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Fully uncemented glenoid component in total shoulder arthroplasty

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Background: Loosening of the glenoid component remains the most common problem in total shoulder arthroplasty. It has been described that the round-backed, all-polyethylene components with cemented peg fixation perform better biomechanically and clinically than flat-backed, metal-backed, or keeled components. However, side effects of cementing have been described. We hypothesized that cementing of a specific type of all-polyethylene glenoid component with 3 peripheral pegs and 1 central anchor peg is not necessary to obtain good clinical and radiologic results.

Materials and methods: Thirty-four shoulders (34 patients), with a mean follow-up of 28.3 months, were evaluated clinically with the Constant-Murley score and the SF-12 Health Survey score. The fixation of the glenoid component was evaluated with computed tomography scan.

Results: The Constant-Murley score increased from 40.2 points (range, 13-73 points) preoperatively to 72 points (range, 54-93 points) postoperatively. The SF-12 Physical Component Summary score was 45, and the SF-12 Mental Component Summary score was 50. No signs of loosening were seen around the pegs or glenoid in 30 shoulders. Signs of loosening were seen around the central anchor peg and the peripheral pegs in 4 shoulders. There was no statistical difference between the clinical outcome of patients with and without signs of loosening.

Conclusion: The clinical and radiologic evaluation of an uncemented all-polyethylene glenoid is promising, with good clinical results and with no signs of loosening in 88% of the patients on computed tomography scans.

Level of evidence: Level IV, Case Series, Treatment Study.

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Keywords: Total shoulder arthroplasty; glenoid component; polyethylene; uncemented

Several types of design and fixation of the glenoid component in total shoulder arthroplasty (TSA) have been described, but failure of the glenoid remains the most common complication and accounts for most of the unsatisfactory results after this procedure.[4,21,41] The round-backed, all-polyethylene components with peg fixation have been described as performing better biomechanically and clinically than flat-backed, metal-backed, or keeled

This study was reviewed by the UZ Ghent Ethics Committee (Registration No.: B67020084984, dated Jan 16, 2009), which is organized and operates according to the International Conference on Harmonisation Good Clinical Practice rules.

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components.[1,12,15,20,37,38] These tests were performed with completely cemented polyethylene components.

Adverse effects of cementing have been described, however. First, a biomechanical study described that all implants, irrespective of the particular fixation design, are failing at the implant–cement interface.[29] Second, glenoid cementing may generate sufficient heat to endanger the surrounding bone.[6] Third, a thin layer of polymethylmethacrylate may be subject to fatigue failure and fragmentation,[9] which in turn can cause third-body wear between the humeral and the glenoid component.

In 2001, Wirth et al[39] reported the trial of a novel, partially cemented, pegged glenoid implant in a canine model that was superior to a keeled implant design. This new implant design had 3 cemented peripheral pegs and an uncemented central peg. The uncemented central peg was larger and had 4 sequentially spaced radial fins at its distal tip. This space between the adjacent fins allowed for possible bone growth incorporation to improve long-term fixation.

This minimally cemented pegged glenoid implant became available for clinical use in TSA in 2001. Long-term follow-up of this implant showed low rates of lucency,[7,18] and bone incorporation was seen around the central peg fins in 85% of the glenoids.[7]

Because of the side effects of cementing and that bone can incorporate between the fins around the central peg, we hypothesized that cementing is not necessary to obtain good fixation in this type of all-polyethylene glenoid component. The purpose of this study was to determine the clinical and radiologic short-term results of this uncemented, pegged glenoid.

Materials and methods

Operative procedure

Between 2006 and 2009, 35 TSA procedures were performed in 35 patients with the diagnosis of glenohumeral osteoarthritis. All patients had a preoperative computed tomography (CT) scan in addition to regular x-ray images. Glenoid type was evaluated according to the Walch classification[35] and glenoid version according to the Friedman method.[30] Also assessed was the subluxation index (SI), according to the method of Gerber et al.[16] An SI of less than 65% is defined as a centered head.

