



Atraumatic dissociation of a modular shoulder hemiarthroplasty: a case report and literature review

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Shoulder hemiarthroplasty is a viable option for the management of unreconstructable fractures of the proximal humerus as well as for end-stage degenerative and inflammatory arthritis. The evolution of shoulder arthroplasty has led to the development of fourth-generation implants, with successive designs offering more options to reconstruct the shoulder joint. Modularity has played a major role in this progress, but it is not without drawbacks. Spontaneous dissociation of the components of a shoulder hemiarthroplasty has been rarely reported in the English literature and is confined to systems using a “reverse” Morse taper. We report a case of spontaneous dissociation of a conventional Morse taper in a modular third-generation shoulder hemiarthroplasty.

Case history

A 47-year-old male epilepsy patient presented 1 month following a seizure to our clinic with a painful stiff shoulder. Clinical examination revealed a diffusely swollen shoulder in a resting position of adduction and internal rotation with limited active and passive movement.

Plain radiographs of the involved joint revealed an impacted humeral head fracture with posterior subluxation of the shoulder joint (Fig. 1). A computed tomography of the shoulder was requested to aid decision making (Fig. 2). Available surgical options were explained to the patient and a mutually agreeable and informed decision was made to proceed with a shoulder hemiarthroplasty (SH).

Because of logistic delays, the surgery was performed almost 4 months after his first outpatient clinic visit using the Integra Titan

Modular Shoulder System (Integra LifeSciences Corporation, Princeton, NJ, USA) that was available at the local hospital.⁶

A deltopectoral approach was used to expose the shoulder joint and a lesser tuberosity osteotomy performed to aid exposure and preparation of the humeral canal. A size 6 uncemented humeral stem with a small fracture body was implanted along with a 42×16-mm head component. Intraoperative testing indicated that the shoulder was stable within a functional range of motion, the osteotomy was repaired using a single screw, and the soft tissues closed in layers (Fig. 3).

Two months after surgery, he reported increased pain and loss of movement in his left shoulder. Plain radiographs revealed a dissociated humeral head lying anteriorly (Fig. 4). Treatment options were discussed with the patient, and it was decided that an attempt at revision surgery should be made.

At surgery, the dissociated humeral head was found lying separate in the anterior soft tissues, with a nonunion of the lesser tuberosity. The loose humeral component was easily removed, and revised with a size 12 stem and a 46×20-mm head. Transosseous absorbable suture fixation was used to repair the lesser tuberosity osteotomy, and the joint was taken through a range of movements to confirm stability (Fig. 5).

Three years after surgery, the patient is satisfied with his outcome and has a limited but pain-free range of shoulder movement.

Discussion

SH is one of the many options available in the management of complex proximal humeral fractures as described in Neer's landmark article presenting the results of his case series.¹⁴ In that publication, he indicated that 3-part fractures should be treated by internal fixation whereas 4-part fractures should be reconstructed with a hemiarthroplasty because of the high risk of osteonecrosis of the humeral head. Unreconstructable, depressed fractures of the articular surface involving more than 50% of the surface area are

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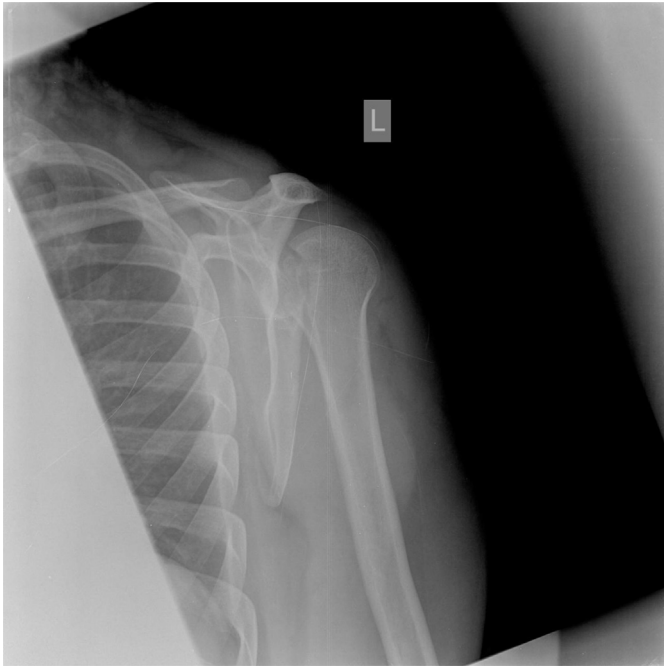


Figure 1 Lateral view of left shoulder showing posterior subluxation with a fracture of the humeral head.

also indications for a hemiarthroplasty. The loss of articular surface was the deciding factor in this case.

