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Clinical and radiographic comparison of a hybrid cage glenoid to a cemented polyethylene glenoid in anatomic total shoulder arthroplasty

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Background: This study reports the clinical and radiographic outcomes of a hybrid cage glenoid compared with an age-matched, sex-matched, and follow-up–matched cohort of cemented all-polyethylene peg glenoids in patients undergoing anatomic total shoulder arthroplasty with 2 years' minimum follow-up.

Materials and methods: We reviewed 632 primary anatomic total shoulder arthroplasty patients from an international multi-institutional database; 316 patients received hybrid cage glenoids and were matched for age, sex, and follow-up with 316 patients with cemented all-polyethylene peg glenoids. Each cohort received the same humeral component. Scoring was performed in all patients preoperatively and at latest follow-up using 5 outcome scoring metrics and 4 active range-of-motion measurements. A Student 2-tailed unpaired *t* test identified differences in outcomes; $P < .05$ denoted a significant difference.

Results: Cage glenoid patients had significantly lower rates of radiolucent glenoid lines (9.0% vs. 37.6%, $P < .0001$) and radiolucent humeral lines (3.0% vs. 9.1%, $P = .0088$) than all-polyethylene peg glenoid patients. In the cage glenoid cohort, 4 cases of aseptic glenoid loosening (1.3%) and 4 cases of articular surface dissociation (1.3%) occurred. In the all-polyethylene peg cohort, 12 cases of aseptic loosening (3.8%) occurred. Cage glenoid patients had a significantly lower revision rate than all-polyethylene peg glenoid patients (2.5% vs. 6.9%, $P = .0088$).

Conclusion: At 50 months' mean follow-up, cage glenoids demonstrated equally good clinical outcomes to all-polyethylene peg glenoids. Cage glenoids had significantly fewer radiolucent lines around both the

The Institutional Review Board of the Medical University of South Carolina approved this study (Pro00030914) on February 18, 2014. The study was approved by the Western Institutional Review Board or the local institutional review board based on each hospital's policy.

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glenoid and humeral components and a lower revision rate. Longer-term follow-up is required to confirm these promising short-term results.

Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Anatomic; shoulder arthroplasty; glenoid; radiolucent lines; fixation; outcomes

Anatomic total shoulder arthroplasty (aTSA) has proved to be a successful procedure for relieving pain and improving function in patients with osteoarthritis.[19] However, aseptic glenoid loosening remains a common complication.[7] The incidence of early radiolucent glenoid lines has been reported to range from 22% to 95% in various types of cemented keel or peg glenoid components.[1-4,9,21,26] However, clinical loosening resulting in revision surgery is much less common, with 90% to 95% survivorship reported at 10 years.[13]

Although a cemented all-polyethylene glenoid remains the gold standard, long-term fixation concerns persist, especially in younger patients undergoing aTSA. As a result, other forms of glenoid fixation have been studied. In the early 1990s, porous coated metal-backed glenoids became popular based on the success of porous coated metal-backed implants in total hip and knee arthroplasty. Unfortunately, these metal-backed glenoids experienced greater complications.[2,7,13,14,25,27]

Over the past 10 years, hybrid glenoid components have been developed, consisting of porous metal pegs or coatings attached to the polyethylene, with no metal backing on the face of the glenoid. Clinical and biomechanical studies have demonstrated excellent bone ingrowth but have also reported problems with metal debris formation, fracture, and/or dissociation at the metal-polyethylene interface.[5,6,11,28] These complications have been accompanied by early revisions for aseptic loosening.[6,11,28]

The initial clinical results of hybrid glenoids are now being reported.[8,12,15,16,20,22] Although a number of hybrid glenoid designs are available for clinical use, there are few clinical data to support their widespread use, as most of these studies have either short-term follow-up or a small number of patients and lack any controls. For the particular hybrid glenoid design investigated in this study, early fixation is obtained by a combination of peripheral metal peg cementation and an interference fit of the central cage peg. Long-term fixation is supplemented with bone ingrowth around or through the central cage peg. Unlike polyethylene pegs, metal pegs offer the potential for bone ingrowth; however, the modular connection introduces a potential new failure mode relative to all-polyethylene glenoid components. The purpose of this large clinical study was to compare the clinical and radiographic outcomes and complications associated with a hybrid cage glenoid relative to an age-matched, sex-matched, and follow-up–matched comparison cohort of cemented all-polyethylene peg glenoids in aTSA patients.

