Is the stemless humeral head replacement clinically and radiographically a secure equivalent to standard stem humeral head replacement in the long-term follow-up? A prospective randomized trial

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Background: Stemless humeral head replacement represents a young generation of shoulder arthroplasty. This study evaluated the differences of this new stemless design compared with the fourth-generation standard stemmed design.

Methods: Total shoulder arthroplasty was performed in 20 patients with a stemless shoulder prosthesis (group 1) and in 20 patients with a standard stem humeral head replacement (group 2). Twenty-nine patients were examined clinically and radiographically at a minimum follow-up of 2 years and a minimum follow-up of 5 years. Functional results were assessed using the age- and gender-related Constant Score (CS). The radiographic analysis used native x-rays in 3 planes.

Results: The postoperative CS improved significantly in both groups, with no significant difference between the minimum of 2-year and 5-year follow-up. The difference in the CS, its subcategories, and active range of motion between the implant groups was not significant. A significant difference was observed in the radiographic analysis for the zone adjacent to the humeral calcar, with a lower bone mineral density in 41\% of group 2 and in 0\% in group 1. Radiolucent lines were statistically more frequent in group 2. No statistical differences were observed between the implant groups for the change of the inclination angle, the medial offset, and the lateral offset.

Conclusion: Both implants showed consistently good functional and radiologic results without a significant difference and achieved an anatomic reconstruction of the humeral head geometry in the coronal plane.

Level of evidence: Level II; Randomized Trial; Treatment Study

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IRB statement

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The stemless generation of humeral head replacements was introduced in 2004 and 2005 with the Total Evolutive Shoulder System (TESS; Biomet Inc Warsaw, IN, USA) and the Eclipse stemless shoulder prosthesis (Arthrex, Freiham, Germany), respectively. These systems are anchored in the metaphysis of the humerus instead of using a stem that is anchored in the diaphysis of the humerus. The benefit, which is achieved by the stemless replacement of the humeral head, is the reconstruction of the rotational center independent of the axis of the humeral shaft. This system also allows an unimpeded access to the glenoid cavity for reconstruction of the glenoid. The advantages in revision surgery after shoulder arthroplasty using a stemless design are the preservation of metaphyseal bone stock and the lack of an osteotomy of the humeral shaft because of the absence of a diaphyseal anchorage.

The anatomical reconstruction of the glenohumeral joint using an Eclipse prosthesis was evaluated in a finite-element study\(^\text{9}\) in 2012. A similar load transfer was found after stemless arthroplasty compared with a healthy humerus.\(^\text{13}\)

Shoulder arthroplasty using a standard stem humeral head replacement is described as providing good clinical results with a reasonable complication rate.\(^\text{5,18,22}\) Comparable results in functional and radiographic outcome have been shown for the stemless shoulder arthroplasty in the short-term to midterm follow-up.\(^\text{2,4,7,8,10}\) Bone remodeling caused by stress distribution after shoulder arthroplasty has been described.\(^\text{12,16,18}\) Those studies concluded that a shorter stem benefitted the proximal bone stock because of proximal stress distribution at the bone-to-implant interface.

This prospective randomized trial evaluated the clinical and radiographic outcome of the Eclipse stemless replacement of the humeral head compared with the standard fourth-generation Univers II stemmed shoulder prosthesis (Arthrex).

Materials and methods

Clinical follow-up

From November 2005 to May 2008, 40 patients with primary osteoarthritis of the shoulder were included into a prospective randomized trial and treated by total shoulder arthroplasty implanting the Univers II standard shaft prosthesis or the stemless Eclipse prosthesis. Exclusion criteria were prior surgery of the affected shoulder, lesions of the rotator cuff, osteoporosis, formation of subchondral cysts, prior infection, and secondary arthritis due to instability, fracture sequelae, or rheumatoid arthritis.

The patients were randomized into 2 groups. Group 1, comprising 20 patients (10 women, 10 men) with a mean age of 65 years at the time of operation, received a total shoulder replacement using an Eclipse stemless humeral head replacement. Group 2, also comprising 20 patients (13 women, 7 men), with a mean age of 69 years at the time of operation received the Univers II, a fourth-generation anatomical total shoulder arthroplasty. The glenoid cavity in all patients was resurfaced using a metal-backed Univers Mark 2 glenoid or a keeled polyethylene glenoid (Arthrex).

