Radiographic Evaluation of Glenoid Components and its Survivorship

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Abstract

Introduction: This study evaluated the survivorship of pegged versus keeled cemented, all-polyethylene glenoid components using modern cementing and glenoid preparation techniques. Survival of glenoid design was determined according to severity of radiolucencies on follow-up radiographs.

Methods: Between April 22, 1999, and February 17, 2009, retrospective chart review was performed on 194 total shoulder arthroplasties. A minimum of 3-year follow-up was established. Scapular plane anteroposterior radiographs (Grashey view) were analyzed and graded for the degree of radiolucency surrounding the glenoid anchor using Franklin's method for keeled components and a modification of that method for pegged components. Radiographs were evaluated by 3 raters. Unpaired 2-tailed t-test was used to calculate significance, p < 0.05. Interobserver correlation was computed using the intraclass correlation coefficient (ICC) 2-way mixed model with measures of absolute agreement to analyze the measurement reliability. Values of ICC range from 0 to 1, with a higher value indicating better reliability. Active forward elevation (AFE) and active external rotation (AER) were recorded before and after surgery. The range of motion scores for pegged glenoids was compared to keeled glenoids, as well as grading lucency from 0-1 to >1 lucency.

Results: Fifty-two total shoulders met the inclusion criteria, with 36 pegged glenoid components and 16 keeled components. Average length of follow up was 67 months. Average radiolucency was 1.01 on a modified Franklin scale of 0 to 5 in the pegged glenoid component group, compared to 1.90 in the keeled group, (p<0.01). Interobserver correlation coefficient was 0.31. For the pegged group, AFE increased from 123° to 150°, and AER increased from 24° to 59°. For the keeled group, AFE increased from 105° to 148°, and AER increased from 14° to 59°. For grade 0-1 lucency, AFE increased from 120° to 151°, and AER increased from 20° to 56°. For grade >1 lucency, AFE increased from 114° to 148°, and AER increased from 21° to 61°.

Conclusions: Significantly greater component survival was found with pegged as opposed to keeled anchoring design. Poor interobserver reliability was noted. There did not appear to be a difference in range of motion between pegged and keeled glenoids or with respect to degree of radiolucency.

Introduction

Total shoulder replacement has been demonstrated to be an effective treatment for end-stage glenohumeral arthritis [1]. The presence of radiolucencies at the glenoid bone-cement interface has continued to be a concerning finding [2-21]. An association between glenoid radiolucencies and a worse functional outcome has been reported in the literature [22]. Torchia and colleagues reported that 39 (44%) of 89 glenoids had radiographic signs of loosening after a minimum duration of follow-up of 5 years and noted that these changes were associated with worsening function [18]. The reported prevalence of glenoid radiolucencies has varied from 0% to 96%, and this wide range has been postulated to be as a result of a lack of uniformity in grading and follow-up among studies [23,24]. Biomechanical, animal, and retrospective studies have implicated glenoid design in the development of glenoid lucency [25-28]. In the literature, the effect of using pegged-back versus keeled-back glenoid components has been controversial. Some studies have found no difference in glenoid lucency between the 2 designs [31-35], whereas others have reported a lower radiolucent lines rate for pegged-back glenoids [19,26,27,36]. These studies indicate that cemented pegged glenoid components appear to have better fixation and a lower rate of radiographic lucency over time when compared with keeled components [25-28].

Gartsman and colleagues conducted a prospective, randomized study to compare the components, as used by a single surgeon, and found that glenoid lucency was seen in 9 (39%) of 23 keeled-back glenoids versus 1 (5%) of 20 pegged back glenoids (P = .026) [37,38]. The current definition of a modern cementing technique relating to glenoid component fixation minimizes removal of subchondral sclerotic bone, compacts the cancellous bone during anchorage preparation, thoroughly cleans any blood and soft tissue debris, achieves meticulous drying of the glenoid by any method, inserts cement with a
syringe, and pressurizes the cement after insertion by mechanical means [39]. The hypothesis is that in the Bigliani-Flatow Total Shoulder Arthroplasty (TSA) System, the use of cemented pegged glenoid components will have lower grades of radiolucencies as compared to keeled cemented glenoid components in medium to long-term radiographic evaluation.

