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ORIGINAL ARTICLE

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Cementless hemiarthroplasty in femoral neck fractures: evaluation of clinical results and measurement of migration by EBRA-FCA

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Abstract Aim of the present study was to evaluate migration rates of cementless primary hemiarthroplasty in acute femoral neck fractures. In a longitudinal, prospective study 46 patients were treated by cementless hemiarthroplasty. Clinical follow up was correlated with the EBRA-FCA method. In 30% of all patients stem migration amounted to more than 2 mm; further, these patients were seen to have a high level of activity. A high degree of migration in more than 30% of all patients requires critical scepticism toward further use of the investigated cementless stem as hemiarthroplasty. According to literature, migration of more than 2 mm suggests a high probability of early aseptic loosening. In patients with a low degree of activity good results could be observed; nevertheless, in patients with a high level of activity the combination of the investigated cementless stem with a solid fracture head cannot be recommended.

Keywords Hemiarthroplasty · Femoral neck fracture · Migration

Introduction

Primary hemiarthroplasty in femoral neck fractures of the elderly patient is a well-established treatment alternative to osteosynthesis [19, 29, 32, 33]. Contradicting results and suggestions of treatment and surgical management of acute femoral neck fractures in the elderly patient are reported in the literature. Various authors reported better results following primary reduction and osteosynthesis [16, 18, 30, 34, 38]; whereas, others reported better results following primary hemiarthroplasty in acute femoral neck fractures in the elderly patient [13, 14, 20, 36–38]. The reported better results for both treatments were based on subjective pain, mobility, a lower revision rate, and better cost-effectiveness.

For hemiarthroplasty the standard treatment in our clinic included cemented fixation. However, arguments for the use of cementless femoral implants are a shorter surgical time achieved by abolition of the cementing phase, together with a reduced risk of intra-operative thrombo-embolic complications [4–6, 35].

Aim of the present study was to evaluate if the reported excellent results of total hip arthroplasty with a cementless implant [8] can also be achieved in the elderly patient with the diagnosis of an acute femoral neck fracture. Corresponding to the high average age of the present patient population, 40% of these patients die within the first year after surgery [1]. Therefore, in addition to clinical parameters the migration rates of implanted stems were also examined, in order to make an early prognosis to the long-term survivorship of the used implant.

Materials and methods

Between 1999 and 2002, a total of 327 patients had been treated for the diagnosis of an acute femoral neck fracture by 5 independent surgical teams. Of these, 198 patients were treated by hemiarthroplasty. In the present longitudinal study 46 patients were treated by one surgical team, who consecutively implanted a cementless stem combined with a fracture head (Figs. 1, 2).

Inclusion criteria for this study were a patient's age of more than 61 years, and the presence of a femoral neck fracture classified as AO type B2 (more than 6 h) and B3.

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Fig. 1 Endo SL® Stem

All surgeries were carried out randomized by the same two experienced surgeons after preoperative determination of the stem size radiographically using templates. In all cases, supine position was chosen, using a transgluteal approach. Perioperative antibiotic prophylaxis was applied by Gentamycine for a period of 48 h. All patients received 50 mg Indometacine two times per day over a period of 10 days as prophylaxis against heterotope ossification. Further, a low dose heparin derivate was administered over 6 weeks. Mobilization was carried out by partial weight bearing from the second postoperative day on by use of two crutches, and for another 4 weeks by the use of one crutch.

Total number of female patients was 65%. The average age at the time of operation was 75.7 years (median: 74, standard deviation: 8.1). The frequency curve in regard to the affected side (52% left, 48% right) and the two surgeons showed no significant differences, neither in the frequency curve nor in the evaluated stem migration.

Fig. 2 Endo SL® Fracture head

All patients were followed up clinically 1 year postoperatively according to SICOT and hip society [21]. The collected parameters are shown in Table 1. Range of motion was documented by the neutral-zero-method.

Stem migration was assessed by the EBRA-FCA method, which is a well-established method for measuring migration in hip arthroplasty (Ein–Bild–Röntgen-Analyse—femoral component analysis) [1–3, 14, 25, 26]. Various studies demonstrated the possibility to prognosticate long-term survivorship of hip arthroplasties by measurement of migration of acetabular cups and stems after a period of 1–2 years [2, 3, 9, 12, 14, 25, 26, 31, 39]. However, one of the drawbacks of the EBRA-FCA program is that it requires a minimum of four consecutive radiographs taken at different dates. In the present study radiographs were assessed immediately postoperatively and after 3, 12 and 24 months.

