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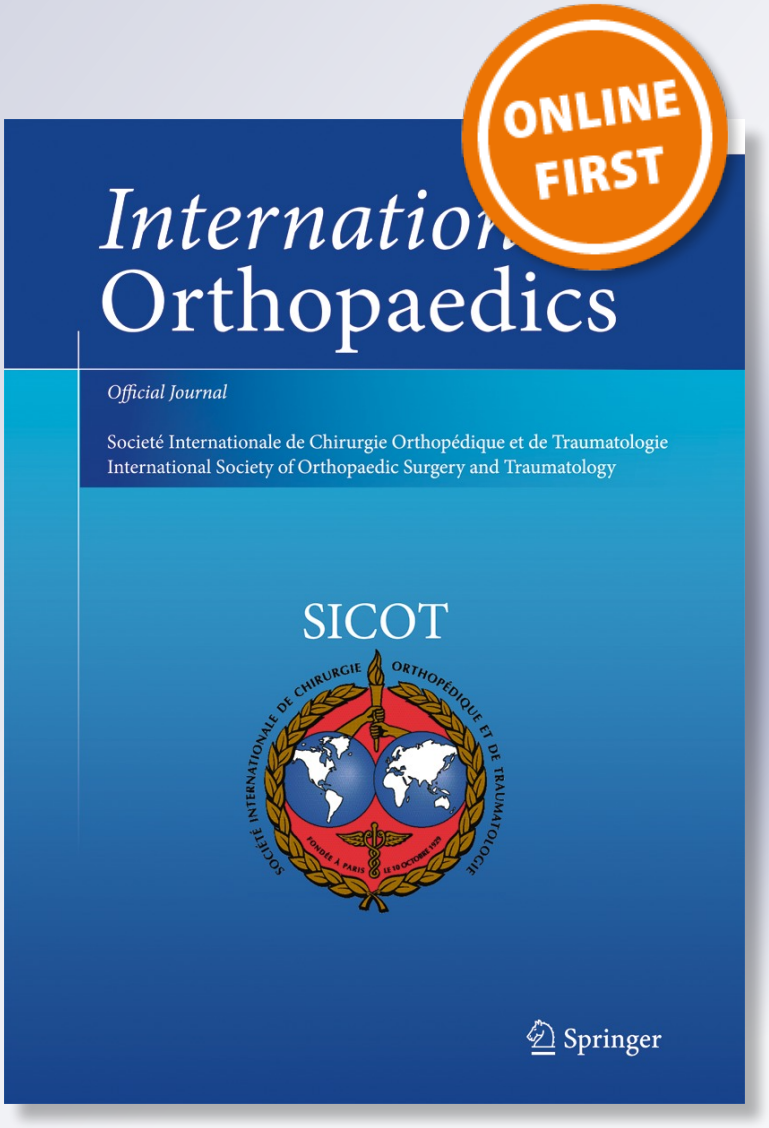

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ORIGINAL PAPER

Stemless shoulder prosthesis for treatment of proximal humeral malunion does not require tuberosity osteotomy

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Abstract
Purpose When the proximal humeral anatomy is altered because of malunion, shoulder arthroplasty is a challenge for the orthopaedic surgeon, and tuberosity osteotomy should be avoided whenever possible. The purpose of this study was to investigate the clinical and radiological outcomes of anatomic stemless shoulder arthroplasty in cases of malunion. We hypothesized that a stemless prosthesis can be implanted without performing tuberosity osteotomy.
Methods We conducted a continuous, single surgeon, retrospective case series study with a minimum follow-up of two years (mean of 44 months, range 24–80). The Constant-Murley score, active range of motion and X-rays were evaluated in 27 patients (mean age of 60 years, range 37–83) with proximal humeral malunion who were treated with a stemless anatomic shoulder prosthesis.
Results In all patients, the prosthesis was implanted without the need for tuberosity osteotomy. The Constant score improved from 27 to 62 ($p \leq 0.001$), active anterior elevation from 81° to 129° ($p \leq 0.001$), and external rotation from 5° to 40° ($p \leq 0.001$). There was no evidence of radiological loosening.
Conclusions Use of a stemless anatomic shoulder prosthesis avoids the need for tuberosity osteotomy and certain surgical difficulties, even in cases of severe tuberosity malunion, and leads to good functional outcomes in the short term.

