A large collar increases neck resorption in total hip replacement

204 hips evaluated during 5 years

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We evaluated the effect of a prosthetic collar on the proximal femoral bone in 204 hips without any signs of loosening after 5 years. The patients were operated on at 5 centers, using different prosthetic designs, but the same cementing technique. Resorption was more often found in cases with a true and large collar (Lubinus, HD2, Scanhip) than in cases with a flanged or tapered stem (Charnley, Exeter). The resorption was also more pronounced with the former designs. It was concluded that, in spite of theoretical advantages, a large collar is not only unnecessary but may also have negative long-term effects.

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Two recent papers (Harris 1992, Ling 1992) show that the question whether a femoral stem prosthesis should be fitted with a collar is not solved. Much theoretical and experimental research has been done, but the results do not correlate with clinical observations.

In a randomized study of low and high viscosity cement in total hip surgery, there was no difference with respect to radiographic component loosening (Carlsson et al. 1993). To evaluate the effect of the collar, hips without radiographic signs of loosening were again scrutinized for changes in the upper femur.

Patients and methods

In 1984 and 1985, 352 hips were randomly assigned to total hip surgery with either low or high viscosity cement at 5 Swedish orthopedic departments. Separate randomizations were performed at each center. The surgical approach and type of prosthesis differed in the participating centers. However, agreement was reached on the insertion of a bone or plastic plug in the femoral canal and, thereafter, cleaning the canal thoroughly by using a pulsating lavage. The vacuum-mixed cement was applied through a cement gun in a retrograde fashion sealing off, exerting pressure proximally with a silicone plug. The femoral neck was cut with a conventional power saw and no special instrument was used to enhance the contact between collar and bone.

For this study, we excluded all cases with radiographic signs of component loosening and cases with diagnoses other than arthrosis. There remained 204 hips and radiographic evaluations of the proximal femur were possible in 190 cases: 57 Charnley (Chas. F. Thackray Ltd, U.K.), 33 Lubinus IP (Valdemar Link GmbH & Co, Germany), 58 Exeter (Howmedica Int), 16 Harris design 2 (HD2) (Howmedica Int) and 26 Scanhip (Mitab AB, Sweden). 10 hips were excluded because the neck had been resected just above the lesser trochanter, 3 because the radiographs were lost and 1 because of femoral fracture one year after the hip operation.

The Exeter prostheses were of the non-polished generation and without any protrusion from the proximal part, whereas the Charnley prostheses had flanges at their shoulders and a minimal step medially below the neck. The other three designs (Lubinus, HD2 and Scanhip) had a fairly similar construction with a large collar.

The radiographic evaluation

Serial radiographs (pelvic, a–p and oblique views) of each hip obtained immediately postoperatively and after 3 months, 1 year, 2 years and 5 years, were scrutinized by the three authors together. In case of differing opinions, the radiologist, not previously involved, had the casting vote.

In prostheses with a large collar (Lubinus, HD2 and Scanhip), we observed whether the collar rested on bone and, in all designs, whether bone cement

Table 1. Number of patients with neck resorption, osteopenia of the proximal femur and bone-cement demarcation at the resected neck

Prosthesis	n	Neck resorption			
		3 months	1 yr	2 yrs	5 yrs
Neck resorption					
Charnley	57	11	10	11	11
Exeter	58	8	9	10	11
Lubinus	33	13	13	14	14
HD2	16	2	6	7	9
Scanhip	26	9	11	14	14
Osteopenia					
Charnley	57	50	52	52	54
Exeter	58	50	53	54	55
Lubinus	33	28	29	30	31
HD2	16	8	12	14	14
Scanhip	26	19	20	20	22
Bone-cement demarcation					
Charnley	57	3	3	3	3
Exeter	58	2	2	2	2
Lubinus	33	3	3	3	3
HD2	16	0	1	1	2
Scanhip	26	1	1	1	1

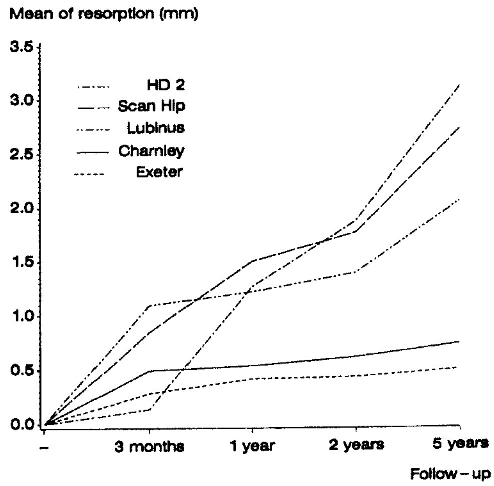

Figure 1. The mean neck resorption in the 5 prosthetic designs.

could be seen on the cortex of the resected femoral neck. Rounding off of the resected femoral neck, resorption of the femoral neck in mm, osteopenia, development of a zone of resorption between bone and cement along the resected neck and, finally, new bone formation were evaluated at each follow-up examination.

