunn-France) was used.

The glenoid component thickness is 6.5 mm, 3.5 mm for the PE and 3 mm for the metal tray. The deep convex surface and the keel are covered with hydroxyapatite. Four sizes are available 44, 46, 48 and 50. The primary fixation is insured by 2 axial cancellous screws (diameter 5.5 mm) and can be enhanced by a third sagittal screw. This third screw goes through an anterior plate and the keel. It can be useful in case of osteoporotic patient and glenoid bone loss, allowing an easy bone graft fixation. A long peg (2 cm length extended the keel and 6 mm diameter) MB glenoid component is available in case of a need for glenoid bone graft reconstruction.

A standard deltopectoral approach is used. Partial tenotomy of the upper pectoralis major tendon (1 cm) is done just at its humeral shaft insertion. The subscapularis tendon is incised "en bloc" with the capsule at their insertions on the lesser tuberosity and released along the anterior edge of the scapula from the coracoid process to the distal part of the glenoid. After the long head of the biceps tenodesis and the humeral instrumentation, the trial stem is placed to protect the humeral cut while preparing the glenoid. The glenoid is prepared by releasing the capsule and clearing the labrum to allow for exposure. Care must be taken about the limits of the glenoid vault. Osteophytes and glenoid version can be evaluated and controlled by preoperative CT scan. The ancillary system allows a precise preparation of the glenoid with a reaming of the bone surface and a press-fit preparation of the keel grove in order to insure a perfect contact between hydroxyapatite and bone.

In a normal glenoid version, optimal glenoid component placement can be achieved with the help of standard shoulder prosthesis to find the perpendicular glenoid vault axis to ream.

In case where correction of retroversion to being perpendicular to the plane of the scapula is possible without severe compromise in the healthy bone volume, asymmetric anterior reaming alone is performed and the MB glenoid component is seated. A good press-fit is needed and necessary at this step.

In the cases where correction of retroversion to being perpendicular to the plane of the scapula is not possible without severe compromise in the healthy bone volume, the option is to combine differential anterior glenoid vault reaming and posterior bone graft to recreate the native glenoid version option. Cancellous bone graft from the

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humeral head is placed posteriorly onto the micro-perforated underlying glenoid bone, and either a normal MB component or an extended one (long peg) is seated. A very good press-fit is the key to success. Therefore, in case of bad press-fit, the long peg crosses the medial wall of the glenoid, looking for the native bone and acting as the keel of a boat. A superior cancellous screw and an inferior one screws (length from 32 to 36 mm) compress the back of the glenoid MB onto the cancellous graft. These screws have to cross the medial cortical wall of the scapula, in order to have a strong compression of the glenoid MB onto the glenoid vault.

Results

Since November 2003, 143 total anatomical shoulder arthroplasties have been performed for GHOA. We reviewed 120 TSR. In the Walch classification, there were 50 glenoid A1 (41.6 %), 29 glenoid A2 (24.2 %), 11 glenoid B1 (9.1 %), 20 glenoid B2 (16.7 %) and 10 glenoid C (8.4 %).

We will only analyze glenoid type B2 and type C (Fig. 1a, b).

Mean follow-up is 11.2 months (from 2 months to 49 months).

A total of 30 cases (15 females and 15 men, 14 right side, 23 right-handed) were evaluated. The average age was 67.8 years (49–82).

Cancellous posterior bone graft was performed for every case.

There is no glenoid loosening, no joint narrowing and no RLL. There was no bone graft osteolysis.

The common size for the MB was 44 in 3/4 cases and 46 in 1/4 cases.

Three dislocations occurred (10 %) after *x* months needing revision [conversion to a reverse shoulder replacement (RSR)].

In one case with a type B2 glenoid, the conversion consisted in simply changing the PE tray to a glenosphere. The MB tray was not touched. This patient is 18 months post-operatively with an active flexion of 120°, no pain and a Constant score of 54 (76 %).

For the 2 cases with a glenoid type C, it was necessary to take the metal tray out despite a good integration.