Keywords Shoulder arthroplasty · Stemless shoulder prosthesis · Proximal humeral malunion · Stemless arthroplasty · Shoulder

Introduction

Shoulder arthroplasty in cases of late sequelae of proximal humeral fracture is a challenge for the orthopaedic surgeon. More joint replacement procedures are now being performed because of increased patient activity levels and longevity. According to the literature, osteotomy of the greater tuberosity in patients with severe malunion has a significant negative impact on functional outcomes [1–3]. Inserting a classic stemmed prosthesis can be difficult or even impossible in some cases without performing tuberosity osteotomy. In the literature, greater tuberosity osteotomy was required in 11 % [2] to 60 % [4] of cases. Because an osteotomy makes the surgery more difficult and increases the potential for complications, some authors recommend tolerating the distorted anatomy of the proximal humerus and adapting the prosthesis to the modified anatomy [1, 2, 5]. In cases of distorted metaphyseal and diaphyseal anatomy, inserting a stem may prove impossible due to considerable angulation, narrowing or obstruction of the medullary canal. Although a modular prosthesis could be used, the prosthetic panels do not correspond to each patient's uniquely altered anatomy [4]. Another option would be to create a

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custom implant specific to each malunion, but this solution is time consuming and expensive [5].

We hypothesized that a stemless anatomic prosthesis in cases of proximal humeral malunion would avoid resorting to tuberosity osteotomy and eliminate some technical difficulties.

The purpose of this study was to evaluate the clinical, surgical and radiological outcomes of stemless anatomic shoulder prosthesis in the case of malunion of the proximal humerus.

Materials and methods

This study was a continuous, single surgeon, retrospective case series. We included all patients with late sequelae of proximal humerus fracture undergoing stemless anatomic shoulder arthroplasty in our department. We enrolled patients who had been operated on by the senior surgeon in a private non-profit hospital and a private hospital between 2006 and 2010 and who had a minimum of two years' follow-up. Indications for surgery were pain and/or functional limitations. Patients received an informed consent form approved by the hospital's committee.

We performed a physical examination to measure the active range of motion with a goniometer. An independent examiner determined the Constant-Murley score. These evaluations were performed pre-operatively and at the last follow-up. Radiographic examination included standard anteroposterior radiographs in three shoulder rotation positions, and a