The program consists of an input- and a graphic-program. The input-program serves to take over data from the marked radiographs. The second component, the graphic-program, calculates these results and illustrates them two-dimensionally. This computerized procedure enables to accurately measure migration values by a simple and cost-saving, non-stereophotogrammetric method [2, 22, 25, 26]. According to the literature, the sensitivity/specificity of this method to discover a migration of 1 mm or greater is 100%/78%, respectively [2].

Parameters (pain, activity level, ROM, etc.; Table 1) were evaluated by the Johnston Score, correlated with migration values obtained from EBRA-FCA and statistically analyzed using the Fischer's exact test and Spearman correlation coefficient in the SAS Software (SAS Institute, NC, USA) [20].

Results

Eight patients died within the follow up period of 1 year. Due to their bad general health condition 15 patients were not able to appear for the follow up examinations to get their X-ray taken. Because the EBRA-FCA method requires 4 comparable radiographs taken at different times only 23 of the 46 treated patients met the criteria for the assessment of stem migration using the EBRA-FCA.

In all cases, postoperative x-rays proved correct dimension and seating of the implant according to preoperative planning (Fig. 3). The results of the clinical follow up are summarized in Table 1. Within this collective more than 30% of all patients ($n = 7$) showed a comparably high migration rate of more than 2 mm (average: 4.2 mm, standard deviation: 1.5). The patients

Table 1 Results of the questionary and clinical exam according to Johnston et al. [20]

Hip-score	
Pain	
Degree	
13	None
3	Mild (slight and occasional pain; unchanged patterns of activity or work)
6	Moderate (patient is active but has had to modify or give up some activities, or both, because of pain
0	Severe (major pain and serious limitations)
Occurrence	
14	None
1	With first steps, then dissipates
3	Only after long (30 min.) walks
4	With all walking
0	At all times
Work/level of activity	
Level of activity	
1	Bedridden or confined to a wheelchair
4	Sedentary–minimum capacity for walking or other activity
9	Semi-sedentary–white-collar job, bench work, light housekeeping
3	Light labor–heavy house cleaning, yard work, assembly line, light sports (walking <5 km)
4	Moderate manual labor–lifts more <23 kg, moderate sports (walking >5 km)
1	Heavy manual labor–frequently lifts 23–45 kg, vigorous sports (single tennis)
Work capacity in last 3 months	
8	100%
4	75%
1	50%
2	25%
2	0%
Putting on shoes and socks	
14	No difficulty
3	Slight difficulty
3	Extreme difficulty
2	Unable
Ascending and descending stairs	
8	Normal
5	Foot over foot using banister or assistive device
8	2 feet on each step
0	Any other method
1	Unable
Sitting to standing	
8	Can arise from chair without upper-extremity support
12	Can arise with upper-extremity support
2	Cannot arise independently
Walking capacity	
Usual support needed	
11	None
3	1 cane for long walks
2	1 cane
1	2 crutches
5	Walker
0	Unable to walk
Time walked without support	
8	Unlimited
4	31–60 min
4	11–30 min
2	<2 min or indoors only
4	Unable to walk
Time walked with support	
7	Unlimited
2	31–60 min
3	11–30 min
2	<2 min or indoors only
0	Unable to walk
Satisfaction of patient	
Operation increased your function?	
14	Yes
6	No

Table 1 (Contd.)

