Humeral Tray-Taper Failure in Modular Reverse Total Shoulder Arthroplasty

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Abstract *Background:* Reverse total shoulder arthroplasty (RTSA) provides reconstructive options in patients previously not candidates for total shoulder arthroplasty (TSA) or who have failed previous anatomic TSA. Revision from anatomic TSA to RTSA previously required removal of all components, a difficult and extensive procedure. Modular humeral components permit conversion from anatomic TSA to RTSA without removal of well-fixed humeral components. *Questions/Purposes:* Our purpose is to present a case series of patients treated for the unique and not previously reported complication of humeral tray-taper failure following modular RTSA. Challenges in diagnosis and treatment are described, including the use of dynamic fluoroscopy and manufacturer-specific instruments for component revision. *Methods:* Five patients with a total of six humeral tray-taper failures were identified from 300 patients with first-generation (titanium) humeral trays over a 7-year period. Dynamic fluoroscopic evaluation aided in diagnosis in a majority of the cases. All cases have been revised to second-generation (cobalt chrome) humeral trays. *Results:* Average follow-up was 22±23 months (range 3–60 months). One individual required a second revision for the same complication, but otherwise, no additional procedures were required. Symptom relief was obtained in all patients.

Conclusions: This case series illustrates a previously unpublished complication of humeral tray-taper junction failure following modular RTSA. Clinical and radiographic diagnosis is challenging; however, dynamic fluoroscopic evaluation permits identification of the component failure, and revision surgery results in good outcomes. We must, however, continue to evaluate what activities are recommend for patients following shoulder arthroplasty, specifically reverse total shoulder arthroplasty.

Keywords reverse total shoulder arthroplasty · complication · humeral tray-taper failure · modular components · revision surgery

Introduction

Reverse total shoulder arthroplasty (RTSA) provides reliable improvement in shoulder function and pain relief for patients not candidates for anatomic total shoulder arthroplasty (TSA). Recently, modular prostheses have revolutionized surgical treatment, specifically in revision settings, permitting conversion from TSA to RTSA without explanting well-fixed humeral components [1].

New technology is accompanied by new complications. With any shoulder arthroplasty, complications of infection, instability, and glenoid component failure are well described. Humeral-sided component failure, however, is uncommon.

Our purpose is to present a series of patients treated for the unique and not previously reported complication of humeral tray-taper failure in a modular RTSA. Specifically, we describe the use of dynamic fluoroscopy to assist with a challenging diagnosis while reviewing treatment methods and potential causal factors.

Patients and Methods

Operative records from two sports medicine/shoulder surgeons were reviewed, identifying all cases of RTSA utilizing a first-generation modular reverse shoulder arthroplasty

Work performed at Hospital for Special Surgery, New York, New York.

Level of Evidence: Level IV: Therapeutic Study.

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system. All cases of humeral tray-taper failure following RTSA from 2008 to 2015 were identified from surgeon case logs. Patient data including age at the time of RTSA index surgery, time between implantation and revision, causal factor for disassociation, method of diagnosis, and revision procedure performed were reviewed.

Following primary RTSA, five cases of humeral tray-taper failure were identified from a total of 300 first-generation (titanium taper) Biomet Comprehensive Reverse Shoulder System implants (Biomet, Warsaw, Indiana). Mean age at primary surgery was 65 ± 3.6 years (range 60–69 years) and 69 ± 4.1 years (range 62–73 years) at revision. All RTSA surgical procedures were performed at our institution. The dominant shoulder was affected in three patients. Indications for RTSA included a failed TSA due to subscapularis insufficiency in one patient and rotator cuff tear arthropathy in four. Sized 36 glenospheres and sized 44-mm humeral trays were used in all cases and implanted an average of 46 ± 22 months (range 20–74 months) prior to revision.

Three of the patients sustained traumatic falls immediately before presentation with symptoms identified as humeral tray-taper failure. One patient felt a mechanical pop when swinging a golf club, and the final patient presented with an acute shoulder injury while bench-pressing with subsequent mechanical clicking and discomfort.

Plain radiographs were normal in three out of five patients (Figs. 1 and 2). An MRI was obtained on three of five patients, which demonstrated no abnormalities. In patients with normal plain radiographs, dynamic fluoroscopic evaluation clearly demonstrated failure at the tray-taper interface (Fig. 3, Video 1). Live fluoroscopic evaluation was performed in the supine position with abduction and adduction followed by internal and external shoulder rotation. In external rotation, a radiolucent region was visible at the tray-taper interface in a region that is radiopaque when no metallic separation is present.

All five patients underwent revision RTSA with similar surgical treatments. A standard deltopectoral approach through the previous incision with a subscapularis tendon peel or tenotomy was utilized to gain glenohumeral access. The humeral tray was loose and separated from the taper in all cases with a well-fixed polyethylene component. The taper remained well fixed in the humeral stem and failed at the junction between the morse taper male component and the posterior aspect of the tray. No abnormal wear at the tray-taper interface, metallic debris, or glenoid notching was encountered in any of the cases.

