Femoral alignment of the Charnley stem

A randomized trial comparing the original with the new instrumentation in 123 hips

Hans Christian Östgaard[2], Liljane Helger[1], Hans Regnér[2] and Göran Garellick[2]

Departments of Orthopaedics, [1]Skene Hospital, [2]Institute of Surgical Sciences, Sahlgrenska University Hospital, Göteborg University, SE-413 45 Göteborg, Sweden. E-mail: goran.garellick@orthop.gu.se
Correspondence: Dr. G. Garellick
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ABSTRACT – Deficient cement mantles are associated with aseptic loosening of the stem component of total hip replacement. In a former study of 206 Charnley stems, we found high frequencies of stem malalignment, especially on the lateral view, consequently resulting in a high percentage of low cement mantle grading. If the "true" lateral radiographic projection is not used, there is a risk that the frequency of mantle defects is underestimated. A logistic regression analysis showed a high correlation between low cement mantle grading and stem loosening after a mean follow-up of 10 years.

The new Charnley instrumentation was introduced in 1994 and we started a randomized trial including 123 prostheses to determine whether the new instrumentation improved the position of the stem in both the AP and lateral planes. Postoperative radiographs revealed a significant change in AP positioning—i.e., from a high percentage of varus with the original method to valgus with the new instrumentation. However, there was no difference on the lateral view, with a persisting high frequency of stems with implant-inner cortex contact resulting in high percentages of low cement-mantle grading in both systems. If this deficiency, in a long-term perspective, is associated with aseptic loosening, as many authors have claimed, the manufacturers should address the problem.

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According to many studies, deficient cement mantles are associated with an increased frequency of aseptic loosening (Huddleston 1988, Anthony et al. 1990, Maloney et al. 1990, Jasty et al. 1991, Ebramzadeh et al. 1994, Star et al. 1994, Kawate et al. 1998, Garellick et al. 1999). Garellick et al. (1999) recently published a randomized study in which the Charnley (cobra design) prosthesis was compared to the Spectron. The postoperative radiographic examination revealed a significantly higher frequency of malalignment of the Charnley stem than of the Spectron stem. The commonest mode of malalignment was seen on the lateral projection (true lateral—"shot through"). Many stems were angled posteriorly resulting in a high percentage of implant-inner cortex contact. Consequently, there was a high amount of cement mantle deficiencies, with a low grade of mantle quality which was associated with loosening of the stem in a long-term follow-up. The inferior positioning of the Charnley stem could be explained by several factors, such as the use of the original quite unsophisticated instrumentation which includes only one (not oversized) femoral broach and with no distal stem centralizer.

We started a randomized trial to determine whether the new Charnley instrumentation might facilitate an adequate stem positioning with consequently better cement mantle quality on the postoperative radiograph.

Patients and methods

Patients

All patients with primary coxarthrosis, who were operated on for a total hip replacement (THR) during the study period, were included in the trial. 123 (68 women) patients were recruited between

April 1, 1995 and May 1, 1998. The hips were preoperatively randomized to be operated on with the original (61 hips) or the new instrumentation (62 hips). The allocation by a random number table was kept in a sealed envelope until the morning of the operation. The mean age of the patients at operation was 72 (45–92) years. There were 68 women and 55 men. The randomization gave a similar distribution of age and gender. In the group operated on with the original technique, 50% were women and the mean age was 71 (45–88) years. Corresponding figures for patients operated on with the new instrumentation were 60% and 73 (52–92) years.

Surgical procedure

The Charnley cobra designed stem and the ogee flanged cup was the standard prosthesis in the department. Preoperative planning with use of templates was routine. All procedures were performed using a modification of Charnley's technique without trochanteric osteotomy. The patients were operated on in a modern operating room with air changes 20 times/hour and UV-light, in a lateral position and through an anterolateral and transgluteal approach. All 3 surgeons were experienced and well aware of the necessity of an adequate entry point (piriformis fossa) to the femoral canal. The posterior cortex of the femoral neck was routinely cut and the straight reamer advanced laterally and posteriorly in the trochanter major. Femoral cementing was performed with a brush, high pulsatile lavage, adrenaline swab, distal polyethylene cement restrictor, retrograde cement filling, and a proximal seal for pressurization. No distal centralizer was used.

Original instrumentation. The old instrumentation with only one (not oversized) femoral broach was used.

New instrumentation. The new instrumentation was introduced in 1994 and includes Excel initiator and incremental canal probes to ensure an adequate entry point into the femoral canal and an anteversion osteotome. It also includes broaches which are oversized to permit a cement mantle of minimum 1.5 mm thickness.

Radiography

Standard anteroposterior (AP) pelvis, frontal hip and true lateral radiographs were performed at all examinations. The AP pelvis was centered over the symphysis, and the frontal at the neck of the stem. Stem alignment was referenced from the axial alignment of the proximal femur on the AP and lateral films. On the AP projection, the minimum cement mantle thickness in each Gruen zone was recorded (Gruen et al. 1979). Cement mantle deficiency, indicating implant-inner cortex contact, was evaluated on AP and lateral views. The cement mantle quality was estimated by Barrack et al.'s method (1992). The radiographs were interpreted by a specially trained radiologist who had no information about which instrumentation was used.