Materials and methods

A multinational database was analyzed to compare the outcomes of a hybrid cage glenoid with those of a cemented all-polyethylene peg glenoid with a minimum follow-up period of 2 years to determine whether there were any clinical or radiographic differences in outcomes between glenoid designs. This database contained 530 hybrid cage glenoids (278 in male patients and 252 in female patients; average age, 65.3 years; average follow-up period, 40.5 months) and 449 all-polyethylene peg glenoids (212 in male patients and 237 in female patients; average age, 67.3 years; average follow-up period, 66.4 months). Of the cage glenoid patients, 20 received posterior augmentations and were excluded; the remaining patients received standard non-augmented glenoids. The all-polyethylene peg glenoid has been available for a longer period, which gave it a differing age and sex ratio, as well as a longer follow-up period. Therefore, we performed a subanalysis of the glenoid cohorts in this study, in which each hybrid cage glenoid was age, sex, and follow-up matched with an all-polyethylene glenoid patient. No cage glenoid patients with any reported adverse event were excluded in this control matching. As a result, preoperative and postoperative data were analyzed for 316 patients (140 male and 176 female patients) who underwent primary aTSA with a hybrid cage glenoid (Equinoxe platform shoulder system; Exactech, Gainesville, FL, USA), which incorporates a titanium plasma-coated central cage that is clean room assembled with a 4-mm-thick molded, all-polyethylene, 4-peg glenoid component (Fig. 1). These patients were age, sex, and follow-up matched with 316 patients who underwent primary aTSA with cemented all-polyethylene peg glenoids. All patients received the same humeral component. The 2 glenoid designs had an identical peg pattern and were prepared using the same instrumentation; the cage glenoids had larger-diameter pegs than the all-polyethylene peg glenoids, and as such, the cage glenoids had a smaller cement mantle in the peripheral pegs.

All 632 patients underwent primary aTSA for osteoarthritis and had an intact rotator cuff. These procedures were performed by 13 different fellowship-trained orthopedic surgeons, of whom 10 implanted glenoids in both cohorts. From the time of market introduction of the cage glenoid in 2011, both glenoid options

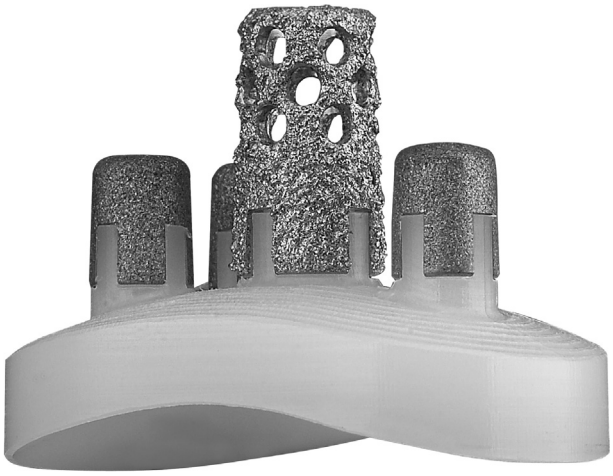

Figure 1 Equinoxe cage glenoid (Exactech).

were available in each case for each surgeon and the selection of glenoid type was based on surgeon preference. Table I details additional demographic and implant information related to the glenoid cohorts.

All patients underwent evaluation and scoring preoperatively and at latest follow-up using the Simple Shoulder Test; University of California–Los Angeles; American Shoulder and Elbow Surgeons; Constant; and Shoulder Pain and Disability Index scoring metrics. Active abduction, forward flexion, internal rotation, and external rotation were also measured. Internal rotation was measured by vertebral segments and scored by the following discrete assignment: 0°, 0; hip, 1; buttocks, 2; sacrum, 3; L4 to L5, 4; L1 to L3, 5; T8 to T12, 6; and T7 or higher, 7. Each patient was also asked to rate the operative shoulder at latest follow-up relative to his or her preoperative condition as "much better," "better," "unchanged," or "worse"; these data were analyzed to assess patient satisfaction between cohorts.

Grashey and axillary radiographs were obtained preoperatively and at scheduled follow-up visits. Radiographs were evaluated regarding the humerus and glenoid and were graded by the operating surgeon for the presence of radiolucent lines at the bone-cement interface according to the method of Lazarus et al[18] (Fig. 2). For all patients with radiolucent glenoid lines, radiographic data from every postoperative visit were assessed to identify the time of radiolucent line development and to quantify the follow-up duration associated with each radiolucent line grade. Statistical analysis was performed using a Student 2-tailed unpaired *t* test to identify differences in preoperative, postoperative, and preoperative-to-postoperative results between cohorts, in which $P < .05$ denoted a significant difference.