Thirty-three patients (82.5%), 15 group 1 patients and 18 group 2 patients, were examined at a minimum of a 2-year follow-up, and 29 of these patients (72.5%) were recruited for a further follow-up examination at 5 years. Fourteen patients of group 1 were examined at a mean follow-up of 68 months (range, 59-84 months). Nine patients of group 1 received a metal-backed Univers Mark 2 glenoid and 5 received a keeled polyethylene glenoid, because we changed our philosophy about the use of cementless glenoid components as a result of a higher complication rate of cementless glenoid components after a mean of 5 years.\(^\text{11}\) Fifteen patients of group 2 were examined at a mean follow-up of 70 months (range, 60-81 months). Thirteen patients of group 2 received a metal-backed Universe Mark 2 glenoid, and 2 patients received a keeled polyethylene glenoid.

The patients were objectively evaluated using the Constant score (CS)\(^\text{9}\) as well as the age- and gender-related CS.\(^\text{24}\) Strength of the CS was measured with the arm 90° abducted in the scapular plane using an ISOBEX dynamometer (IsoForceControl, MDS AG, Oberburg, Switzerland), and was set at 0 if the patient could not reach this position.

Eleven patients were lost for follow-up. Seven patients could not be reached by phone and mail, 2 patients were not able to attend the examination because of long-term disease not related to the shoulder, 1 patient had died, and 1 patient declined further participation in the study.

The statistical evaluation was performed using SPSS 21 software (IBM Corp., Armonk, NY, USA) using the Wilcoxon signed rank test, the Mann Whitney U test, and by the calculation of Spearman rank correlation coefficient.

Radiographic follow-up

The radiographic follow-up was assessed on standardized native x-rays in 3 planes (true anteroposterior [AP], axillary, and Y views). The glenoid morphology was assessed on the preoperative axillary view x-rays and graded as described by Walch et al.\(^\text{23}\) In group 1, 4 patients were graded as type A2, 5 as type B1, and 5 as type B2. In group 2, 4 patients were graded as type A2, 8 as type B1, and 3 as type B2. No patients were graded type A1 or type C.

The humeral bone-to-prosthesis interface was divided into 3 zones in the coronal plane, with zone A below the cranial trunnion, zone B at the cage screw or the humeral stem for the Eclipse prosthesis and the Univers prosthesis, respectively, and zone C below the caudal trunnion. A similar division was used for the axillary view, with zone A below the anterior trunnion, zone B at the cage screw of the Eclipse prosthesis (Fig. 1) or the humeral stem of the Univers prosthesis (Fig. 2), and zone C below the posterior trunnion. The glenoid component was similarly divided into 3 zones in the true AP radiograph and the axillary radiograph.

The radiographic changes were divided into 5 groups for both the humeral and the glenoidal implant. No radiographic changes were classified as group 0. Group 1 was classified as a reduction in bone mineral density at the bone prosthesis interface of the humeral implant or the presence of an osteolysis at the bone prosthesis interface of the glenoidal implant. The presence of radiolucent lines was classified depending on the degree: radiolucent lines of less than 1 mm were classified as group 2, radiolucent lines with 1 to 2 mm were classified as group 3, and radiolucent lines greater 2 mm were classified as group 4.

Also evaluated was the presence of a cranial migration of the humeral head, defined by a loss of the gothic arc in the AP...
A migration of the humeral head combined with a loss of shoulder function was defined as insufficiency of the rotator cuff.

The assessment of the position of the humeral implant was analyzed measuring the inclination angle between the humeral shaft axis and anatomic neck at the preoperative true AP view as well as between the humeral shaft axis and the undersurface of the prosthetic head at the last postoperative true AP view as described by Robertson et al.\textsuperscript{17}

The angle between the humeral shaft axis and the axis of the prosthetic stem was measured in patients treated with the standard stem humeral implant. The measurement of the medial offset was performed according to Pearl and Kurutz,\textsuperscript{14} and the lateral humeral offset was measured as described by Takase et al.\textsuperscript{20} at the preoperative and last postoperative true AP radiograph.