All patients were operated on by the first author with an implantation of the Global Advantage humeral prosthesis and the fully uncemented Anchor Peg glenoid prosthesis (DePuy, Warsaw, IN, USA). The Anchor Peg glenoid is available in 6 sizes: 40, 44, 48, 52, 56, and 56 XL. It has 3 peripheral pegs, with diameters of 4.78 mm, and a central peg with an outer diameter of the flutes of 8.79 mm, a root diameter of 4.78 mm, and a diameter of the base of 6.78 mm.

A standard deltopectoral approach was used. A C-block osteotomy of the lesser tuberosity was performed and consequent dislocation of the humeral head.[10] The rotator cuff was always intact. A humeral cut of 135° varus/valgus was made with the retroversion guided by the anatomic neck, after which osteophytes were removed. The humeral shaft was reamed and broached to the appropriate size to permit the implantation of a cementless humeral prosthesis.

The size of the definitive glenoid implant was chosen according to the sizing of the humeral head. Always a lesser mismatch than advised by the manufacturer was chosen; meaning that, for example, a 44 glenoid was implanted for a 48 head.

The glenoid was exposed in standard fashion with resection of the capsular structures anterior and posterior to release the joint. The inferior capsule was not resected, but a release of the long head of the triceps tendon at the infraglenoid tubercle was done to improve the view of the glenoid. The amber glenoid template was used to determine and drill the glenoid center point. Then the glenoid was reamed concentrically to remove as little subchondral bone as possible to maximally support the glenoid implant and to have a perfect contact between the implant and the glenoid (the perfect contact group included aseptic necrotic shoulders and osteoarthritic A1, A2, and B1 glenoids). In the B2 classified glenoids, according to Walch et al,[35] the anterior area is down-reamed with minimal bone resection to remain a minimal of 80% of supportive area. At the same time, however, an attempt is made for maximal correction of retroversion (imperfect contact group).

To accept the anchor peg center post, the central hole was overdrilled with the appropriately sized drill. By means of a drill guide, the 3 peripheral holes were drilled into the glenoid, after which the glenoid trial was inserted to check the primary stability. This was considered optimal in all cases. Next, the central anchor peg was prepared with a ''bone paste'' derived from bone harvested during reaming and drilling, which was interposed between the flanges of the central anchor peg to help facilitate tissue integration (Fig. 1).

The completely uncemented glenoid component was implanted manually. After a humeral head trialing, the final Global Advantage humeral stem and head (DePuy Orthopaedics Inc), which were impacted on the back table, were implanted. The subscapularis osteotomy was then repaired back to its original place with 3 strong Tiercon 5 cerclage sutures (Tyco, Waltham, MA, USA) according to Frankle et al.[13]

Finally, the superior part of the subscapularis and the rotator cuff interval were closed with Ethibond 2 sutures (Ethicon, Somerville, NJ, USA) to obtain a stable construction that could permit immediate passive and active shoulder exercises starting the day after surgery. Beyond the limits of pain sensation, no limits of forward elevation, neither lifting of the shoulder nor external rotation were advocated, and no sling was used. A suction drain was removed after 24 hours. At 6 weeks, a physical therapy and strengthening program, if desired, could be started.

Follow-up evaluation

Patients were evaluated at 3, 6, 12, and 24 months, and at the latest follow-up with the Constant-Murley score and a standard radiology assessment. The Physical Component Summary (PCS) and the Metal Component Summary (MCS) of the SF-12 Health Survey score was also performed.[14]

A CT scan was performed at the latest follow-up, and the version of the prosthetic glenoid component and the SI were calculated on the transverse images according to, respectively, the methods of Friedman[30] and of Gerber et al.[16]

Next, signs of loosening were evaluated. We used a modification of the Lazarus method, which was originally designed to