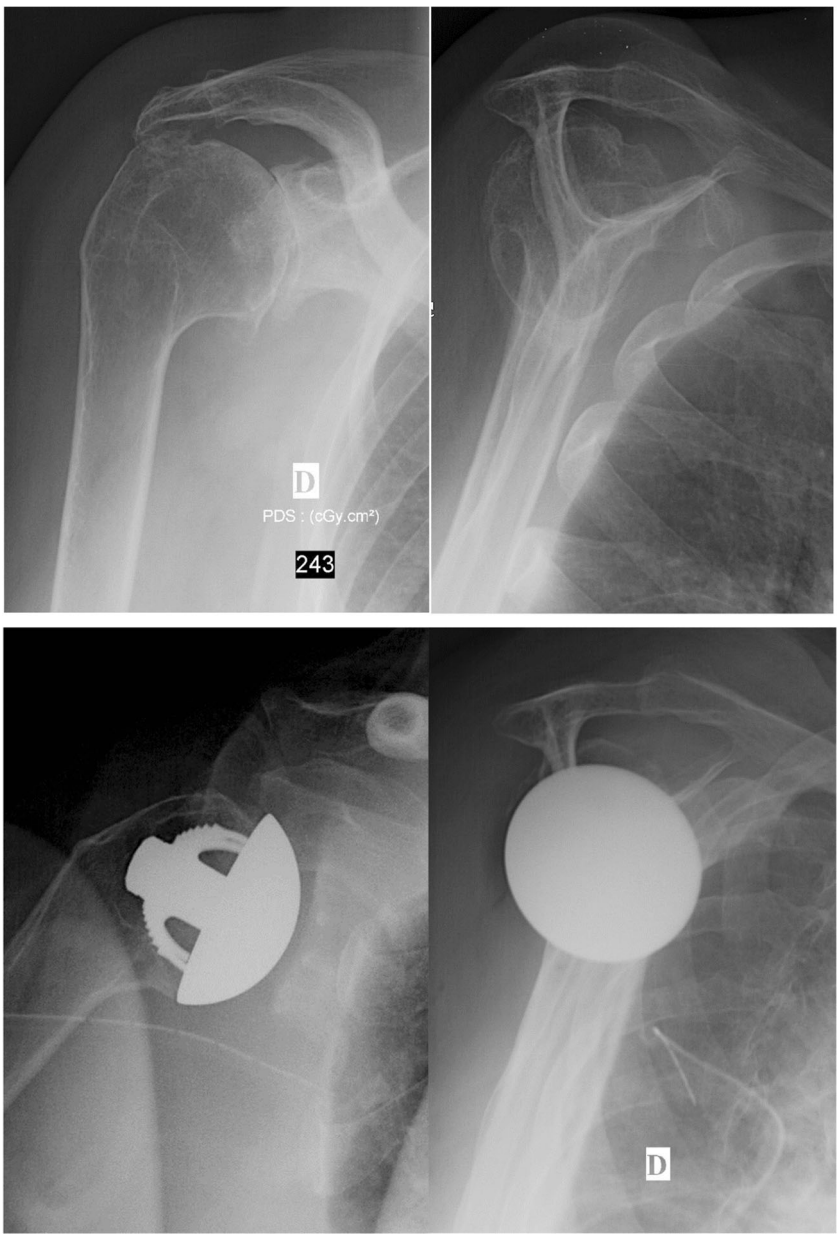

Fig. 1 Adaptation of a stemless prosthesis in one case of malunion with distorted anatomy. Implantation was performed without tuberosity osteotomy despite the cephalo-diaphyseal offset. Pre-operative and post-operative X-rays in anteroposterior view and lateral views

scapular-Y view (Lamy view) pre-operatively and then at each post-operative follow-up visit at 45 days, three months, six months and annually thereafter. We looked for evidence of implant migration, radiolucent lines and lysis. The Neer classification system was used to classify the initial fractures into two-, three- or four-part fractures with or without dislocation [6]. Sequelae were classified according to Boileau [1] into type 1 (cephalic collapse or necrosis), type 2 (locked dislocation or fracture dislocation) and type 4 (severe tuberosity malunion or non-union) [1]. Note that type 3 sequelae involve surgical neck non-union that cannot be treated with a stemless prosthesis.

Two different models of the TESS prosthesis (Biomet Inc., Warsaw, IN) were used: hemiarthroplasty (TESS-C) in ten cases and anatomic total (TESS-A) in 17 cases. Total shoulder anatomic arthroplasty was preferred over hemiarthroplasty in cases of glenoid arthritis, glenoid dysplasia or young age. The type of prosthesis used did not depend on the sequelae type. These implants provide metaphyseal press-fit fixation without a stem and adjustments to the bone stock. In cases of malunion, the implant position was not constrained due to the medullary axis or remodelled anatomy. The humeral component could be implanted in a free position by obviating the medial and posterior offset induced by the axis of the humeral shaft without being dependent on stem alignment (Figs. 1, 2 and 3).

A deltopectoral approach was used in all cases except for one patient in which an external approach was used. A metaphyseal bone cut was performed, centred on the distorted anatomy, with or without a guide-pin. The implant version and inclination were free and independent of the humeral shaft. A humeral punch was used on the metaphyseal bone to introduce the corolla of the anatomic humeral implant, with a guide-pin used in some cases. The surgical procedure on the

Fig. 2 Implantation of a stemless prosthesis in one case of medullary narrowing, obstruction and distortion. Pre-operative and post-operative X-rays in anteroposterior and lateral views

glenoid was chosen based on the type of prosthesis selected (hemiarthroplasty or anatomic total). The need for greater or lesser tuberosity osteotomy was determined.

Statistical analyses were performed using SPSS software (SPSS version 17.0 software, SPSS Inc., Chicago, IL). The normal distribution for quantitative variables was assessed using the Lilliefors test. The parametric Student *t* test for paired samples was used to compare pre-operative and post-operative values. A non-parametric test was used when the variable was not normally distributed. Statistical significance was set at $p \leq 0.05$ for all tests.