Methods

Materials
Between April 22, 1999, and February 17, 2009, 194 total shoulder arthroplasties were performed by a single shoulder surgeon. A retrospective chart review was performed. Inclusion criteria for this study were primary standard total shoulder arthroplasty performed without concurrent procedures, such as capsulorraphy. Revision procedures and concurrent capsulorraphies or other procedures were excluded. A minimum of 3-year follow-up was established. Scapular plane anteroposterior radiographs (Grashey view) were then analyzed and graded for the degree of radiolucency surrounding the glenoid anchor. Franklin’s method was used to grade keeled components, and a modification of that method was used to grade pegged components. The radiographs were evaluated by 3 raters, including a shoulder surgeon and an orthopaedic resident. After familiarizing themselves with the described grading criteria by reviewing the previously published articles by Franklin et al [23] and Lazarus et al [26] the raters independently graded the radiographs for each of the patients in this study. The orthopaedic surgeon who had performed the arthroplasties was not a rater. An unpaired 2-tailed t-test was used to calculate statistical significance, with significance being \( p < 0.05 \). Interobserver correlation was computed using the intraclass correlation coefficient (ICC) 2-way mixed model with measures of absolute agreement to analyze the measurement reliability. Values of ICC range from 0 to 1, with a higher value indicating better reliability. ICC less than 0.40 is considered poor; 0.40 to 0.59 as fair; 0.60 to 0.74 as good; and 0.75 to 1.00 as excellent.

Active forward elevation (AFE) and active external rotation (AER) were measured by the operating surgeon before and after surgery and the data was analyzed by retrospective chart review. Range of motion scores for pegged TSAs was compared to the keeled TSA glenoids. In addition, range of motion scores for those TSA glenoids with grade 0-1 lucency was compared to grade >1 lucency.

Surgical Procedure

All patients underwent reconstructive surgery at a single institution using the Bigliani/Flatow® The Complete Shoulder Solution system (Zimmer, Warsaw, IN). All procedures were performed by a single experienced senior staff shoulder surgeon. Cementing of the glenoid component was performed in a standard fashion with a modern cementing technique. The range of operative dates for the study group varied from April 22, 1999 to February 17, 2009.

Radiographic Lucency
Radiographic lucency of the keeled glenoid components was graded according to criteria previously described by Franklin et al [23]. The pegged components were graded according to the modification described by Lazarus et al [26]. The keeled components were graded between 0 and 5. A grade of 0 represented no lucency. Grades

1. through 5 were as follows 1. Radiolucency at inferior and/or superior flange
2. Incomplete radiolucency at keel
3. Complete radiolucency of less than 2 mm in width around keel
4. Complete radiolucency of 2 mm or greater in width around keel
5. Gross loosening

The pegged components were also graded between 0 and 5, with 0 representing no lucency. The remaining grades were as follows

1. Incomplete radiolucency around 1 or 2 pegs
2. Complete radiolucency of less than 2 mm in width around 1 peg only, with or without incomplete radiolucency around one other peg
3. Complete radiolucency of less than 2 mm in width around 2 or more pegs
4. Complete radiolucency of 2 mm or greater in width around 2 or more pegs
5. Gross loosening