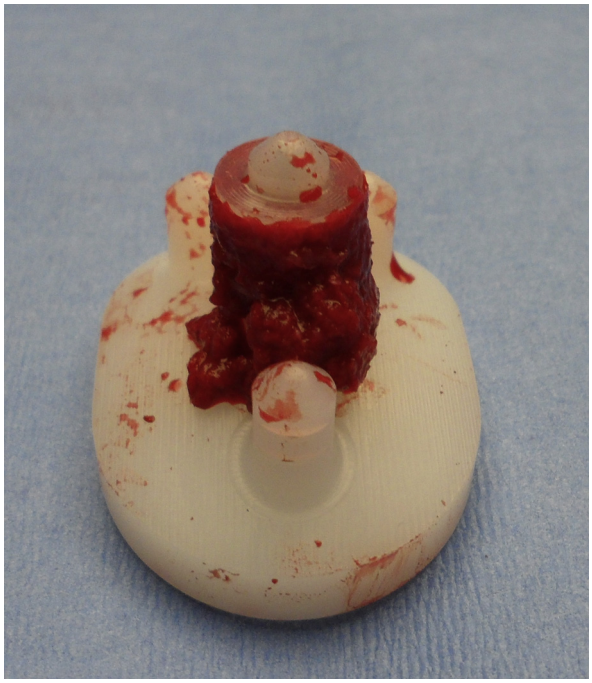

Figure 1 Morselized bone retrieved during the glenoid preparation (reaming and drilling) is used to create a bone paste that is interposed between the flanges of the central anchor peg.

assess the standard 5-pegged cemented glenoid component on standard radiographic images.[7,20] We used CT because Yian et al[42] described that, "computed tomography scans were a more sensitive and reproducible tool for the assessment of loosening of pegged glenoid components" than fluoroscopically guided conventional radiography. This grading system for the pegs is based on the diameter of the central pegs and on the peripheral pegs in 3 planes of the body. Because the pegs are cementless, no bone–cement interface is present; therefore, grading of the pegs was completed by measuring the lucency of the bone in the region of the peg. Loosening was considered if the diameter of the lucency was greater than the diameter of the prosthetic anchor peg or the peripheral peg(s), or both. These measurements were digitized with 0.1-mm precision and performed in the transverse, scapular, and sagittal planes to increase accuracy.[17]

Statistical analysis

The Kruskal-Wallis test was used to analyze the potential relationship between the Constant-Murley score and signs of loosening. The Mann-Whitney *U* test was used to analyze the potential relationship between the SF-12 PCS and MCS and signs of loosening.

Results

We studied 35 shoulders (35 consecutive patients), with 1 drop out due to a cerebral hemorrhage; thus, 34 shoulders (34 patients) were incorporated with a minimum follow-up of 24 months (mean, 28.3 months) between the period 2006 and 2009 (Table I). We treated 4 shoulders with aseptic necrosis and 30 osteoarthritic shoulders (5 A1 glenoids, 3 A2 glenoids, 1 B1 glenoid, and 21 B2 glenoids, according to the Walch classification).[35]

Table I Demographics of the patients

Variable	No. or mean (range)
Shoulder	34
Left	15
Right	15
Sex	
Male	9
Female	25
Age, y	68 (52-79)
Follow-up, mo	28.3 (24-48)
Constant-Murley score	40.2 (13-73)

Table II Clinical characteristics of the patients

Assessment	Preoperative (N = 34)	Postoperative (N = 34)
	Mean (range)	Mean (range)
Constant-Murley score		
Pain	4.3 (0-11)	12.7(5-15)
Activity	10.1 (4-17)	17.9 (7-20)
Mobility	18.8 (4-36)	34.4 (18-40)
Strength	7.0 (0-29)	8.7 (4-15)
Total	40.2 (13-73)	73.8 (54-93)
Mobility		
AAE	80 (30-150)	150 (90-180)
ER2	21 (10-45)	59.7 (30-90)

AAE, anterior active elevation; *ER2,* external rotation in abduction.

The Constant-Murley score increased from 40.2 points (range, 13-73 points) preoperatively to 72 points (range, 54-93 points) postoperatively. Active elevation range increased from 80° (range 30°-150°) preoperatively to 150° (range 90-180°) postoperatively. Active external rotation in abduction increased from 21° (range 10°-45°) preoperatively to 59.7° (range 30-90°) postoperatively (Table II). At the latest follow-up, the SF-12 PCS score was 43.6 (standard deviation, 7.56) and the SF-12 MCS score was 50 (standard deviation, 9.76). The mean retroversion of the glenoids decreased from 14.6 ° (range, 5°-30°) preoperatively to 5° (range, 0°-16°) postoperatively (Table III).