Results

The mean age of the 632 patients was 67 years (range, 42-91 years). All patients had greater than 2 years' follow-up, with a mean follow-up period of 50.3 months (range, 24-79 months); no difference in follow-up was observed between glenoid cohorts (49.4 months for cage vs. 51.1 months for peg, $P = .1787$). Each glenoid cohort demonstrated significant improvements in pain and function. Of cage glenoid patients, 93.3% rated themselves as much better (81.5%) or better (11.8%), which was significantly more ($P = .0095$) than the 87.1% of all-polyethylene peg glenoid patients who rated themselves as much better (68.9%) or better (18.2%). A significantly greater percentage of cage glenoid patients rated themselves as being much better compared with all-polyethylene glenoid patients (81.5% vs. 68.9%, $P = .0003$). In addition, a significantly greater percentage of all-polyethylene peg glenoid patients rated themselves as being worse compared with cage glenoid patients (7.3% vs. 2.6%, $P = .0064$).

Differences in range of motion and outcomes were observed between glenoid cohorts. Table II demonstrates that mean active abduction, forward flexion, and external rotation and the mean Simple Shoulder Test metric score were significantly greater preoperatively in the cage glenoid cohort than in the all-polyethylene peg glenoid cohort. Table III demonstrates that mean active abduction, forward flexion, and external rotation, as well as all 5 outcome metric scores, were significantly greater in the cage glenoid cohort than in the all-polyethylene peg glenoid cohort at latest follow-up. Table IV demonstrates statistically significant differences in preoperative-to-postoperative improvement between cohorts, in which cage glenoid patients experienced significantly greater improvements in active forward flexion and the University of California–Los Angeles, Constant, and American Shoulder and Elbow Surgeons metrics compared with all-polyethylene peg glenoid patients.

Radiographic data were available for 300 of 316 cage glenoid patients (95%) and 297 of 316 all-polyethylene peg glenoid patients (94%) at various time points, for a total of 1015 patient visits with radiographic data for cage glenoid patients and 894 patient visits with radiographic data for all-polyethylene peg glenoid patients. Specifically, at latest clinical follow-up, radiographic data were available for 211 of 316 cage glenoid patients (67%) at an average follow-up of 48.4 months and 242 of 316 all-polyethylene peg glenoid patients (77%) at an average follow-up of 50.8 months. At this latest follow-up, cage glenoid patients had a significantly lower rate of radiolucent glenoid lines than all-polyethylene peg glenoid patients (9.0% vs. 37.6%, $P < .0001$); in addition, 1.9% of cage glenoid patients had a radiolucent line grade greater than 2 compared with 10.7% of all-polyethylene peg glenoid patients ($P < .0001$). No difference in average follow-up period was observed between glenoids with and without radiolucent lines for either cage glenoids (52.1 months vs. 47.8 months, $P = .1248$) or all-polyethylene peg glenoids (54.1 months vs. 49.3 months, $P = .0711$). Figure 3 illustrates the impact of follow-up duration on the formation of radiolucent lines for each glenoid type. At latest follow-up, the radiolucent line

Table I Comparison of patient demographic, implant, and surgical technique information for cage glenoids and age- and sex-matched cohort of all-polyethylene peg glenoids

Characteristic	Demographic and implant comparison		*P* value
	Cage	All-polyethylene peg	
n	316	316	NA
Sex, n	176 F and 140 M	176 F and 140 M	NA
Age, yr	65.2 ± 9.0	68.0 ± 8.8	<.0001*
Height, cm	169.4 ± 11.7	169.2 ± 9.7	.8232
Weight, kg	86.8 ± 19.3	85.1 ± 19.9	.2906
BMI	30.3 ± 6.5	29.7 ± 6.3	.2240
Previous shoulder surgery, %	19.9	15.2	.1172
No comorbidities, %	38.1	31.2	.1091
Hypertension, %	49.8	48.7	.7979
Heart disease, %	14.0	21.8	.0154*
Diabetes, %	12.7	13.5	.7965
Tobacco use, %	6.3	5.5	.6635
Intraoperative blood loss, mL	287.9 ± 240.2	413.8 ± 664.5	.0019*
Cemented humeral stem, %	29.7	18.7	.0011*
Humeral stem diameter, mm	12.2 ± 2.2	12.0 ± 2.1	.3169
Humeral head diameter, mm	45.9 ± 3.4	45.9 ± 3.4	.9790

NA, not applicable; *F*, female; *M*, male; *BMI*, body mass index.
* Statistically significant ($P < .05$).