Hemiarthroplasty is an effective method of treatment for unreconstructable fractures of the proximal humerus. Robinson et al in an observational study assessed 138 patients who were treated with a hemiarthroplasty for 3- and 4-part fracture-dislocations of the proximal humerus.¹⁷ Their results showed a 1-year median modified Constant score of 64, with good scores for pain relief but lower scores for function. Better results could be anticipated in younger patients, with no preoperative neurologic deficits and who developed no postoperative complications while maintaining a satisfactory radiologic appearance of the shoulder at 6 weeks.

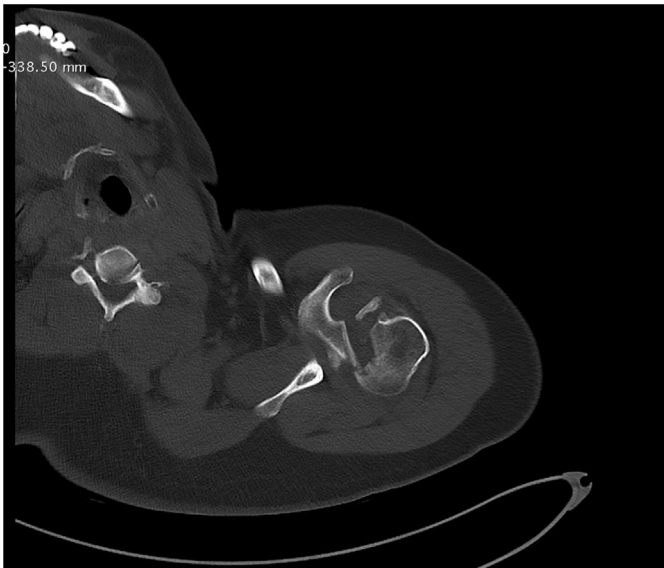


Figure 2 Axial computed tomography of the left shoulder demonstrating the impacted fracture of the humeral head with posterior subluxation.

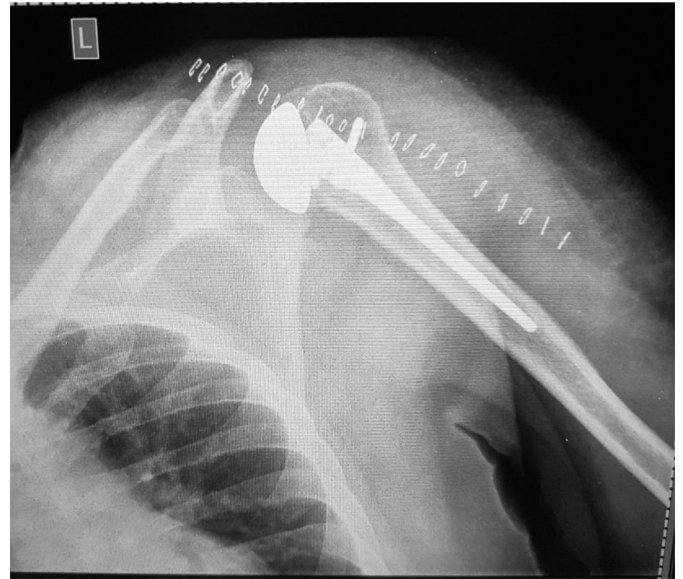


Figure 3 Initial postoperative radiographs of the left shoulder hemiarthroplasty.

