Original Article

Results in Cementless Total Hip Arthroplasty Using Hydroxyapatite Granules to Fill the Femoral Medullary Cavity

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Since 1988, we have been performing cementless total hip arthroplasty (THA) using hydroxyapatite (HA) granules to fill the femoral medullary cavity around the stem. We evaluated roentgenographic and clinical results in 38 patients (44 hips) who were mean 63.7 years old at the time of surgery and followed up for mean 6.4 years. Stem subsidence was observed in 2hips (4.5%). Radiolucent lines around the stem were observed in zones 1, 3, and 4 however the frequency was relatively low with the value of 13.6% to 18.2% respectively. Furthermore the width was≤1mm, and there was no progression over time and in no case was there radiolucency around the entire stem. Osteolysis around the stem was observed in only1hip in zone 7. The annual wear rate of the polyethylene cup ranged from 0.02 mm to 0.81mm (mean, 0.18 ±0.14mm). The JOA score (mean) improved from 48.5 before surgery to 86.1 at final examination.

Thus radiological assessment as well as clinical interim results of this new procedure was satisfactory as compared with the reported studies.

(key words: cementless total hip arthroplasty, hydroxyapatite granules, radiolucent line, wear rate)

Introduction

In patients undergoing hip replacement, cementless total hip arthroplasty (THA), in which procedure implant fixation is achieved without using bone cement (methylmethacrylate), is now generally performed. Since 1988, we have been performing cementless THA using hydroxyapatite (HA) granules to fill the femoral medullary cavity around the stem to improve femoral stem fixation and reduce the incidence of postoperative implant loosening (Fig. 1). Use of this method in THA has not previously been reported. We now report on our interim results using this procedure.

Patients and Methods

One hundred and four primary cementless THA had been performed in 92 patients between 1988 and 1997. We used hydroxyapatite (HA) granules to fulfill the medullary canal around the

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Table wear of THA

Study	Number of hips	Femoral head	Diameter (mm)	Average linear wear rate (mm/year)	Coment	implant
Livermore (1990)	227	SS	22	0.13	X ray	
Livermore (1990)	97	SS	28	0.08	X ray	
Kabo (1993)	23	CoCr	28	0.23	Direct	
Bankston (1995)	54	CoCr	28	0.10	X ray	cemented (metal-back)
Bankston (1995)	?		28	0.08	X ray	cemented (nonmetal-back)
Callaghan (1995)	?			0.07~0.14	X ray	
Devane (1995)	141	CoCr	26	0.15	computer	PCA (cementless)
Nashed (1995)	74	CoCr		0.17	X ray	Harris-Galante (cementless)
Woolston (1995)	80	CoCr	28	0.14	X ray	Harris-Galante (cementless)
Sychterz (1997)	96	CoCr	32	0.09	X ray	
Shaver (1997)	43	CoCr	28	0.09	computer	Cemented (metal-back)
Martel (1997)	25	CoCr	0.21		computer	Harris-Galante (cementless)

