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Difference of the roentgenographic findings between recent and old cementless total hip arthroplasty femoral component

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Abstract: Two groups of 53 cementless total hip replacement were compared retrospectively after 3-7 years average follow-up. The design of femoral components in cementless total hip arthroplasty has progressed with emphasis placed on prevention of stress shielding in recent years. However, whether the stress shielding is actually prevented with the progress in stem design is open to debate. The purpose of this manuscript is to study radiologically whether the progress of the stem design in cementless total hip arthroplasty really reduced stress-shielding. We used 24 Omnifit stems and 29 Lord Mark II stems. They were investigated in accordance with Gruen's classification with respect to osteolysis, atrophy, cortical hypertrophy and pedestal bone formation at the tip of the stem. With the Omnifit stem, less bone atrophy was produced at the proximal femur but hypertrophic changes at the distal femur were more pronounced compared with Lord Mark II. It is concluded that the press-fit design does not prevent stress shielding completely.

Key words: Total hip arthroplasty - Cementless stem - Stress shielding

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Because radiographic failure often precedes clinical failure in total hip arthroplasty, various methods have been developed to achieve precise postoperative radiographic evaluation [1-3, 5]. In the proximal femur, bone resorption often raises problems in cases with longstanding cementless total hip arthroplasty, because wear debris from the acetabular component readily enter into the femoral medullary cavity if bone resorption occurs, possibly causing osteolysis.

Bone resorption in the proximal femur is thought to occur when stress on the proximal femur is shielded through transfer of almost the entire body weight from the distal femoral component to the femoral diaphysis.

Press-fit femoral stems, in which stress loading is transferred to wider areas, covering the proximal to distal femur, were developed to reduce this stress shielding [10]. We have gradually replaced Lord Mark II stems, which are designed to have a long and straight shape, with Omnifit press-fit stems, since 1993. In the present study, radiographic findings were compared in detail between stems manufactured with and without consideration of the press fit design.

Purpose

To compare radiographic differences between different stem designs used for cementless total hip arthroplasty.

Materials and methods

Fifty-three hips in 49 patients who had a cementless total hip replacement between January 1993 and December 1995, and who were continuously followed up for at least 1 year after surgery, were used as subjects. The mean duration of follow-up was 3.7 years (range, 1 to 5.7 years). The mean age at surgery was 63 years (range, 37 to 82 years). There were 11 men (11 hips) and 36 women (42 hips). Secondary osteoarthritis was observed frequently, in as many as 40 hips (75%). Other diseases observed in the hip included idiopathic osteonecrosis (7 hips; 13%), rapidly destructive coxitis (3 hips; 6%), and rheumatoid arthritis (3 hips; 6%). Lord Mark II stems were used in 29 hips, and Omnifit stems in 24 hips. The Lord Mark II stem is a modified type of the early Madréporique stem, which had a porous coating entirely over it; the Lord markII stem has no porous coating on the distal 1/4. Lord Mark II stems have almost equal thickness from the proximal end to the distal end, showing a straight and long shape, and this design gives weight-bearing loads on the femoral diaphysis, differing from the more recent press-fit design. Omnifit stems have a shorter overall length, compared with Lord Mark II stems, and have the press-fit design in which weight-bearing loads occur on the proximal femur. In this study, Omnifit Micro-