Boyd et al² enumerated a number of benefits for the retention of the native glenoid in an attempt to provide clear indications for hemiarthroplasty vs. total shoulder replacement (TSR). They compared 64 Neer hemiarthroplasties with 146 Neer TSRs at an average follow-up of 44 months. Similar functional outcomes were

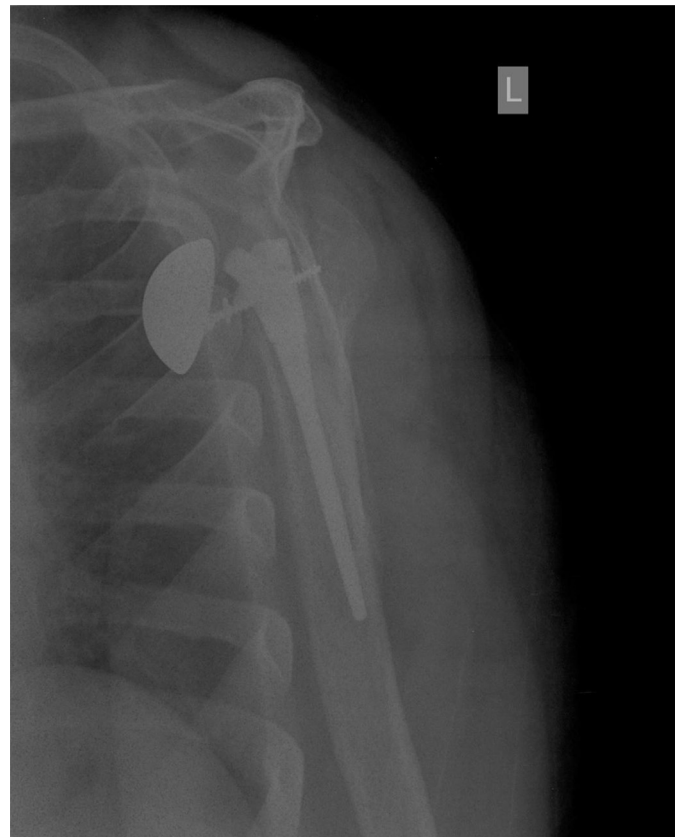


Figure 4 Radiographs showing the humeral head dissociated from the body of the prosthesis.

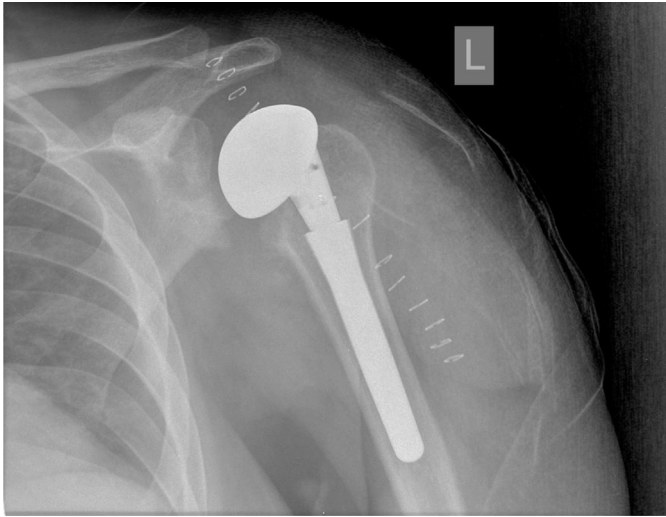


Figure 5 Anteroposterior view of the shoulder. The postoperative radiographs of the revision show a better match between the stem of the prosthesis and the humeral canal.

