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ORIGINAL PAPER

Benefits of a metallic lateralized baseplate prolonged by a long metallic post in reverse shoulder arthroplasty to address glenoid bone loss

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Abstract

Background Severe glenoid bone loss remains a surgical challenge. This condition is known to be associated with high rates of glenoid component failure.

Purpose The objective of this study was to evaluate clinical and radiological outcomes of a lateralized metal-backed 15.2-mm keeled baseplate prolonged by a thin 24.8-mm metallic post fixed directly in the subscapularis fossa in primary cases of reverse shoulder arthroplasty (RSA) for severe glenoid bone loss and in revision cases.

Materials and methods Between January 2011 and December 2014, 51 shoulders (50 patients) underwent primary or revision RSA using this baseplate. Forty-five shoulders in 44 patients were followed for a minimum of two years (mean, 33 months; range, 24–60 months). The mean age of the patients was 76 years (range, 55–93 years). Outcome measures included pain, range of motion, Constant Score, and complications.

Results The complication rate was 12% in primary cases and 25% in revision cases. One glenoid implant (4%) failed in primary cases and one glenoid implant (5%) failed in revision cases. Pain and range of motion were significantly improved in both groups. The mean Constant Score improved from 24 (± 7) to 62 (± 9) in primary cases and from 24 (± 10) to 58 (± 12) in revision cases.

Conclusion A lateralized metal-backed 15.2-mm keeled baseplate prolonged by a thin 24.8-mm metallic post fixed directly in the subscapularis fossa may provide satisfactory mid-term outcomes in patients with large glenoid bone defects where initial press-fit of a regular baseplate is impossible to obtain.

Keywords Reverse shoulder arthroplasty · Glenoid deficiency · Revision · Primary fixation · Long peg · Cuff tear arthropathy

Introduction

Severe glenoid bone loss can be found in patients with degenerative bone erosion [1, 2], congenital glenoid dysplasia [1], or revision shoulder arthroplasty [3] and remains a surgical challenge. This condition is known to be associated with high rates of complications and glenoid component failure [3–7]. Major glenoid bone defects can even be a contraindication to implant a reverse shoulder arthroplasty (RSA), and a hemiarthroplasty (HA) may be preferred in these cases to avoid glenoid implantation [8–11]. Results of HAs in this indication are known to be poor, especially in cases of associated rotator cuff insufficiency [8, 10], and various techniques have been proposed to allow implantation of a RSA in these patients. These include RSA with [3, 12] or without glenoid bone grafting by reaming the glenoid flat [13], augmented glenoid baseplates [14], and custom-made implants [15, 16]. In addition, implantation of a standard Grammont-design glenoid in these glenoids which are already

Investigation performed at the Paris Shoulder Unit, Paris, France

Level of evidence: Level IV; Case Series; Treatment Study

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excessively medialized due to bone wear can increase the risk of complications related to the medialized design [17–22], such as scapular notching [17, 22–24], limited shoulder rotation, and instability [19]. Therefore, metallic or bony lateralization appears to be essential in this specific population [25–27] to at least restore the joint line position. In addition, the increased compressive forces due to a lateralized offset could improve the incorporation of an eventual bone graft [28].

One of the key factors to obtain a strong initial fixation of the glenoid implant is the depth of the glenoid vault which has been previously reported to average 31.5 mm (range, 26–40 mm) in non-arthritic cadavers [29]. However, in cases of severe glenoid erosion, depth of the glenoid vault can be significantly reduced, leading to perforation of the glenoid vault by the approximately 15-mm-long peg of the glenoid implant. Perforation of the glenoid vault by a short and thick central peg could weaken the vault and may impair primary fixation of the glenoid component.

A lateralized metal-backed 15.2-mm keeled baseplate with a strong press-fit prolonged by a thin 24.8-mm metallic post fixed directly in the subscapularis fossa as an abutment rather than exclusively in the vault could offer an alternative in cases of severe glenoid bone loss and could allow better bone graft healing.

The objective of this study was to evaluate clinical and radiological outcomes of this glenoid implant in primary cases of reverse shoulder arthroplasty for severe glenoid bone loss and in revision cases.