Upward migration due to secondary rotator cuff tear occurred in one type B2 case after *x* months and needed revision to RSR. The Constant score progressively worsened. During revision performed at 2 years, a postero-superior PE wear was found with a contact between the metal tray and the humeral head. At 6 months, the result was excellent with a Constant score of 68 (100 %) and an active elevation of 140°.

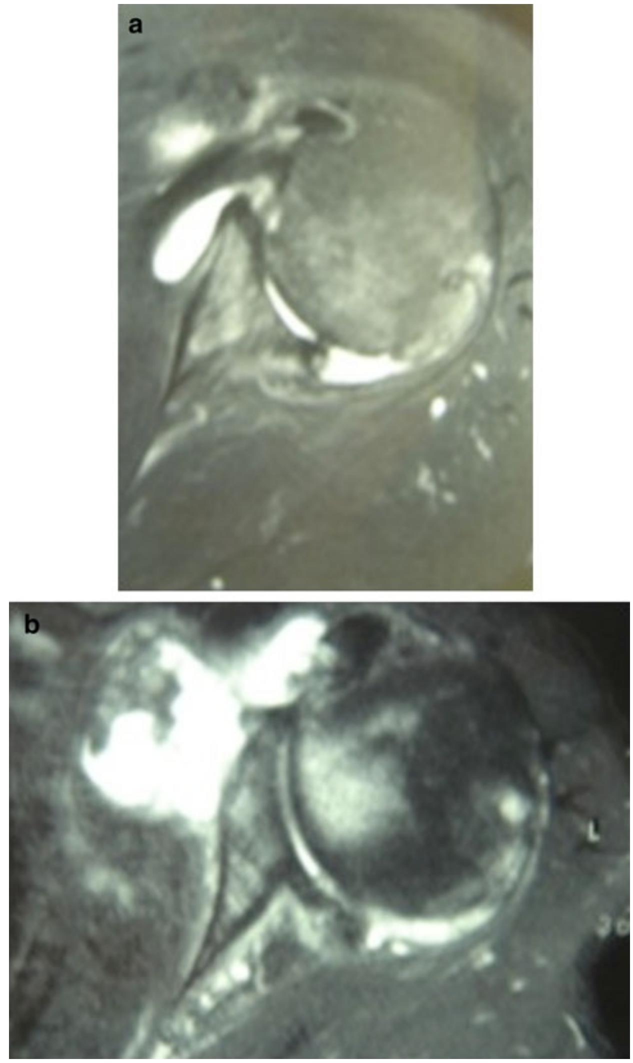

Fig. 1 Walch glenoid classification. **a** Type B2. **b** Type C

Finally with 4 patients revised, on the overall 30 patients cohort, Constant score pain increased from 1.6 to 13.4, forward flexion from 92° to 146° and Constant score from 27 (36 %) to 70 (95 %). The statistical difference between pre- and post-operative values is greatly significant.

Discussion

GHOA anatomic specificities

Normal glenoid version varies within the population over a range of about −20°, with the majority of patients having slight retroversion and average retroversion of −1° or −2° [6–9].

In primary glenohumeral osteoarthritis (GHOA), glenoid involvement and proper morphology vary considerably. Neer [10, 11] stated that there is a frequent posterior

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erosion of the glenoid in this condition and a posterior subluxation of the humeral head. Friedman et al. [12] and Mullaji et al. [13] reported an excessive retroversion of the glenoid. In a series of 1,150 scapular bone specimens, Edelson [14] showed that localized glenoid hypoplasia was present in 20–35 % of the cases depending on the population group studied. This postero-inferior glenoid hypoplasia could be associated with some degree of osteoarthritis. With a serial computed tomography scans of 113 osteoarthritic shoulders, Walch et al. [5] described three main glenoid types: Type A, Type B and Type C. Type A (59 %) is marked by a well-centered humeral head and a balanced distribution of strengths against the surface of the glenoid. The symmetric erosion is explained by the absence of subluxation. In Type B (32 %), the posterior subluxation of the humeral head is responsible for the asymmetric load against the glenoid and was involved in the development of primary GHOA, particularly the exaggerated posterior wear pattern. Two subgroups were identified: B 1 (17 %) showed narrowing of the posterior joint space, subchondral sclerosis and osteophytes, and B2 (15 %) demonstrated a posterior cupula that gave an unusual biconcave aspect of the glenoid. Type C (9 %) is defined by a glenoid retroversion of more than 2 5°, regardless of erosion; retroversion is primarily of dysplastic origin and explained the early event of osteoarthritis. In our study, we just studied glenoid type B2 and type C. Like Walch, we found 16.7 % of type B2 and 8.4 % type C.