grade distribution for the cage glenoid cohort was 11 grade 1, 4 grade 2, 1 grade 3, 1 grade 4, and 1 grade 5. Considering all radiographic data for cage glenoid patients, the average time to glenoid radiolucent line development was 37.5 ± 19.2 months; grade 1 and grade 2 lines developed at 37.1 ± 21.1 and 34.6 ± 16.5 months, respectively. Representative 4-year follow-up radiographs of a cage glenoid patient are depicted in Figure 4. By comparison, the radiolucent line grade distribution at latest follow-up for the all-polyethylene peg glenoid cohort was 36 grade 1, 28 grade 2, 13 grade 3, 7 grade 4, and 6 grade 5. Considering all radiographic data for all-polyethylene peg glenoid patients, the average time to glenoid radiolucent line development was 40.6 ± 24.1 months; grade 1, 2, 3, 4, and 5 lines developed at 35.8 ± 22.5, 41.5 ± 23.8, 49.2 ± 26.9, 59.3 ± 16.0, and 56.4 ± 21.8 months, respectively. Cage glenoid patients also had a significantly lower rate of humeral radiolucent lines than all-polyethylene peg glenoid patients (3.0% vs. 9.1%, $P = .0088$). For cage glenoids, no difference ($P = .3455$) was observed in the glenoid radiolucent line rate with the use of press-fit (8.2%) or cemented (12.5%) humeral stems, whereas for all-polyethylene peg glenoids, the use of a press-fit humeral stem was associated with a significantly greater glenoid radiolucent line rate than the use of a cemented humeral stem (42.6% vs. 21.2%, $P = .0198$).

Table II Comparison of preoperative outcomes of cage glenoids and age- and sex-matched cohort of all-polyethylene peg glenoids

Glenoid type	Preoperative value, mean ± SD								
	SST score	UCLA score	ASES score	Constant score	SPADI	Active abduction, °	Active forward flexion, °	IR score	Active external rotation, °
Cage	4.0 ± 3.0	14.0 ± 4.0	34.1 ± 16.6	37.8 ± 15.0	84.2 ± 25.2	88.2 ± 33.6	100.1 ± 34.6	3.2 ± 1.6	22.2 ± 18.8
All-polyethylene peg	3.4 ± 2.6	13.6 ± 4.2	34.4 ± 15.9	36.3 ± 11.8	87.5 ± 21.7	80.5 ± 27.6	93.0 ± 29.5	3.1 ± 1.6	18.5 ± 19.0
P value	.0341*	.2514	.8644	.3032	.1683	.0038*	.0100*	.1591	.0214*

SD, standard deviation; *SST*, Simple Shoulder Test; *UCLA*, University of California, Los Angeles; *ASES*, American Shoulder and Elbow Surgeons; *SPADI*, Shoulder Pain and Disability Index; *IR*, internal rotation.
* Statistically significant ($P < .05$).

Table III Comparison of postoperative outcomes at latest follow-up of cage glenoids and age- and sex-matched cohort of all-polyethylene peg glenoids

Glenoid type	Postoperative value, mean ± SD								
	SST score	UCLA score	ASES score	Constant score	SPADI	Active abduction, °	Active forward flexion, °	IR score	Active external rotation, °
Cage	10.7 ± 2.4	30.8 ± 5.8	86.7 ± 18.6	73.6 ± 14.6	15.7 ± 22.8	130.6 ± 37.2	150.0 ± 30.4	5.0 ± 1.4	50.7 ± 20.6
All-polyethylene peg	9.9 ± 2.7	28.4 ± 6.7	79.0 ± 21.6	64.9 ± 16.6	25.0 ± 26.9	117.2 ± 34.1	132.1 ± 35.7	4.9 ± 1.5	46.2 ± 18.9
P value	.0004*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	<.0001*	.5208	.0150*

SD, standard deviation; *SST*, Simple Shoulder Test; *UCLA*, University of California, Los Angeles; *ASES*, American Shoulder and Elbow Surgeons; *SPADI*, Shoulder Pain and Disability Index; *IR*, internal rotation.
* Statistically significant ($P < .05$).