Materials and methods

Patient group

Between January 2011 and December 2014, 51 RSAs (50 patients) with a metal-backed lateralized baseplate prolonged by a thin and long metallic post (Arrow, FH Orthopedics, Mulhouse, France) were implanted with a minimum 2-year follow-up. Three patients were lost to follow-up and three died before the minimum two year follow-up, leaving 45 shoulders in 44 patients. The inability to obtain a satisfactory initial press-fit of a standard glenoid implant was the primary indication for this prolonged baseplate.

Patients were divided into two groups: primary cases and revisions.

Primary cases

Twenty-five shoulders in 24 patients (2 men, 22 women) with a rotator cuff insufficiency associated with severe glenoid bone loss received a primary RSA with prolonged baseplate. The mean age of the patients was 77 years (range, 55–93 years). They were followed for an average of 33 months (range, 24–60 months). Indications for RSA were cuff tear arthropathy in 19 cases and post-traumatic arthritis in six cases (Fig. 1). During the study period, we performed 112 primary RSAs with standard keeled implants for patients with little to no glenoid bone loss.

Revision cases

Twenty patients (4 men, 16 women) who received a revision reverse shoulder replacement with a prolonged baseplate were included. The mean age of the patients was 74 years (range, 55–89 years) and they were followed for an average of 32 months (range, 24–48 months). The primary indications for revision surgery included glenoid loosening after RSA (8), painful glenoid arthrosis after HA (5), instability of RSA (2), glenoid loosening after total shoulder arthroplasty (2), rotator cuff tear after total shoulder arthroplasty (2), and infection after total shoulder arthroplasty (1). During the study period, we performed 24 revision RSAs with standard keeled implants for patients with little to no glenoid bone loss.

Clinical assessment

Revision surgeries, re-operations, and complications were analyzed. Revision surgery was defined as removal of any component. Pre- and post-operative range of motion was assessed in degrees; internal rotation was assessed by the most cephalad vertebral segment reached by the thumb. Pain was evaluated using the visual analog scale (VAS). Post-operative function was assessed using evaluation questionnaires including the subjective shoulder value (SSV) score, the Simple Shoulder Test (SST), and the Constant Score. Subjective satisfaction was determined by asking the patients to compare the shoulder with before surgery and to assign a rating of much better or very satisfied (1), better or satisfied (2), the same (3), or worse or disappointed (4).

Radiological assessment

Pre-operative planning was systematically performed using standard radiographs (anteroposterior view in neutral, external and internal rotation, and axillary view). All patients underwent computed tomography (CT) of the involved shoulder in order to evaluate glenoid shape, extent of glenoid bone defect, trophicity, and fatty infiltration of the remaining cuff (teres minor and subscapularis).

In primary cases, glenoids were classified into four groups depending on the location and severity of the glenoid wear:

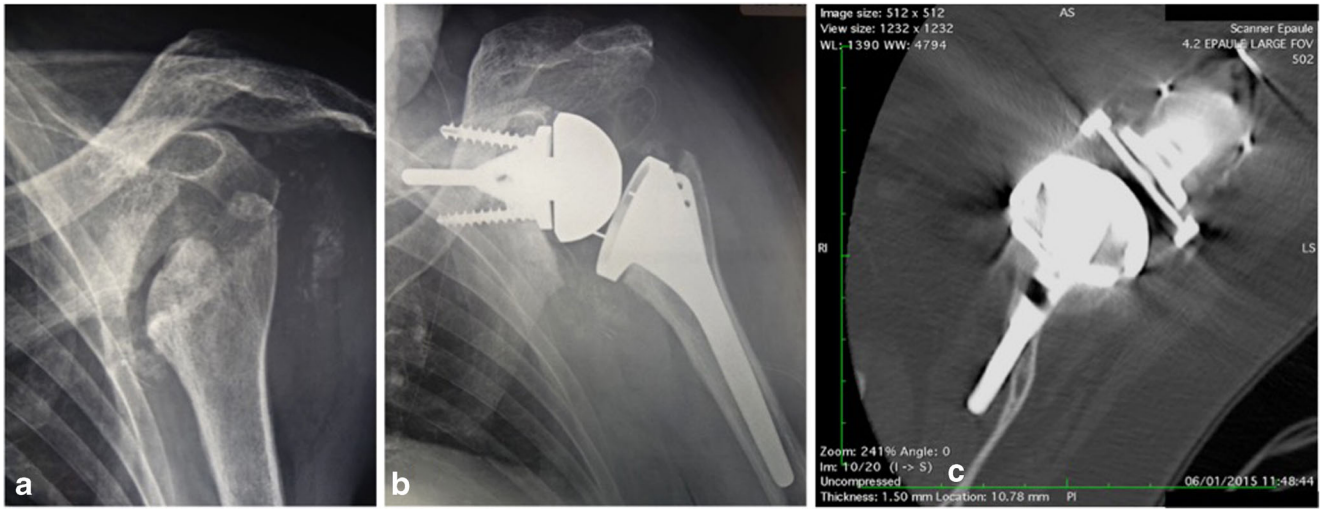


Fig. 1 A 77-year-old female patient with post-traumatic avascular necrosis and glenohumeral arthritis with severe glenoid bone loss and excessive medialization. Pre-operative anteroposterior radiograph of her left shoulder (**a**). Reverse shoulder arthroplasty using a 15.2-mm keeled baseplate prolonged by a thin 24.8-mm-long metallic post fixed in the subscapular fossa. Post-operative radiograph at 30-month follow-up (**b**). Lateral offset is restored thanks to the metallic lateralization of the implant without the need for any structural bone grafting. Post-operative CT-scan at 30-month follow-up (**c**). Glenoid medial post can be seen perforating anteriorly in the subscapularis fossa

Group 1 ($n = 10$): severe central glenoid erosion with medialization of the joint line.
Group 2 ($n = 3$): anterior glenoid bone loss (D glenoid [30]).
Group 3 ($n = 3$): posterior glenoid bone loss with a posterior subluxation (B3 glenoid [30]).
Group 4 ($n = 9$): small glenoids with osteoporotic bone with a glenoid vault ≤ 20 mm of depth in the coronal plane.

Glenoid erosion in the sagittal plane was evaluated with the Favard classification [2]. There were eight cases of E0 glenoids, ten cases of E1, five cases of E2, and three cases of E3.

In revision cases, glenoid bone loss was quantified pre- and intra-operatively according to the Sauzieres' classification [31] into five different types (Fig. 2):

Type A ($n = 10$): central defect respecting cortical bone.
Type B ($n = 3$): peripheral defect of the anterior wall of less than a third of the depth of the glenoid vault.
Type C ($n = 2$): peripheral defect of the posterior wall of less than a third of the depth of the glenoid vault.
Type D ($n = 2$): peripheral defect of both walls of less than a third of the depth of the glenoid vault.
Type E ($n = 3$): bone defect of the greater than a third of the depth of the glenoid vault.

Templates were systematically used pre-operatively on standard radiographs (AP view) to estimate whether a structural bone graft would be necessary to restore the lateral offset (Fig. 2).

Glenoid fixation was evaluated on the last shoulder radiographs (anteroposterior and axillary views). Radiographic