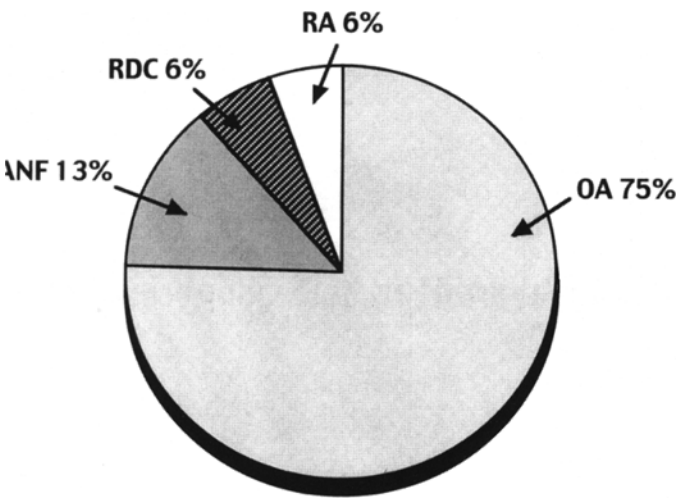

Fig. 1
Distribution of the diseases

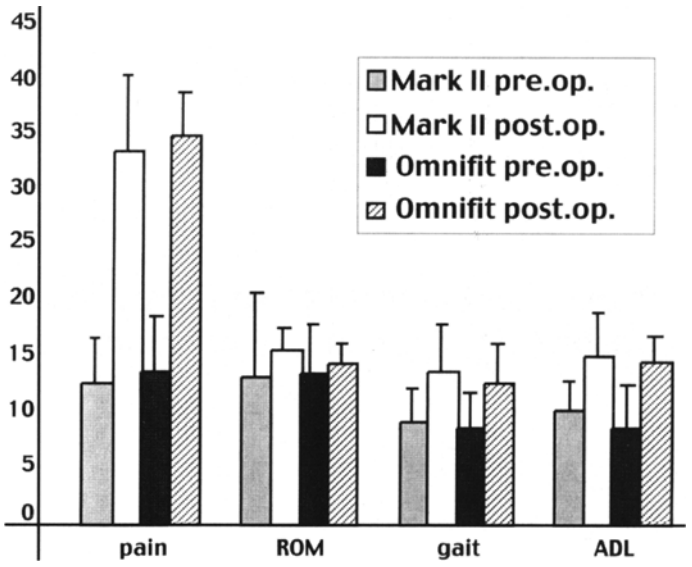

Fig. 2
Clinical results

structured stems, in which only the proximal 1/3 had a porous coating, and Omnifit HA stems, which had the same shape as that of the Omnifit Microsturc-trued stem, were used respectively in 12 hips each. Surgery was done with the patient in the lateral position. Each component was inserted through the posterolateral approach, without the trochanterotomy. The femoral canal was reamed slowly, to avoid fracture, and a stem of the maximum feasible size for insertion was then inserted, without cement. After that, intraoperative radiography was done, to determine if the stem was adequate in size, depending on the medullary-filling of the stem. 10 kg weight-bearing using crutchs was first allowed on the affected hip at postoperative week three, and full-weight-bearing was achieved several weeks later. No serious complications, postoperative infection, or dislocation occurred. Clinical evaluation was made using the JOA hip score [8, 9], and the presence or absence of thigh pain was also determined. In radiographic evaluation, a radio-opaque line of 2 mm or less, formed between bone and stem, was defined as a reactive line; a radio-opaque line of 2 mm or more was defined as a radiolucent line. The presence or absence of osteolysis and/or atrophy was investigated according to Gruen's classification [6]. Bone formation into the stem is known to appear as a pedestal [4] in zone 4, but as cortical hypertrophy in other zones. The presence or absence of this cortical hypertrophy or pedestal formation was also investigated according to Gruen's classification. X-ray films selected for radiographic evaluation were obtained as far as possible, under the same imaging conditions. If an abnormal finding was detected in a film, films taken during several weeks before and after that film was obtained were precisely examined, to determine if the preceding and/or succeeding films had the same abnormality.

No abnormality was counted unless two or more orthopedists, each having more than 10 years of clinical experience, made the same judgment.

Results

Although Omnifit stems with or without HA coating were used in the present study, these 2 types of Omnifit stems were compared as one group, with Load Mark II stems, because there were no apparent differences in clinical outcomes or radiographic findings between the 2 types.

JOA scores of all items examined, except for the range of motion, were significantly improved in both groups after surgery ($P < 0.01$). The incidence of thigh pain was 14% (4/29 hips) in the Load Mark II group, and 13% (3/24 hips) in the Omnifit group, showing no intergroup difference.

In the overall radiographic evaluation of stems, osseous fixation, fibrous fixation, and unstable fixation were found in 96% (23/24), 4% (1/24), and 0% of the Omnifit group, respectively, and in 79% (23/29), 14% (4/29), and 7% (2/29) of the Lord Mark II group, respectively. No clear evidence of osteolysis was observed in either group.

