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

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Keywords: Shoulder hemiarthroplasty, dissociation, Morse taper

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. 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. 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...
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. 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.

Boyd et al 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
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tations means that orthopedic applications do not use the
included 13 patients with 14 dissociations (1 patient dissociated
ports using the Biomet Total Shoulder Prosthesis (Warsaw, IN, USA)
and shoulder.10,19 The sketch in Fig. 6 illustrates a longitudinal
modular parts around joint arthroplasties, particularly for the hip
his designs, it has now been adapted widely in the creation of
phen Morse (a mechanic) for connecting rotating components in
derstanding is the Morse taper. Initially designed in 1864 by Ste-
emall,14,15,18 which he called a Morse taper. Initial designs were
for the hip or shoulder.3,5,18 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.4,18 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 re-
ports using the Biomet Total Shoulder Prosthesis (Warsaw, IN, USA)
cluded 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.4 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 con-
taminants 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.

Blevin 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. With the anatomy distorted, and multiple

![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.](image)

![Figure 6 A cross-sectional illustration of the basic Morse taper design.](image)
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.23,24 The use of cemented stems is supported by a recent systematic review and meta-analysis25 and the findings of a randomized controlled trial by Litchfield et al26 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.1 In the cases of glenosphere dissociation, the authors implicated improper taper engagement as one of the causative factors.7 The report by Byrne et al 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 successfull 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

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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