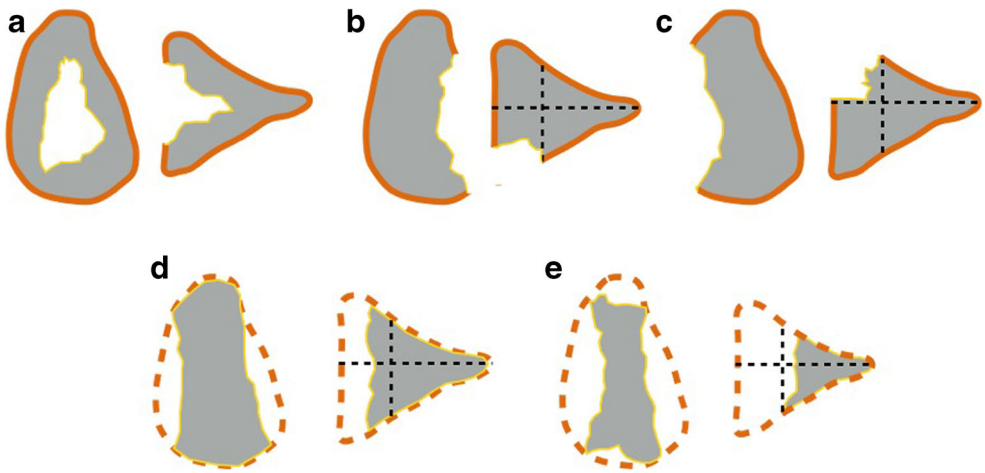


Fig. 2 Sauzieres' classification [31] for glenoid bone loss in cases of revision. Type A: central defect respecting cortical bone. Type B: peripheral defect of the anterior wall of less than a third of the depth of the glenoid vault. Type C: peripheral defect of the posterior wall of less than a third of the depth of the glenoid vault. Type D: peripheral defect of both walls of less than a third of the depth of the glenoid vault. Type E: bone defect of the greater than a third of the depth of the glenoid vault

glenoid loosening was defined as follows: tilt or migration of the glenoid component or breakage of a screw. Scapular notching was classified according to Sirveaux et al. [24]. Implant position and bone graft healing were assessed on CT scans.

Specific glenoid baseplate

To improve the primary stability of the glenoid component in the native glenoid bone, especially when there is no anterior or posterior wall or both, a specific keeled baseplate (15.2 mm) prolonged by a thin long metallic post (24.8 mm) was designed and implanted in all cases (FH Orthopedics, Mulhouse, France) (Fig. 3). Three sizes were available for this oval-shaped baseplate (44, 46, 49) to optimize the contact surface of the convex back of the baseplate with the glenoid bone. The posterior surface of the baseplate has a rough surface coated with hydroxyapatite to improve healing of the bone graft. The long smooth thin post is implanted at the base of the scapular spine or perforates the subscapular fossa allowing a strong initial stability especially when there is no anterior or posterior wall support. With this specific glenoid component, there are three points of fixation to maximize initial fixation without the need for any bone graft: medially with the long post; anteriorly with an anterior winglet and medially with the keel. A cortico-cancellous bone graft can then easily be secured between the anterior winglet and the keel to restore an anterior or a posterior wall as the winglet can be placed anteriorly or posteriorly depending on the quality of the primary stability of the implant. Cancellous bone graft is impacted superiorly and posteriorly to compensate for superior erosion. In cases where a central defect is present, the volume of the keel is designed to fill the bone defect without the need for any bone grafting. The glenosphere is impacted over the baseplate and creates with the convex baseplate an 8.5-mm lateralization of the centre of rotation (COR). Therefore, the design of this baseplate is useful in cases where the glenoid is medialized and in revision cases, when the glenoid component has failed. This allows diminishing the size of the autograft or allograft needed. Moreover, the use of a stem with a neck-shaft angle of 135° and an onlay asymmetric polyethylene humeral insert allows an extra lateralization in the humerus to restore a lateral offset useful to retention the remaining cuff and to increase compressive forces on the graft, improving its chances of healing.

Surgical technique

All patients were operated through the deltopectoral approach in the beach chair position under general anaesthesia with an additional interscalene block. The catheter was left in place for 48 hours for analgesic purposes. The shoulder and iliac crest were prepped and draped simultaneously. When present, the subscapularis was peeled off the lesser tuberosity in all cases during the deltopectoral approach and was repaired with a double row construct and medialized to obtain at least 40° of passive external rotation. The first step of the surgery was systematically a complete release of all adhesions at the deep part of the deltoid and the pectoralis major. The conjoint tendon was identified and the location of the musculocutaneous and axillary nerves was recognized with the index finger. The second step was the implantation of the prolonged glenoid keeled baseplate. In all cases, the goal was to implant the baseplate flush to the inferior rim of the glenoid with a 10° inferior tilt to increase compressive forces and to decrease shear forces. The objective was always to obtain a strong press-fit fixation with a primary stability of the baseplate without any bone graft. In this technique, cancellous bone graft or sometimes cortical bone graft was