Statistics

SPSS was used for the statistical calculations (Version 9.0, SPSS, Chicago, IL). The statistical methods are indicated in the text. Two-tailed tests were performed.

Results

Radiographic results 1 week after operation

Original instrumentation. Femoral cement mantle thickness in the different Gruen zones is shown in Figure 1. On the AP view, 23% of the stems were in varus and 7% in valgus position (Table). On the lateral view, 43% were angled posteriorly, resulting in high frequencies of implant-inner cortex contact in zones 3, 8 and 12 (Figure 1). Consequently, the percentage of cement mantle deficiencies was high with a low grade of mantle quality (31% grade C) (Table).

New instrumentation. Femoral cement thicknesses were similar, compared to the stems inserted with the original method (Figure 2). On the AP view, 10% of the stems were in varus and 24% in valgus position (Table). 37% of the stems were angled posteriorly and there was a lower, but not significant, difference (Fisher's exact test) in percentage of stem-bone contact (Figure 2).

The differences in AP alignment, with higher frequencies of varus position with the original instrumentation and valgus position with the new instrumentation, were statistically significant ($p = 0.03$, Fisher's exact test). There were no significant differences in lateral position (Fisher's exact test) and

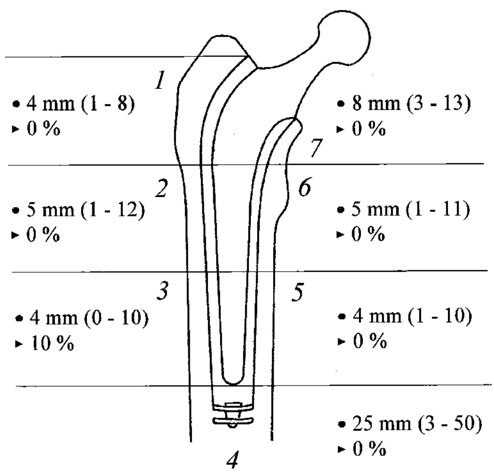
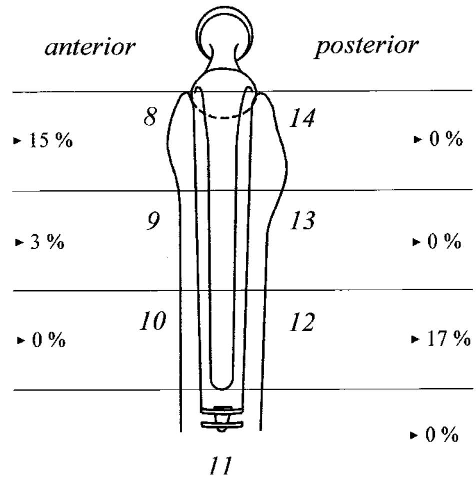


Figure 1. A. Frontal view – original instrumentation. Mean cement thickness and range and prosthesis-inner cortex contact in Gruen zones 1–7. ● = cement thickness, ▶ = inner cortex contact – "broken cement mantle".



B. Lateral view – original instrumentation. ▶ = prosthesis-inner cortex contact in Gruen zones 8–14.

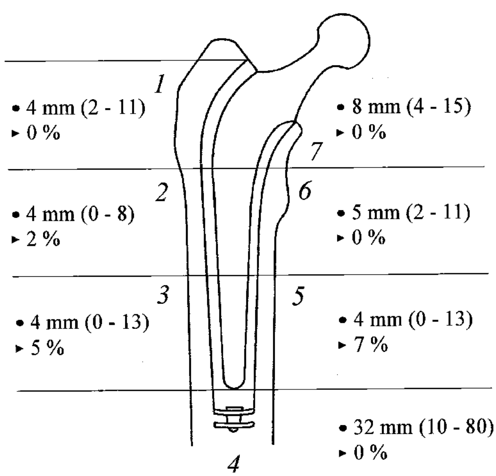
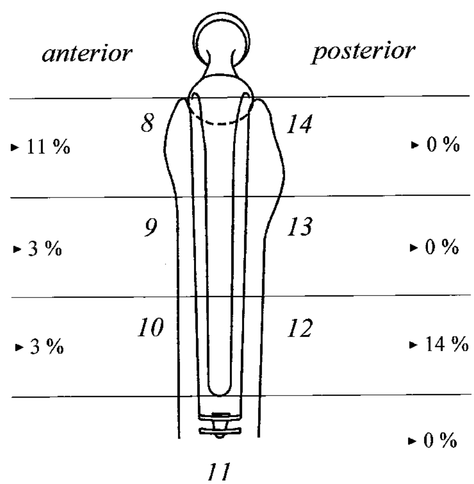


Figure 2 A. Frontal view – new instrumentation. Mean cement thickness and range and prosthesis-inner cortex contact in Gruen zones 1–7. ● = cement thickness, ▶ = inner cortex contact – "broken cement mantle".