**Figure 1** Radiographic assessment of the Eclipse prosthesis (Arthrex, Freiham, Germany) in zones A, B, and C in the (1) anteroposterior projection and (2) the axillary projection.

**Figure 2** Radiographic assessment of the Univers prosthesis (Arthrex, Freiham, Germany) in zones A, B, and C in the (1) anteroposterior projection and the (2) axillary projection.
Surgical technique

For both types of prosthesis, the patient was placed in a beach chair position. Via a deltopectoral approach, the subscapularis tendon was released leaving a 5-mm stump at the lesser tuberosity for a tendon-to-tendon reattachment and followed by a capsular release for a full exposure of the articular surface of the humeral head.

For the stemless Eclipse prosthesis, the humeral head was resected using a resection guide. After resection of the humeral head at the level of the anatomical neck, a drill plate was used to determine the size of the trunnion. The hole for the cage screw was prepared using a reamer, followed by placing a centering device. The length of the cage screw was determined, and a resection protector was placed for preparation of the glenoid implant. After the glenoid was implanted, the trunnion was impacted to the resection plane. The cage screw was placed, and a sized humeral head was impacted to the trunnion.

This same approach was used for the stemmed Univers II prosthesis. The medullary canal was prepared using a reamer after exposure of the humeral head, and the head was resected using a cutting guide. After the reamer was removed, the medullary canal was further prepared using broaches increasing in size with the attached alignment guide until the fit was appropriate. A resection protector was placed for preparation of the glenoid implant, and was replaced after implantation of the glenoid by the definite humeral head. The inclination and version screw were locked using a torque driver. After trial reduction using a trial head, the definite humeral head was impacted to the trunnion.

For implantation of the metal-backed Univers Mark 2 glenoid, the glenoid cavity was exposed, and a drill guide was used to prepare the central drill hole. The articular cavity was reamed, and a resection protector was placed for preparation of the glenoid implant. After resection of the humeral head at the level of the anatomical neck, a drill guide was used to prepare the central peg hole. Bone bridges were removed using a rongeur. The keel was further prepared using the glenoid punch. Then the polyethylene glenoid was impacted using bone cement.

The stability for both implants was checked before reattachment of the subscapularis tendon and wound closure.

The patients were immobilized postoperatively in a 30° abduction brace for 3 weeks. The rehabilitative program began directly postoperative with passive movement and a limited range of motion for 6 weeks. Starting from the seventh postoperative week, active and passive movements without a restriction to the range of motion and additional strengthening exercises were allowed.

Results

Functional results

The functional results of group 1 and group 2 at a minimum follow-up of 2 and 5 years are reported in Table I.

Patients receiving a standard stem humeral implant had significantly lower age- and gender-related CS (P = .002) with its subcategories pain (P = .006), activities of daily living (P = .008), range of motion (P = 0.005), as well as lower active flexion (P = .018) and active external rotation (P = .013).

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### Table I  Constant score and range of motion

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preoperative</th>
<th>Minimum 2-year follow-up</th>
<th>Minimum 5-year follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 1</td>
</tr>
<tr>
<td>Constant score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute, mean (SD), points</td>
<td>53.9 (11.3)</td>
<td>25.6 (15.2)</td>
<td>65.5 (15.4)</td>
</tr>
<tr>
<td>Relative, mean (SD), %</td>
<td>70.7 (18.8)</td>
<td>34.8 (19)</td>
<td>83.6 (19.3)</td>
</tr>
<tr>
<td>P value ( ^)</td>
<td>.374</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcategories, mean (SD), points</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>8.2 (3.5)</td>
<td>3.6 (2.3)</td>
<td>10.9 (4.4)</td>
</tr>
<tr>
<td>Activities of daily living</td>
<td>11.3 (4.7)</td>
<td>4.6 (3.3)</td>
<td>15.2 (4.6)</td>
</tr>
<tr>
<td>Range of motion</td>
<td>25.5 (4.7)</td>
<td>14.3 (8.7)</td>
<td>32.7 (6.2)</td>
</tr>
<tr>
<td>Strength</td>
<td>4.7 (3.1)</td>
<td>3.1 (3)</td>
<td>5.9 (3.9)</td>
</tr>
<tr>
<td>Range of motion, mean (SD), °</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>135.7 (31.1)</td>
<td>104.4 (33.7)</td>
<td>155 (15.7)</td>
</tr>
<tr>
<td>Abduction</td>
<td>110 (32.6)</td>
<td>93.3 (31.1)</td>
<td>136.7 (31.4)</td>
</tr>
<tr>
<td>External rotation</td>
<td>32.1 (15.8)</td>
<td>18.1 (20.1)</td>
<td>40.8 (13.1)</td>
</tr>
</tbody>
</table>