Preoperatively, the SI was more than 65% (40%-81%) in 19 shoulders. Postoperatively, the SI was always less than 65% (range, 30%-62%). Among the 21 glenoids classified as B2, the postoperative SI showed a correction up to 50% (range, 38%-62%) at minimum 2-year follow-up. In 5 shoulders, SI was not influenced by the operation (Table III).

The CT scan grading system for the cementless peripheral pegs and the central peg are quantified in Table IV and Table V. No signs of loosening were seen in 30 of 34 patients (88%). One or more bony flange(s) in the anchor were identified in 27 patients (Fig. 2). In 4 patients, the

Table III Pre- and postoperative relation between glenoid classification and glenoid retroversiong, subluxation index and posterior subluxation

	Total	Pre-operative			Post-operative		
		Mean Angle	Mean SI * (%)	Posterior Subluxated **	Mean Angle	Mean SI * (%)	Posterior Subluxated**
A1	5	7° (5-9)	46 (43-57)	0	5° (4-6)	50, 4 (47-53)	0
A2	3	5° (4-6)	52 (51-53)	0	6° (4-8)	41 (40-43)	0
B1	1	10°	47	0	7°	41	0
B2	21	15°	67 (53-81)	19	7, 5°	50 (38-62)	0
Aseptic Necrosis	4	7°	46 (40-50)	0	3° (0-4)	42 (30-50)	0

* SI: subluxation index, ** posterior subluxation >65% according to Friedman method.

Table IV Computed tomography scan grading system for cementless peripheral pegs

Score	Indicator	Total, No.	
		Patients	Pegs
0	Lucency diameter ≤5 mm	30	90
1	Lucency diameter 5-9 mm partial length in 1 or 2 pegs	2	4
2	Lucency diameter 5-9 mm complete length in 1 peg, with or without Lucency diameter 5-9 mm partial length in 1 other peg	0	0
3	Lucency diameter 5-9 mm complete length in 2 or more pegs	2	4
4	Lucency diameter > (complete length in 2 or more pegs)	0	0
5	Gross loosening	0	0

Table V Computed tomography grading system for cementless central peg

Score	Indicator	Patients (No.)	≥1 bony flanges
0	Lucency diameter ≤9 mm	30	27
1	Lucency diameter 10-13 mm partial length	2	2
2	Lucency diameter 10-13 mm complete length	2	2
3	Lucency diameter >13 mm partial length	0	0
4	Lucency diameter >13 mm complete length	0	0
5	Gross loosening	0	0

greatest diameter of the lucency at the central anchor was greater than the prosthetic diameter, and the diameter of the lucency was also greater at 2 of 3 peripheral pegs (Fig. 3). Preoperatively, these 4 shoulders showed signs of osteoarthritic changes, including 2 shoulders from the perfect contact group (1 A2, 1 B1 glenoid) and 2 shoulders from the imperfect contact group (2 B2 glenoids). Postoperatively, these 4 shoulders showed no signs of subluxation when the SI was used. Radiolucency was also seen on plain x-ray images at the 2-year follow-up. There was a progressive increase in radiolucency during the first year, but no progression between the 1-year and 2-year follow-up.

There was no statistical difference between the Constant-Murley score of those patients with and without signs of loosening a bony ingrowth (69 vs 73). Similarly, no significant difference was found between the group with and without signs of loosening for scores on the SF-12 PCS (43.8 vs 43.2 $P = .8$) or MCS (51.5 vs 45.9 $P = .301$).

Discussion

Since its evolution, TSA has become an effective treatment for primary glenohumeral arthritis; yet, glenoid component loosening remains a major concern. Several glenoid designs and fixation methods have been proposed. To our knowledge, no study has described the results of an uncemented polyethylene glenoid component.