A manufacturer-specific device was secured on the taper at its humeral stem insertion assisting with extraction, and the broken component was successfully removed in all cases (Figs. 4 and 5). The humeral and glenoid implants were queried for signs of wear or loosening. The humeral implant was cleaned at the insertion point and dried before a new humeral tray, taper, and polyethylene were inserted. The glenohumeral joint was reduced and stability and motion tested. When possible, subscapularis repair was performed through bone tunnels and a standard layered closure undertaken.

In the first patient, a repeat failure of the humeral tray-taper occurred 6 months after re-implantation requiring a second revision, yielding six total failures in five patients.

Fig. 1. Anterior-posterior radiograph of humeral tray-taper failure initially interpreted as a normal post-surgical radiograph.

This recurrent failure was easily identified by clinical examination and plain radiographs. In this patient, first-generation (titanium) modular humeral trays were used at initial revision surgery, as second-generation (cobalt chrome) components were not yet available. The second revision was with second-generation components and has required no further surgical treatments.

Fig. 2. Axillary radiograph of humeral tray-taper failure initially interpreted as a normal post-surgical radiograph.

Fig. 3. Still image captured from dynamic fluoroscopic examination clearly demonstrating humeral tray-taper failure noted by radiolucent region (*arrow*) between the tray and humeral stem.

The average duration of follow-up following revision RTSA for humeral tray-taper failure was 22 ± 23 months (range 3–60 months). Save for the one individual who required a second revision for the same complication, no additional surgical procedures were performed. Symptom relief was obtained in all patients with a return to their baseline activities.

Fig. 4. Manufacturer-specific humeral taper extraction tool after removal of the broken implant.

Fig. 5. Manufacturer-specific humeral taper extraction tool after removal of the broken implant. Failed taper is noted by *arrow*.

Discussion

This complication is rare and not previously reported. The historic complication rate for TSA is as high as 15%, though decreasing as the procedure becomes more commonly performed. The complication rates in RTSA and revision TSA with conversion to reverse prostheses are even higher. In this subset of RTSA cases, Kelly and colleagues reported an overall complication rate of 50% with a 23% reoperation rate, though despite this found an 80% patient satisfaction rate [3]. More recently, Saltzman reviewed complication rates associated with RTSA, reporting a 25% complication rate for primary RTSA and 69% complication rate for revision RTSA [7]. Technical- and component-related complications include scapular notching, glenohumeral instability, fractures of the acromion or scapular spine, and failure of the glenoid and humeral components. Glenoid disassociation is more common than any humeral-sided complications including polyethylene dissociation and diaphyseal-epiphyseal component dissociation.

This retrospective case series has limitations. As our primary goal is to identify this complication, methods of diagnosis and tips for treatment, we do not have outcomes scores or detailed clinical examination to include motion analysis on our patients. Additionally, follow-up is as short as 3 months following revision surgery, especially considering one of the repeat failures of first-generation components occurred at 6 months. Despite this, there have been no failures of second-generation components, though continued regular radiographic and clinical monitoring of post-operative patients is warranted.

In our cases, component failure was not a simple disassociation of the humeral tray-taper from the humeral stem collar, but rather an intrinsic component failure at the

humeral tray-taper interface. This portion of the implant is not one of the modular components, and the taper is manufactured as part of the humeral tray. It is designed to seat completely in the humeral stem in the same manner as the anatomic TSA humeral head taper allowing component revision without complete implant removal. Identification of this complication is not straightforward.

Patient presentations include vague symptoms of pain and mechanical clicking, and in all cases, there was an acute change after a heavy loading activity including weight lifting, golfing, and mechanical falls. Plain radiographs are often normal despite a complete separation of the humeral tray component from the humeral stem. Subtle proximal migration of the humeral stem on the tray may be visible; however, often the components appear attached. The diagnostic test confirming this method of component failure is dynamic fluoroscopic evaluation. Upon external rotation, a radiolucent space at the center of the humeral tray component is visible, identifying the site of failure.

A standard deltopectoral approach is utilized and the loose humeral tray is removed. Manufacturer-specific tools exist for extracting the taper from the stem (Figs. 4 and 5). They are secured to the exposed portion of the taper permitting removal without complete humeral stem extraction. The humeral stem and glenoid component are queried ensuring stability, and if they can be retained, a new humeral tray and polyethylene is inserted. The latest generation of Biomet Comprehensive Reverse Shoulder System (Biomet, Warsaw, Indiana) is manufactured out of cobalt chrome rather than titanium and in revision settings is interchangeable with the original implant. Our rate for this specific complication is 1.67% (5/300 cases) from surgeons involved in early use of this modular RTSA. Since transitioning to the second-generation cobalt chrome humeral tray, we have encountered no new humeral tray-taper failure in either revision or primary cases. Senior author correspondence with the manufacturer identified 80 total cases of humeral tray-taper failure out of 13,133 first-generation titanium tray implants, a rate of 0.61%. Since conversion to cobalt chrome implants, 22,485 have been inserted without any reported humeral tray-taper failures. It is too early to draw firm conclusions on whether this complication has been eliminated with transition to second-generation implants; however, no recurrences have occurred, and we recommend continued monitoring of post-surgical patients, especially if they experience a change in function of their prosthetic shoulder.

