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ORIGINAL PAPER

Glenosphere disengagement in a reverse total shoulder arthroplasty with a non-Morse taper design

Corey B Fuller · Stephen F Gregorius · Eric K Lim

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Abstract
Purpose In modern modular reverse total shoulder arthroplasty designs, glenosphere disengagement has recently been described in systems that use a locking screw and Morse taper for fixation between the glenosphere and baseplate. This complication is unreported in modern systems that do not use a Morse taper design. The purpose of this paper is to report cases of glenosphere disengagement and its incidence in a previously unreported design.
Methods This study is a retrospective review of 40 patients who underwent reverse total shoulder arthroplasty for rotator cuff arthropathy using the Equinoxe® reverse total shoulder system, which uses a non-Morse taper design. Two patients were diagnosed with glenosphere disengagement postoperatively.
Results In this series two of 40 patients were retrospectively diagnosed with glenosphere disengagement. One patient had complete and one partial disengagement. Both patients were revised and subsequently did well. This represents an overall incidence of glenosphere disengagement of 5 % in this design.
Conclusions This series demonstrates an overall incidence of glenosphere disengagement of 5 % in reverse total shoulder arthroplasty with a non-Morse taper design. The incidence of overall and complete disengagement is higher in this series than previously published in modern designs with Morse tapers. Features unique to this design, include the non-Morse taper interface, offset screw placement and unique bone graft cage, may explain its higher incidence of disengagement. Surgeons who use this system should be aware of this potential complication.

Keywords Glenosphere disengagement · Morse taper · Reverse total shoulder

C. Fuller (✉)
Department of Orthopaedic Surgery, Loma Linda University, Loma Linda, CA, USA
e-mail: cbfuller@llu.edu

S. Gregorius · E. Lim
Department of Orthopaedic Surgery, Loma Linda Veterans Hospital, Loma Linda, CA, USA

Introduction

The reverse total shoulder arthroplasty is an accepted surgical option in the treatment of glenohumeral arthritis associated with an irreparable rotator cuff tear. Glenosphere disengagement was originally described in an early design of Grammont's reverse total shoulder arthroplasty in which the glenosphere screwed into the baseplate via peripheral threads. The glenosphere had a tendency to unscrew, particularly in right shoulders, leading to catastrophic failure. The glenosphere–baseplate fixation was subsequently changed in 1996 to a peripheral Morse taper reinforced by a central countersunk screw [1]. This was thought to have solved the problem, and glenosphere disengagement was largely unreported in the literature until Middernacht et al. [2], in 2008, published a report of 14 cases of glenosphere disengagement in two modern systems with Morse-taper and central-screw design.

The Equinoxe® reverse total shoulder system (Exactech, Gainesville, FL, USA) is a modern design that has several unique design features. These include using a non-Morse taper design between the glenosphere and baseplate and a central post cage on the baseplate for bone graft. This design is purported to decrease the risk of soft tissue interposition as well as improved biologic fixation of the baseplate to the glenoid via bony ingrowth. However, we have seen disengagement in this design. We report two cases of glenosphere disengagement,

previously unreported in this design, using the Equinoxe® reverse total shoulder system.

Case 1

A 69-year-old Caucasian man with long-standing history of right shoulder pain and previous failed rotator cuff repair presented with rotator cuff arthropathy on radiographs. Magnetic resonance imaging (MRI) demonstrated an irreparable rotator cuff tear. Examination showed active forward flexion of 40°, 40° of abduction and 20° of external rotation. The patient underwent a right reverse total shoulder arthroplasty using the Equinoxe® reverse total shoulder system. The surgery was uncomplicated, and no apparent complication was encountered during glenosphere positioning and fixation to the baseplate. The central screw was inserted and tightened with tactile and auditory feedback consistent with thread engagement. The glenosphere appeared fully seated and was securely fixed.

Immediate postoperative radiographs demonstrated a clear stepoff between the glenosphere and baseplate (Fig. 1). The patient was followed and initially did well, with no change in his implant position. However, he returned at six months with increased shoulder pain and significantly reduced motion. Radiographs demonstrated complete disengagement between the glenosphere and baseplate. The patient subsequently underwent a revision of the baseplate, glenosphere and polyethylene. Intra-operative findings included complete disengagement of the glenosphere from the baseplate as well as a broken central screw, with clear evidence of cross threading. There was no obvious evidence of soft tissue interposition or incomplete glenoid reaming. Intra-operative fluoroscopy was used to ensure complete seating of the glenosphere. Postoperatively, the patient did well clinically and at the seven month follow-up demonstrated a pain-free right shoulder with 120° of active forward flexion, 90° of abduction and 20° of external rotation.