Uncemented polyethylene components using macro-interlocking pegs have been used in knee arthroplasty but resulted in poor fixation and a high revision rate.[27] This is probably why, although the initial research on the Anchor Peg center post was done in fully uncemented conditions,[39] it was advised to use this prosthesis cemented at the peripheral pegs.[7] This advice resulted in good clinical results at the medium-term follow-up.[2,7,40]

Nevertheless, it seems advisable to concentrate on cementless designs at the glenoid, especially because the supposed adverse effects of cement, such as third-body wear,[19] thermal necrosis,[22] and potential difficulties at revision,[1] seem to be very important at the glenoid due to its size and bony volume. Moreover, a cementless implantation of a prosthesis reduces the operative time.[3] To achieve this goal, uncemented metal-backed designs, with and without tissue-ingrowth components, have been developed but without clinical success.[5,8,11,23,28,32]

This study is the first study to describe the short-term follow-up results of a completely cementless polyethylene glenoid. The clinical outcome for this series is similar

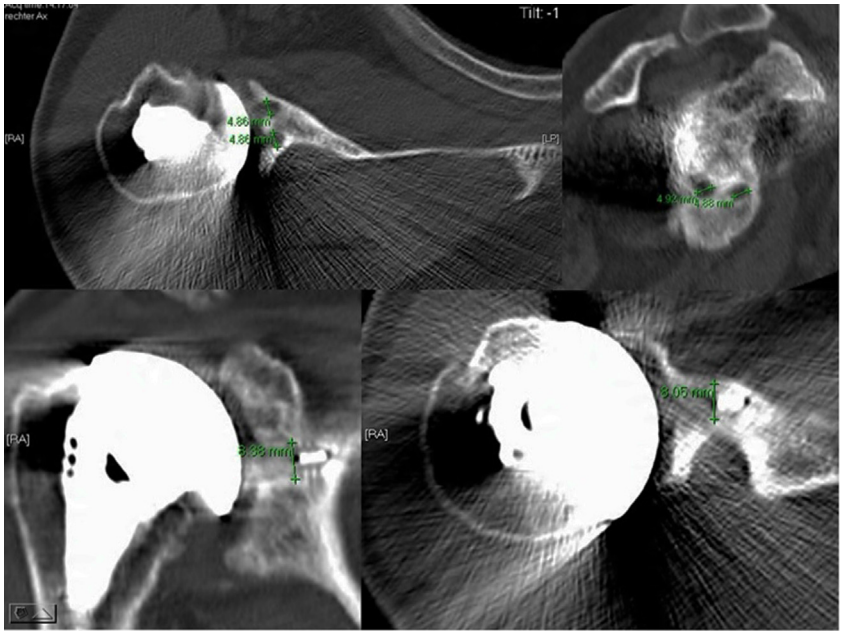

Figure 2 A computed tomography evaluation shows no signs of loosening at the peripheral peg but signs of ingrowths of bone into the flanges of the central peg.

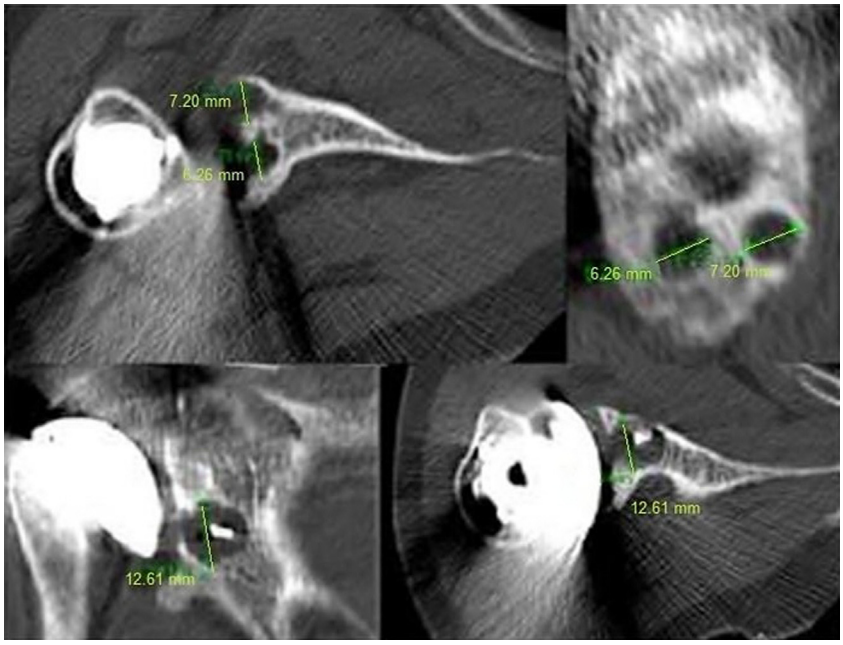

Figure 3 Computed tomography evaluation shows signs of loosening at the central peg and peripheral pegs.

to outcomes of other studies,[2,7,40] with patients reporting much reduced pain together with a large improvement in self-assessed function.