Results

We included 27 patients with a mean follow-up of 43.5 ± 17.8 months (24–80): nine males and 18 females, 15 right-handed and 12 left-handed. The average age was 60 years (range 37–83). Sixteen patients had suffered a fall, four were involved in a traffic accident (motorbike or car) and seven in a sports accident (2 biking, 4 skiing, 1 horse-riding). Eight of them had undergone previous surgery. Arthroplasty was performed on average 8.1 years after the initial trauma (6 months to 63 years). No patients were lost to follow-up or excluded.

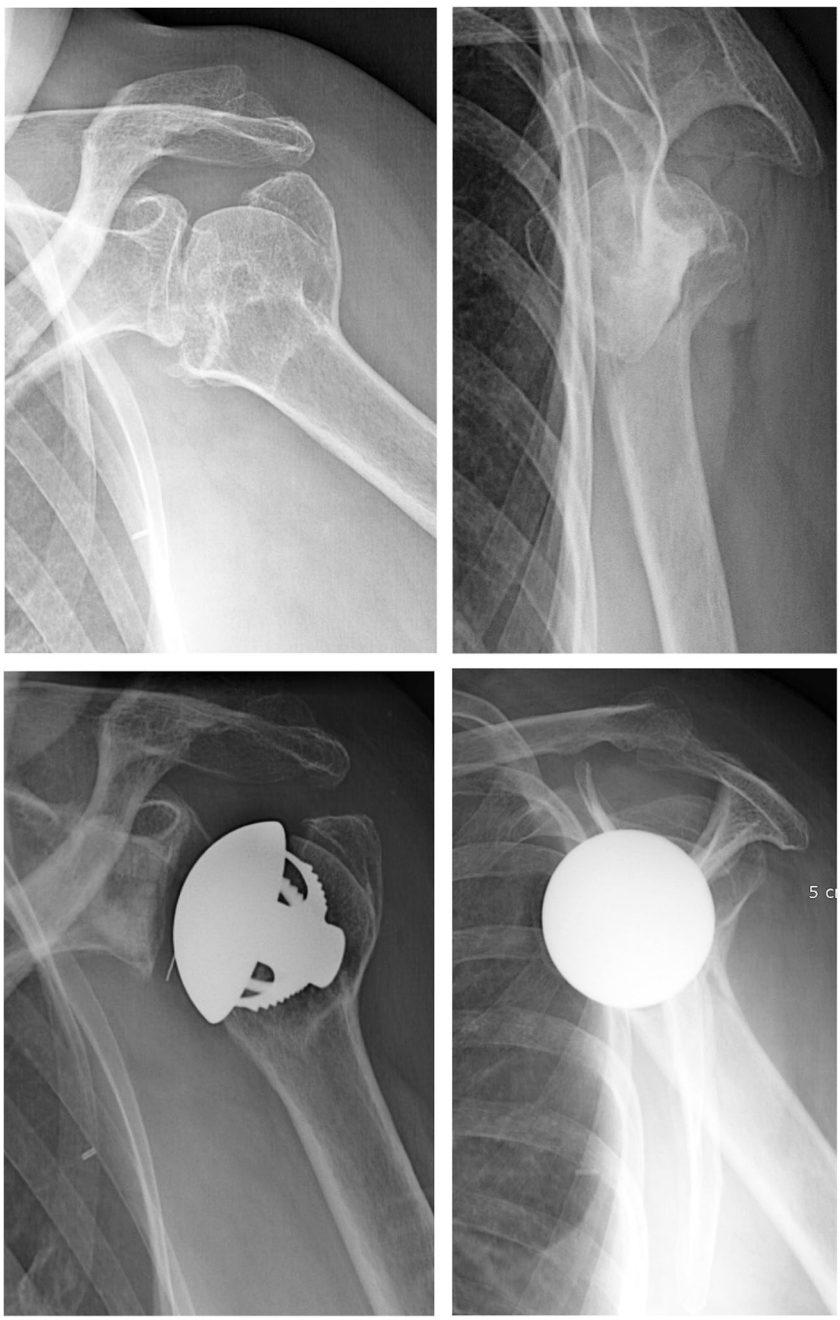

Fig. 3 Adaptation of a stemless prosthesis in one case of four-part valgus impacted fracture and malunion. Pre-operative and post-operative X-rays in anteroposterior view and lateral views