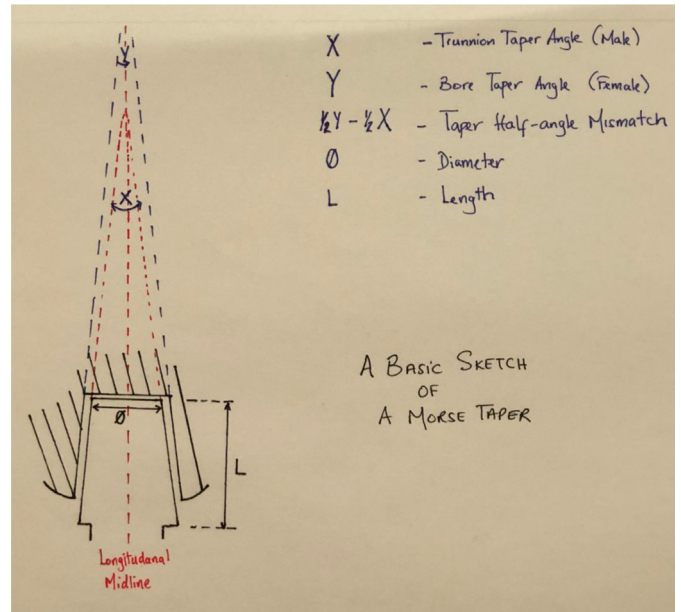


Figure 6 A cross-sectional illustration of the basic Morse taper design.

reported for both procedures but they noted a 12% incidence of glenoid component loosening. This prompted the authors to recommend hemiarthroplasty for the treatment of complex 4-part humeral fractures with no synovitis and a congruent glenoid. Our patient had a normal glenoid surface and intact rotator cuff muscles and was younger than 50 years, all of which made him a good candidate for a hemiarthroplasty.

The first-generation shoulder implant introduced ca. 1951 had a mono-block design that offered only 1 humeral head size based on an approximation using cadaveric measurements. Third-generation prostheses addressed height, inclination, offset, and version while eliminating the subarticular gap and avoiding overstuffing. For our case, we selected the Integra Titan Modular Shoulder System (Integra LifeSciences), which is a third-generation modular shoulder prosthesis.⁶

Modularity, although offering several important advantages, does have some potential drawbacks including corrosion and fretting at the Morse taper and dissociation or dislocation of the humeral components.¹ One key aspect that warrants further understanding is the Morse taper. Initially designed in 1864 by Stephen Morse (a mechanic) for connecting rotating components in his designs, it has now been adapted widely in the creation of modular parts around joint arthroplasties, particularly for the hip and shoulder.^{10,19} The sketch in Fig. 6 illustrates a longitudinal dissection of a basic Morse taper design. It highlights the small mismatch angle and how it allows for an interference fit between trunnion and bore to facilitate a cold weld (intersurface material transfer) of the parts. Generally, the smaller the taper half-angle and the longer the trunnion, the greater the distraction force required to separate the components. Modification in length and taper angles means that orthopedic applications do not use the Morse taper according to its true and standard specifications.¹⁰

Dissociation of modular implants is not uncommon in the hip, usually occurring during attempted closed reduction of a dislocated arthroplasty.^{4,9} Dissociation of a shoulder prosthesis is extremely uncommon, with an estimated incidence of 0.1%.¹ To date, there are only 3 case reports describing this phenomenon.^{3,5,18} Two of the reports describe dissociation of a specific second-generation SH implant with a unique reverse Morse taper design.^{5,18} These 2 reports using the Biomet Total Shoulder Prosthesis (Warsaw, IN, USA) included 13 patients with 14 dissociations (1 patient dissociated

twice). A more recent report describes humeral separation in a third-generation TSR with a standard Morse taper.³ The joint kinematics, laxity, and off-axial dissociation forces are significantly different between a TSR and an SH.¹³ Our case is unique in that we report dissociation of a third-generation SH with a standard Morse taper.

Blevin et al¹ looked at the reasons for dissociation of the Morse taper in the Biomet Total Shoulder Prosthesis, hypothesizing that improper taper fit is caused by contaminants. The effect of contaminants on the dissociation force showed that when the bore was filled with fluid (water, blood, or oil) there was a significant decrease in the force required to separate the components as compared with dry conditions. Water decreased the dissociation force by 24.3%, oil by 85.4%, and blood by 76.9% ($P < .001$).¹ The authors felt that if as little as 0.2–0.4 mL of fluid was trapped in the bottom of the bore, its noncompressible nature could prevent the trunnion from seating and therefore preclude a frictional fit.