Table IV Comparison of preoperative-to-postoperative improvement in outcomes at latest follow-up for cage glenoids and age- and sex-matched cohort of all-polyethylene peg glenoids

Glenoid type	Improvement, mean ± SD								
	SST score	UCLA score	ASES score	Constant score	SPADI	Active abduction, °	Active forward flexion, °	IR score	Active external rotation, °
Cage	6.7 ± 3.4	16.9 ± 5.8	53.3 ± 21.9	35.1 ± 15.0	69.2 ± 30.0	43.5 ± 46.0	50.7 ± 41.8	1.9 ± 1.7	29.2 ± 22.2
All-polyethylene peg	6.5 ± 3.3	15.2 ± 7.2	46.3 ± 24.6	29.8 ± 17.5	64.5 ± 30.9	36.4 ± 42.3	37.9 ± 41.3	1.9 ± 2.0	28.6 ± 21.2
P value	.6885	.0183*	.0024*	.0113*	.1473	.1139	.0024*	.7257	.7714

SD, standard deviation; *SST*, Simple Shoulder Test; *UCLA*, University of California, Los Angeles; *ASES*, American Shoulder and Elbow Surgeons; *SPADI*, Shoulder Pain and Disability Index; *IR*, internal rotation.
* Statistically significant ($P < .05$).

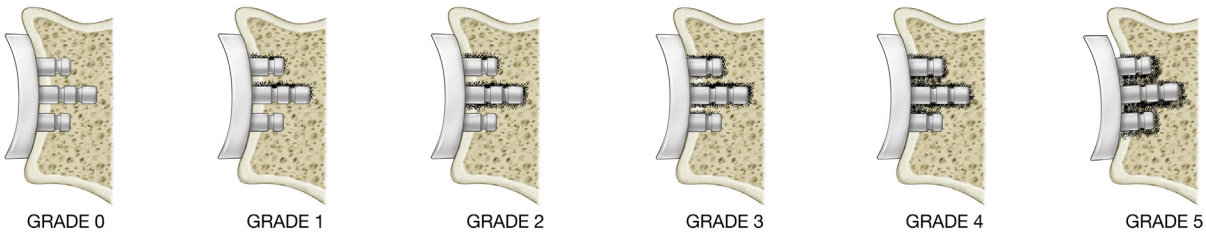

Figure 2 Radiolucent line scoring method, adapted from Lazarus et al[18] (2002), in which grade 0 indicates no radiolucency; grade 1, incomplete radiolucency around 1 or 2 pegs; grade 2, complete radiolucency around 1 peg only (<2 mm) irrespective of incomplete radiolucency around 1 other peg; grade 3, complete radiolucency measuring less than 2 mm around 2 or more pegs; grade 4, complete radiolucency measuring greater than 2 mm around 2 or more pegs; and grade 5, gross loosening.

A total of 60 complications were reported, 25 in the cage glenoid cohort (7.9%) and 35 in the all-polyethylene peg glenoid cohort (11.1%); the difference in complication rates was not significant ($P = .2854$) between glenoid cohorts. There were 4 cases of aseptic glenoid loosening (1.3%) and 4 cases of articular surface dissociation (1.3%) in the cage glenoid cohort and 12 cases of aseptic loosening (3.8%) in the all-polyethylene peg cohort; the difference in glenoid-sided

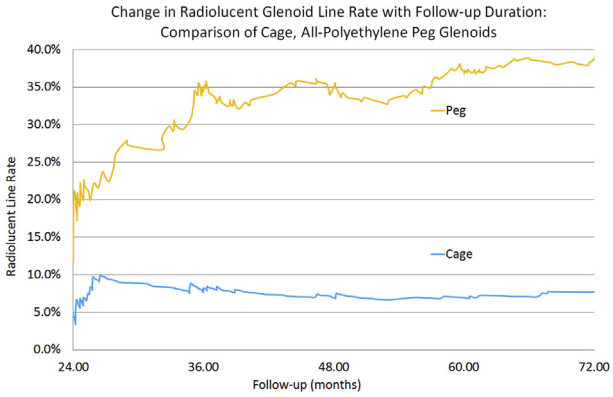

Figure 3 Change in radiolucent glenoid line rate with follow-up duration.

failure was not significant ($P = .3642$) between glenoid cohorts. Other complications in the cage glenoid cohort included 4 rotator cuff tears, 4 patients with pain, 3 infections, 2 nerve injuries, 1 acromioclavicular joint injury, 1 clavicle fracture, 1 hematoma, and 1 case of aseptic humeral loosening. Other complications in the all-polyethylene peg glenoid cohort included 5 infections, 5 rotator cuff tears, 5 patients with pain, 4 cases of aseptic humeral loosening, 2 periprosthetic humeral fractures after falling, 1 clavicle fracture, and 1 nerve injury. A total of 30 patients required revision; cage glenoid patients had a significantly lower revision rate than all-polyethylene peg glenoid patients (2.5% vs. 6.9%, $P = .0088$). Revision was required in 3 of 4 cage glenoid patients with aseptic glenoid loosening, 4 of 4 cage glenoid patients with articular surface disassociation, and 10 of 12 all-polyethylene patients with aseptic glenoid loosening. Finally, patients in each glenoid cohort with radiolucent glenoid lines had a significantly greater rate of revision than patients without radiolucent glenoid lines (2.2% vs. 21.1% for cage, $P < .0001$, and 5.2% vs. 14.3% for polyethylene peg, $P = .0172$).