For comparison of frequencies we calculated odds ratios and for comparison of means between groups the analysis of variance.

Results

Resorption of the resected femoral neck was more often observed in prostheses with a true collar, i.e., Lubinus, HD2 and Scanhip, than in Charnley and Exeter hips (Table 1). The odds ratios after 3 months, 1, 2 and 5 years were 2.4 ($p < 0.01$), 3.5 ($p < 0.001$), 3.9 ($p < 0.001$) and 4.1 ($p < 0.001$), respectively. Besides being more frequent the mean neck resorption was also larger in the three designs with a true collar ($p < 0.001$) (Figure 1). There was no difference between the Lubinus, HD2 and Scanhip designs nor between the Exeter and Charnley designs. In the former group the mean resorption increased throughout the observation period up to 5 years, whereas in the latter group no progression was observed after 3 months (Figure 1).

In almost all cases without neck resorption, we observed a rounding off of the medial aspect of the resected femoral neck—irrespective of implant design.

Osteopenia of the proximal end of the femur was observed in three fourths or more of the four commonest prostheses even after 3 months. A lower proportion was observed for the HD2 prostheses, but only 16 such hips were included. Later, some additional osteopenia was observed (Table 1).

New bone formation starting at the resected neck was rare. It was almost always observed after only 3 months and occurred in a few percent of the Charnley, Lubinus and Exeter hips, but not in the HD2 or Scanhips.

Demarcation between cement and bone at the resected neck rarely occurred and there was no difference between the designs (Table 1).

Discussion

Ling (1992) defined a collar as any projection from the surface from the proximal third of the stem that interferes with the capacity of the stem to move distally in the mantle of cement. This definition includes the flanged Charnley stem among the collared prostheses, but in our study the tapered and completely collarless Exeter stem and the flanged Charnley stem behaved similarly with respect to the rate and the degree of neck resorption.

It may be argued that radiographic changes are more easily observed below a large collar and that a definite point of reference is lacking in stems without a true collar. However, by using serial radiographs and measuring the presence or absence of resorption and its progression, we believe one can reduce this risk.

In a randomized study with rather small groups, Kelley et al. (1993) found less neck resorption in 38 collared HD2 prostheses than in 32 collarless prostheses of the same design. No difference was observed at one or two years but developed over the 4-year period. These results seem to be different from ours, but the investigations may not be comparable, as their results were presented as mean values but not as proportions and number of cases without resorption. Furthermore, no changes other than the height of the femoral neck were measured.

In a previous study (Carlsson et al. 1993) we did not find any difference with respect to radiographic stem loosening between collared, flanged and collarless designs. Whether the present findings will have any clinical implications is questionable, but loss of support may jeopardize the stability of the implant. O'Hara and McMinn (1991) also observed resorption exceeding 2 mm in 26 of 43 well-seated Link SP collared prostheses after 2 years and in all 43 cases after 4 years. They found no evidence of progression and no impending prosthetic loosening. Blacker and Charnley (1978) reported femoral neck resorption greater than 3 mm in 117 of 167 low-friction arthroplasties and resorption below 3 mm in 50 such hips after 10 years. The onset of the resorption was detected as early as 4 months and, on average, after 13 months. They expected that an improved cementing technique would reduce the changes in the upper femur and this is also probably what has occurred with respect to the Charnley low-friction arthroplasty. However, this does not seem to apply to designs with a large collar although an identical cementing technique has been used. Munuera and Garcia-Cimbrelo (1992) reported 37 percent neck resorption, in the majority of the cases below 5 mm, in 533 Charnley hips implanted in 1971–1977. Concerning polished Exeter prostheses, 77 percent showed no resorption of the femoral neck after 15–20 years (Timperley et al. 1993).

Polyethylene wear, over- and underload may be other explanations of neck resorption. In our study, all prostheses with a true collar had a femoral head diameter of 32 mm, whereas the Charnley and Exeter prostheses had diameters of 22 and 30 mm, respectively. It is well known that a large head diameter implies larger volumetric wear than a small head diameter. It has also been demonstrated that rapid wear of the socket coincides not only with a high rate of socket loosening but also with bone resorption in the proximal part of the femur (Ohlin and Persson 1989, Ohlin 1990). However, a relationship that was not statistically significant between radiographic polyethylene wear and neck resorption was reported by Munuera and Garcia-Cimbrelo (1992). Even if not the whole explanation, minor degrees of wear may well contribute to the neck resorption observed in our study. Against the theory of polymer wear as the main explanation of neck resorption speaks the fact that resorption differed significantly between the collarless Exeter stem and stems with a large collar, although the difference in head diameter—30 and 32 mm, respectively—is marginal. Radiographic wear measurements were not considered appropriate in our study, which had a follow-up of 5 years.

