Clinical Results of the Uncemented Link Ribbed Hip Prosthesis
—Comparative Evaluation of Smooth and Microporous Surfaced Stems—

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Abstract

We reviewed clinical results of 35 uncemented bipolar endoprosthesis implantations using a Link ribbed hip prosthesis in 34 patients with an average follow-up of 4.0 years. The clinical evaluation showed very good improvement. Radiological evidence of reactive lines around the stems was more significant in the smooth surfaced group than in the microporous surfaced group. There was a significant negative correlation between the medullary canal filling ratio and the cumulative appearance rate of reactive lines. Even for an uncemented prosthesis with macro-anchoring, a microporous surface structure and sufficient canal filling are essential to obtain successful stem fixation.

INTRODUCTION

Aseptic loosening has been the most important long-term problem in prosthesis implantations. The use of bone cement for prosthetic fixation has proved to cause the so-called “cement disease” which can occur in addition to aseptic loosening. Thus, for a decade, uncemented prosthesis implantations have been adopted as the alternative method of implant fixation. The shape of the femoral stem and structure of its surface are important factors which influence the fixation of an uncemented prosthesis. As for the stem shape, the mechanical principle of a press fit type design (macro-anchoring) was introduced into the uncemented stems of the first generation-including Austin Moore and Thompson-prostheses. These uncemented stems have smooth-surfaced structures and shapes which are anatomically adapted to the medullary canal of the femur. The second generation group of uncemented prostheses uses the concept of bony ingrowth providing micro-anchoring of the stem in the femoral medullary canal. The PCA, Harris-Galante and AML prostheses are examples of this type with the surface structure for bony ingrowth.

key words : uncemented hip prosthesis, Link ribbed system, bipolar endoprosthesis, macro-anchoring, microporous
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The Link ribbed hip prosthesis is made of Ti-Al-V alloy, which has good biocompatibility, excellent mechanical strength and a low modulus of elasticity\(^6\). The stem is anatomically adapted to the medullary canal of the femur and has characteristic deep grooves on its surface to attain macro-anchoring in the proximal femur (Fig. 1)\(^10\). The Link ribbed hip prosthesis was originally expected to achieve tight fixation just by so-called macro-anchoring even with a smooth-surfaced structure, but recently a micro-porous (bony ingrowth) surface structure has been added to this cementless hip prosthesis. In the present study, we compared clinical and radiological results of these different surfaces of uncemented prostheses to assess the effects of microporous surface structure for implant fixation.

**MATERIALS AND METHODS**

**Patients and surgical technique:** From 1993 to 1998, 35 endoprosthesis implantations were performed in 31 patients (13 men and 18 women) using uncemented Link ribbed hip prostheses (Waldemar Link GmbH & Co, Hamburg, Germany). The mean age of the patients was 52.0 years (range 29 to 76) at the time of the operation. Endoprostheses implantations were indicated by idiopathic osteonecrosis of the femoral head in 23 hips of 19 patients, osteoarthritis in 7 hips of 7 patients and fracture of the femoral neck in 5 hips of 5 patients. Smooth-surfaced femoral stems were used in 9 hips of 8 patients (S group) before 1994. After January 1994, 26 hips of 23 patients were implanted with microporous surfaced stems, of which the proximal three fifths was covered with a 70 μm porous structure (M group). We used a 135° CCD angle stem in combination with a bipolar cup for all cases in both groups. We also used the stem collar, but did not use lag screws for the stem shoulder. The average follow-up period was 5.2 years for the S group and 3.6 years for the M group. Surgery was

![Fig. 1. Link ribbed hip stem](image-url)

a. Smooth-surfaced stem
b. Microporous-surfaced stem
chiefly performed through the posterolateral approach. An attempt was always made not to damage the longitudinal bone ribs which were formed in the medullary cancellous bone, during the broaching procedure. Cancellous bone from the resected femoral head was grafted between the ridge of stem ribs when cancellous bone ribs in the proximal medullary canal were damaged at broaching. The patients were mobilized on the third post-operative day with a continuous passive motion device, but remained non-weight-bearing until after the 4th postoperative week. Full weight-bearing was then permitted 4 weeks later.

