Glenoid Perforation With Pegged Components During Total Shoulder Arthroplasty

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abstract

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A subset of patients undergoing primary total shoulder arthroplasty (TSA) have a medialized joint line secondary to glenoid wear. In some cases, the central pegs or peripheral pegs of a peg design glenoid component may violate the medial cortex of the glenoid vault. It is unknown whether this leads to early failure. The objectives of this study were to determine (1) whether glenoid components with uncontained pegs would be associated with a high rate of failure and (2) whether peg perforation would be associated with inferior clinical outcomes. The authors performed a case-control retrospective review comparing 25 TSAs in which one or multiple pegs perforated the medial glenoid vault (uncontained group) with 25 TSAs without peg perforation (contained group). Implant survival was calculated with revision for glenoid component loosening as the primary outcome variable. Clinical outcomes were determined using American Shoulder and Elbow Surgeons (ASES) and Penn Shoulder Scores. Average follow-up was more than 5 years. No patient in either group had symptomatic glenoid loosening. Two (8%) patients in the uncontained group required revision for rotator cuff tears. Penn and ASES scores were significantly lower in the uncontained group (Penn, \(P = 0.002\); ASES, \(P = 0.004\)). Pain and satisfaction subscores were similar between the groups, but function subscores were significantly lower in the uncontained group (Penn, \(P = 0.002\); ASES, \(P = 0.005\)). Uncontained pegs of an anchor peg glenoid component are not associated with early glenoid loosening. Similar pain relief is obtained when compared with contained glenoid components, but shoulder function is significantly lower in patients with uncontained pegs.
Total shoulder arthroplasty (TSA) can provide reliable pain relief and functional recovery to patients with debilitating glenohumeral arthritis.\(^1\)\(^-\)\(^4\) However, failure of the glenoid component secondary to mechanical loosening is a major obstacle to long-term survivorship of these implants.\(^4\)\(^-\)\(^7\) Numerous factors have been associated with glenoid component failure, including component malpositioning, rotator cuff tears, glenoid bone loss, glenoid design, and poor-quality bone.\(^3\)\(^,\)\(^8\)\(^,\)\(^9\)

A subset of patients undergoing primary TSA have a medialized joint line secondary to glenoid wear. Severe glenoid erosion is often accompanied by eccentric posterior glenoid wear and anterior soft tissue contractures (Figure 1).\(^1\)\(^0\),\(^1\)\(^1\) Glenoid medialization and posterior wear may alter rotator cuff balance and length-tension relationship, which are critical to a well-functioning shoulder.\(^1\)\(^2\),\(^1\)\(^3\) Implantation of a glenoid component in cases of medialized glenoid erosion may be compromised due to decreased surface area of the glenoid face and reduced depth of the glenoid vault. Bone stock may be further compromised by asymmetric reaming aimed to restore neutral version of the glenoid component. In some cases, the bone stock may be deficient to the point where the central or peripheral pegs of a peg design glenoid component violate the medial cortex of the glenoid vault.

The implications of peg perforation of the glenoid vault are unknown. Survivorship of the glenoid component and functional outcomes in these cases have not been previously reported. In the current study, the authors used a case-control design with a group of patients with uncontained pegs and a matched group of patients with contained components. By comparing these 2 groups, the objectives of this study were two-fold: (1) to determine whether there is decreased survivorship of the glenoid component in patients with uncontained pegs, and (2) to determine whether patients with un-contained pegs have inferior clinical outcomes (pain, satisfaction, and function) compared with patients with contained components. The authors hypothesized (1) that a pegged glenoid component would provide adequate stability in cases in which the medial glenoid vault was perforated and that early glenoid loosening would not occur, and (2) that peg perforation would be associated with inferior functional outcomes.

**Materials and Methods**

Institutional review board approval was obtained for this study. A computerized search of the authors’ health system’s database was performed to identify patients treated with a TSA between September 2004 and May 2008 based on Current Procedural Terminology (CPT) code 23472 (total shoulder arthroplasty). A total of 421 cases were identified. Medical records for each case were obtained and reviewed. Cases were excluded if (1) a reverse TSA was performed, (2) the case involved revision of a glenoid component, or (3) a keeled glenoid component was used. During this time period, breach of the medial glenoid vault and location of the breach were documented by the surgeon in the operative note. Operative reports of 243 anatomic TSAs were reviewed to identify those cases with severe glenohumeral arthritis in which a peg breached the medial glenoid vault. All TSAs were performed using the same anatomic total shoulder prosthesis with a pegged glenoid design (Anchor Peg Glenoid; DePuy, Warsaw, Indiana) (Figure 2). Patient charts were reviewed to collect the most recent clinical follow-up data. An American Shoulder and Elbow Surgeon (ASES) score\(^1\)\(^4\) and a Penn Shoulder Score\(^1\)\(^5\) were routinely collected for all patients at each clinic visit to assess pain, function, and satisfaction. Those patients without a clinical follow-up within the past 2 years were contacted by telephone to obtain updated information. Patients with less than 2 years of clinical follow-up were excluded. Any complications or need for subsequent surgery were recorded. Any reoperation was classified as related to or unrelated to glenoid component loosening.