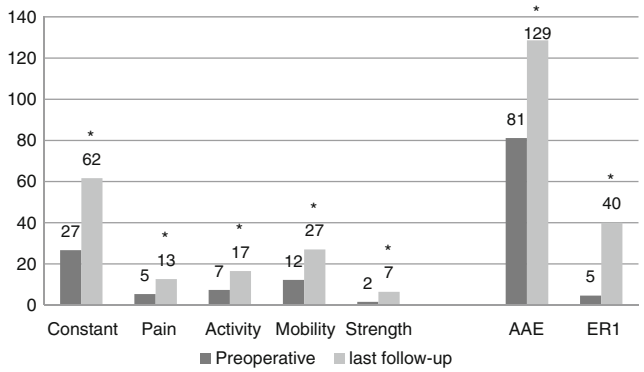

Fig. 4 Results of the series prior to surgery and at the last follow-up: Constant-Murley score and its components. *AAE* active anterior elevation, *ER1* external rotation. * Significant difference in paired *t*-test between pre-operative and post-operative periods with $p \leq 0.001$

There were initially eight 2-part fractures according to the Neer classification system (2 anatomical neck fractures, 4 surgical neck fractures, 2 greater tuberosity fractures), two 3-part fractures (1 greater and 1 lesser tuberosity fracture including an anterior glenohumeral dislocation) and 17 four-part fractures. Sequelae were classified as type 1 in 19 cases, type 2 in two cases and type 4 in six cases.

In all patients, the prosthesis was implanted without the need for tuberosity osteotomy.

Active range of motion (active anterior elevation, external rotation) and Constant-Murley score are reported in Figs. 4, 5 and 6. All improvements in the Constant global score, pain, activity, mobility, strength, anterior active elevation and external rotation were significant ($p \leq 0.001$) (Fig. 4). There were no significant differences between all these post-operative results as a function of the type of sequelae (Fig. 5) or the type of arthroplasty (Fig. 6).

There was no evidence of loosening. Lysis under the humeral anatomic head appeared at the six-month follow-up in one case and progressed until the one-year follow-up without clinical impact (Fig. 7). There was one re-operation to replace an anatomic prosthesis with a reverse prosthesis because of rotator cuff failure one year after the first arthroplasty.

Discussion

A stemless shoulder prosthesis can be implanted without performing tuberosity osteotomy and provides good functional outcomes without loosening at a mean follow-up of 44 months. All clinical outcomes improved significantly post-operatively (Fig. 4). The Constant score, outcomes and range of motion did not differ according to the type of sequelae (Fig. 5). Active anterior elevation in our series increased by 48° and external rotation by 35°. Mansat reported an improvement of 36° and 28° [2], Antuña [7] of 37° and 23°, and Boileau [1] of 28° and 34°, respectively.

Tuberosity osteotomy was not needed in any of our patients. In their series, Mansat reported three greater tuberosity (GT) osteotomies on 28 patients [2], Boileau [1] 20 GT and eight lesser tuberosity (LT) osteotomies in 71 patients, Antuña [7] 24 GT and one LT osteotomies in 50 patients, and Beredjiklian 13 osteotomies in 24 patients [8]. Even in cases with type 4 sequelae, no tuberosity osteotomy was needed in our study; in contrast 11 GT and eight LT osteotomies were performed in 16 cases in the Boileau study [1]. Previous studies have shown that patients who did not require tuberosity osteotomy had better results [1, 2, 4, 7]. Therefore, authors recommend adapting the prosthesis to the distorted anatomy [1, 2, 5] by inserting a modular prosthesis [1]. But in some cases, the anatomy is altered so much that the stemmed prosthesis cannot fit all malunion types [4]. And since an anatomic prosthesis cannot be implanted without performing tuberosity