Results

Subjects
Fifty-two total shoulder arthroplasties in 45 patients met our inclusion criteria, with 36 pegged glenoid components and 16 keeled components. One hundred and forty-two total shoulder arthroplasties were excluded due to the lack of follow-up radiographs performed at least 3-years from the date of the index procedure. The average length of follow-up radiographs was 67 months (range 36 to 128 months). The average degree of radiolucency was 1.01 (0 to 2.33) on a modified Franklin scale of 0 to 5 in the
pegged glenoid component group, as compared to 1.90 (0.67 to 3.67) on a Franklin scale of 0 to 5 in the keeled group, (p<0.01). The interobserver correlation coefficient was 0.31. Active forward elevation (AFE) and active external rotation (AER) were recorded before and after surgery for 49 total shoulder arthroplasties. The range of motion scores for 33 pegged glenoid total shoulder arthroplasties were compared to 16 keeled glenoid total shoulder arthroplasties. For 3 of the total shoulder arthroplasties there was insufficient documentation on the range of motion, either pre-operative or postoperative and these total shoulder arthroplasties were excluded from this portion of the study. For the pegged group, (33), AFE increased from an average of 123° (80° to 170°) to 150° (30° to 180°), and AER increased from an average of 24° (-20° to 70°) to 59° (30° to 80°). For the keeled group, (16), AFE increased from an average of 105° (35° to 165°) to 148° (100° to 180°), and AER increased from an average of 14° (-30° to 50°) to 59° degrees (30° to 80°). In addition, the range of motion scores for 22 total shoulder arthroplasties with grade 0 - 1 glenoid lucency was compared to 27 patients with grade >1 glenoid lucency. Nineteen pegged glenoid total shoulder arthroplasties and 3 keeled glenoid total shoulder arthroplasties comprised the group with grade 0 - 1 lucency. Fourteen pegged glenoid total shoulder arthroplasties and 13 keeled glenoid total shoulder arthroplasties comprised the group with grade >1 lucency. For grade 0 - 1 lucency, the 22 total shoulder arthroplasties’ AFE increased from an average of 120° (60° to 165°) to 151° (90° to 180°), and AER increased from an average of 20° (-20° to 60°) to 56° (30° to 70°). For grade >1 lucency, the 27 total shoulder arthroplasties’ AFE increased from an average of 114° (35° to 170°) to 148° (30° to 180°), and AER increased from an average of 21° (-30° to 70°) to 61° (30° to 80°). This study contained 1 keel (1/16, 6.25%) and 1 peg (1/36, 2.7%) component which required revision surgery. They reported a mean lucency rating of 1.8 points for keeled components and 1.3 points for pegged components. Gartsman and colleagues [38] in their series of randomized patients, reported that keeled glenoid components had a higher grade of radiographic lucency (39%) immediately after surgery than pegged glenoid components (5%). They reported a mean lucency ratings of 1.4 points for keeled components and 0.5 points for pegged components. This study found lucency grades of 1.90 for keeled glenoid components and 1.01 for pegged glenoid components. These findings support the conclusion regarding keel vs. peg glenoids that prior studies have reported. An association between glenoid radiolucencies and a worse functional outcome which has been reported in the literature was not observed in this study [22]. This study showed no difference with respect to range of motion for keeled glenoids as compared to pegged glenoids. In addition, we found no difference with respect to range of motion as related to the severity of the radiolucencies. This finding is, to our knowledge the first reported lack of association regarding degree of radiolucency with respect to functional outcome.

Controversy still exists as to the relationship between glenoid lucency and clinical failure of the glenoid component. However, the long-term study by Torchia et al. suggests a positive correlation [18] The present study contained 1 keel (1/16, 6.25%) and 1 peg (1/36, 2.7%) component which required revision surgery. Study limitations were that this was a retrospective review of a small group of patients that primarily focused on radiographs and range of motion as recorded in the medical record. The use of radiographs for the assessment of radiolucent lines in the glenoid has been suggested to be inaccurate [28,29] Differences between the modified Franklin scale and Franklin scale rating systems, such as assessing radiolucency around flanges as opposed to pegs, may be sources of inaccuracy in comparisons. There was poor interobserver correlation reflecting variation in grading experience of the raters who were used in this study. However, each grade was based on the average grade of the 3 raters, and assuming that each rater was consistent in his approach, an averaged value would incorporate these grading differences across the board and improve the reliability of the averaged measurements. Gartsman and colleagues reported a high level of intraobserver and interobserver consistency not seen in prior studies [37,38]. They attributed the consistency in their grading to a training process done on non-study radiographs to develop a consensus for grading, a process that could have been implemented in our

Discussion

The literature has previously suggested that round-backed, all-polyethylene components with peg fixation perform better than do flat-backed, metalbacked, or keeled components [40] Lazarus et al. compared lucency rates between cemented pegged and cemented keeled components immediately after surgery [26]. They found that keeled components had a lucency rate (grade 2 lucency or higher) of 72% (11/39 components) whereas pegged components had a lucency rate of only 38% (180/289 components).
study.

Conclusion

Significantly greater component survival was found with pegged as opposed to keeled anchoring design. Poor interobserver reliability was noted with the Franklin grading system among orthopaedic physicians at various levels of training. In contrast to prior studies, this study did not demonstrate a difference in range of motion between pegged and keeled glenoids, nor a correlation between diminished range of motion and degree of radiolucency.

Abbreviations

Intraclass correlation coefficient (ICC)
Active forward elevation (AFE) and active external rotation (AER)
Total Shoulder Arthroplasty (TSA)

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