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ORIGINAL ARTICLE

Radiographic changes and clinical outcomes associated with an adjustable diaphyseal press-fit humeral stem in primary reverse shoulder arthroplasty

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Background: Press-fit humeral fixation in reverse shoulder arthroplasty (RSA) has become increasingly popular; however, radiographic analysis of these stems is limited. We aimed to evaluate the radiographic and clinical outcomes of an adjustable diaphyseal press-fit humeral stem in primary RSA.

Methods: We conducted a retrospective review of 232 primary RSAs in 219 patients performed by a single surgeon using this system. Radiographic outcomes were evaluated in patients with at least 2 years of radiographic follow-up. Standardized postoperative digital radiographs were analyzed for loosening, osteolysis, and stress shielding. Clinical outcomes in patients who also had complete clinical data sets were evaluated at the most recent follow-up.

Results: Radiographic evidence of loosening was identified in 1 RSA (0.4%) associated with deep infection. Aseptic loosening was not observed. No stems were identified as being at high risk for loosening. Internal stress shielding was observed proximal to the coated diaphyseal component in 226 shoulders (97.4%). This finding was often visible at 3 months (92.7%) and predictably progressed on subsequent radiographs. Progression beyond the 2-year period was rarely seen (4.4%). No external stress shielding or osteolysis was observed. Thirty-six complications occurred in 33 patients (15.1%). At an average follow-up of 36.6 months, significant improvements were identified in all measured clinical outcomes ($P < .001$).

Conclusion: Predictable fixation is achieved using an adjustable diaphyseal press-fit humeral system in primary RSA. Internal stress shielding is commonly observed but does not appear to compromise quality of fixation or clinical outcomes.

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

Keywords: Reverse shoulder arthroplasty; press-fit; stress shielding; humeral loosening; radiographic analysis; adjustable reverse

Shoulder replacement surgery is associated with good to excellent results for a variety of shoulder pathologies[7,12,16,27,37,41,49-51] and has become increasingly popular.[11,22] As the incidence of these operations increases,

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the number of complications will inevitably increase as well. Complication profiles have been well documented and suggest that glenoid component loosening is the primary mode of failure.[2,35,37,46,55] Humeral component loosening is much less common. Historically, successful humeral fixation with low loosening rates has been achieved with cementation techniques.[23,24,39,43]

Recently, however, the use of press-fit humeral components has become more prevalent.[12,14,18,28,38,45,54] Proposed advantages of press-fit fixation include decreased operative time and lower complication rates with stem removal during revision surgery. Early-generation press-fit humeral components were associated with high loosening rates and poor results.[44,48,51] With improvements in technology and techniques, later-generation implants have shown much more favorable results with low loosening rates.[12,14,18,24,28,38,45,54] However, significant radiographic humeral changes, including stress shielding, osteolysis, and radiolucent lines, have been observed.[28,29,34,38,45] Stress shielding and osteolysis of the femur have been associated with poor clinical outcomes with hip arthroplasty,[13,34,38] but these radiographic changes have not yet been shown to correlate with poor clinical results in anatomic shoulder arthroplasty.

Reverse shoulder arthroplasty (RSA) has revolutionized the care of patients with cuff-deficient shoulder pathologies.[5,6,8-10,15,26,31,33,36,56] As with anatomic shoulder arthroplasty, humeral component loosening has not been reported with high incidence, and a shift toward the use of press-fit humeral systems has been seen with successful clinical outcomes. However, few studies have assessed the radiographic changes seen with press-fit stems in RSA.[17,30,59]

This study evaluated the radiographic and clinical outcomes of an adjustable diaphyseal press-fit humeral system in primary RSA. This system consists of a fully hydroxyapatite-coated diaphyseal component, optional smooth segmental stacking inserts if required, and a detachable smooth inset metaphyseal component (Fig. 1). Height and version can be adjusted at the time of initial implantation or revision surgery without the need to remove the fixed diaphyseal component. We hypothesize that this system will (1) provide predictable press-fit fixation with low loosening rates, (2) have a high rate of proximal stress shielding secondary to solid diaphyseal fixation, and (3) be associated with excellent clinical outcomes, consistent with the RSA literature, that are unaffected by the radiographic changes observed.

Figure 1 Adjustable diaphyseal press-fit humeral system.

Materials and methods

We retrospectively reviewed all primary RSAs performed by the senior author (T.R.N.) using the adjustable press-fit humeral system between 2007 and 2013. All patients in this series were entered in a prospectively gathered database intended for outcome analysis of shoulder replacement surgery. All patients provided consent for inclusion in the database before surgical intervention.

The inclusion criteria for this study were primary RSA using the Aequalis Adjustable Reverse Shoulder System (AARS; Tornier, Inc., Edina, MN, USA) for any indication, minimum of 2-year radiographic follow-up, and complete radiographic series at each follow-up interval. All revision operations were excluded. As a secondary outcome, clinical results in those patients who met the inclusion criteria and who also had complete preoperative and postoperative clinical data sets extending to or beyond 24-months were also evaluated.

All preoperative, intraoperative, and postoperative records and imaging were reviewed. Patient demographics, indications for surgery, complications, and radiographic findings were reviewed. If revision surgery was required, the utility of the adjustable system for improving stability with height or version changes, the ability to retain and reuse the diaphyseal component, and any complications associated with removal of the diaphyseal component, if required, were also assessed.

Radiographic evaluation

Postoperative digital radiographs were obtained at time 0, 3 months, 6 months, 1 year, 2 years, and at the most recent follow-up. Standard radiographs included true anteroposterior (with the humerus in neutral rotation), scapular Y, and axillary views. Axillary views were not obtained at time 0 but were obtained at all other scheduled times. All preoperative and postoperative radiographs were obtained using a standardized technique and performed by the same technician. All radiographs were assessed for subsidence or migration of the humeral component, presence of radiolucent lines around the humeral component, osteolysis, and stress shielding by three American Shoulder and Elbow Surgeons (ASES) shoulder and elbow fellowship-trained orthopedic surgeons. A consensus was reached on all radiographic changes identified.

The humeral component was divided into 7 zones.[5,44,48] Zones 1 and 7 included the metaphyseal component and extended to the level of the diaphyseal/metaphyseal component junction. This junction represented the transition zone from smooth to the hydroxyapatite-coated implant. If stack spacers had been placed, these zones were extended beyond the metaphysis distally to the level of the smooth spacer/coated stem junction. Zones 2 and 6 represented the proximal half of the diaphyseal component. Zones 3 and 5 represented the distal half of the diaphyseal component. Zone 4 represented the area distal to the tip of the stem (Fig. 2).

Radiolucent lines were assessed according to Sperling et al[49]: measured in 0.5-mm increments up to 2 mm and then identified as >2 mm. If radiolucent lines were identified, each subsequent radio-