\( ^\) Comparing intergroup values.

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Eclipse, Arthrex, Freiham, Germany; SD, standard deviation; Universe II, Arthrex, Freiham, Germany.
preoperatively. No significant difference was found in preoperative strength ($P = .192$) and preoperative active abduction ($P = .171$) between the groups.

The age- and gender-related CS and its subcategories of pain, activities of daily living, range of motion, and strength improved significantly at the minimum follow-up assessments at 2 years and 5 years in both humeral implant groups, and we observed no significant difference in the age- and gender-related CS, its subcategories, and active range of motion between both patient groups.

**Group 1 (Eclipse)**

The age- and gender-related CS improved significantly at the minimum of 2 years ($P = .05$) and the minimum of 5 years of follow-up ($P = .013$). There was no statistical difference between the minimum of 2-year and 5-year follow-up ($P = .062$).

The subcategory pain improved significantly ($P = .031$) after a minimum of 5 years and the subcategory range of motion improved significantly after a minimum of 2 years ($P = .012$) and a minimum of 5 years after surgery ($P = .005$), without a difference between the 2-year and 5-year follow-up. The subcategories activities of daily living and strength did not significantly improve at the minimum of 2-year and 5-year follow-up.

Active flexion improved significantly at a minimum of 2-year follow-up ($P = .036$) but showed a trend at a minimum of 5-year follow-up ($P = .097$). Active abduction and active external rotation improved significantly at the last follow-up ($P = .008$ and $P = .010$, respectively) and showed a trend at the minimum of 2-year follow-up ($P = .061$ and $P = .066$, respectively). There was no significant difference in active flexion ($P = .915$), active abduction ($P = .128$), and active external rotation ($P = .277$) between the minimum of 2-year and 5-year follow-up.

**Group 2 (Univers II)**

The age- and gender-related CS improved significantly after a minimum of 2 years ($P = .012$), after a minimum of 5 years ($P = .018$), and between both follow-ups ($P = .019$). The subcategories pain, activities of daily living, and range of motion improved significantly at the minimum of 2-year ($P = .017$, $P = .017$, and $P = .018$, respectively) and at the minimum of 5-year follow-up ($P = .017$, $P = .018$, and $P = .018$, respectively), but we observed no difference between the 2-year and 5-year follow-up for all these 3 subcategories.

Active flexion, abduction, and external rotation increased significantly at the 2-year ($P = .002$, $P = .004$, and $P = .001$, respectively) and 5-year follow-up ($P = .003$, $P = .010$, and $P = .009$, respectively). Between both follow-ups, we found no statistical difference for active flexion, abduction, and external rotation.

**Radiologic results**

The radiographic findings are reported in Table II in detail. Partial lowering of the bone density near the humeral