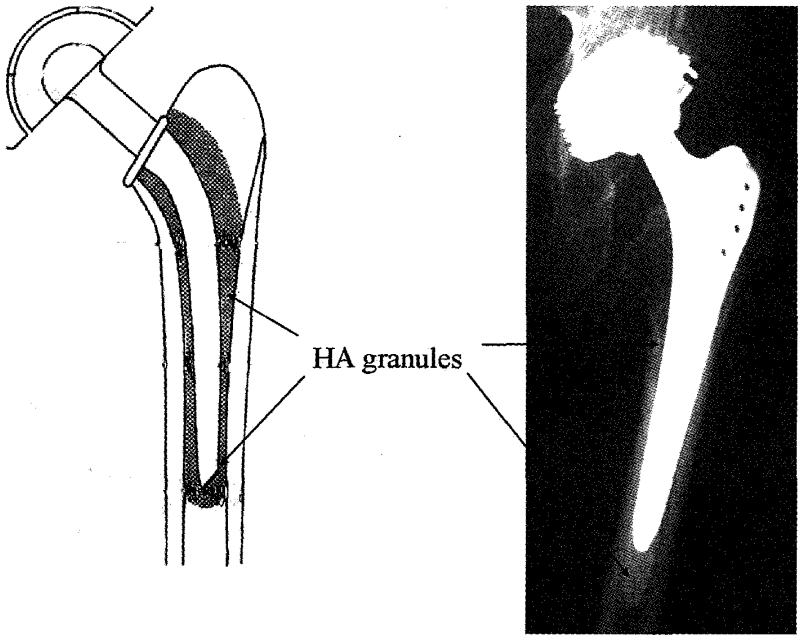

Figure 1.

femoral stem for all cases except three severe osteoporotic patients. Six patients (8hips, 8%) died before our review and 45 patients (49hips, 47%) were lost to follow-up. These left 38 patients (44hips) who were followed for more than 3 years.

The age range at the time of surgery was 54 to 76 years (mean, 63.7 years), and the follow-up period ranged from 3 to 12 years (mean, 6.4 years). The indication for surgery was degenerative arthritis in 31hips (28 patients), aseptic necrosis of the femoral head in 3hips (3 patients), and rheumatoid arthritis in 10hips (7 patients). The implant was a Zweymuller prosthesis in 28 hips, Kirschner prosthesis in 14hips, and Harris-Galante prosthesis in 2hips. In the Zweymuller prosthesis, the stem has grit-blasted surface. In the Kirschner and Harris-Galante prostheses,

the anterior, medial and posterior portion of proximal stem has porous-coated surface.

The femoral heads were made of cobalt-chromium (CoCr) alloy, with diameters of 22mm, 26 mm, and 28mm. The surface of all the acetabular components was polyethylene (ultra high molecular weight polyethylene).

After the reaming and rasping of the medullary canal of the femoral stem, five grams of HA granule sized 1-2mm in diameter and five grams of 2-4mm in diameter granule (Boneceram-P, Sumitomo pharm,Inc. Tokyo, Japan) were filled in the cavity. Then, we performed the reaming and rasping again, for safe insertion of the real femoral stem. After the insertion of the femoral stem, we washed the joint thoroughly with saline of 5 litters or more, and meticulously removed the excessive granule of HA outside of the femoral canal.

X-ray studies were performed periodically after surgery until final examination. We evaluated the subsidence of the stem (≥2mm), radiolucent lines around the stem (≥1mm), bone atrophy and hypertrophy, pedestal formation,[1),2)] and osteolysis in each Gruen zone (Fig. 2).[7)] Evaluation of the acetabular component included cup migration and radiolucent lines around the cup(≥1mm) and osteolysis in each zone (Fig. 2).[8)]

To clarify the polyethylene cup wear, frontal X-rays were scanned with a film scanner (Epson, Nagano, Japan). Using a computer,with a picture analyzing softwear (MiniCad, A&A Co., Tokyo, Japan) the coordinates for the cup center and femoral head center were calculated, and displacement of the femoral head center relative to the cup center was measured to determine linear wear. This value was divided by the number of years of follow-up to calculate the linear wear per year (Fig. 3).

Joint function were evaluated by the Japanese Orthopedic Association's scoring system (JOA score)