Discussion

A cemented all-polyethylene keel or peg glenoid remains the gold standard for aTSA.[1,3,4,9,13,17,19,21,26] However, aseptic glenoid loosening remains an unsolved problem and is the most common long-term complication of aTSA. The results of this age-matched, sex-matched, and follow-up–matched comparative analysis of 632 patients demonstrate that hybrid cage glenoids are associated with equally good clinical outcomes and a significantly lower revision rate relative to cemented all-polyethylene peg glenoids at 2 years' minimum follow-up. This is the largest series published to date to examine the clinical and radiographic outcomes of a hybrid glenoid, with a mean follow-up period of 50 months, and the only series with a cemented all-polyethylene peg glenoid matched control. In addition, cage glenoids were associated with significantly greater preoperative-to-postoperative improvements in 3 of 5 outcome scores and in active forward flexion relative to the all-polyethylene peg glenoid cohort. However, only 1 of these parameters exceeded the threshold for a minimal clinically important difference (MCID) for total shoulder arthroplasty, as reported by Simovitch et al.[24] Specifically, the 12.8° mean difference in active forward flexion improvement experienced by cage glenoid patients exceeded the 12° active forward flexion MCID threshold.[24] It is noteworthy that the difference in Constant score improvement of 5.3 experienced by cage glenoid patients nearly met the Constant score MCID threshold of 5.7.[24] In addition, no outcome parameters were observed to be statistically worse with the hybrid

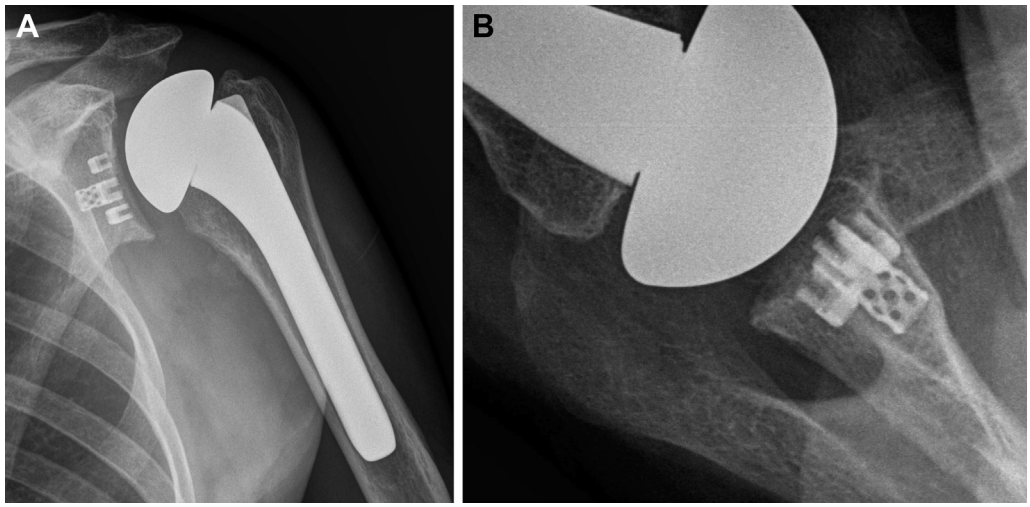

Figure 4 Typical anteroposterior (**A**) and axillary lateral (**B**) radiographs of an anatomic total shoulder arthroplasty with a hybrid cage glenoid at 4 years postoperatively.