**Matched Control Group**

Twenty-five patients with peg perforation of the medial glenoid vault were matched with a cohort of 25 patients without peg perforation, referred to as the un-contained and contained groups, respectively. Controls were selected from the same database based on age and sex. For each patient in the study group, a list of all eligible patients with the same sex and age (within 2 years) was collected. A random number generator was then used to select the corresponding control patient.

**Radiographic Evaluation**

A radiographic analysis was attempted in all patients with pre- and postoperative radiographs available. To assess and compare the amount of medialization in the perforated and nonperforated groups, the lateral glenohumeral offset,
defined as the distance from the greater tuberosity to the lateral margin of the acromion, was measured on preoperative anteroposterior radiographs. Initially, an attempt was also made to obtain radiographs performed more than 2 years postoperatively in both groups to rule out radiographic loosening of the glenoid component. However, a large number of patients were either unable to obtain new radiographs under this study protocol or had radiographs done at another institution that the authors were unable to obtain, and this was abandoned.

**Statistical Analysis**

Chi-square test was used to determine any significant differences between groups in the rate of revision surgery for symptomatic glenoid component loosening. Pain (ASES and Penn), satisfaction (Penn), and function (ASES and Penn) subscores were compared using a paired t test. To remain conservative, the level of significance was adjusted with the Bonferroni method to reflect the fact that 5 different variables were studied; therefore, the P value was set to .05/5, or .01. Subgroup analysis within the uncontained group comparing posterior peg perforation vs central peg perforation was performed using a 2-sided unpaired t test. Statistical analysis was performed using SPSS version 17.0 statistical software (SPSS Inc, Chicago, Illinois).

**RESULTS**

Demographic data from the 25 patients in the uncontained group and 25 patients in the contained group are shown in the Table. Average follow-up was 5.4 years (range, 3.1-7.0 years), and average patient age was 68.5 years (range, 50.7-81.7 years). In the uncontained group, 15 patients had central peg perforation of the glenoid vault and 12 patients had posterior inferior peripheral peg perforation; 2 patients had both central and posterior peg perforations.

Preoperative radiographs with adequate views and quality to measure lateral glenohumeral offset were available in 33 (66%) of the 50 patients. Measurements revealed an average lateral glenohumeral offset of 9.1 mm (range, 3.1-17.1 mm) in the uncontained group vs 11.6 mm (range, 4.0-20.3 mm) in the contained group (P=0.9).

Of the 25 patients in the uncontained group, no patient required revision surgery for a loose glenoid component at latest follow-up. Two (8%) patients required revision surgery; both for rotator cuff tears, at 8 months and 3 years postoperatively, respectively. Both patients then underwent conversion to a reverse TSA. At the time of revision surgery, the glenoid component was found to be stable in both patients. In the contained group, no patient required revision surgery for a loose glenoid component or revision for any reason.

Pain, function, and satisfaction as reported by ASES and Penn Shoulder Scores are shown in **Figures 3 and 4**. Pain and satisfaction were similar between the 2 groups. Function, graded by both Penn and ASES scoring systems, was significantly lower in the uncontained group than the contained group (Penn, P=0.002; ASES, P=.005), and total Penn and ASES scores were significantly lower as a result (Penn, P=.002; ASES, P=.004). Subgroup analysis of the uncontained group showed no significant difference between patients with central peg perforation and posterior peg perforation.

**DISCUSSION**

In patients with severe wear of the glenoid, medialization and retroversion of the joint line can lead to perforation of the glenoid vault by one of the peripheral or central pegs of a pegged glenoid component. In this study, a case-control method was used to evaluate the implications of peg perforation in terms of symptomatic loosening and functional outcomes. With no patients requiring revision surgery for a loose glenoid component at a mean follow-up of more than 5 years, results support the authors’ hypothesis that peg perforation of the medial cortex is not associated with early glenoid loosening in this subset of patients. Also, although pain and satisfaction were similar between the contained and uncontained groups, function was significantly decreased in patients with perforated pegs. To the authors’ knowledge, this is the first study to characterize patients in which the glenoid component was not contained within the glenoid vault.