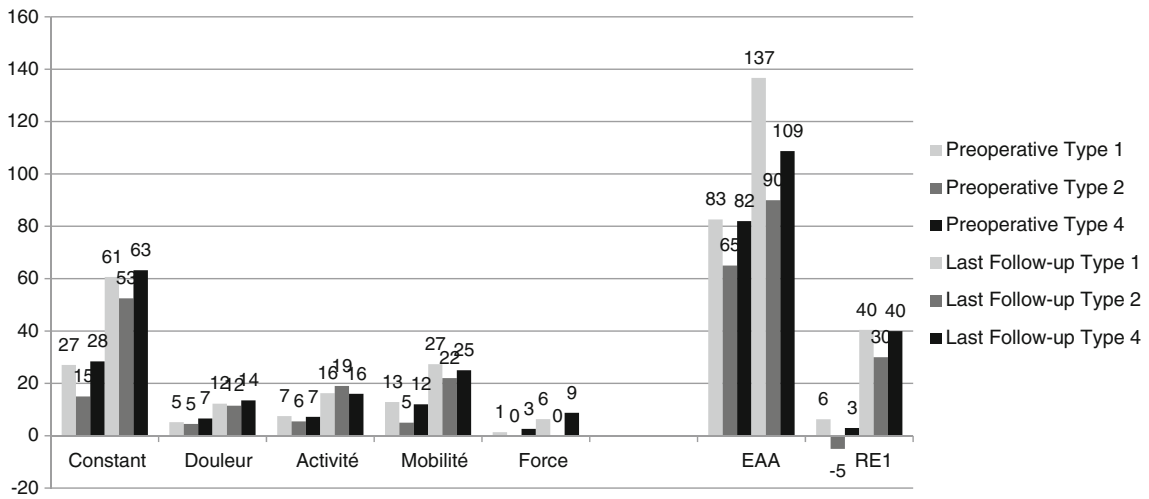

Fig. 5 Results according to the sequelae type. There was no significant difference between types 1, 2 or 4. *AAE* active anterior elevation, *ER1* external rotation

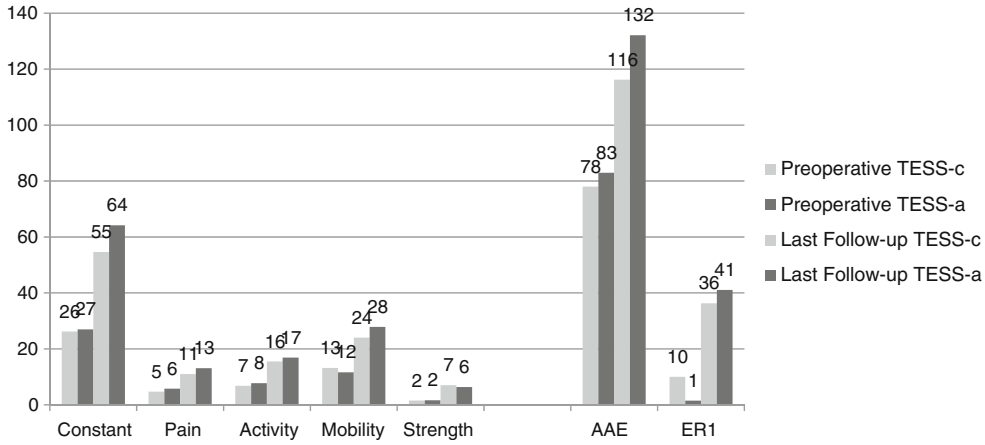

Fig. 6 Results according to the arthroplasty type. *TESS-C* hemiarthroplasty, *TESS-A* total anatomic arthroplasty, *AAE* active anterior elevation, *ER1* external rotation. There was no significant difference between TESS-C and TESS-A

osteotomy, some authors recommend performing reverse shoulder arthroplasty [1, 3, 5, 9–11]. Custom prostheses can be designed, but this is a time consuming and expensive process [5]. The advantages of stemless implants in malunion cases are particularly interesting because positioning is independent of the humeral shaft orientation. In the case of obstruction or angulation of the humeral shaft, independent implant positioning was not compromised (Figs. 1, 2 and 3).

There was no evidence of loosening. One case of non-progressive lysis was observed but it had no clinical significance. The reported complication rate is usually high in these indications (3.5 % to 48 %, depending on the series [2]), but was very low in our study.

The surgical procedure with stemless implants is easier than with a stemmed prosthesis. The exposure and glenoid approach are straightforward as the metaphyseal bone is cut (unlike humeral resurfacing). There is lower risk of intra-operative complications (humeral fracture, false route, malposition) and post-operative complications (disassembly, stem fracture, periprosthetic fracture, loosening, migration of the stem) [12] when using a stemless implant. Recently, the trend in shoulder arthroplasty has shifted to stemless and short stem implants [13]. Anatomic stemless prostheses have been shown to provide good functional outcomes that are comparable to those of a stemmed prosthesis, with excellent bone fixation and without radiolucent lines or loosening [14, 15]. Even in the reverse configuration, studies report good results without loosening [12, 16, 17]. Anatomic stemless prostheses help to restore the pre-operative proximal humerus anatomy [18]. If the need for revision arises, stemless implants facilitate the surgical procedure as the bone stock is preserved. However, type 3 sequelae (surgical neck non-union) cannot be treated with a stemless prosthesis.

