Aseptic loosening rate of the humeral stem in the Coonrad-Morrey total elbow arthroplasty. Does size matter?

Gabor J. Puskas, MD\textsuperscript{a}, Bernard F. Morrey, MD\textsuperscript{b}, Joaquin Sanchez-Sotelo, MD, PhD\textsuperscript{b,}*  

\textsuperscript{a}Belgrist University, Zürich, Switzerland  
\textsuperscript{b}Department of Orthopedic Surgery, Mayo Clinic, Rochester, MN, USA  

\textbf{Background:} Aseptic implant loosening is one of the most common complications leading to revision surgery in total elbow arthroplasty. Different humeral stem lengths are available with varying designs. In general, the decision of which stem length to use depends on the surgical diagnosis or simply the surgeon preference. Often, the longer stem is used for post-traumatic or revision cases while for rheumatoid patients the shorter stem is preferred. There are no data in the literature to favor one humeral stem size over the other according to the diagnosis. 

\textbf{Methods:} We analyzed the total elbow joint database of the Coonrad-Morrey design at our institution for aseptic loosening leading to revision and compared the revision rate and the survival of the 4- and 6-inch humeral stems.

\textbf{Results:} Overall, revision for aseptic humeral loosening is infrequent and occurred in only 16 of 711 total elbow arthroplasties during a mean follow-up of 88 months. There was no significant difference in the revision rate between the 2 stem lengths (1.9% for the 4-inch stems and 2.6% for the 6-inch stem).

\textbf{Conclusion:} Revision rate was correlated to the surgical diagnosis and was significantly higher for post-traumatic patients than for rheumatoid patients (5.1% vs 0.66%, \textit{P} < .001). Of interest, and possibly not surprising, the mean time to revision was shorter for the 4-inch stems than it was for the 6-inch stems (37 vs 95 months, \textit{P} = .034).

\textbf{Level of evidence:} Level III, Retrospective Cohort, Treatment Study.  
© 2014 Journal of Shoulder and Elbow Surgery Board of Trustees.

\textbf{Keywords:} Aseptic loosening; humeral stem; Coonrad-Morrey total elbow arthroplasty

Total elbow arthroplasty has developed over the last decades and has become a reliable treatment option for patients with inflammatory joint disease,\textsuperscript{7,13,16,17} acute comminuted closed distal humeral fractures,\textsuperscript{4,6,9,15,18} distal humeral nonunion,\textsuperscript{3} instability,\textsuperscript{19} post-traumatic arthropathy of the elbow,\textsuperscript{1,19-21} and primary elbow osteoarthritis.\textsuperscript{20} The 2 largest patient populations are rheumatoid patients and patients with post-traumatic conditions. In literature reviews and large nationwide joint registry publications, aseptic loosening of the implant is reported to be the most common complication leading to implant revision.\textsuperscript{5,12,23,26} Different implant types are available and are generally categorized as linked or unlinked and as constrained or semiconstrained. The Coonrad-Morrey prosthesis is a linked, semiconstrained implant and is a popular implant for total elbow arthroplasty. Several modifications over the years were done at the ulnar component, but none at the...
humeral stem since the anterior flange was added in 1981. Three different humeral stem lengths exist. The 4- and 6-inch stem are typically used for primary arthroplasties, and the 8-inch humeral stem is reserved for difficult revision cases. For patients with inflammatory diseases, many surgeons would use the shorter stem. The rational for this decision is if the disease progresses, an ipsilateral shoulder arthroplasty might become necessary. In this situation, a possible conflict of the shoulder prosthesis with the implanted humeral stem and the cement of the elbow arthroplasty might dictate the subsequent choice of the shoulder implant or might complicate its insertion. For this reason, an elbow arthroplasty with a shorter humeral stem has a theoretical benefit. Additionally, in the case of reimplantation after infection, less bone stock would be contaminated.

A longer humeral stem has the potential benefit of a larger interface for implant fixation and force distribution. Therefore, in post-traumatic conditions with less probability of future shoulder surgery, often the longer stem is chosen. However, scientific data is lacking for this current practice.

Although publications about total elbow arthroplasty frequently reported the rate of implant loosening, the affected component is not consistently specified and its size is rarely mentioned. Additionally these reports are often focused on the experience with only one specific diagnosis. To date, the question of an adequate or optimum stem length has not been studied in a clinical series.