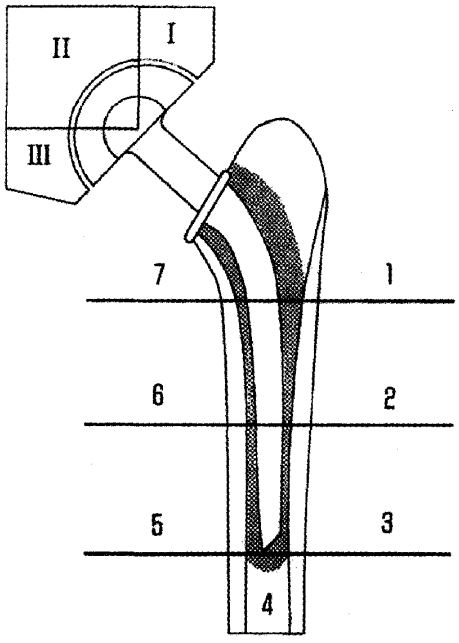

Figure 2. Femoral and acetabular zones

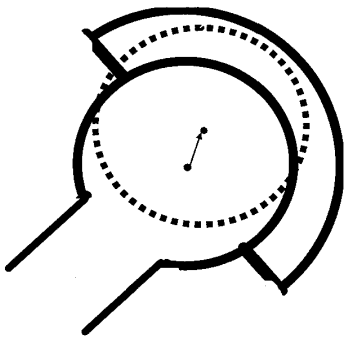

Figure 3. Computer measurement of displacement of center of the femoral head relative to center of acetabular component.

Results

Stem subsidence was observed in 2hips (4.5%) (2mm and 3mm). This stopped within 1 year, with no progression over time.

Radiolucent lines around the stem were observed in zones 1, 3, and 4 in 6 to 8hips (13.6% to 18.2%) (Fig. 4). In no case was there radiolucency around the entire stem. The width was ≤ 1mm, and there was no progression over time.

Bone atrophy around the stem was observed in zone 1 in 35hips (79.5%) and in zone 7 in 29 hips (65.9%). Thus, bone atrophy occurred often in the proximal femur (Fig. 5). Bone hypertrophy around the stem was observed in zone 3 in 14hips (31.8%) and zone 4 in 10hips (22.7%). Thus, bone hypertrophy occurred relatively often in the distal femur (Fig. 6).

Pedestal formation was noted in 2hips, but there was no medullary expansion or radiolucent lines in the distal stems. The implants were stable.