Satisfied with results?	
21	Yes
1	No
Status of hip compared with your last visit?	
7	Better
15	Same
0	Worse
Physical examination	
Limp without support	
7	None
4	Slight–detected by trained observer
3	Moderate–detected by patient
4	Severe–markedly alters or slows gait
Range of motion hip	
Flexion	99°
Ab-adduction	56°
External/internal rotation	47°
Trendelenburg-sign	
26	Present
14	Absent
Limb lengths	
16	Equal
4	Short left
1	Short right

with a higher migration (Table 2) differentiate from those with a lower migration ($n = 16$; average: 0.4 mm; standard deviation: 0.8) by a high activity level (Fig. 4; Spearman correlation-coefficient, $r = 0.5$, $P = 0.011$, $n = 22$), a longer walking distance ($r = 0{,}67$, $P = < 0{,}001$, $n = 22$), and a higher working level ($r = 0{,}72$, $P = 0{,}001$, $n = 17$). Those seven patients with high migration rates also significantly and more frequently showed a positive Trendelenburg sign (Fischer's exact test, $P = 0{,}049$). This group additionally had a higher demand for pain relieving medication and showed a decreased amount of hip flexion by an average of 10°.

Fig. 3 Radiograph taken 24 months postoperatively (patient 14 with 1.3 mm of axial migration)

Table 2 Migration values and activity level of all patients in the study group

Patient ID	Sex	Age	Migration	Activity level
1	Male	61	0.8	2
2	Female	78	−0.8	**4**
3	Male	97	−1.0	3
4	Male	65	**−6.1**	**5**
5	Female	81	−0.6	2
6	Male	84	0.1	3
7	Female	73	−0.8	3
8	Female	74	0.8	3
9	Male	72	**−5.5**	**6**
10	Male	74	**−3.0**	2
11	Female	70	**−2.2**	3
12	Female	92	−0.2	**4**
13	Female	69	−0.4	3
14	Male	68	−1.3	**4**
15	Female	80	−0.5	1
16	Female	91	**−4.5**	3
17	Female	71	−0.1	2
18	Female	61	−0.2	3
19	Female	74	**−5.5**	**5**
20	Male	89	−1.2	**5**
21	Female	75	−0.9	3
22	Female	65	−1.2	**5**
23	Female	81	**−2.8**	3

The patients with a high migration value and high activity rate are highlighted

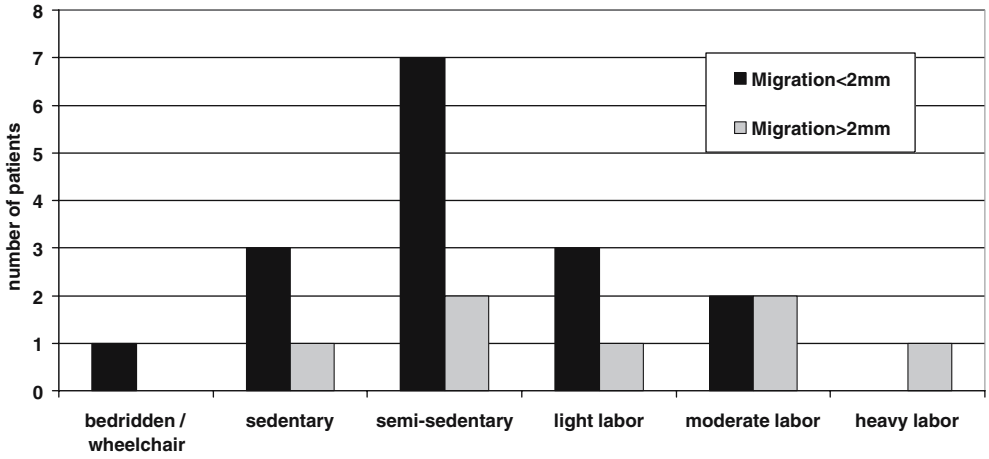

Fig. 4 Activity level and migration for patients with migration less than 2 mm (*black*), patients with migration more than 2 mm (*grey*)

In summary, high migration rates of the implanted stem were found within the group of patients with a higher activity level. The remaining group of patients with a low activity level showed no signs of increased stem migration. No intraoperative thrombo-embolic complications were observed. No postoperative dislocations, infections, neuro-vascular problems or other severe complications were seen.

Discussion

In a prospective controlled study, Clark et al. could demonstrate a significant decrease of cardiac output and stroke volume during the introduction of cement. No hemodynamic changes were observed in the cementless control group [6]. In a retrospective analysis, Parvizi et al. reported 23 acute intraoperative deaths during a period of 28 years within a total of 29.431 patients, who had undergone cemented total hip arthroplasty. A lung autopsy of the 23 showed evidence of microembolism in 11 patients and in 3 of these methylmethacrylate-particles were found in the lung. Furthermore, it was concluded that patients with an underlying fracture have a higher risk of acute intraoperative death. [35].