While the primary purpose of this case series is to report a rare complication and methods of identification and treatment, it is also important to evaluate the underlying cause. Impingement of the implant on the glenoid can cause increase loads predisposing to failure; however, none of our cases demonstrated signs of glenoid notching or glenoid component wear. We suspect that implant overload was a major contributing factor as all events occurred following specific high-loading events. One of the failures occurred in an obese woman who fell down a flight of stairs. Another failure occurred in an avid golfer. A final failure was in a patient who at age 75 increased his upper extremity loads when started weightlifting as a sport after undergoing a failed total shoulder arthroplasty that was converted with modular components to a RTSA.

Activity recommendations by operative surgeons following TSA and RTSA vary based on region and type of implant. In an international survey, Magnusson and colleagues reported that overall there was not a consensus on whether to permit a return to higher impact sports following hemiarthroplasty or anatomic TSA but recommendations against doing so following RTSA [5]. Interestingly, European surgeons were more restrictive in their activity recommendations. A more recent survey of American Shoulder and Elbow Surgeons by Golant and colleagues reported that more than 90% of surgeons permitted return to non-contact low-load sports regardless of arthroplasty type [2]. In high-load sports, however, surgeons were more restrictive following RTSA with only 36% recommending return to sport while greater than 75% of surgeons permitted doing so following anatomic TSA [2]. Importantly, in both studies, recommendations of return to sport were contingent on patient level of participation prior their arthroplasty [2, 5].

Patient expectations differ from surgeon recommendations, and this may contribute to high loading of TSA and RTSA following implantation. Following TSA, McCarty and colleagues reported that 64% of patients underwent surgical treatment with a goal of returning to sporting activity, and 71% had an improved ability to participate in sports following arthroplasty [6]. Lawrence and colleagues investigated patient-reported activity following RTSA, finding that 83% returned to low-demand activities, 65% returned to medium-demand activities, and 52% returned to high-demand activities [4]. We recommend patients return to lower load activities with a goal of returning to sporting activities they participated in prior to arthroplasty without adding new high-load activities. Like arthroplasty in other joints, we also counsel patients on increased failure rates if they undertake higher loading activities.

Shoulder arthroplasty remains a growing field with new indications, surgical techniques, and implants. With these advances come potential complications. We present a case series of RTSA implant failure in a first-generation modular RTSA at the humeral tray-taper junction resulting in pain, mechanical symptoms, and loss of function. Clinical and radiographic diagnosis is challenging; however, dynamic fluoroscopic evaluation permits easy identification of the component failure location. Revision surgery can be successful with proper planning and utilization of manufacturer-specific implant extraction devices resulting in overall good outcomes. Finally, we must continue to evaluate what activities are recommended for patients following shoulder arthroplasty, specifically reverse total shoulder arthroplasty.

Disclosures

Conflict of Interest: Lucas S. McDonald, MD, and Christopher Chin, BA, have declared that they have no conflict of interest. Joshua S. Dines, MD, reports personal fees from Arthrex, outside the work; family member receives royalties from Biomet. Russell F. Warren, MD, reports personal fees from Biomet and other fees from Ivy Sports Medicine and Orthonet and receives royalties for Shoulder Arthroplasty patent, outside the work. David M. Dines, MD, reports personal fees from Biomet and receives royalties for a Shoulder Arthroplasty patent and is a board member of Journal of Shoulder and Elbow Surgery, outside the work.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: Informed consent was waived from all patients for being included in the study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

References

1. Dines DM, Warren RF. Modular shoulder prosthesis. US Patent Office; 4865605, 1989.
2. Golant A, Christoforou D, Zuckerman JD, Kwon YW. Return to sports after shoulder arthroplasty: a survey of surgeons' preferences. *J Shoulder Elbow Surg.* 2012; 21: 554-560.
3. Kelly JD, Zhao JX, Hobgood ER, Norris TR. Clinical results of revision shoulder arthroplasty using the reverse prosthesis. *J Shoulder Elbow Surg.* 2012; 21: 1516-1525.
4. Lawrence TM, Ahmadi S, Sanchez-Sotelo J, Sperling JW, Cofield RH. Patient reported activities after reverse shoulder arthroplasty: part II. *J Shoulder Elbow Surg.* 2012; 21: 1464-1469.
5. Magnussen RA, Mallon WJ, Willems WJ, Moorman CT. Long-term activity restrictions after shoulder arthroplasty: an international survey of experienced shoulder surgeons. *J Shoulder Elbow Surg.* 2011; 20: 281-289.
6. McCarty EC, Marx RG, Maerz D, Altchek D, Warren RF. Sports participation after shoulder replacement surgery. *Am J Sports Med.* 2008; 36: 1577-1581.
7. Saltzman BM, Chalmers PN, Gupta AK, Romeo AA, Nicholson GP. Complication rates comparing primary with revision reverse total shoulder arthroplasty. *J Shoulder Elbow Surg.* 2014; 23: 1647-1654.