In this study, we analyzed the experience at one institution with special interest in the survival of 4- and 6-inch humeral stems in primary total elbow arthroplasty in both rheumatoid and post-traumatic patients.

### Material and methods

After approval of the study by the institutional review board, all Coonrad Morrey total elbow arthroplasties implanted at the Mayo Clinic from 1983 until 2011 were identified. Cases that were revised for aseptic loosening of the humeral stem were isolated. Patients were first grouped in post-traumatic and rheumatoid, as these are the most frequent etiologies for patients that require a total elbow arthroplasty and are known to differ in the post-operative outcome. The post-traumatic group included acute fractures, pathologic fractures, nonunions, post-traumatic osteoarthritis, and ankylosis. In the rheumatoid group, all patients with rheumatoid arthritis or juvenile rheumatoid arthritis as the primary diagnosis were included. If these patients had a concurrent traumatic condition, they were grouped according to the underlying rheumatoid disease. Patients with other etiologies and total elbow revision cases were excluded. Next, the patients were grouped according the humeral stem length. Finally, the database was researched for aseptic humeral stem revision for loosening in these patients. The clinical data of these latter cases were analyzed in detail and primary revisions for aseptic loosening were isolated.

### Results

Patient consent for data review was available for 806 primary Coonrad-Morrey total elbow arthroplasties that were performed between May 24, 1983 and June 28, 2011. Four hundred sixty-seven total elbow arthroplasties were performed in rheumatoid patients and 265 in patients with a post-traumatic condition, making a total of 732 cases of interest in this study. In 257 of the 732 cases, patients had died at a mean of 91 months (range, 0-302) after surgery. Of the patients alive, follow-up data were available for 97% of the elbows. Eighty-seven percent were followed for more than 2 years after surgery, 71% for more than 5, 43% for more than 10, and 19% for more than 15. The 711 elbows with available follow-up data in the total elbow joint registry database were further analyzed. The group of 255 post-traumatic patients consisted of patients with an acute fracture (n = 35), pathologic fracture (n = 6), nonunion (n = 92), post-traumatic osteoarthritis (n = 106), and ankylosis (n = 16). In 86 cases, patients with a post-traumatic indication for total elbow arthroplasty had a background diagnosis of rheumatoid arthritis. These patients were grouped as rheumatoid patients and made up 19% of the rheumatoid group of 456 cases. The mean follow-up was 88 months (range, 0-260), which was significantly longer for rheumatoid patients than for post-traumatic patients (93 [range, 0-260] vs 79 months [range, 0-246]) (P < .001).

In total, the 4-inch stem was used in 370 cases and the 6-inch stems in 341. The follow-up time for the 2 stem lengths in patients without revision differed by a little more than a year with a mean of 82 months (range, 0-260) for the 4-inch stems and 95 months (range, 0-46) for the 6-inch stems; however, this was not significant (P = .08).

For the majority of post-traumatic patients, the 6-inch stem was used (72%), and even more often in cases of nonunion (79%) than in the other post-trauma cases (67%).
(P = .43). In contrast, the 4-inch stem was most used for rheumatoid patients, and independently of an additional post-traumatic condition in about two thirds of the cases (Table I).

**Revision rate**

Of the 711 elbow arthroplasies, a total of 16 humeral stems (2.3%) were revised for aseptic loosening at a mean of 70 months (range, 16-165) after implantation. Seven of the 370 4-inch stems (1.9%) and 9 of the 341 6-inch stems (2.6%) had to be revised. The revision rate for the 2 different stem lengths did not differ significantly (P = .615). However, there was a statistically significant difference in the time until revision between the 2 stems with earlier revision for 4-inch stems (Table I) (Fig 1, A).

Thirteen humeral stem revisions had to be performed in post-traumatic patients and 3 in rheumatoid patients at a mean of 69 (range, 16-195) and 70 months (range, 23-158) after primary total elbow arthroplasty, respectively. Revision rates for the different humeral stem lengths and additional diagnostic variables are summarized in Tables II and III, and their survival curves are illustrated in Fig 1, B.

