Changes in femur dimensions in asymptomatic non-cemented hip arthroplasties

20 cases followed for 5–8 years

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We assessed changes in proximal femur diameter during 5–8 years follow-up of 20 clinically successful press-fit cementless isoelastic implants. Total bone diameter, medullary diameter and cortical thickness were measured over the distal half of the prosthesis and just beyond the prosthesis tip. During the follow-up period total bone diameter did not change. However, cortical thickness declined by an average of 1 mm, while the size of the medullary canal increased by the same amount. As the patients remained asymptomatic during this period, the phenomenon observed did not appear to be related to loosening. We concluded that age-related changes in bone diameter can lead to widening of the tight interface between the stem and the femur.

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Some uncemented hip implants depend on a press fit only of the prosthesis to the bone for fixation (Butel and Robb 1988, Amstutz et al. 1989, Aldinger and Weipert 1991, Bands et al. 1991). Changes in bone dimensions with age may jeopardize the fixation and constitute a potential mechanism for loosening. Comadoll et al. (1988) have observed a decrease in cortical thickness as well as widening of the medullary canal without periosteal expansion in symptomless cemented hip replacements with a long-term follow-up. We investigated whether such changes in bone dimensions occur in femurs, in which a noncemented press-fit arthroplasty had been performed.

Patients and methods

20 subjects who had a unilateral hip replacement for primary or secondary arthrosis between 1985–1987 and no pain or other evidence of loosening were included in the study. The implant used was an isoelastic non-cemented press-fit total hip replacement (Morscher 1983, Andrew et al. 1986). 12 patients were women and the mean age at operation was 53 (30–61) years. The observation time was 5–8 years.

The protocol used for monitoring bone dimensions was that used by Comadoll et al. (1988) modified for the special radiographic appearance of the isoelastic prosthesis. The total length of the prosthesis (L) was defined as the vertical distance from the top of the head to the end of the metal core. Cortical dimensions were measured at 5 cross-sectional levels, namely L/2, 2L/3, 5L/6, L, 13L/12. The following cortical dimensions were measured on anteroposterior hip radiographs: C_1 lateral cortical thickness, C_2 medial cortical thickness, M_1 lateral medullary canal thickness (from the edge of the polyacetal coating to the endosteum), M_2 medial medullary canal thickness (from the edge of the polyacetal coating to the endosteum), P width of the metal core, T_m total medullary canal thickness, T_d total bone thickness. Measurements were made on the AP radiographs only because mediolateral radiographs are much more difficult to standardize (Comadoll et al. 1988).

All measurements were performed using the Java image analysis software (Jandel Scientific, 2591 Kerner Boulevard, San Rafael, CA 94901, U.S.A.). Each measurement was repeated 3 times and any measurements which deviated by more than 5 percent from the average were considered inaccurate and discarded. Another internal control for the accuracy of the set of measurements was the calculation of the sum $C_1 + C_2 + T_m$. This sum should equal T_d. Any deviation by more than 5 percent led to the abandonment of the whole data set. All data were corrected for magnification. In each radiograph, the total length of the prosthesis (L) as well as its width at L/2 were measured. As the actual length and width of the implant were known, calibration of the measurements was possible.

Analysis of variance was performed by utilizing a within subjects repeated analysis measures design.

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Table 1. Changes in proximal femoral dimensions during follow-up

Parameter		Months follow-up				F-value[a]
		Postop.	9–15	30–40	> 60	
L/2	T_d	38	38	38	38.5	0.8
	T_m	26	26	26.5	27.1	*6.9*
	C_1	6.5	5.5	5.6	5.5	*11.3*
	C_2	5.5	5.6	5.4	5.0	*9.0*
2L/3	T_d	37	36.5	37	37.3	0.04
	T_m	21	21	22	22	*16.8*
	C_1	8	8	7	7.5	*15.4*
	C_2	9	9.5	8	8	*8.3*
5L/6	T_d	34	34	34.3	34.6	0.9
	T_m	20.5	21	21	22	*25.6*
	C_1	6.5	6	6	5.9	*12.4*
	C_2	9	9	9	8.6	*6.3*
L	T_d	33	34	34	34	*2.9*
	T_m	17	17	18	18.9	*12.5*
	C_1	11	11	11	10	*18.4*
	C_2	6	6	6	5.2	*4.5*
13L/12	T_d	33	33	33.6	33.4	0.5
	T_m	17	17	18	18.6	*11.5*
	C_1	10	9.5	9.4	9	*8.5*
	C_2	7	7.2	7	6.5	*5.5*

[a] ANOVA, *Italics* indicates that the F-value is significant at the $P < 0.01$ level.

The calculations were performed using the CSS:Statistical program (CSS, complete statistical system, StatSoft Inc., Tulsa, OK 74104, U.S.A.).

Results

The bone dimensions changed in all subjects during the observation period. There was a decrease in both medial and lateral cortical thickness (Table 1) without any change in total bone thickness, except at the tip of the prosthesis in which a slight (1 mm) widening of the Td was observed. Obviously, an increase in medullary thickness was also observed. These changes appeared to be quite uniformly distributed over the proximal shaft.

No difference was observed between women and men in relation to the rate of change in bone dimensions (F 0.65). However, males tended to have larger bones and thus the differences observed in bone dimensions were significant for all measured parameters (F 3.1, $P < 0.02$). The increase in medullary canal diameter averaged 1.2 mm over the mean observation period of approximately 7 years.

Discussion

The increase in the medullary diameter over time which we observed may possibly be related to the well known age-related changes in bone dimensions. Subperiosteal dimensions of unoperated bones increase with aging (Dana 1982). The area of the femoral midshaft cross-section has been found to increase by approximately 12 percent from 25 years of age to 55 years of age. The changes were more striking in females than in males. In the proximal femur the cross-sectional areas increased by about 7.5 percent, while the cortical area decreased by 3 percent. Similar results have been reported for cemented arthroplasties by Comadoll et al. (1988). While our patients are not directly comparable, it does seem that the rate of decrease in cortical thickness was faster in the isoelastic group. This may indicate that an isoelastic prosthesis not only does not protect bone stock but actually leads to a faster loss of bone. However, this phenomenon might be due to the production of isoacetal wear particles, and theoretically be prevented by a more inert material.

The implications of this subtle phenomenon are not entirely clear. The implants functioned well and showed no evidence of loosening. However, the increase in medullary canal diameter bodes ill for the long-term stability of press-fit implants. It appears that despite good canal fill during operation and early on in the post-operative period, an eventual increase in the distance between the endosteum and the prosthesis will occur. Such an increase in the medullary canal diameter can be expected to allow micro-motion. Micro-motion has been implicated as responsible for the generation of particulate debris responsible for eventual loosening of the prosthesis (Dorr et al. 1990). It remains unclear whether such a phenomenon is of clinical importance, as the rate of enlargement of the medullary canal is very slow.

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