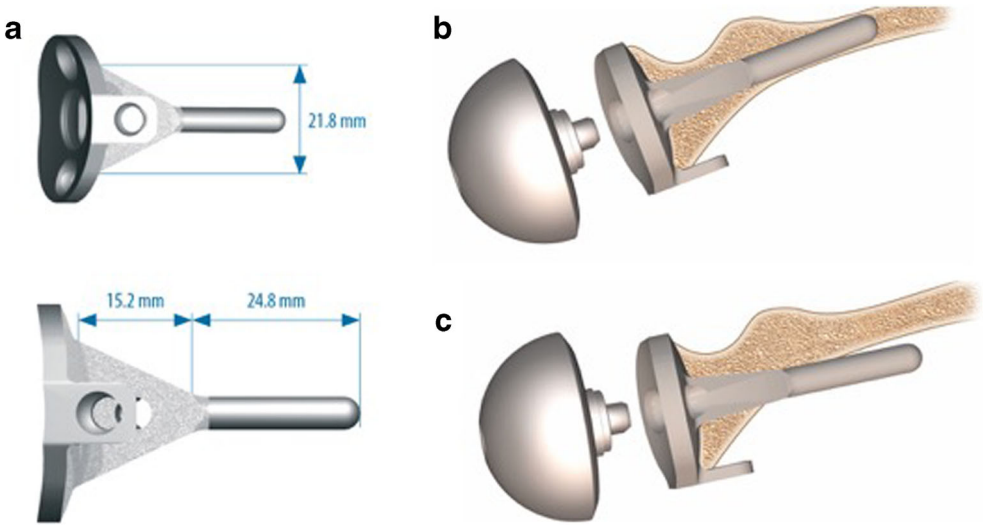


Fig. 3 Specific 15.2-mm keeled baseplate (**a**) prolonged by a thin 24.8-mm-long metallic post (FH Orthopedics, Mulhouse, France). The long smooth thin post is implanted at the base of the scapular spine (**b**) or perforates the subscapular fossa (**c**)

only used to fill the bone defect under the baseplate (mainly in the superior part because of the inferior tilt). The reconstruction of the glenoid depended on the type of glenoid bone loss according to the Sauzieres' classification [31]. In type A glenoids, the keel had sufficient size to fill the glenoid vault without any graft. In type B or type C glenoids, the coracoid process was used as a cortico-cancellous bone autograft to restore an anterior or posterior wall. In type D or type E glenoids with severe glenoid bone loss and medialization of the native glenoid, a cortico-cancellous iliac crest autograft or an allograft or both fixed to the baseplate was used to restore the lateral offset and the tension of the deltoid to minimize the risk of instability.

Post-operative management

A shoulder splint in neutral rotation was used for the first four weeks. Passive range of motion (ROM) was started immediately with pendulum exercises and passive anterior elevation. Active assisted and active ROM were started after six weeks and physiotherapy was carried on for six months. Elderly patients were referred to a rehabilitation center.

Statistical analysis

Descriptive statistics are detailed as mean (standard deviation) for continuous measures and number (percentage) for discrete variables. A paired t test was used to compare pre-operative vs. post-operative changes. The α level for all tests was set at 0.05 for statistical significance.

Results

Primary cases

Complications and re-operations

Follow-up data was available for 25 primary RSAs at a mean 33 months (range, 24–60 months). Of the 25 shoulders, three (12%) had post-operative complications: humeral aseptic loosening (1) that was revised with a cemented humeral implant, subsidence of the glenoid implant (1), complete brachial plexus palsy (1) with partial recovery at the last follow-up after open release of the brachial plexus. The case of glenoid subsidence was due to a technical mistake. The medial post had perforated posteriorly preventing satisfactory medial support. In addition, these patients had a major glenoid defect with a medialized joint line and no anterior glenoid wall (Sauzières E). This led the glenoid component to shift in position anteriorly.