**Clinical and radiographic evaluation:** Pre- and postoperative clinical findings were evaluated using the Japanese Orthopaedic Association (JOA) score\(^{12}\). Proximal femoral pain at the start of ADL or after long periods of walking was recorded as thigh pain. Canal filling ratio of the stem was evaluated, using antero-posterior and lateral radiographs, at 1 cm under the lesser trochanter, 1 cm above the stem tip and at the middle of those two planes. The mean canal filling ratio was the average of the ratios of 6 points at these 3 planes which can show good anatomically-adapted stem fixation to the medullary canal of the femur. The location of reactive lines at the bone-implant interface was assessed according to the zonal criteria proposed by Gruen, et al, for radiological evaluation\(^{3}\). The resorptive bone remodeling changes of the proximal portion of the femur (calcar lesions) and the formation of sclerotic bone below the stem tip (pedestal) were also recorded in the radiological evaluation. Subsidence of the implant was assessed by measuring the distance between the top of the greater trochanter and the shoulder-like portion of the prosthesis, and subsidence greater than 2 mm was considered as significant.

**Statistical analysis:** Data were analyzed by simple regression analysis and Pearson's correlation coefficient. P-values less than 0.05 were regarded as significant.

**RESULTS**

**Clinical evaluation:** As for the pre- and postoperative JOA scores, with the exception of

![Fig. 2. Appearance rate of reactive lines in 14 zones](image)
those for the 5 femoral neck fracture cases, a significant improvement of JOA score was found both in the S group (from an average score of 53.3 points to 85.9 points) and in the M group (from an average score of 56.5 points to 87.6 points). There was no statistically significant difference in improvement of JOA scores between the two groups. Thigh pain was observed in 2 hips in the S group (22.2%) and in 6 hips in the M group (23.1%) 6 months after surgery. In most cases, this pain disappeared by one year postsurgery, but continuous pain after a long period of walking was observed in 1 hip in each group at this point.

**Radiographic evaluation:** Reactive lines around the femoral component were frequently observed at zones 1 (66.7%), 4 (88.9%) and 11 (88.9%) in the S group and zones 4 (56.3%) and 11 (43.8%) in the M group (Fig. 2). The cumulative appearance rate of reactive lines in all 14 zones was 54.6% in the S group and 13.7% in the M group, and a statistical difference was observed between the two groups (Fig. 3, p<0.05). Two hips in the S group showed reactive lines around the entire bone implant interface (Fig. 5a); and one stem of S group showed subsidence. The mean canal filling ratio was 0.74 in the S group and 0.81 in the M group on anteroposterior radiographs and 0.57 in the S group and 0.67 in the M group on lateral radiographs. There was no statistically significant difference in the mean canal filling ratio between the two groups. Correlation between the cumulative appearance rate of reactive lines and mean canal filling ratio of the stem was sought using all 35 hips. A significant negative correlation was observed between the cumulative appearance rate of reactive lines and mean canal filling ratio (p<0.001, Fig. 4). Bone sclerosing at the stem tip (pedestal) was found in all 9 hips in the S group (Fig. 5b), but in only 1 hip (3.8%) in the M group. Bone resorption in the proximal part of the femur was observed in 1 hip (11.1%) in the S group and 5 hips (14.3%) in the M group; however, all of these hips showed

![Fig. 4. Correlation between the mean canal filling ratio and the cumulative appearance rate of reactive lines. Significant negative correlation was observed between the two parameters (rs=0.711, p<0.0001).](image-url)
rounding off of the femoral neck, which suggested a low grade of stress-shielding. Osteolysis was observed in one case in the M group during the present follow-up period. One patient of the M group had a bipolar cup revised due to the breakage of a polyliner by accident.