Case 2

A 60-year-old Caucasian man presented with long-standing history of right shoulder pain and previous history of a ligament release and thermocapsular reduction done at an outside institution. Examination demonstrated active forward flexion of 40°, 40° abduction and 15° external rotation. Workup demonstrated rotator cuff arthropathy on radiographs and partial-thickness tears of the supraspinatus, infraspinatus and teres minor on MRI. Intra-operatively, the rotator cuff was extremely attenuated, with partial thickness tears consistent with the pre-operative MRI. The patient underwent a right reverse total

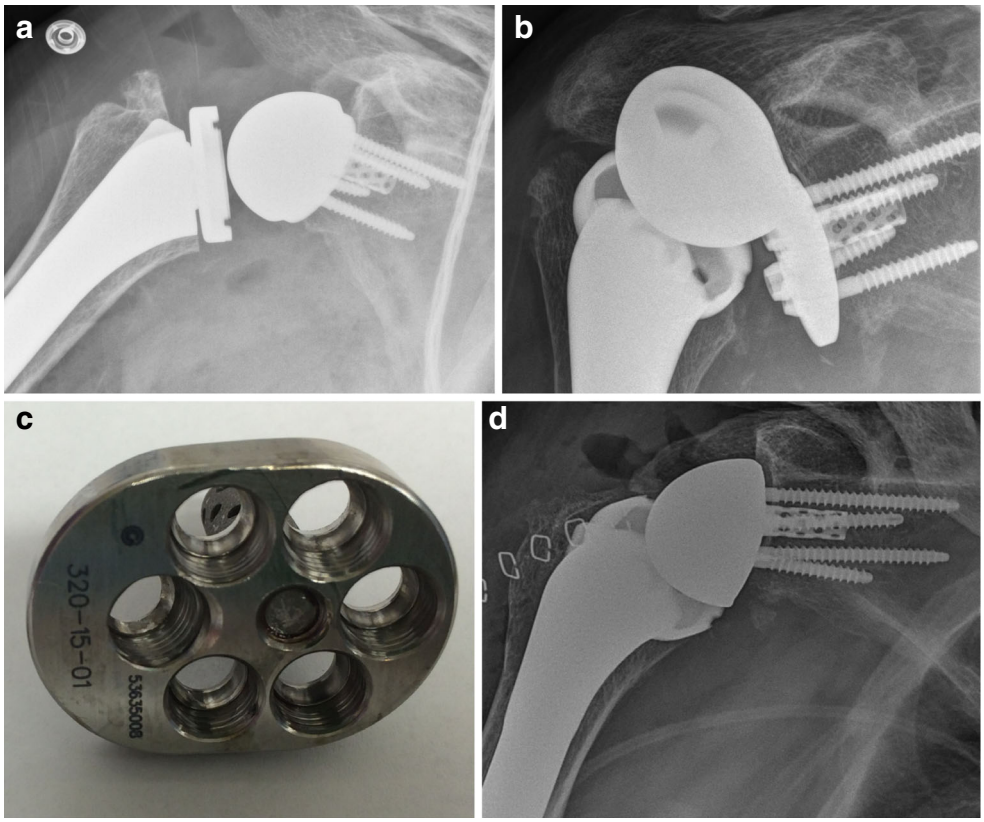

Fig. 1 Case 1: **a** immediate postoperative radiographs showing clear stepoff between glenosphere and baseplate; **b** complete glenosphere disengagement; **c** baseplate with tip of broken screw still cross threaded; **d** postoperative radiographs after revision (note glenosphere flush with baseplate)

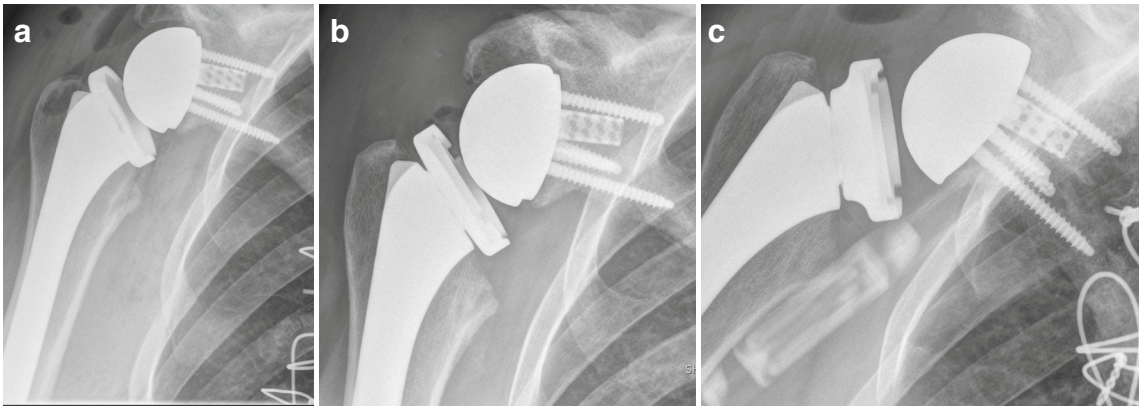

Fig. 2 Case 2: **a** immediate postoperative radiographs with clear stepoff between glenosphere and baseplate; **b** stable incomplete glenosphere disengagement at two months; **c** postoperative radiographs after revision surgery (note glenosphere flush with baseplate)

shoulder arthroplasty using the Equinoxe® reverse total shoulder system. The surgery was uncomplicated, and no apparent complication was encountered during glenosphere positioning and fixation to the baseplate. The central screw was inserted and tightened with tactile and auditory feedback of thread engagement. The glenosphere appeared fully seated and was securely fixed.