Clinical outcomes

At last follow-up after primary RSA, pain and range of motion were significantly improved. The mean VAS score decreased from 7 (± 2) to 0.6 (± 0.7) ($p < 0.0001$). Mean anterior elevation improved from 63° (± 23°) to 133° (± 30°) ($p < 0.0001$), external rotation with the arm on the side improved from 7° (± 19°) to 25° (± 14°) ($p = 0.006$), external rotation with the arm at 90° of abduction improved from 20° (± 23°) to 52° (± 24°) ($p < 0.0001$), and internal rotation improved from the sacrum to L3 ($p = 0.03$). The SSV score increased from 24% (± 6) to 74% (± 14) ($p < 0.0001$). The Constant Score improved from 24 (± 7) to 62 (± 9) ($p < 0.0001$) and the weighted score improved from 33 (± 10) to 89 (± 14) indicating both subjective and objective shoulder improvement. Subjectively, 17 were very satisfied, 6 satisfied, and one was disappointed.

Radiographic outcomes

In all cases, the radiological evaluation at the last follow-up showed a good healing of the bone graft on the superior and posterior part of the glenoid with no radiolucency. There was no bone graft resorption and no scapular notching. In 24 cases (96%), the medial post had perforated the scapula anteriorly in the subscapularis fossa. In one case (4%), the medial post had perforated the scapula posteriorly. In one case, subsidence of the glenoid implant with a progressive superior migration of the glenoid component was observed. The implant stabilized under the acromion and the patient did not require revision. Humeral radiolucent lines were observed in three cases and one of them had to be revised for aseptic humeral loosening.

Revision cases

Complications and reoperations

Follow-up data was available for 20 revision RSAs at a mean 32 months (range, 24–48 months). Of the 20 shoulders, 5 (25%) had post-operative complications and were all revised. Two cases of instability of the RSA were treated with a spacer and a bigger glenosphere (size 39). One case of subsidence of the glenoid implant was revised with a new long post baseplate combined with an asymmetric posterosuperior allograft. As for the case of glenoid failure in a primary RSA, this glenoid subsidence was due a technical mistake on a Sauzières E glenoid where the medial post perforated the scapula posteriorly leading to an anterior shift in position of the implant. One case of humeral loosening was revised with a long stem and a metaphyseal allograft. One case of periprosthetic humeral fracture below the prosthesis was treated with a plate, cortical strut allograft, and long stem.

Clinical outcomes

At the last follow-up after revision RSA, pain and range of motion were significantly improved. The mean VAS score decreased from 7 (± 2) to 1 (± 1) ($p < 0.0001$). Mean anterior elevation improved from 67° (± 30°) to 121° (± 31°) ($p < 0.0001$), external rotation with the arm on the side improved from 11° (± 19°) to 23° (± 18°) ($p = 0.001$), external rotation with the arm at 90° of abduction improved from 15° (± 14°) to 38° (± 30°) ($p < 0.0001$), and internal rotation improved from the sacrum to L5 ($p = 0.05$). The SSV score increased from 30% (± 15) to 66% (± 20) ($p < 0.0001$). The Constant Score improved from 24 (± 10) to 58 (± 12) ($p < 0.0001$) and the weighted score improved from 35 (± 16) to 85(± 19) indicating both subjective and objective shoulder improvement. Subjectively, 15 patients were very satisfied, two were satisfied, and three were disappointed.