However, with the introduction of modern cementing techniques including jet lavage and various suction techniques of the medullary canal complication related to PMMA cement could be reduced [5, 15]. In the present study no case was seen with intra- or postoperative cardio-vascular or thrombo-embolic problems correlated to implantation of this cementless stem.

Iorio et al. reported of superiority of endoprostetic treatment of acute femoral neck fractures of the elderly patient in comparison to reduction and osteosynthesis regarding subjective pain, mobility, and cost-efficiency [18]. In a comparative study by Hudson et al., a significantly higher mortality rate is reported in the osteosynthesis group than in the endoprosthesis group [17]. In a multicenter study of 409 patients with acute femoral neck fracture, a failure rate of 43% was seen in the osteosynthesis group, whereas the failure rate for the endoprosthesis group was only 6% [37].

In the present study only patients with a low activity rate showed low migration values ($n = 16$).

In a histological study, Dalldorf et al. reported of severe degenerative changes found in acetabular cartilage obtained during revision surgery 128 months after implantation of hemiarthroplasty [7]. In their meta-analysis of 106 publications of results after surgical treatment of dislocated femoral neck fractures with hemiarthroplasty, Lu-Yao et al. reported that the most frequent revision procedure was conversion to total hip arthroplasty [30]. Iorio et al. demonstrated a revision rate of 12% within the total hip arthroplasty group and of 16% within the hemiarthroplasty group [18]. Eiskjaer et al. reported of 679 implanted hemiarthroplasties. No differences could be found between cemented and non-cemented implants [10]. In their comparative study Lennox et al. found a significantly higher perioperative mortality rate within the cemented group [28]. Delaunay reported 8 years survival rates of 99.3% using the uncemented Endo SL® Stem in total hip arthroplasty [8]. This contrasts to reports of Beck and Rüter about a comparably high rate of aseptic early loosening of cemented hemiarthroplasties [1].

Kenzora et al. reported of 270 patients, who had been treated by cemented and cementless hemiarthroplasties. They observed a decreased gait-function, a higher rate of subjective pain and a higher dependency of external walking devices within the non-cemented group [24]. Despite the lack of a cemented control group we observed similar clinical findings in the present study (Table 1). Mjöberg et al. stated that "migration is identical to loosening" [31]. Migration causes thigh pain and partially leads to limited range of motion and insufficiency limbing. In the present study, the Endo SL® Stem was applied in combination with a solid fracture head; thereby 30% of all patients showed stem migration greater than 4.2 mm. The patients with the high migration rate were identical with the group with the high activity level, which results in a higher mechanical loading of the implant. Various authors demonstrated

that stem migration of more than 2 mm within the first 2 years is connected to early aseptic loosening [2, 12, 23, 26, 39]. In the present study, the high migration rate of patients with a high activity level led to an early abandonment of implanting this stem in connection with a solid fracture head at a low total number of patients ($n = 46$). The question, if the high migration values of this non-cemented stem in combination with a solid fracture head within the present patient cohort were a result of higher friction between the fracture head and the acetabulum of lower elasticity and damping coefficients of a solid fracture head and consecutively different load transfer into a weakened bone stock in the elderly patient, remains to be topic of future biomechanical studies. These theories seem to be supported by other clinical reports of better long-term results after total hip arthroplasty in comparison to hemiarthroplasty in acute femoral neck fractures [11, 18, 20, 27, 36, 38].

Within the present study patients with a low activity level showed good clinical and radiological results with the use of the investigated cementless implant in combination with the fracture head. However, elderly patients with a high activity level and good general health condition showed a high migration of the stem in combination with the fracture head. Therefore, we would not recommend a cementless stem in combination with a solid fracture head for the treatment of femoral neck fractures in elderly patients.