No radiolucent lines were detected in the Omnifit group, whereas two cases in the Lord Mark II group had radiolucent lines.When the incidence of reactive lines was determined by zones, the highest incidence was observed in zone 4 in both groups, and this tendency was particularly remarkable in the Lord Mark II group, compared with the Omnifit group. When time-sequence changes in the incidence of reactive lines were examined, reactive lines appeared at a high frequency in zones 1and 4 within 1 year after surgery in the Lord Mark II group, and the same tendency was observed in the Omnifit group, but less remarkably. When pedestal formation in zone 4 and cortical hypertrophy in other zones, which were thought to indicate bone formation onto the stem,

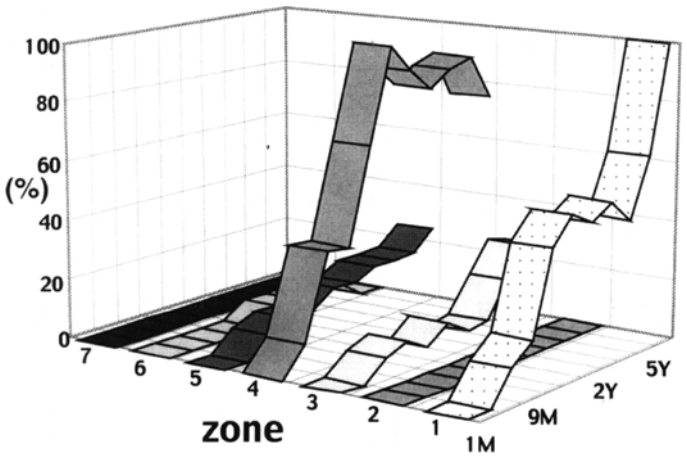

Fig. 3
Reactive line (Lord)

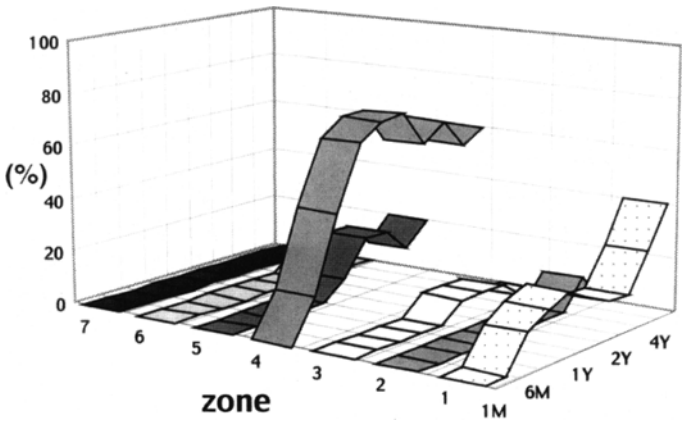

Fig. 4
Reactive line (Omnifit)

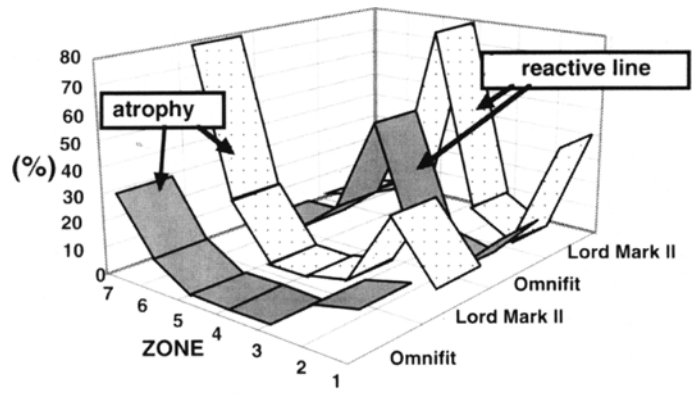

Fig. 5
Reactive line and atrophy (at the final follow-up)

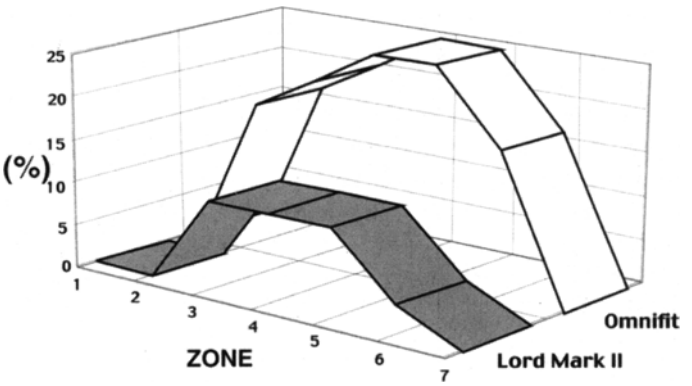

Fig. 6
Pedestal formation at zone 4 and cortical hypertrophy of the other zones (at the final follow-up)

were compared between the two groups, bone formation was observed in a wider area in the Omnifit group, compared with the Lord Mark II group. In intergroup comparison of bone atrophy at the final follow-up observation, particularly remarkable bone atrophy was observed in zones 2 and 7 in the Load Mark II group.