Glenoid component loosening is one of the most common causes of TSA failure, and various glenoid implants have been designed in attempts to improve durability. The glenoid component used in this study was an all-polyethylene anchor peg design with 1 central and 3 pe-
ripheral pegs. The central peg has flanges designed for bone ingrowth. Neither group of patients had any cases of symptomatic glenoid loosening. This study’s results are consistent with a recent study by Wirth et al,\textsuperscript{16} who used the same all-polyethylene pegged glenoid implant. In 44 patients with a mean clinical follow-up of 4 years, Simple Shoulder Test scores, ASES scores, and visual analog scale scores all improved significantly. Three of the 44 patients demonstrated osteolysis on postoperative radiographs. Twenty had perfect seating and radiolucency grades, and 30 had increased radiodensity between the flanges of the central peg. The Wirth et al\textsuperscript{16} study suggests that this component provides durable fixation, and the data from the current study further suggest that adequate stability is achieved in cases where one or multiple pegs perforated the medial cortex of the glenoid.

The difference in ASES and Penn Shoulder Scores between the uncontained and contained groups in the current study was 8.8 and 11.4 points, respectively. This was statistically significant difference for both scoring systems. In addition, the differences in both scoring systems was equal to or above the minimal clinically important difference of 6.4 points for the ASES scores\textsuperscript{17} and 11.4 for the Penn Shoulder Scores,\textsuperscript{15} suggesting that this is a clinically significant difference as well. Subscores for pain and satisfaction were similar between the 2 groups, but the function subscores were significantly different between groups for both scoring systems. Although the minimal clinically important difference for function subscores is not reported in the literature, this difference is likely clinically significant. This study’s results suggest that patients with peg perforation have adequate pain relief from TSA but significantly worse shoulder function compared with patients without peg perforation.

The inferior function in patients with uncontained pegs may be explained by preoperative differences in disease severity, joint line medialization, and joint line retroversion. In the current study, the preoperative lateral glenohumeral offset was greater in the perforated group than in the nonperforated group, suggesting that the joint line was more medialized in patients in which pegs perforated the medial glenoid vault. Although the difference did not reach statistical significance, this likely represents a clinically significant amount of medialization on plain radiographs. The patients in the uncontained group likely had more severe disease, joint line medialization, and retroversion than patients in the contained group. This may lead to more difficulty in intraoperative soft tissue balancing. Also, there may have been a significant change in the length-tension relationship of the rotator cuff tendons.
cuff musculature. Ward et al. performed a study of rotator cuff muscle architecture and showed that rotator cuff muscles are highly sensitive to length changes. Because concentric rotation of the humeral head within the glenoid and dynamic stability is dependent on an intact balance of forces, or force couple, across the glenohumeral joint, small changes in the resting length of the anterior or posterior rotator cuff muscles may cause an uncoupling of these forces. Force couple and soft tissue imbalance in TSA has shown to yield poor results, and revision TSA for soft tissue problems generally has unsatisfactory outcomes. Particular attention to soft tissue balancing in cases of medial vault perforation may be critical to a good functional outcome.

This study has limitations. First, although the study shows that peg perforation has an effect on shoulder function as shown by decreased Penn and ASES scores, it does not provide evidence to explain why shoulder function would be decreased in a shoulder in which the medial glenoid vault was violated. Although the authors can hypothesize that medialization of the joint line can affect soft tissue tensioning and that glenoid components may be implanted in retroversion due to severe posterior glenoid wear, numerous other variables were unable to be documented (eg, version of the implanted glenoid component). Second, the authors’ intraoperative documentation did not include the amount of asymmetric reaming that was performed in each patient. The surgeons involved in this study preferred to ream the high side to provide some version correction, but neutral or native version was not always obtained or even preferred by surgeons in cases of severe posterior wear. Third, although the authors were able to obtain preoperative radiographs in the majority of patients to measure lateral glenohumeral offset, these radiographs were of inadequate quality to classify the amount of posterior wear that would be evident on 3-dimensional imaging. Therefore, classification of glenoid morphology was not possible. In addition, the postoperative radiographic follow-up was inadequate. Finally, these cases were performed by surgeons who perform a high volume of TSA. These surgeons may be more adept at handling more difficult cases, and, therefore, these results may not be applicable to a surgeon who performs TSA at a much lower volume.

Further studies with longer follow-up and prospective data are warranted. Additional preoperative functional data and postoperative cross-sectional imaging to document version and any eccentric wear of the polyethylene component would be useful.

CONCLUSION

At an average follow-up of more than 5 years, glenoid component loosening did not occur in any cases in which the central or peripheral pegs of a pegged glenoid component violated the medial glenoid vault. Although pain relief and satisfaction were similar in patients with contained and uncontained glenoid components, shoulder function was significantly lower in patients with uncontained components.

REFERENCES