References

1. Beck A, Ruter A (1998) Femoral neck fractures—diagnosis and therapeutic procedure. Unfallchirurg 101(8):634–648
2. Biedermann R, Krismer M, Stockl B, Mayrhofer P, Ornstein E, Franzen H (1999) Accuracy of EBRA-FCA in the measurement of migration of femoral components of total hip replacement. Einzel–Bild–Rontgen-Analyse-femoral component analysis. J Bone Joint Surg Br 81(2):266–272
3. Biedermann R, Stockl B, Krismer M, Mayrhofer P, Ornstein E, Franzen H (2001) Evaluation of accuracy and precision of bone markers for the measurement of migration of hip prostheses. A comparison of conventional measurements. J Bone Joint Surg Br 83(5):767–771
4. Christie J, Burnett R, Potts HR, Pell AC (1994) Echocardiography of transatrial embolism during cemented and uncemented hemiarthroplasty of the hip. J Bone Joint Surg Br 76(3):409–412
5. Christie J, Robinson CM, Singer B, Ray DC (1995) Medullary lavage reduces embolic phenomena and cardiopulmonary changes during cemented hemiarthroplasty. J Bone Joint Surg Br 77(3):456–459
6. Clark DI, Ahmed AB, Baxendale BR, Moran CG (2001) Cardiac output during hemiarthroplasty of the hip. A prospective, controlled trial of cemented and uncemented prostheses. J Bone Joint Surg Br 83(3):414–418
7. Dalldorf PG, Banas MP, Hicks DG, Pellegrini VD Jr (1995) Rate of degeneration of human acetabular cartilage after hemiarthroplasty. J Bone Joint Surg Am 77(6):877–882
8. Delaunay C, Cazeau C, Kapandji AI (1998) Cementless primary total hip replacement. Four to eight year results with the Zweymuller–Alloclassic prosthesis. Int Orthop 22(1):1–5
9. Eingartner C, Heigele T, Dieter J, Winter E, Weise K (2003) Long-term results with the BiCONTACT system—aspects to investigate and to learn from. Int Orthop 27(Suppl 1):S11–S15
10. Eiskjaer S, Ostgard SE (1993) Survivorship analysis of hemiarthroplasties. Clin Orthop (286):206–211
11. Eyssel M, Schwenk W, Badke A, Krebs S, Stock W (1994) [Total endoprosthesis or dual head prosthesis in endoprosthetic management of femoral neck fractures?]. Unfallchirurg 97(7):347–352
12. Freeman MA, Plante-Bordeneuve P (1994) Early migration and late aseptic failure of proximal femoral prostheses. J Bone Joint Surg Br 76(3):432–438
13. Gerber C, Strehle J, Ganz R (1993) The treatment of fractures of the femoral neck. Clin Orthop (292):77–86
14. Hamadouche M, Witvoet J, Porcher R, Meunier A, Sedel L, Nizard R (2001) Hydroxyapatite-coated versus grit-blasted femoral stems. a prospective, randomised study using EBRA-FCA. J Bone Joint Surg Br 83(7):979–987
15. Heisel C, Clarius M, Schneider U, Breusch SJ (2001) [Thromboembolic complications related to the use of bone cement in hip arthroplasty—pathogenesis and prophylaxis]. Z Orthop Ihre Grenzgeb 139(3):221–228
16. Holt EM, Evans RA, Hindley CJ, Metcalfe JW (1994) 1000 femoral neck fractures: the effect of pre-injury mobility and surgical experience on outcome. Injury 25(2):91–95
17. Hudson JI, Kenzora JE, Hebel JR, Gardner JF, Scherlis L, Epstein RS, et al (1998) Eight-year outcome associated with clinical options in the management of femoral neck fractures. Clin Orthop (348):59–66
18. Iorio R, Healy WL, Lemos DW, Appleby D, Lucchesi CA, Saleh KJ (2001) Displaced femoral neck fractures in the elderly: outcomes and cost effectiveness. Clin Orthop (383):229–242
19. Jalovaara P, Virkkunen H (1991) Quality of life after primary hemiarthroplasty for femoral neck fracture. 6-year follow-up of 185 patients. Acta Orthop Scand 62(3):208–217
20. Johansson T, Jacobsson SA, Ivarsson I, Knutsson A, Wahlstrom O (2000) Internal fixation versus total hip arthroplasty in the treatment of displaced femoral neck fractures: a prospective randomized study of 100 hips. Acta Orthop Scand 71(6):597–602
21. Johnston RC, Fitzgerald RH Jr, Harris WH, Poss R, Muller ME, Sledge CB (1990) Clinical and radiographic evaluation of total hip replacement. A standard system of terminology for reporting results. J Bone Joint Surg Am 72(2):161–168
22. Karrholm J (1989) Roentgen stereophotogrammetry. Review of orthopedic applications. Acta Orthop Scand 60(4):491–503
23. Karrholm J, Borssen B, Lowenhielm G, Snorrason F (1994) Does early micromotion of femoral stem prostheses matter? 4–7-year stereoradiographic follow-up of 84 cemented prostheses. J Bone Joint Surg Br 76(6):912–917
24. Kenzora JE, Magaziner J, Hudson J, Hebel JR, Young Y, Hawkes W, et al (1998) Outcome after hemiarthroplasty for femoral neck fractures in the elderly. Clin Orthop (348):51–58
25. Krismer M, Tschupik JP, Bauer R, Mayrhofer P, Stockl B, Fischer M, et al (1997) [Single-image roentgen analysis for the measurement of hip endoprosthesis migration]. Orthopade 26(3):229–236
26. Krismer M, Biedermann R, Stockl B, Fischer M, Bauer R, Haid C (1999) The prediction of failure of the stem in THR by measurement of early migration using EBRA-FCA. Einzel–Bild–Roentgen-Analyse-femoral component analysis. J Bone Joint Surg Br 81(2):273–280
27. Lee BP, Berry DJ, Harmsen WS, Sim FH (1998) Total hip arthroplasty for the treatment of an acute fracture of the femoral neck: long-term results. J Bone Joint Surg Am 80(1):70–75
28. Lennox IA, McLauchlan J (1993) Comparing the mortality and morbidity of cemented and uncemented hemiarthroplasties. Injury 24(3):185–186
29. Livesley PJ, Srivastiva VM, Needoff M, Prince HG, Moulton AM (1993) Use of a hydroxyapatite-coated hemiarthroplasty in the management of subcapital fractures of the femur. Injury 24(4):236–240
30. Lu-Yao GL, Keller RB, Littenberg B, Wennberg JE (1994) Outcomes after displaced fractures of the femoral neck. A meta-analysis of one hundred and six published reports. J Bone Joint Surg Am 76(1):15–25