**DISCUSSION**

The present data indicate good early- through middle-term clinical results using the Link ribbed hip prosthesis. There were no stem revisions during the postoperative follow-up period averaging 4.0 years. Two types of prostheses with different surface structures were used in our facility. They have the same shape which is anatomically adapted to the femoral medullary canal, and the microporous stem has a porous surface-structure with pore size of 75 μm on its proximal part for bony ingrowth.

In general, it still remains to be determined which is more important for the implant fixation of uncemented femoral prostheses, macro-anchoring (stem shape) or micro-anchoring (surface structure). When these prostheses were introduced to our facility, we expected it to be possible to obtain sufficient fixation with a deep rib structure even in the case of a smooth-surfaced stem. However, recent studies on the clinical results have reported the marked superiority of micro-anchoring over macro-anchoring for the stability of a prosthesis. Osseo-integration of the smooth-surfaced stem has been shown by Lintner, et al.⁴, and they showed that an extensive radiolucent reactive line was not a good sign for stabilization. Indeed, Duparc J., et al. reported that 59 of 203 (29.1%) smooth-surfaced uncemented stems had extensive radiolucentencies, and 22 were unstable at a two-year
radiographic follow-up\cite{1}. Poor clinical results with the smooth surfaced uncemented Link ribbed hip stem has already been reported by Sweetnam, et al.\cite{10} They reported that 7 of 12 patients who had undergone THA with an uncemented smooth-surfaced stem experienced aseptic loosening within five years after the surgery. Savilahti, et al. reported that the survival ratio of the smooth-surfaced stem is 89% at five years and 78% of cases at seven years\cite{9}. Jensen, et al. reported femoral component revision of the smooth-surfaced stem in 17% of cases at 3-year follow-up\cite{3}.

The Link ribbed hip prosthesis is designed to achieve sufficient fixation by a unique macro-anchoring structure on its anatomically shaped stem. However, the significantly high appearance rate of reactive lines in the present study suggests that macro-anchoring of the smooth-surfaced Link ribbed hip prosthesis did not provide permanent stability of the femoral component. In contrast, the cumulative appearance rate of the reactive lines in the M group was only 14.6%, and most of these lines appeared around the stem tip. However, the present study showed that the cumulative appearance rate of reactive lines was higher in the S group than in the M group. The low rate of the appearance of reactive lines in the M group suggests that the micro-porous surface structure is essential for the achievement of both sufficient early stabilization and good osso-integration in this specially-shaped uncemented prosthesis (Fig. 6).

Bone resorption in the proximal femoral portion, which was the result of the stress-shielding phenomenon, was observed in 11.1% of the S group and 14.3% of the M group. The Link ribbed hip prosthesis has a low modulus of elasticity\cite{4,7}, and therefore we expected to avoid stress-shielding phenomenon. Although most of the stress-shielding in this study was low-grade, the appearance rate at an average of 4.0 years after surgery was definitely higher than we had expected.

The Link ribbed hip prosthesis is designed to achieve good initial fixation with a broadened and deeply grooved proximal portion\cite{11}. Petrou, et al. reported that the distal part of the stem has a relatively small diameter in order to avoid press-fitting in the canal which may result in stress shielding in the proximal part of the femur\cite{8}. However, the present result indicated that the cumulative appearance rate of the reactive lines was negatively correlated with the mean canal filling ratio. Therefore, our present policy in the selection of stem size is to choose a sufficiently large size stem to fill the medullary canal of the femur. The present result indicates that a microporous
structure and sufficient canal filling are essential to achieve successful fixation using the Link ribbed hip prosthesis.

CONCLUSIONS

We reviewed clinical results of 35 uncemented bipolar endoprosthesis implantations using a Link ribbed hip prosthesis in 34 patients with an average follow-up of 4.0 years. The clinical evaluation showed good improvement. Radiographic evidence of reactive lines around the stems was more significant in the smooth-surfaced group than in the microporous-surfaced group. Even with the uncemented prosthesis with macro-anchoring, a microporous surface structure and sufficient canal filling are essential to obtain successful stem fixation.

REFERENCES