71 % of TSR is being carried out for GHOA [15]. Although TSA has been shown to significantly yield better outcomes than hemiarthroplasty [16], glenoid prosthesis loosening remains the most common complication [17–19].

Why and how to look for a centered perpendicular scapular plan for the glenoid component?

While many factors have been described [20] as possible contributors to glenoid component failures (failure of the component itself, failure of the component fixation, failure of bone, prosthetic loading, patient selection), one of the main problems still remains the glenoid component version. The so-called rocking horse phenomenon [1, 2, 20] induces eccentric (i.e., off-center) loading by the result of humeral head subluxation. Therefore, loosening results from loading one edge of the component causing lifting of the opposite edge away from the bone.

Most of the time, glenoid vault anatomic landmarks are difficult to find. Care must be taken with the surgical approach with a circumferential glenoid release because this is part of the key to success.

In a normal glenoid version, optimal glenoid component placement can be achieved with the help of standard shoulder prosthesis instrumentation to ream in the perpendicular glenoid vault axis. Nevertheless, although main bone stock is anterior (Fig. 2) [21] and because of the anterior (deltopectoral) approach, the most frequent mistake is to anteriorly position the centering hole closer to the anterior cortical wall than expected, and consequently to increase the risk of glenoid fracture. In case of glenoid biconcave type B2, it is not so difficult to find an anatomic landmark and therefore to define the center of the glenoid vault and the perpendicular axis to ream. Type C glenoid remains the most difficult one. In order to find the center hole and the perpendicular scapular plane line, a specific guide or an assisted computerized technique can be helpful. The glenoid reamer is used to remove the articular cartilage and create a concave congruent base for the final prosthesis.

Glenoid component implantation options in case of posterior glenoid bone loss

Failures of the component seating increase because of inadequate support of the body of the glenoid component by underlying bone. The goal is to minimize wobble (progressive loosening by off-center loads) and warp (bending of the PE) of the component described by Collins [22] in response to the eccentric loads.

With a dysplastic glenoid, risk of glenoid component mal-positioning is common [23]. The amount of correction that is required is not clearly defined. Without knowing the patient's native version, an arbitrary goal of glenoid