31. Mjoberg B, Selvik G, Hansson LI, Rosenqvist R, Onnerfalt R (1986) Mechanical loosening of total hip prostheses. A radiographic and roentgen stereophotogrammetric study. J Bone Joint Surg Br 68(5):770–774
32. Mollers M, Stedtfeld HW, Paechtner S, Wald A (1992) [Hemiarthroplasty of the hip joint: concentric or positive eccentric (self-centering) dual head prosthesis? A retrospective comparison]. Unfallchirurg 95(5):224–229
33. Overgaard S, Jensen TT, Bonde G, Mossing NB (1991) The uncemented bipolar hemiarthroplasty for displaced femoral neck fractures. 6-year follow-up of 171 cases. Acta Orthop Scand 62(2):115–120
34. Parker MJ, Pryor GA (2000) Internal fixation or arthroplasty for displaced cervical hip fractures in the elderly: a randomised controlled trial of 208 patients. Acta Orthop Scand 71(5):440–446
35. Parvizi J, Holiday AD, Ereth MH, Lewallen DG (1999) The Frank Stinchfield Award. Sudden death during primary hip arthroplasty. Clin Orthop (369):39–48
36. Ravikumar KJ, Marsh G (2000) Internal fixation versus hemiarthroplasty versus total hip arthroplasty for displaced subcapital fractures of femur—13 year results of a prospective randomised study. Injury 31(10):793–797
37. Rogmark C, Carlsson A, Johnell O, Sernbo I (2002) A prospective randomised trial of internal fixation versus arthroplasty for displaced fractures of the neck of the femur. Functional outcome for 450 patients at two years. J Bone Joint Surg Br 84(2):183–188
38. Skinner P, Riley D, Ellery J, Beaumont A, Coumine R, Shafighian B (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury 20(5):291–293
39. Walker PS, Mai SF, Cobb AG, Bentley G, Hua J (1995) Prediction of clinical outcome of THR from migration measurements on standard radiographs. A study of cemented Charnley and Stanmore femoral stems. J Bone Joint Surg Br 77(5):705–714