Radiographic outcomes

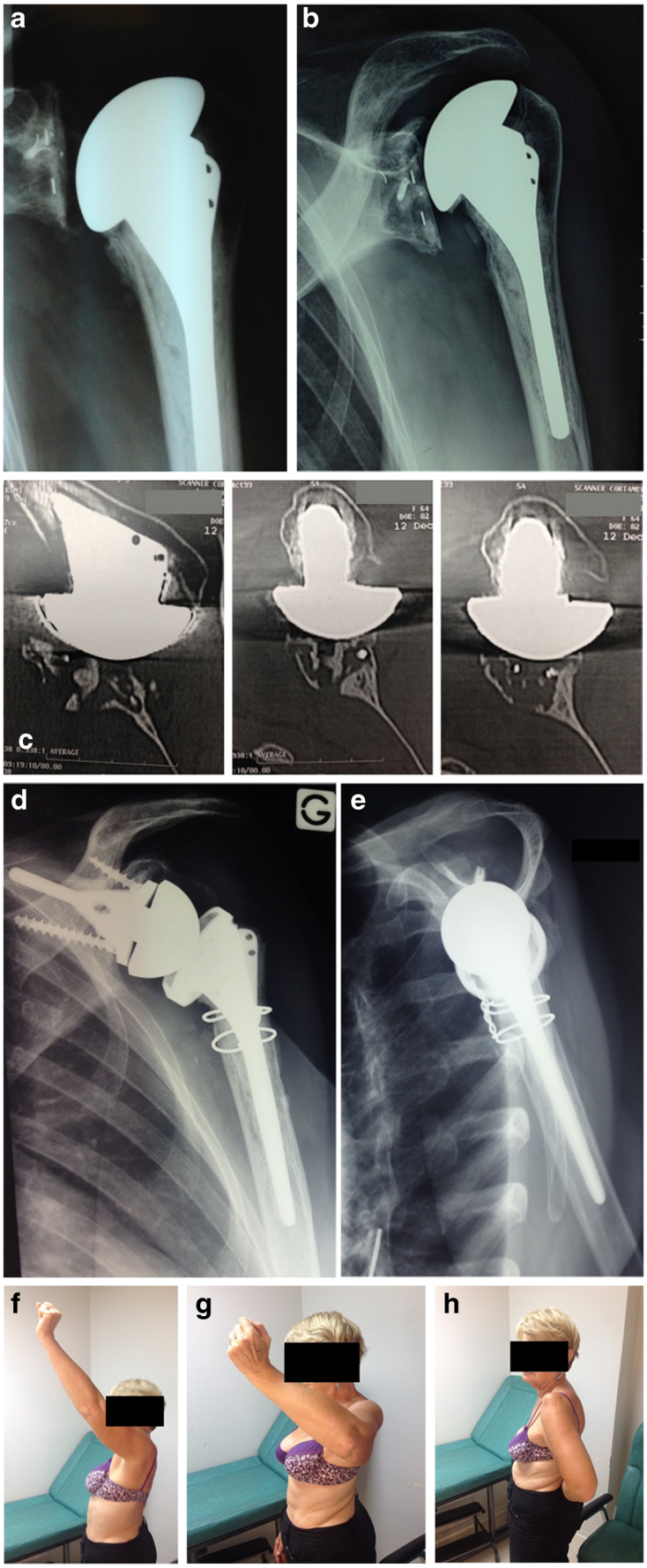
In all cases, the radiological evaluation at the last follow-up showed a good healing of the bone graft on the superior and posterior part of the glenoid with no radiolucency. There was no bone graft resorption and one patient had a grade 1 scapular notch [24]. In 19 cases (95%), the medial post had perforated the scapula anteriorly in the subscapularis fossa. In one case (5%), the medial post had perforated the scapula posteriorly. In one case, subsidence of the glenoid implant with progressive superior migration of the glenoid component was found and the patient was revised with a new long peg and a superior asymmetric allograft to obtain an inferior tilt and better compressive forces. A humeral radiolucent line was observed in one case.

Discussion

A lateralized metal-backed 15.2-mm keeled baseplate prolonged by a thin 24.8-mm metallic post fixed directly in the subscapularis fossa provided satisfactory mid-term outcomes in both primary and revision cases with poor glenoid bone stock (Fig. 4).