Our radiologic results showed no signs of loosening in 30 of 34 patients (88%). Using the same glenoid component, but partially cemented, Arnold et al[2] described no signs of loosening on CT in 32 of 34 patients (93%) after a minimum follow-up of 2 years. Using standard radiography, Wirth et al[40] and Churchill et al[7] described no evidence of glenoid lucency in, respectively, 93% (minimum 2-year follow-up) and 75% (minimum 5-year follow-up) of shoulders after using the same implant and a partially cemented technique. Our study and the studies of Arnold et al[2] and of Wirth et al[40] used a bone paste between the radial fins, in contrast to Churchill et al.[7] We believe that interposing as much bone and bone-stimulating tissue

as possible between the flanges enhances bone ingrowth[26] and that this surgical act can probably be improved with the introduction of a bone press to increase the initial amount of bone and bone-growing factors between the flanges of the central peg.

Using radiostereometric analysis measures on the same partially cemented implant, Nuttall et al[25] hypothesized that lack of initial fixation can lead to early movement of the glenoid component and failure of osseointegration. Because our osseointegration can be compared with the studies that used a partially cemented technique, we postulate that cementing is not the most important technique to obtain primary fixation. To the contrary, it is possible that cement may prevent adequate interaction between the bone and the polyethylene component and actually inhibit bony ingrowth due to stress shielding. To the best of our knowledge, no such studies exist.

In our opinion, bone quality and perfect contact between the backside of the prosthesis with the glenoid surface are more important to obtain good primary fixation. It is important not to harm the subchondral bone plate during reaming, but this can be difficult when trying to correct B2 glenoids. This is why we used as a consensus a minimum coverage of 80% in B2 glenoids to obtain as much contact between the prosthesis and the bone while harming the subchondral plate as little as possible. In this study, we could not find a difference between implants with imperfect and perfect contact, but how much coverage minimal is necessary to obtain an adequate fixation is not clear.

Another important issue can be the mismatch between the humeral head and the glenoid diameter. Previous studies of cemented glenoid components have shown that a highly conforming joint surface might be related to a higher prevalence of radiolucent lines around the implant on postoperative radiographs.[36] However, the same highly conforming components offer lower contact stresses and, subsequently, less wear.[31] It has also been described that when evaluating glenohumeral contact pressure, shear stress, and micromotions at 0° of retroversion, conformity had only a slight effect, whereas at 15° of retroversion, all quantities increased by more than 200% and exceeded critical values.[33] In our study, we used a mismatch of 4 mm and tried to position the glenoid in a minimal retroversion.

As described, we did not find a statistical difference between the Constant-Murley score of those patients with and without signs of loosening a bony ingrowth. This confirms some literature that has stated there is no relationship between the radiographic findings and the clinical outcome[24,34] but contrasts with the findings of Yian et al,[42] who did find a relationship with CT radiolucency scores and a worse clinical outcome. This might be explained by the small number patients with loosening that were identified (12%), the smaller cohort, and the shorter follow-up.

We did not see any progression of the radiolucency after 1 year on plain x-ray images. Because there was no progression and no clinical deterioration, we propose a wait-and-see policy in these situations and advise a clinical and radiologic follow-up every year.

The short-term follow up is the major weakness of this study. However, we point out that for cemented glenoids, a radiolucent line is already seen in 60% of the shoulders at the first conventional radiologic follow-up,[5] with an increase to 85% at 3 years.[17,30] We did not detect a similar phenomenon in 3 shoulders in this study that were evaluated at 36 months or more. Another weakness is that we did not measure if there was centralization of the glenoids.

Conclusion

Short-term clinical and radiographic follow-up of the use of a fully uncemented polyethylene glenoid implant seems to yield similar results as previously described with the minimally cemented technique at the short-term. Medium-term and long-term evaluation is mandatory before this new treatment can be promoted, but we have decided to continue to implant the fully uncemented anchor pegged glenoid for the treatment of glenohumeral osteoarthritis.

Disclaimer

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