The strength of this study was that it demonstrated a new reliable use of stemless prostheses to address these challenging surgical indications. The results presented in this study have limitations, as the follow-up was short (44 months mean, minimum of 2 years). There are only few studies on this topic in the literature and they had a similar or shorter follow-up: 47 months for Mansat [2], 37 months for Willis [5] and 19 months for Boileau [1]. The Antuña study had a mean follow-up of nine years (2–21) [7]. Our series was short in duration, it was a single surgeon study and only 27 patients were included over a four year period. Twenty patients were

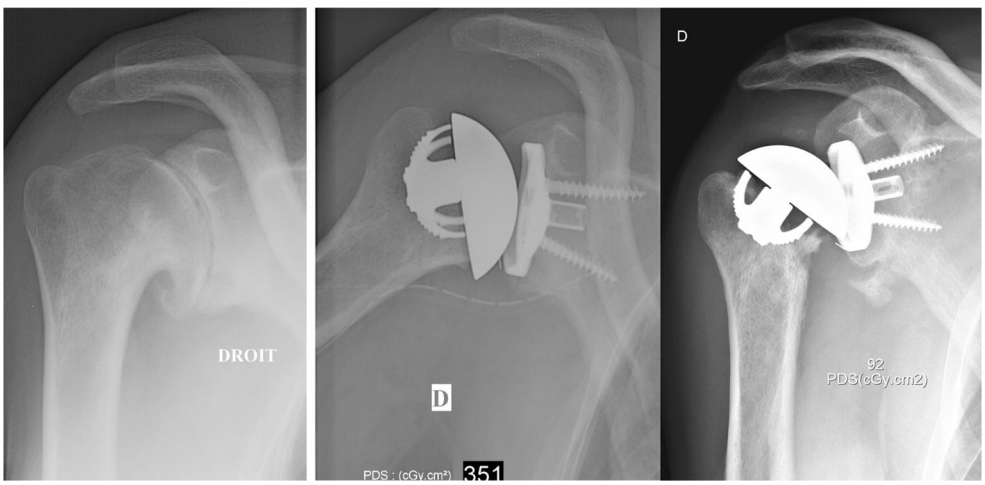

Fig. 7 Implantation of a stemless prosthesis in one case of anatomical neck fracture. Lysis under the humeral anatomic head appeared at the six-month follow-up and progressed until the one-year follow-up without clinical consequence. Pre-operative, post-operative and final follow-up (32 months) X-rays in anteroposterior views

included by Willis over a period of three years [5], 28 patients over 13 years by Mansat [2], 50 patients over 21 years by Antuña [7] and 70 patients over four years operated in ten centres by Boileau [1]. This low enrolment is due to proximal humeral malunion rarely being treated by shoulder arthroplasty; as a result the patient populations are not homogenous. The patients in our study have a wide range of characteristics: follow-up from 24 to 80 months, age from 37 to 83 years, and time from trauma to surgery of six months to 63 years. The range of the results of the cited studies are as wide [1, 2, 5, 7]. As a consequence, our results should be interpreted carefully because the patient characteristics affect the outcomes.

Like other authors, we consider the stemless prosthesis to be an ideal alternative when faced with distorted anatomy [12, 15]. Use of a stemless shoulder prosthesis avoids the need for tuberosity osteotomy and provides good functional outcomes without loosening at a mean follow-up of 44 months.

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Compliance with ethical standards Not applicable. French law does not provide for consultation of an ethics committee for non-interventional biomedical research (Article L1121-1 of the Code of Public Health).

Conflict of interest Richard Ballas and Philippe Teissier have no competing interests to declare. Dr Jacques Teissier received Royalties and Personal Fees from Biomet Compagny, Warsaw, Indiana, which is related to the subject of this work.