### Table II  Radiographic changes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Humeral component</th>
<th>Glenoidal component</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1 (Eclipse)</td>
<td>Group 2 (Univers II)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. (%)</td>
<td>No. (%)</td>
<td></td>
</tr>
<tr>
<td>Anteroposterior view</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone A</td>
<td>4 (28.6)$^*$</td>
<td>8 (47.1)$^*$</td>
<td>.400</td>
</tr>
<tr>
<td>Zone B</td>
<td>1 (7.1)$^*$</td>
<td>3 (17.6)$^*$</td>
<td>.455</td>
</tr>
<tr>
<td>Zone C</td>
<td>0</td>
<td>7 (41.2)$^*$</td>
<td>.009</td>
</tr>
<tr>
<td>Humeral head migration</td>
<td>2 (14.3)</td>
<td>4 (23.5)</td>
<td>.619</td>
</tr>
<tr>
<td>Axillary view</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone A</td>
<td>1 (7.1)$^*$</td>
<td>6 (35.3)$^*$</td>
<td>.085</td>
</tr>
<tr>
<td>Zone B</td>
<td>0</td>
<td>1 (5.9)$^*$</td>
<td>.439</td>
</tr>
<tr>
<td>Zone C</td>
<td>0</td>
<td>4 (23.5)$^*$</td>
<td>.046</td>
</tr>
</tbody>
</table>

**Eclipse, Arthrex, Freiham, Germany; Universe II, Arthrex, Freiham, Germany.**

- $^*$ Reduction in bone density/osteolysis.
- $^1$ Radiolucent lines ≤1 mm.
- $^2$ Radiolucent lines 1-2 mm.
- $^3$ Radiolucent lines 2 mm.

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Implant was observed less frequently in 4 patients (28.6%) of group 1 compared with 10 patients (66.7%) of group 2 at a minimum follow-up of 5 years, without a statistical significance ($P = .133$). In group 1, lowering of the bone density was observed in 3 patients in zone A only in the true AP radiograph and in 1 patient in zone A at the true AP and at the axillary view.

After standard stem humeral head replacement (group 2), 1 patient had a lowering of the bone density in zone A at the true AP view, and another 2 patients showed these radiologic changes in zone A at the axillary view. In the other 7 patients, the lowering of bone density was observed in more than 1 zone at the last follow-up: zones A and C in the true AP view in 1 patient, zones A and C in the true AP and the axillary view in 3 patients, zones A, B, and C in the true AP and zone A and C in the axillary view in 1 patient, and in zones B and C in the true AP and zone C in the axillary view. Of these 10 patients, 5 showed a thinning of the lateral humeral cortex (stress shielding) at the 2-year follow-up, with progression in 3 of the 5 patients at the minimum follow-up of 5 years.

There was no statistically significant difference between the stemmed and the stemless implants ($P > .05$) except for the data obtained for zone C at the humeral implant ($P = .047$), where a reduction in bone mineral density was seen only in group 2. This had no influence on the functional outcome.

At the glenoid side, 2 patients (14.3%) in group 1 and 4 (26.7%) in group 2 showed a partial radiolucent line at the last follow-up ($P = .619$; Table II).

A cranial migration of the humeral head without functional deficit was observed in 2 patients (14.3%) in group 1 and in 4 (23.5%) in group 2. This was statistically not significant ($P = .619$).

The radiographic parameters describing the reconstruction of the humeral head compared with the preoperative situation are reported in Table III.

Both humeral head implants showed a significant decrease of the inclination angle in the direction of a “normal” inclination angle according to Robertson et al.\(^7\) (mean, 41°; range, 34°-47°).

Patients of group 1 showed a significant smaller medial offset postoperatively than patients of group 2, although there was no statistical difference in the change of the medial offset from preoperatively to postoperatively between both humeral implants.

The lateral offset increased significantly ($P = .001$) in group 2 after humeral head replacement but remains within the normal range (according to Takase: average 55.7 ± 5.7 mm).\(^8\) There was no increase of the lateral offset after stemless humeral head replacement (group 1).

In patients treated with the standard stem humeral head replacement (group 2), we measured the deviation of the implanted prosthetic stem from the humeral shaft axis. The mean angle deviation of the prosthetic stem from the humeral shaft axis was 1.6° (± 1.4). Twenty-five percent were implanted in the correct axis, 18.8% showed a slight varus deviation, and 56.3% showed a slight valgus deviation. We observed a high correlation of this parameter ($r = 0.597, P = .024$) with the radiolucent lines at the glenoid side. In all 4 patients with a glenoid radiolucent line at the last follow-up in this group, the standard stem prosthesis was implanted in a slight valgus position.