Blevins et al¹ hypothesized that the reverse Morse taper of the Biomet Total Shoulder prosthesis made it more likely that fluid would be trapped in the humeral bore, reducing the dissociation force and resulting in a greater likelihood of dissociation. This is supported by the literature, which reveals that 13 cases of shoulder dissociation have involved the Biomet Total Shoulder prosthesis (11 of these cases were not reported but were made known to Blevin et al [personal communication from Biomet]). The Titan Shoulder Replacement in our case with its conventional Morse taper would have been unlikely to have had fluid trapped in the bore; however, it is possible that the trunnion may have been contaminated with blood or tissue fluid, reducing the frictional fit.

Errors in surgical technique need to be explored in examining the etiology of shoulder dissociation. Although the number of shoulder arthroplasty procedures are increasing worldwide, these operations are still relatively infrequent in the Caribbean, thus limiting the development of surgical expertise.^{8,15} In addition, very few local surgeons have had any formal training in shoulder arthroplasty, so in many instances, as in this case, the patient is treated by a general orthopedic surgeon.

The trauma scenario, in which many shoulder arthroplasties are performed, is perhaps the least favorable environment for the inexperienced surgeon. With the anatomy distorted, and multiple

displaced bone fragments in the presence of edematous and friable soft tissues, there are many opportunities for surgical error to occur.²²

Several technical aspects of shoulder arthroplasty deserve mention. Precise osteotomy of the humeral neck is of paramount importance in restoring anatomy and shoulder function. Inadequate resection may result in impingement of the prosthetic humeral head, preventing firm seating on impaction and producing a levering mechanism during shoulder movement, both of which can result in shoulder dissociation. At revision surgery, it was observed that the initial resection was inadequate and a fresh neck resection was performed.

Blevins et al¹ noted that rigid fixation and solid support of the humerus and elbow were important during intraoperative impaction. The lack of initial rigid humeral fixation may have resulted in a weak connection at the Morse taper as the humeral stem subsided on impaction of the head. The capacious humeral canal and undersized stem would also have allowed rotational movement to occur as the shoulder joint was mobilized. This nonphysiological movement likely contributed to impingement and subsequent dissociation. There is a trend toward increased use of uncemented humeral components, although this problem could have been avoided with a cemented stem.²⁰ The use of cemented stems is supported by a recent systematic review and meta-analysis²⁰ and the findings of a randomized controlled trial by Litchfield et al¹² concluding that both fixation techniques show similarly good clinical outcomes. The Integra Titan Modular Shoulder System (Integra LifeSciences) used in this case only allowed for uncemented fixation. The use of a larger, more canal-filling stem in the revision surgery allowed for firm impaction without rotational instability or subsidence.

There are significant differences in the shoulder movement and kinematics following a TSR and a SH.¹¹ In neither instance are normal kinematics restored. One may also argue that it is easier to restore normal shoulder kinematics with a TSR because the surgeon has options to make changes on the glenoid side. There are several reports of dissociation of the glenosphere following reverse shoulder arthroplasty but only 1 report of humeral dissociation in a third-generation TSR.⁷ In the cases of glenosphere dissociation, the authors implicated improper taper engagement as one of the causative factors.⁷ The report by Byrne et al³ did not comment on the cause of dissociation, only mentioning that theirs was the first reported case in a third-generation TSR. Our case represents a unique and as yet unreported finding of humeral dissociation following a third-generation SH.

Surgeon, patient, and implant factors all contribute to the successful outcome of any surgical procedure. Modern third-generation SH for the treatment of complex unreconstructable proximal humeral fractures produces a satisfactory clinical outcome in the majority of cases, with excellent pain relief but marked limitation of function.^{16,21} Improvements in implant technology have made failure of the implant a rare occurrence. Surgeon experience and technical capabilities play a major role in the prevention of humeral dissociation.

Conclusion

The last century has seen the evolution of shoulder arthroplasty from a mono-block design with a single head size and press-fit humeral stem to fourth-generation modular components with more than 1000 available options in 1 implant set.

Dissociation of a third-generation modular proximal humeral prosthesis is rare and usually occurs because of a technical error. Awareness of this fact may enable surgeons to avoid complications. To our knowledge, this case is the first such report in the literature

that involves a third-generation SH, with previous reports describing dissociation in a TSR.

Disclaimer

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