References

1. Boileau P, Trojani C, Walch G et al (2001) Shoulder arthroplasty for the treatment of the sequelae of fractures of the proximal humerus. J Shoulder Elbow Surg 10:299–308. doi:10.1067/mse.2001.115985
2. Mansat P, Guity MR, Bellumore Y, Mansat M (2004) Shoulder arthroplasty for late sequelae of proximal humeral fractures. J Shoulder Elbow Surg 13:305–312. doi:10.1016/S1058274604000370
3. Mansat P, Bonnevialle N (2015) Treatment of fracture sequelae of the proximal humerus: anatomical vs reverse shoulder prosthesis. Int Orthop 39:349–354. doi:10.1007/s00264-014-2651-0
4. Dines DM, Warren RF, Altchek DW, Moeckel B (1993) Posttraumatic changes of the proximal humerus: Malunion, nonunion, and osteonecrosis. Treatment with modular hemiarthroplasty or total shoulder arthroplasty. J Shoulder Elbow Surg 2:11–21. doi:10.1016/S1058-2746(09)80132-8
5. Willis M, Min W, Brooks JP et al (2012) Proximal humeral malunion treated with reverse shoulder arthroplasty. J Shoulder Elbow Surg 21:507–513. doi:10.1016/j.jse.2011.01.042
6. Neer CS 2nd (1970) Displaced proximal humeral fractures. I. Classification and evaluation. J Bone Joint Surg Am 52:1077–1089
7. Antuña SA, Sperling JW, Sánchez-Sotelo J, Cofield RH (2002) Shoulder arthroplasty for proximal humeral malunions: long-term results. J Shoulder Elbow Surg 11:122–129
8. Beredjiklian PK, Iannotti JP (1998) Treatment of proximal humerus fracture malunion with prosthetic arthroplasty. Instr Course Lect 47:135–140
9. Boileau P, Chuinard C, Le Huec J-C et al (2006) Proximal humerus fracture sequelae: impact of a new radiographic classification on arthroplasty. Clin Orthop Relat Res 442:121–130
10. Brunner U, Köhler S (2007) Shoulder arthroplasty for treatment of the sequelae of proximal humerus fractures. Orthopade 36:1037–1049. doi:10.1007/s00132-007-1157-5
11. Ortmaier R, Resch H, Matis N et al (2013) Reverse shoulder arthroplasty in revision of failed shoulder arthroplasty-outcome and follow-up. Int Orthop 37:67–75. doi:10.1007/s00264-012-1742-z
12. Ballas R, Béguin L (2013) Results of a stemless reverse shoulder prosthesis at more than 58 months mean without loosening. J Shoulder Elbow Surg 22:e1–e6. doi:10.1016/j.jse.2012.12.005
13. Schnetzke M, Coda S, Walch G, Loew M (2015) Clinical and radiological results of a cementless short stem shoulder prosthesis at minimum follow-up of two years. Int Orthop 39:1351–1357. doi:10.1007/s00264-015-2770-2
14. Geurts GF, van Riet RP, Jansen N, Declercq G (2010) Placement of the stemless humeral component in the Total Evolutive Shoulder System (TESS). Tech Hand Up Extrem Surg 14:214–217. doi:10.1097/BTH.0b013e3181e397c5
15. Huguet D, DeClercq G, Rio B et al (2010) Results of a new stemless shoulder prosthesis: radiologic proof of maintained fixation and stability after a minimum of three years' follow-up. J Shoulder Elbow Surg 19:847–852. doi:10.1016/j.jse.2009.12.009
16. Atoun E, Van Tongel A, Hous N et al (2014) Reverse shoulder arthroplasty with a short metaphyseal humeral stem. Int Orthop 38:1213–1218. doi:10.1007/s00264-014-2328-8
17. Teissier P, Teissier J, Kouyoumdjian P, Asencio G (2014) The TESS reverse shoulder arthroplasty without a stem in the treatment of cuff-deficient shoulder conditions: clinical and radiographic results. J Shoulder Elbow Surg 24(1):45–51. doi:10.1016/j.jse.2014.04.005
18. Kadum B, Hassany H, Wadsten M et al (2015) Geometrical analysis of stemless shoulder arthroplasty: a radiological study of seventy TESS total shoulder prostheses. Int Orthop. doi:10.1007/s00264-015-2935-z