Discussion

Although early cementless stems had a straight and long shape, their designs have been gradually changed to a shorter length, in consideration of the press-fit design. Surface treatment has also been improved, in consideration of bone ingrowth. At the present time, stems with circumferential biological anchoring treatments in their proximal 1/3 are most widely utilized [7]. Attempts have also been made to increase the medullary filling of the stem in the cavity of the proximal femur. The results of the present study indicate that those efforts inhibit bone resorption in the proximal stem, to a certain extent, resulting in the prevention of loads focused on the distal stem. The incidence of reactive lines in the proximal femur was higher in Lord Mark II stems, compared with Omnifit stems, and bone atrophy in the same region was also more remarkable in the Lord Mark II stems, suggesting less stress shielding in the Omnifit stems. In overall radiographic evaluation, Omnifit stems were also superior to Lord Mark II stems. Needless to say, bone mineral densities in different regions of the femur were not measured in the present study; only radiographic measurements were obtained. However, it should be noted that differences between stems manufactured with and without a press fit design could be identified, even only by simple radiography, which is the simplest and most economical examination in routine practice. From the results of the present study, it cannot be said that bone atrophic changes in the proximal femur are completely prevented in Omnifit stems, despite their press-fit design. As for bone formation, this phenomenon occurred in a wider area in Omnifit stems, compared with Load Mark II stems. Since the press-fit design was developed to achieve strong stem fixation in the proximal femur,bone formation in a wider area, not only proxi-

mal but also distal to the stem, would be disadvantageous to the prevention of stress shielding. Thus the possibility of bone atrophy in the proximal femur, over the longer term, could not be excluded, even in Omnifit stems.

There have been two main streams in the development of cementless stems. One is that the weight load is entirely transferred to the proximal femur, to prevent the invasion of wear debris. This stem type has provided satisfactory outcomes, although with short-term results. On the other hand, attempts have been made to prevent the occurrence of wear debris through the use of materials other than HDP, or refinement of HDP itself. Mild bone resorption occurring in the proximal femur by a press-fit prosthesis may not cause a problem, if no wear debris is produced. In such cases, the press-fit design that generates bone formation over a wide area of the stem may be rather stable, compared with some types of stems developed in recent years, because their designs so weight the avoidance of stress shielding that their rotational stability or initial fixation is questionable [11].

We should follow up press-fit stems over a longer period of time to observe their ultimate outcomes.

Conclusion

Bone atrophy in the proximal femur occurred less frequently in Omnifit stems, compared with Load Mark II stems, while hypertrophic changes also tended to be stronger in Omnifit stems. Thus there is a possibility that the press-fit design cannot completely prevent stress shielding.

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Différence des résultats radiographiques entre les composants fémoraux récents et anciens pour l'arthoplastie totale de hanche sans ciment

Résumé : Deux groupes de 53 remplacements complets de la hanche sans ciment ont été rétrospectivement comparés après un suivi d'environ 3,7 ans. Le design et la conception des composants fémoraux dans l'arthroplastie totale de la hanche sans ciment a évolué au cours des dernières années avec l'accent mis tout particulièrement sur la prévention du "stress shielding". Toutefois, la question de savoir si les progrès enregistrés dans le design de la tige prothétique permettent de prévenir le "stress shielding" demeure ouverte et peut être débattue.

Le but de cette étude est d'étudier du point de vue radiologique si les progrès au niveau du design de la tige dans le cas d'une arthoplastie totale de la hanche sans ciment réduisent réellement le "stress shielding".

Nous avons utilisés 24 tiges fémorales Omnifit et 29 tiges fémorales Lord Mark II. Au regard de l'ostéolyse, de l'atrophie, d'une hypertrophie corticale et de la base, d'une formation osseuse à l'extrémité de la tige prothétique, on a étudié ceux-ci conformément à la classification des zones de Gruen.

Avec les tiges fémorales Omnifit, moins d'atrophies osseuses ont été produites au niveau du fémur proximal mais les modifications hypertrophiques au niveau du fémur distal étaient plus marquées, par comparaison avec les tiges fémorales Lord Mark II. Nous en concluons que le design "press-fit" ne peut prévenir totalement le "stress shielding".

Mots clés : Prothèses totales de hanche – Tiges fémorales sans ciment – Stress shielding