As with Case 1, immediate postoperative radiographs demonstrated a clear stepoff between the glenosphere and baseplate (Fig. 2). The patient was followed and was recovering appropriately, with no change in implant position, at two months. Due to concern of impending complete disengagement as encountered in case 1, revision surgery was offered. Intra-operatively, the glenosphere was still strongly fixed to the baseplate and the central screw was intact. There was a small lip of bone superior to the baseplate, which was likely the cause of the incomplete seating. The lip of bone was removed, the glenosphere was revised and a new central screw was placed. Intra-operative fluoroscopy was used to ensure complete seating of the glenosphere. The patient did well clinically, and the four month follow-up demonstrated a pain-free right shoulder with 145° of active forward flexion, 90° of abduction and 30° of external rotation.

Discussion

The only known published account on the topic of glenosphere disengagement since Grammont's original design was by Middernacht et al. [2] in 2008, who retrospectively reviewed 437 reverse total shoulders, mostly from the French Multicenter study. Both implant designs used in the study included a Morse taper and central locking screw. Fourteen cases of disengagement were identified, for an overall incidence of 3.2 %. Of these, 11 were only partial and were not associated with a poor outcome. Three cases were complete, all were associated with breakage of the central screw and revision surgery was recommended. This represents an overall incidence of 2.5 % of incomplete disengagement and 0.7 % of complete disengagement. Inadequate bone reaming, soft tissue interposition and variation in locking screw design were all suggested as causes for glenosphere disengagement.

Retrospective radiographic review was performed on all of the senior author's (EL) cases in which the Equinoxe® reverse total shoulder system was used. The two cases presented here are the only ones identified out of 40 cases, resulting in an overall incidence of 5 %. Furthermore, one case was clearly identified as a complete disengagement, resulting in a 2.5 % overall incidence of complete disengagement; one case was a partial disengagement, resulting in a 2.5 % incidence. Although this represents a smaller sample size than Middernacht et al.'s [2] study, the overall and complete disengagement rates are higher in this study (Table 1). We propose that mechanisms unique to the Equinoxe® may explain these higher rates.

Stephen Morse invented the Morse taper in 1864 as a 5/8-in.-per-foot taper as a way to connect parts of a lathe [3]. A male part (trunion) and female part (bore) with a slight difference in angle were impacted together, causing a strong connection via locking zones of contact known as cold welds. This was subsequently applied to orthopaedics in 1974 as a way to secure ceramic femoral heads to metal stems in hip replacements. It was subsequently applied to the reverse total shoulder to fix the glenosphere to the baseplate in 1996 [4]. Equinoxe® does not use a Morse-taper design as it does not require impaction and theoretically is less susceptible to soft tissue interposition. However, when placing the glenosphere using the non-Morse taper design, there is less tolerance if the

Table 1 Incidence of glenosphere disengagement

	Loma Linda, VA	Middernacht et al. [2]
Overall	5 % (2/40)	3.2 % (14/437)
Incomplete	2.5 % (1/40)	2.5 % (11/437)
Complete	2.5 % (1/40)	0.7 % (3/437)

angle of approach is slightly off, making it more difficult to seat completely. Also, there is less interface stability in the non-Morse design, as there is less surface contact and it relies completely on the central screw for stability.

In the Equinoxe® system, the hole in the glenosphere is not in the centre but several millimetres superior. Therefore, the central screw is inserted perpendicular to the baseplate, but since the hole in the glenosphere is not central, the screw will not appear to be entering perpendicular to the glenosphere. This predisposes the central screw to engaging the threads of the baseplate offangle and hence cross threading. Finally, the Equinoxe® baseplate has a unique central cage for bone graft that allows bony ingrowth to the glenoid. There is nothing preventing the bone graft from entering the region of the threads on the baseplate. Therefore, if a substantial amount of bone graft was place, it could either prevent the screw from full seating or interlocking between the screw and baseplate threads. Both scenarios would lead to a screw that was not fully seated, predisposing to an incompletely engaged glenosphere. These unique features make this design more susceptible to both incomplete seating and complete disengagement and could explain why the overall incidence of disengagement and incidence of complete disengagement were higher. Surgeons who use this system should be aware that disengagement can still occur despite intraoperative feedback of complete seating. To overcome this complication, we recommend adequate surgical exposure to prevent soft tissue interposition, complete bony reaming, avoidance of excess bone graft in the baseplate cage and awareness that the locking screw is not inserted perpendicular to the glenosphere. If there is any concern, intra-operative fluoroscopy should be used to ensure full seating.

Conclusions

Glenosphere disengagement can occur in the Equinoxe® shoulder system despite intra-operative feedback consistent with full engagement. Design features, including non-Morse taper design, glenosphere hole position and bone graft cage, may explain the increased incidence of disengagement in this design.

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