No correlations were found between the functional results (CS, active range of motion) and the radiographic parameter describing the geometry of the humeral head replacement in both patient groups. The postoperative inclination angle, the postoperative medial offset, and the postoperative lateral offset showed no correlation with the radiolucency of the glenoid side and the lowering of the bone density at the humeral side.

### Complications

The overall complication rate for both groups was 13.8%. No complication concerning the humeral implant was observed in group 1. For the glenoid implant, atraumatic loosening of the glenoid component was noted in 2 patients, which led to

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1 (Eclipse)</th>
<th>Group 2 (Univers II)</th>
<th>$P$ value (group 1 vs. group 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclination angle, mean (SD), °</td>
<td>48.9 (5)</td>
<td>51.5 (7.9)</td>
<td>.433</td>
</tr>
<tr>
<td>Min. 5-year FU</td>
<td>42.2 (6.4)</td>
<td>45.1 (6.4)</td>
<td>.176</td>
</tr>
<tr>
<td>ΔPost-op to pre-op</td>
<td>6.2 (5.9)</td>
<td>5 (9.4)</td>
<td>.922</td>
</tr>
<tr>
<td>$P$ value pre-op vs. min. 5-year FU</td>
<td>.005</td>
<td>.053</td>
<td></td>
</tr>
<tr>
<td>Medial offset, mean (SD), mm</td>
<td>4.3 (6.2)</td>
<td>4.5 (1.8)</td>
<td>.88</td>
</tr>
<tr>
<td>Min. 5-year FU</td>
<td>3.3 (2.2)</td>
<td>5.6 (3.0)</td>
<td>.031</td>
</tr>
<tr>
<td>ΔPost-op to pre-op</td>
<td>0.67 (3.3)</td>
<td>0.6 (8.0)</td>
<td>.258</td>
</tr>
<tr>
<td>$P$ value pre-op vs. min. 5-year FU</td>
<td>.474</td>
<td>0.391</td>
<td></td>
</tr>
<tr>
<td>Lateral offset, mean (SD) mm</td>
<td>55.4 (4.8)</td>
<td>54.2 (6.9)</td>
<td>.352</td>
</tr>
<tr>
<td>Min. 5 year FU</td>
<td>54.5 (4.3)</td>
<td>57.7 (6.6)</td>
<td>.163</td>
</tr>
<tr>
<td>ΔPost-op to pre-op</td>
<td>0.67 (2.9)</td>
<td>3.7 (3.1)</td>
<td>.003</td>
</tr>
<tr>
<td>$P$ value pre-op vs. min. 5-year FU</td>
<td>0.396</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>

*Eclipse*, Arthrex, Freiham, Germany; *FU*, follow-up; *SD*, standard deviation; *Univers II*, Arthrex, Freiham, Germany.
a revision and exchange of the glenoid component. One rotator cuff deficiency, which led to a revision with conversion to a reverse prosthesis, was observed.

In group 2, a fracture of the greater tuberosity resulted in 1 traumatic loosening of the humeral implant. The further treatment was done in another hospital because of the patient’s residency. There were no complications at the glenoid implant in group 2.

The overall revision rate for both groups was 13.8%. The revision rate between group 1 and group 2 was comparable at 7.1% vs 6.7%, respectively.

**Discussion**

The functional outcome obtained in this series after humeral head replacement using a stemless humeral head implant, with a significant improvement of the CS from 54 preoperatively to 73 at the minimum of 5-year follow-up, was comparable to the results after shoulder arthroplasty using a stemmed fourth-generation shoulder prosthesis, with an increase of the CS from 26 preoperatively to 70 postoperatively. Our comparison of the subcategories of the CS between the Eclipse group and the Univers II group found no significant differences. The analysis of the active range of motion showed a statistically significant improvement for flexion, abduction, and external rotation, without a difference between both groups.

The gain of shoulder function in the midterm follow-up after humeral head replacement with a stemless humeral implant was stable compared with the short-term follow-up. We did not detect any deterioration in shoulder function in the midterm follow-up compared with the short-term follow-up for both implant groups. The functional results are comparable with the reviewed data obtained from the current literature.

Habermeyer et al observed in another study of 25 patients receiving a total shoulder arthroplasty using a stemless implant (Eclipse) for the treatment of primary osteoarthritis a mean postoperative CS of 68 at a mean follow-up of 68 months with an active range of motion of 153° for forward flexion, 140° for abduction, and 46° for external rotation.