The revision rate for post-traumatic patients was significantly higher than for rheumatoid patient (5.1% vs 0.66%, P < .001). This was also the true for separately analyzed 4-inch stems (6.9% vs 0.67%, P = .004) and 6-inch stems (4.4% vs 0.63%, P = .041). The time until revision did not differ significantly between posttraumatic and rheumatoid patients (69 [range, 16-195] vs seventy months [range, 23-158], P = .788). The time to revision was shorter for the 4-inch stems in the post-traumatic patients but did not reach statistical significance (41 [range, 20-90] vs 87 months [range, 25-195], P = .143). In rheumatoid patients, two 4-inch stems were revised at 23 and 29 months, respectively, and a 6-inch stem at 158 months. The 2 revisions of 4-inch stems were in rheumatoid patients with additional trauma diagnosis (3.6% revision rate) and the 6-inch stem in a rheumatoid patient without additional trauma diagnosis (0.8% revision rate). There was a statistically significant difference in the revision rate between rheumatoid patients with and without additional trauma diagnosis for 4-inch humeral stems (P = .035). However, this difference was not significant for 6-inch stems and for the total rheumatoid population.

All revisions were performed for the diagnosis of aseptic loosening of the humeral stem. In 5 patients (2 rheumatoid and 3 post-traumatic) aseptic loosening was concomitant with a humeral fracture. Only 1 of these patients remembered an adequate trauma leading to the humeral fracture 20 months after primary total elbow arthroplasty. In 3 patients the humeral prosthetic component was fractured, once additionally to a nontraumatic humeral fracture at the same level and twice without a humeral fracture. Two implants were 6-inch humeral stems and 1 was a 4-inch stem. They fractured at the superior aspect of the flange and the stem body junction, respectively.

In 5 of the 16 revision cases, the ulna component was also revised because of aseptic loosening at 66 months (range, 25-127). In all 5 patients a polymethyl methacrylate (PMMA) precoat 3-inch ulna component was implanted.

**Discussion**

The aim of this study was to analyze if length of the humeral component in a specific linked semiconstrained implant design—the Coonrad-Morrey—is a factor that influences the implant survival. Therefore, aseptic loosening of the humeral component was chosen as the endpoint as this is the most reliable variable and the one that most affects the patient.

Although in literature reviews aseptic loosening is reported to be one of the most common complications in total elbow arthroplasty, only a few publications systematically compared the influence of the size of the humeral implant on the loosening rate in various prosthetic designs. In a study comparing the Souter-Strathclyde and Coonrad-Morrey prosthesis, Prasad et al reported a similar revision rate for aseptic loosening for the Souter-Strathclyde standard humeral component (3 out of 32) and the long stem humeral component (1 out of 12). None of the 55 Coonrad-Morrey prostheses had to be revised for aseptic loosening. However, aseptic loosening rate seems to be implant specific and different loosening rates for different stem lengths in one design cannot be compared with another design.

In our patient population, revision rate for aseptic loosening of the humeral component was low as reported for this design also by others. For this reason, this question can only be addressed with large study samples with lengthy follow-up.

<table>
<thead>
<tr>
<th>Table I</th>
<th>Numbers of 4- and 6-inch humeral stems implanted and number of the stems revised, as well as the time until revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implant size</td>
<td>Total</td>
</tr>
<tr>
<td>----------</td>
<td>-------</td>
</tr>
<tr>
<td>Total</td>
<td>711</td>
</tr>
<tr>
<td>4-inch humeral stem</td>
<td>370</td>
</tr>
<tr>
<td>6-inch humeral stem</td>
<td>341</td>
</tr>
</tbody>
</table>

(P = .08)

(P = .615)

(P = .034)
Usage of the 2 stem sizes differed between the 2 main diagnoses. This was expected because our routine practice was to use 4-inch stems for rheumatoid patients and 6-inch stems for post-traumatic patients. Yet, there was no statistical difference in the revision rate between the 4- and 6-inch humeral components and no statistical difference in their survival curves, neither for the total patient population nor if patients were grouped according to their surgical and underlying diagnosis. Instead, we found that the operative diagnosis was a significant factor influencing the revision
rate of the humeral component with a higher revision rate for posttraumatic patients. This influence of the trauma diagnosis for higher revision rates could also be observed within the rheumatoid group for patients with 4-inch humeral stems.

In our study, 5 patients had aseptic loosening of both prosthetic components. All of them had an ulnar component with polymethyl methacrylate precoat and metallic debris, and pseudocyst formation was seen intraoperatively. Ulnar aseptic loosening with PMMA coated ulnar stems had been described earlier. With the available data, we were not able determine if the loose ulnar component had led to the humeral loosening or if ulnar loosening was influenced by the humeral stem length and its loosening. However, there was a difference between the 2 stem sizes in terms of time until revision. The 6 revisions of the 4-inch stems were performed significantly earlier than the eight revisions of the 6-inch stems. Because the absolute number of each is small, a precise explanation of this observation is difficult. We hypothesize that if the cementing technique is less than adequate it will be demonstrated earlier with the 4-inch stem. However, this is only speculation, as the true explanation is not known.