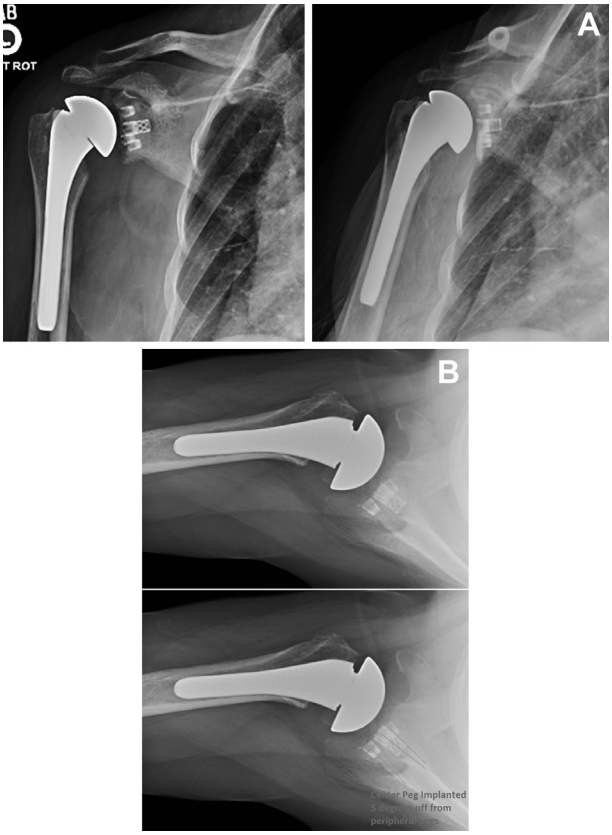

Figure 5 (**A**) Representative anteroposterior radiographs of a cage glenoid patient who experienced articular surface disassociation at 6 weeks (*left*) and 34 months (*right*); the latter depicts failure of the central peg locking mechanism. (**B**) Axillary lateral radiographs at 6 weeks demonstrating 5° of deviation between the central and peripheral pegs. This central peg divergence induced an extra bending moment on the locking mechanism, which led to disassociation. The peg divergence was most likely due to drilling the central peg hole off-axis relative to the peripheral peg holes. The central peg also bottomed out on the medial scapular wall.

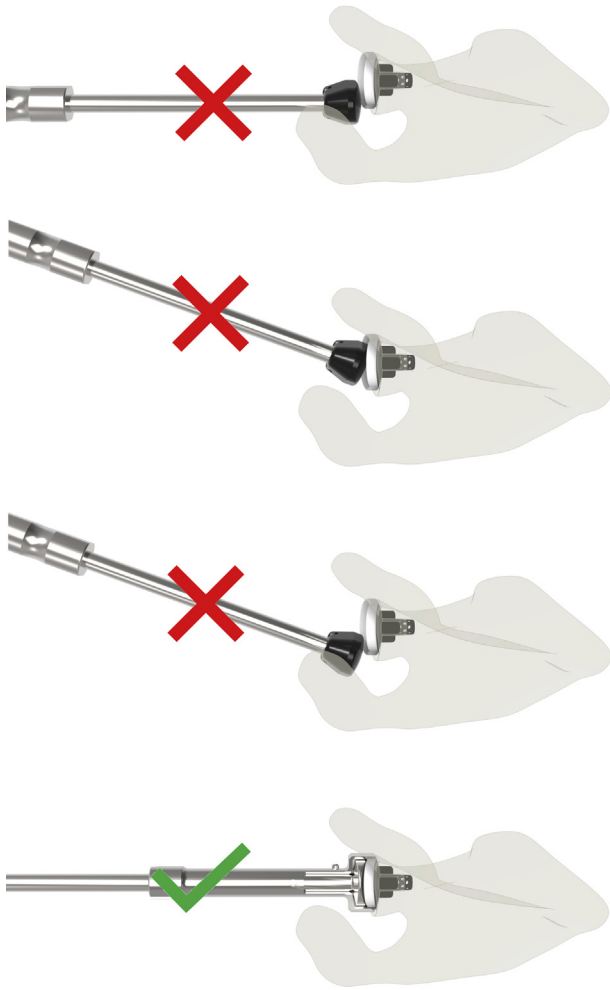

Figure 6 Straight-line impaction of the cage glenoid on-axis with the cage peg (✓) is critical. × indicates incorrect impaction.

cage glenoid than with the all-polyethylene peg glenoid cohort.

More significantly, this is the first study to demonstrate a reduction in the incidence of radiolucent lines for hybrid glenoids compared with a cemented all-polyethylene glenoid, and the incidence of radiolucent lines in this study is the lowest reported rate at a mean of 50 months' follow-up reported in the literature. The cage glenoid cohort demonstrated a 4.2-fold reduction in the incidence of radiolucent glenoid lines compared with the cemented all-polyethylene peg glenoid cohort (9% vs. 38%). It is not known whether this will result in a decreased incidence of aseptic glenoid loosening over the long term, but it is a promising finding and supports the continued clinical use of this glenoid.