Berth et al in 2012 in a series with 49 patients with primary osteoarthritis, detected a mean postoperative CS of 55 after a mean follow-up of 33 months after arthroplasty using a stemless prosthesis (TESS). In 2013, the same research group published a prospective trial with 82 patients with primary osteoarthritis. Forty-one patients received a stemless procedure (TESS), and 41 were treated using a stemmed prosthesis. They noted a mean postoperative CS of 55 after a stemmed implant vs. a CS of 49 after a stemless implant at a mean follow-up of 31 months and 33 months, respectively. The mean active range of motion for the stemless group was 116° of forward flexion, 105° of abduction, and 54° of external rotation vs. 103°, 97°, and 49°, respectively.

In a series by Brunner et al, 66 patients with primary osteoarthritis were examined 21 months after humeral head replacement using a stemless prosthesis (Eclipse). The mean CS was 89 with a mean active forward flexion of 142°, abduction of 132°, and external rotation of 41°.

Huguet et al reported in 2010 a series of 70 patients of which 60 patients suffered from primary or post-traumatic osteoarthritis. Nineteen patients received a total shoulder arthroplasty with a stemless implant (TESS), and 51 patients received a stemless hemiarthroplasty. At a follow-up of 3 years, 61 patients were examined. The mean CS was 75, with an active forward flexion of 145° and an active external rotation of 40°.

In a randomized prospective trial by Mariotti et al, 29 patients with primary osteoarthritis were treated. Ten patients received a stemmed implant, and 9 patients received a stemless implant. At a follow-up of 2 years, a CS of 93 was observed for the stemmed prosthesis, and a CS of 88 was observed for the stemless implants.

Schoch et al monitored 96 patients receiving a total shoulder arthroplasty using a stemless prosthesis (Eclipse) because of primary osteoarthritis. The mean CS was 66 at 12 months after surgery. The mean active range of motion was 145° of forward flexion, 105° of abduction, and 41° of external rotation.

A statistically significant difference was found when the radiographic data were analyzed for zone C in the AP view, which is adjacent to the humeral calcar. The appearance of a lowering in bone density was more frequently observed in the stemmed prostheses than in the stemless prostheses, with a statistical significance of \( P < .05 \). There was no statistically significant difference for the stemless implants vs. the stemmed implants when the remaining zones were analyzed. Similar results were seen for both groups in zone A of the AP view, the zone being of importance because of its proximity to the greater tuberosity. The lowering of bone density that was seen in zone B of the AP x-rays was different when both groups were compared. In group 1, the lower bone density in zone B was observed around the cage screw, whereas in group 2, the lower bone density was observed at the lateral cortex of the humeral shaft. The presence of a reduction in bone density or radiolucent lines in the postoperative x-rays had no influence on the shoulder function (\( P > .05 \)).

When we analyzed the patients in whom osteolysis was present at the glenoid implant, we observed similar radiographic findings directly after the operation, suggesting the positioning of the implant was the cause instead of a true osteolysis.

The cause of the radiographic findings, which we classified as a reduction in bone density, might be a sign of internal remodeling but might as well be a sign of age-related bone loss caused by inactivity. However, a differentiation of the cause by conventional radiography is not possible because of the lack of assessing bone density in conventional x-rays.
A cranialization of the humeral head was observed in both groups, without a significant difference between the groups.

**Conclusion**

Both implants showed a consistently good functional outcome at the minimum of a 5-year follow-up, without significant improvement compared with the 2-year follow-up functional outcome. Both kinds of humeral implants achieved an anatomic reconstruction of the humeral head geometry in the coronal plane. The stemless implants did not show increased radiographic signs of prosthetic loosening. A reduction in bone density was increasingly observed below the trunnion as well as at the lateral shaft with the standard stem implant but seems to have no effect on the functional outcome.

**Disclaimer**

Peter Habermeyer receives patent fees for the Eclipse prosthesis from Arthrex Inc. Sven Lichtenberg is a consultant of Arthrex Inc. The other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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