Another reason that may be of importance is fretting of bone and cement under the collar, caused by predominantly torsional micromotions, described as a debris factory (Ling 1992). Animal experiments have demonstrated that small phagocytosable particles of bone cement, polyethylene and metal, notably cobalt chrome alloy, are associated with a foreign body and chronic inflammatory reaction (Goodman 1994). A high rate of burnishing of the undersurface of the collar was found by Hale et al. (1991).

Numerous studies have verified that the load of the femur is redistributed after a hip arthroplasty. The proximal part of the femur is less loaded than normal, but theoretically more so with a collared prosthesis (Oh and Harris 1978, Crowningshield et al. 1981, Lewis et al. 1984). Thus, the increased neck resorption with a large collar is caused neither by underload nor by overload because strain in the upper part of the femur is less than in the normal hip for all designs. The reduced strain is also confirmed by another observation: osteopenia occurred in almost every case, irrespective of design, and it was in the majority of the cases observed after only 3 months. We believe that all theoretical and experimental efforts to evaluate load and strain in the upper femur after implantations of various designs have limited clinical relevance. Our study supports the view that a large collar, in spite of theoretical advantages, is not only unnecessary but may also have negative long-term effects.

Our cases were not randomized with respect to stem design. A large series of hips allocated at surgery to have either stem without any projection from the surface of its proximal part or the same design but with a large collar, would be the best study to answer the question concerning the benefits and drawbacks of a collar. However, such a study will be extremely difficult to perform.

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References

Blacker G I, Charnley J. Changes in the upper femur after low-friction arthroplasty. Clin Orthop 1978; 137: 15-23.

Carlsson Å S, Nilsson J-Å, Blomgren G, Josefsson G, Lindberg L T, Önnerfält R. Low vs high viscosity bone cement in total hip surgery. A radiographic study of 272 cases followed for 5 years. Acta Orthop Scand 1993; 64: 257-62.

Crowningshield R D, Brand D R A, Johnston R C, Pedersen D R. An analysis of collar function and the use of titanium in femoral prostheses. Clin Orthop 1981; 158: 270-7.

Goodman S B. The effects of micromotion and particulate materials on tissue differentiation. Bone chamber studies in rabbits. Acta Orthop Scand (Suppl 258) 1994; 65: 1-43.

Hale D, Lee A J C, Ling R S M, Hooper R M, Timperley A J. Debris production by the femoral component in total hip arthroplasty. J Bone Joint Surg (Br) (Suppl 1) 1991; 73: 33.

Harris W H. Is it advantageous to strengthen the cement-metal interface and use a collar for cemented femoral components of total hip replacements? Clin Orthop 1992; 285: 67-72.

Kelley S S, Fitzgerald R H, Rand J A, Ilstrup D M. A prospective randomized study of a collar versus a collarless femoral prosthesis. Clin Orthop 1993; 294: 114-22.

Lewis J L, Askew M J, Wixson R L, Kramer G M, Tarr R R. The influence of prosthetic stem stiffness and of a calcar collar on stresses in the proximal end of the femur with a cemented femoral component. J Bone Joint Surg (Am) 1984; 66 (2): 280-6.

Ling R S M. The use of a collar and precoating on cemented femoral stems is unnecessary and detrimental. Clin Orthop 1992; 285: 73-83.

Munuera L, Garcia-Cimbrelo E. The femoral component in low-friction arthroplasty after ten years. Clin Orthop 1992; 279: 163-75.

Oh I, Harris W H. Proximal strain distribution in the loaded femur. J Bone Joint Surg (Am) 1978; 60: 75-85.

O'Hara J N, McMinn D J W. Calcar resorption beneath a well-fitting flanged femoral prosthesis. J Arthroplasty 1991; 6 (2): 147-58.

Ohlin A. Failure of the Christiansen hip. Survival analysis of 265 cases. Acta Orthop Scand 1990; 61 (1): 7-11.

Ohlin A, Persson P G. Failed Christiansen total hip arthroplasty. A radiographic and histologic study. J Arthroplasty 1989; 4 (3): 207-15.

Timperley A J, Gie G A, Lee A J C, Ling R S M. The femoral component as a taper in cemented total hip arthroplasty. Twenty years' experience with a totally collarless femoral component. J Bone Joint Surg (Br) (Suppl 1) 1993; 75: 33.