Aseptic glenoid loosening was less common in the cage glenoid cohort, as all-polyethylene peg glenoid patients experienced a 3-fold greater rate of aseptic loosening than cage glenoid patients (3.8% vs. 1.3%). However, 4 patients in the cage glenoid cohort experienced a unique complication of polyethylene articular surface disassociation from the central peg. These 4 failures occurred at an average of 38 months' follow-up (range, 25-47 months). The failure mechanism identified in each case was technique-induced damage to the central cage polyethylene-locking mechanism. A representative example is depicted in Figure 5 in which the central peg was implanted off-axis by 5° relative to the peripheral pegs; this deviation (and bottoming out of the central peg with the medial scapular wall) induced an extra bending moment that led to a failure of the central peg locking mechanism and the reported disassociation. As illustrated by this case, it is critical to understand that the surgical technique for implanting a hybrid cage glenoid is more demanding than for an all-polyethylene glenoid. Excellent exposure is required so that straight-line glenoid impaction can be performed in the center of the articular surface, on-axis with the central peg, to ensure that the pegs are not bent and the metal-polyethylene interface is undamaged[15] (Fig. 6). If on-axis impaction fails to fully seat the glenoid, the glenoid prosthesis should be removed and the holes re-

drilled to ensure that each hole is drilled to the appropriate depth, ensuring that the prosthesis is not impinging on the scapular wall. Repeated impaction, particularly in the occurrence of scapular wall impingement, can result in plastic deformation of the pegs and damage to the locking mechanism. After the glenoid is fully seated on the reamed glenoid, inspection of the device is recommended, as polyethylene articular surface disassociation can occur acutely[10] with off-axis impaction or owing to inappropriate glenoid preparation. To mitigate this unique failure mode, the appropriately sized drills, drill guides, trials, and depth gauges provided with the system must be used to ensure that the center and peripheral pegs' drill holes are prepared parallel to each other, as well as to the appropriate depth, as the cage glenoid insertion follows the axis of the central cage peg hole and any angular or positional deviation of the drilled peripheral holes relative to that central drill hole will result in splaying and bending of the pegs during impaction. Deviation between the drilled holes can occur if the center hole is not re-drilled after eccentric reaming when correcting a glenoid defect. After reaming and prior to drilling the peripheral peg holes, it is recommended that the center cage peg hole be re-drilled to ensure that all drilled holes are parallel. When appropriately implanted, bench testing has demonstrated that the cage glenoid can withstand high-cycle loading at elevated magnitudes without fracture or disassociation.[23]

This database study has some limitations. This study used data from 13 different surgeons in the United States and Europe, thereby improving the generalizability of the experience but potentially introducing differences in technique between sites. Furthermore, there is inherent bias in the operating surgeon evaluating his or her own radiographic results; however, the trend of a lower rate of radiolucent glenoid lines with cage glenoids was observed by all 10 surgeons who implanted and radiographically self-scored both glenoid types. Specifically, the ratio of all-polyethylene peg glenoid–to–cage glenoid radiolucent line rates for each surgeon varied from 1.34 to 8.31, with an average ratio of 4.28, consistent with the overall cohort ratio comparison of 4.2. In addition, the rate of radiographic follow-up could be improved, as complete radiographs were obtained for only 67% of the cage glenoid patients at the time of the latest clinical follow-up. Future work should use multiple independent evaluators to perform the radiographic analysis to limit user reliability–based and other bias errors. We also did not preoperatively characterize any glenoid wear pattern or quantify glenoid retroversion; however, no posteriorly augmented glenoid components were used in either cohort in this study, so it is assumed that any glenoid wear that was present was uniform. In addition, we did not preoperatively characterize humeral head subluxation between glenoid cohorts. Future work should characterize the preoperative glenoid anatomy and humeral head subluxation to better homogenize the degree of degenerative deformity between the matched comparison cohorts. Finally, longer-term clinical and radiographic follow-up is required to determine whether these short-term radiographic improvements may correlate to lower rates of aseptic glenoid loosening and better long-term implant survivorship.

Conclusion

Equivalent clinical outcomes were observed at a minimum of 2 years' follow-up for the hybrid cage glenoid prosthesis compared with an age-matched, sex-matched, and follow-up–matched cohort of cemented all-polyethylene peg glenoids. Radiographically, a greater than 4-fold reduction in the formation of radiolucent glenoid lines was observed with cage glenoids at an equivalent average follow-up period of 50 months. Cage glenoid patients experienced a significantly lower revision rate and a lower rate of aseptic loosening; however, 4 cases of failure with a unique failure mode occurred, which resulted in similar glenoid-sided failure rates between cohorts. This is the largest series of hybrid glenoids to date and the first series to demonstrate a reduction in the incidence of radiolucent glenoid lines. Additional and longer-term follow-up is required to confirm that these outcomes are maintained long-term; however, these short-term results are promising and suggest that the hybrid cage glenoid may provide an alternative to the gold-standard cemented all-polyethylene peg glenoid.

Disclaimer

Richard J. Friedman reports that he is a consultant for Exactech for work related to the subject of this article.

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