B. Lateral view – new instrumentation. ▶ = prosthesis-inner cortex contact in Gruen zones 8–14.

consequently no difference in cement quality grading (test for trend in contingency table).

Discussion

Several factors may contribute to a high frequency of malalignment (Figure 3) of the Charnley stem. The bulky and flanged "cobra" design and the short and straight stem do not facilitate central positioning in the femur. The posterior cortex of the femoral neck was routinely cut and the straight reamer advanced laterally and posteriorly in the trochanter major (with both instrumentations), but despite these technical maneuvers, many (43% and 37%, respectively) of the stems were angled posteriorly.

The faithful Charnley surgeon may criticize the transgluteal approach and emphasize that the malpositioning is caused by the lack of a trochanteric osteotomy. Garellick et al. (1994) reported a long-

Postoperative radiographic data. Figures are percent

	Instrumentation		
	Original (n 61)	New (n 62)	P-value
Anterior position			
neutral	69	66	0.7 [a]
varus	24	10	0.03 [a]
valgus	7	24	0.03 [a]
Lateral position			
neutral	57	56	1.0 [a]
tip angled posteriorly	43	37	0.5 [a]
tip angled anteriorly	0	7	0.1 [a]
Cement mantle quality			
A	59	66	
B	8	7	0.6 [b]
C	31	27	
D	2	0	

[a] Fisher's exact test
[b] Test for trend in contingency table

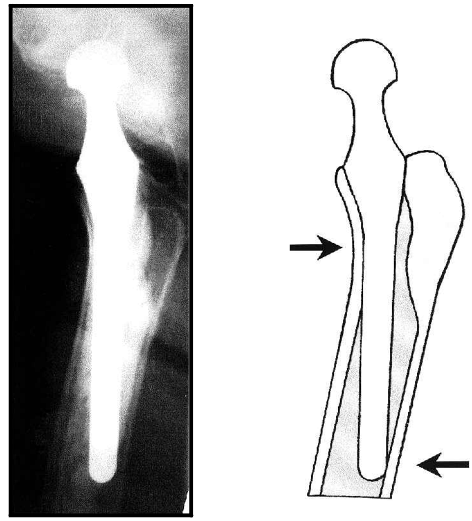


Figure 3. Radiograph – lateral projection showing a deficient cement mantle (grade C) around a Charnley stem with prosthesis-inner cortex contact in zones 8 and 12.

term follow-up of 95 round-back Charnley stems operated on with trochanteric osteotomy and a 50% incidence of stem-bone contact on the lateral radiographs. Even without the "cobra" design and with osteotomy, there was a high percentage of deficient cement mantles. If the "true" lateral radiographic projection is not used, there is a risk that the frequency of mantle defects is underestimated.

In the present study, the use of the new instrumentation significantly changed the stem position on the AP view from a high percentage of varus to a similar percentage of valgus, but there was no difference on the lateral view—i.e., no improvement in cement quality grading or frequency of implant-inner cortex contact. On the other hand, the stem alignment was much better (in both AP and lateral views in the present study, compared to the randomized trial in which the Charnley was compared with the Spectron prosthesis (Garellick et al. 1999). Several factors may explain the improvement in stem alignment, compared to the former trial. The Charnley-Spectron study included 22 surgeons and the current trial only 3. In the present study, the stems were cemented 10 years later with increased attention to the cementing technique. Furthermore, this study was started with awareness of the preliminary results of the Charnley-Spectron study in which we found a high percentage of malpositioned Charnley stems. This can result in some bias with even higher attention to the importance of an adequate entry point in the femoral canal and cementing technique. Nevertheless, the introduction of the new instrumentation did not reduce the unacceptably high frequency of malposition on the lateral view. If a cement mantle deficiency is associated with aseptic loosening, which many authors have claimed, then the manufacturers should address this problem. One way might be to develop further the instrumentation, with attention to positioning in the lateral view. Another way might be to introduce an adequate distal centralizer (Egund et al. 1990, Star et al. 1994, Hanson and Walker 1995, Berger et al. 1997). It is impossible always to avoid posterior angulation so long as straight stems are used in curved femora, but it is possible to avoid implant-inner cortex contact and "broken" cement mantels.

McCaskie et al. (1996) and Kelly et al. (1996) reported poor reproducibility in mantle quality grading. In the Charnley versus Spectron trial, Garellick et al. (1999) performed an intra- and interobserver study with, in general, better agreement both for test-retest measurements and between different observers. The intraobserver agreement was 95% for stem mantle grading. The radiographs in the present study were interpreted by the same independent radiologist (HR).

This trial was not a follow-up study. The aim was to investigate whether the use of the newly-introduced instrumentation resulted in a better positioning of the Charnley stem and so it did. The femoral stems were less often in the varus position with the new instrumentation. However, the worst malposition, with implant-inner cortex contact, especially seen on the lateral radiograph, was not addressed at all.

In a previous trial (Garellick et al. 1999), we found a high correlation between low cement mantle grading and long-term loosening of the stem. We do not know whether the malpositioned stems in this study will become loose to the same extent within 10 years, but the patients will be followed and the long-term results reported.

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