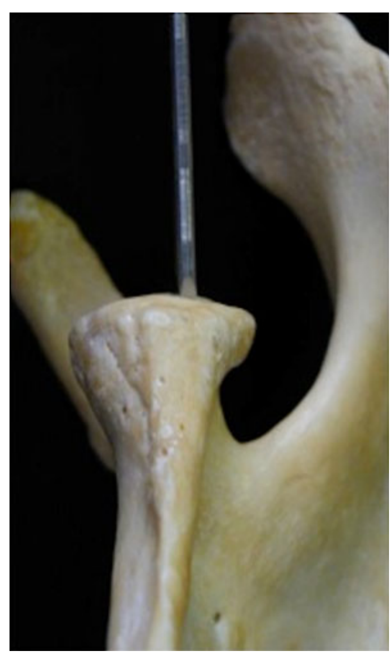

Fig. 2 Main glenoid bone stock is anterior

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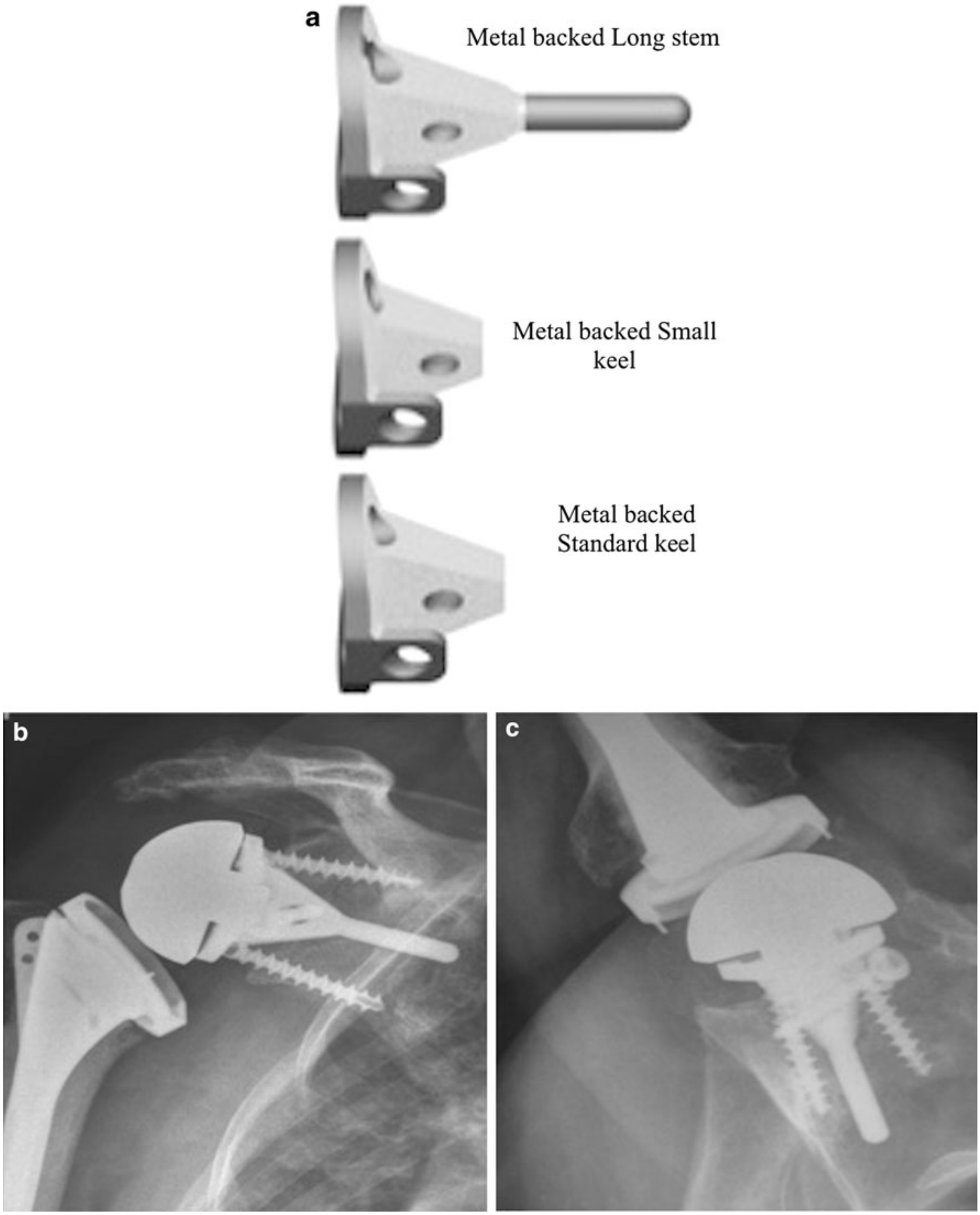

Fig. 3 **a** Metal-backed glenoid component with small keel, normal keel or long peg (*arrow*, FH Orthopedics). **b** X-ray with a long peg metal-backed glenoid component for revision surgery in case of Type C glenoid. **b**, **c** AP and axillary radiographies of the case presented with the Fig. 1b (glenoid type C). Very good primary fixation of the MB glenoid component with the long peg

position has been to place the glenoid perpendicular to the plane of the scapula.