Severe glenoid bone loss has been described as a relative contraindication to perform an anatomic or a RSA. Recently, Mizuno et al. [32] showed that RSA provided excellent clinical outcomes in patients with a biconcave glenoid and an intact rotator cuff. However, standard RSA does not appear to be sufficient in cases where the depth and volume of the glenoid vault do not enable sufficient fixation of the glenoid implant leading to worse short- and mid-term outcomes secondary to glenoid component loosening [33–35]. To overcome this issue, two types of techniques have been developed: bone graft reconstruction [3, 12, 25, 36] or augmented and custom implants [15, 37, 38]. Glenoid bone grafting using either cancellous, cortico-cancellous or structural auto- or allograft can allow satisfactory reconstruction of the glenoid bone stock and restore the lateral offset of the shoulder in case of excessive medialization due to glenoid erosion. However, the purchase of the baseplate-bone graft ensemble in the scapula can be insufficient with standard 15-mm glenoid pegs leading to 18% of glenoid radiolucent lines at a mean 2.8-year follow-up in primary cases and 28% [12] at a mean 3.1-year follow-up in revision cases [3]. Norris et al. described a lengthened central peg of 30 mm to achieve sufficient purchase [36] and more recently Boileau et al. [39] reported the results of an angled bone graft with a similar implant to apply an inferior tilt in order to improve compression on the bone graft. However, even this implant with a longer peg does not allow a purchase in the native glenoid of more than 10 mm and therefore does not allow a strong initial press-fit fixation without having to insert one or more screws. Several authors have reported the results of custom implants in cases of severe glenoid bone loss [14, 40]. But although these implants could provide better results than bone grafting [14], results reported are only at a short follow-up and in a limited number of patients. RSA without bone grafting can be used to treat glenoid bone loss in patients with intact cuff and can avoid the complications associated with the osteolysis and non-union of the bone graft leading to subsequent failure [13]. Indeed, Wagner et al. [3] reported that revision to an RSA for glenoid loosening and implant failure was more complicated if bone graft had to be added. They concluded that survivorship at mid-term follow-up (5 years) was lower for patients who received bone graft compared to those who did not. Structural bone graft had to be used only exceptionally in our series thanks to the design of the baseplate with a metallic long post which allows a strong initial press-fit fixation even in cases with severe glenoid bone loss. Therefore, the glenoid could be reamed down as purchase can be obtained, thanks to the metallic long post, and excessive medialization can be compensated by both the metallic lateralization of the center of rotation and by the shape of the humeral implant (135° neck-shaft angle and onlay humeral bearing). To obtain a strong initial fixation, the long post had to perforate the medial cortices anteriorly and not posteriorly in order for the scapular body to act as an abutment preventing the implant from subsiding. Metallic lateralization of the implant also contributed to decrease the quantity of bone graft (auto or allograft) necessary to maintain the joint line. Cancellous bone graft however was used to fill the superior defect caused by the association of the superior erosion of the glenoid in the setting of cuff tear

Fig. 4 A 65-year-old female patient who had undergone total shoulder arthroplasty of her left shoulder for primary osteoarthritis 7 years before (**a**). Aseptic glenoid loosening and rotator cuff tear (**b**) with severe glenoid bone loss revealed on the CT scan (**c**), type E in the Sauzieres' classification [31]. Revision reverse shoulder arthroplasty (**d**–**e**). Shoulder function at 24-month follow-up (**f**–**h**)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arthropathy and the inferior tilt of the baseplate [22]. This graft is provided from the humeral head in primary cases or from the coracoid process in revision cases.

Lateralization of the center of rotation with a metallic lateralized baseplate combined with 135° neck-shaft angle and an onlay polyethylene insert prevents excessive medialization and related complications such as scapular notching, prosthetic instability, limited post-operative shoulder rotation, and loss of shoulder contour well documented in the literature [18, 41, 42]. Although the complication rate observed in our series is high (12% in primary cases and 25% in revision cases), it is comparable to what has been previously reported in the literature [3, 12, 14, 33, 43–47] and is technically less demanding than the reconstruction of the glenoid using structural bone graft.

Our study has several limitations. It is a retrospective study with a limited number of patients. In addition, patients were both primary and revision cases with different aetiologies which could limit the generalizability of the results.

Conclusion

Large glenoid bone defects remain a challenge for the shoulder surgeon. Poor glenoid bone stock can sometimes be considered a contraindication to implant a glenoid implant. A lateralized metal-backed 15.2-mm keeled baseplate prolonged by a thin 24.8-mm metallic post fixed directly in the subscapularis fossa may provide satisfactory mid-term outcomes in these patients.

Compliance with ethical standards

Conflict of interest Philippe Valenti, Jean Kany, and Jean-David Werthel receive royalties for shoulder prosthesis design from FH Orthopedics.

Ethical approval Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

Informed consent Informed consent was obtained from all individual participants included in the study.

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