The present study has several limitations. It is a retrospective study and is based on the data of a joint registry. It is therefore possible that not all patients had the latest clinical follow-up data integrated in the registry. However, this deficiency would be expected to exist for both cohorts and not influence the observations. In accordance with the institutional review board recommendations, only the clinical reports of patients with revisions were specifically analyzed. With increasing follow-up time, the percentage of available patient data decreased as outlined in the material and methods section above. In addition, some patients retrospectively withdrew their consent for the use of their joint registry data for further research purposes. This and different inclusion criteria might be reasons for slight differences in the actual data pool compared to older studies from our institution. No radiographic analyzes were performed in this study to evaluate aseptic loosening in patients that did not undergo revision surgery. However, in our opinion, implant revision is a discrete well-defined endpoint to determine failure of an implant. We chose aseptic loosening as the cause of failure, as it is the least influenced by factors other than the implant itself. This study presents the largest number of 2 different humeral stems sizes that were implanted by the same surgeons systematically compared for aseptic loosening in total elbow arthroplasty. It should be noted that our practice during this period selectively used the shorter stems for the rheumatoid and the longer stems for the traumatic elbow. However, there was a sufficient number of short- and long-stemmed implants in each diagnostic category to allow assessment of each stem length across both diagnostic categories. We therefore feel that, even with the above discussed limitations, our data are strong enough to make a reliable statement about the influence of the humeral stem size on its failure rate. The shorter 4-inch humeral component has a comparable failure rate to the 6-inch component overall as well as for patients grouped for rheumatoid and the post-traumatic diagnoses. Due to its benefit in compromising less bone stock, the 4-inch humeral component might be considered as the primary choice for either of the 2 operative diagnoses. Based on these data, we have altered our selection standards and

### Table II

<table>
<thead>
<tr>
<th>Implant size</th>
<th>Rheumatoid post-trauma</th>
<th>Rheumatoid no trauma</th>
<th>Rheumatoid revision</th>
<th>Rheumatoid no trauma revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>3 (0.7%)</td>
<td>2 (2.3%)</td>
<td>3 (0.7%)</td>
<td>2 (0.3%)</td>
</tr>
<tr>
<td>4-inch humeral stem</td>
<td>56 (65%)</td>
<td>2 (3.6%)</td>
<td>1 (0.6%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>6-inch humeral stem</td>
<td>30 (35%)</td>
<td>0 (0%)</td>
<td>1 (0.6%)</td>
<td>1 (0.8%)</td>
</tr>
</tbody>
</table>

*P = 0.54*

### Table III

<table>
<thead>
<tr>
<th>Implant size</th>
<th>Post-trauma nonunion</th>
<th>Post-trauma other</th>
<th>Post-trauma revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>7 (7.6%)</td>
<td>163 (100%)</td>
<td>6 (3.7%)</td>
</tr>
<tr>
<td>4-inch humeral stem</td>
<td>19 (21%)</td>
<td>53 (33%)</td>
<td>2 (3.8%)</td>
</tr>
<tr>
<td>6-inch humeral stem</td>
<td>73 (79%)</td>
<td>110 (67%)</td>
<td>4 (3.6%)</td>
</tr>
</tbody>
</table>

*P = 0.152*

80 G.J. Puskas et al.
now use the 4-inch stem in older patients with acute fractures.

**Conclusion**

For the Coonrad-Morrey elbow arthroplasty, the aseptic loosening rate of the humeral component is low. The length of the humeral stem does not statistically influence its revision rate for aseptic loosening. Therefore, these data suggest the shorter 4-inch humeral component might be considered as the primary choice in any primary total elbow arthroplasty using the Coonrad-Morrey prosthesis. However, the revision rate is strongly influenced by the operative diagnosis with a higher failure rate for patients with post-traumatic conditions. Furthermore, if aseptic loosening does occur, it does so more rapidly with the 4- than with the 6-inch stem.

**Disclaimers**

The authors, their immediate families, and any research foundation with which they are affiliated received no financial payments or other benefits from any commercial entity related to the subject of this article.

**References**