Correcting moderate to severe glenoid deformity and placing the glenoid component in the ideal (i.e., perpendicular to the scapula plan) are not consistent [24]. Retroversion greater than −20° makes it difficult, not really reproducible even for an experienced shoulder surgeon. An unperfected (no perpendicular) axis will induce an asymmetric reaming and consequently will increase rate of center peg perforation. In addition, malpositioning the glenoid component can contribute to loosening [24, 25].

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In case where a correction of retroversion to being perpendicular to the plane of the scapula is possible without severe compromise in the healthy bone volume, asymmetric anterior reaming alone is performed and either a full-cemented PE component or a MB one is seated. A good press-fit is needed and necessary at this step.

In the cases where correction of retroversion to being perpendicular to the plane of the scapula is not possible without severe compromise in the healthy bone volume, the options cannot include placing the glenoid component in more retroversion, although many surgeons neglect mild peripheral bone deficiencies and accept a non-anatomic orientation. This may result in central peg anterior wall perforation. Buttressing the defect with bone cement was attempted in the past but is no longer recommended because of a high incidence of cement fractures and implant failures [22, 26]. Anteverting the humeral component to accommodate excessive glenoid retroversion has also been explored, but this remains a controversial technique [11, 17]. Glenoid prostheses augmented with an oblique posterior wedge have been implanted in patients, but these prostheses have failed to show any substantial benefits [11, 27].

The alternative is to combine differential anterior glenoid vault reaming and posterior bone graft to recreate the native glenoid version and avoid excessive retroversion. Since risk of bone graft osteolysis [28] is high, full-cemented PE glenoid component cannot be placed. Conversely, MB glenoid component may be helpful to fix bone graft. In addition, Neer and Morisson [11] stated that at least 80 % of the surface of the MB component should be in contact with good bone stock and the entire back of polyethylene component should be supported by bone. As a result, surgeons who seek to restore normal anatomy and accurate placement of the prosthesis should consider earlier reconstruction in symptomatic type B or type C GHOA.

Bone graft can be cortical (iliac crest bone), but this step is demanding with the use of posterior cortical screws and washers. This challenge is a time-consuming procedure with inconstant success rates [29, 30]. The anterior (deltopectoral) approach is not the best one for a posterior glenoid reconstruction. Moreover, impingement is frequent between screws and glenoid component pegs or keel. Last but not least, recreating the native glenoid vault looking for a perfect underlying bone to support the body of the glenoid component is quite impossible and leads to poor seating.

Cancellous bone graft can be used (humeral head cancellous bone), but since there is no mechanical structure, a specific glenoid component with longer peg (Fig. 3a–c) has to be used as micro-motion leads to a cycle of bone resorption around the implant decreasing stability. Furthermore, recreating the native glenoid vault becomes easier and optimizes seating.

A good press-fit is needed and necessary at this step.

Conclusion

TSA has been shown to significantly yield better outcomes than hemiarthroplasty. Nevertheless, malposition of the glenoid component is one of the most frequent technical mistakes. In addition, a glenoid dysplasia, which is frequent in GHOA, increases the challenge. As a result, a comfortable approach is needed to clear the glenoid vault from the rim and to look for anatomic landmarks. A preoperative CT scan is useful to understand position of the osteophytes and glenoid retroversion. The ideal axis should be perpendicular to the plan of the scapula to prevent central peg anterior wall perforation. Most of the time, because of the (anterior) deltopectoral approach, the central peg is too anterior and induces a high risk of the glenoid anterior edge fracture. We combine differential anterior glenoid vault reaming and posterior cancellous bone graft to recreate the native glenoid version. Although MB prostheses have been noted to have a higher rate of loosening than full-cemented PE, this is not our experience, even in case of glenoid type B2 or C where most of the time a posterior bone graft is necessary.

Conflict of interest The author is "Arrow shoulder prosthesis" designer.

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