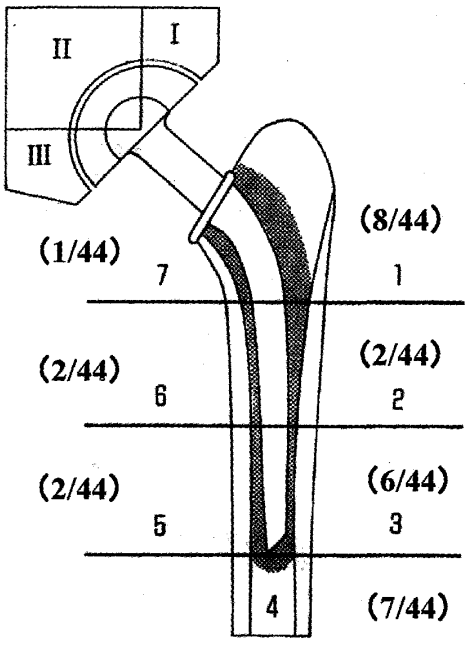

Figure 4. Radiolucent lines around the stem

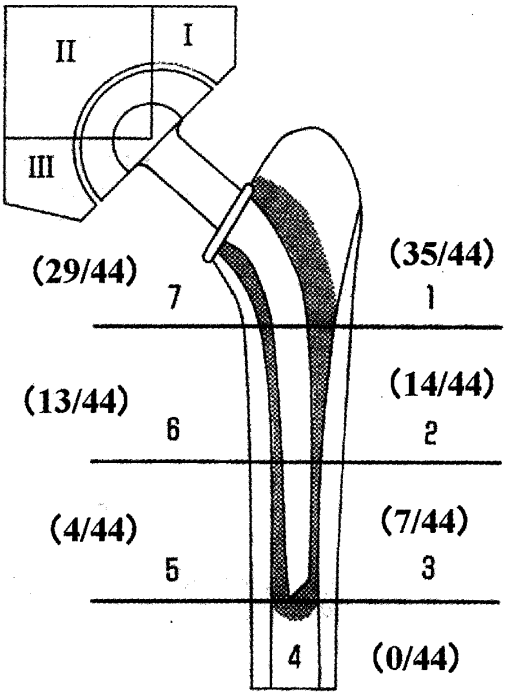

Figure 5. Bone atrophy around the stem

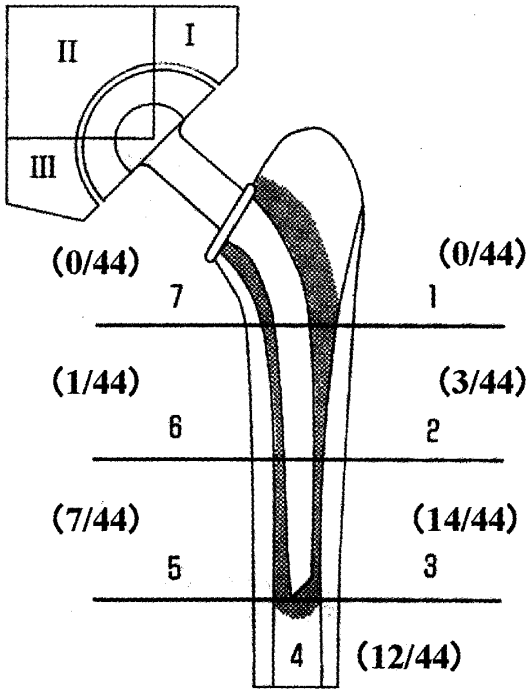

Figure 6. Bone hypertrophy around the stem

Osteolysis around the stem was observed in only 1 hip in zone 7.

There was no cup migration in any hip. Radiolucent lines were noted around the cup in zone 1 in 7hips (15.9%), zone 2 in 3hips (6.8%), and zone 3 in 6hips (13.6%). The findings were

partial, without progression, and≤1mm in each case. There was no osteolysis around the cup.

The JOA score (mean) improved from 48.5 before surgery to 86. 1at final examination. Postoperative thigh pain occurred in 4hips (9.1%), but symptoms disappeared in all cases within 1 year.

The annual wear rate of the polyethylene cup ranged from 0.02mm to 0.81mm (mean, 0.18 (0.14mm).

There was no implant loosening in any hip on final examination, and hip replacement has not been required to date for implant loosening.

Discussion

Hidroxyapatite has some characteristic advantages such as ability of bone conduction and strong stiffness compared with cancellous bone.[19),20)] From these characters, we expected the rigid fixation of the femoral stem immediately after the stem insertion, and also we expected the avoidance of the subsidence of the stem and loosening during postoperative period. We began filling the femoral medullary cavity with HA to improve stem fixation and reduce the incidence of loosening. The potential disadvantage is that if the HA granules impinge on the articular surface, polyethylene wear may increase and thus lead to osteolysis.[22)] In addition, fracture of the femur may occur during stem insertion. In some of our earlier patients, fractures did occur during stem insertion, but since improving the procedure by rasping again after filling with HA granules, we have been able to avoid fractures. No fractures occurred in the present series of cases.

We compared whether stem fixation was improved by filling the femoral medullary cavity with HA granules to previously reported studies. The incidence of radiolucent lines around cementless stems in previous studies includes: 50to 70% in zones 1 and 4 over an 8-year follow-up in Harris-Galante type cementless THAs (Matsumoto et al.[4]),40 to 60% in zones 1, 3,4, and 5 during a 7.3-year follow-up in Harris-Galante type cementless THAs (Saito et a l.[5]), 55.6% in zone 4 over a 8.3-year follow-up in cementless THAs (Kato et al.[3]),and 88% in zone 4 over a 5-year follow-up in PCA cementless THAs (Heekin et a l.[6]). In our study, radiolucent lines also tended to be more frequent in zones 1,3, and 4. However, the incidence of radiolucent lines was low at 13.6 to 18.2%.

Roentgenographic assessment criteria described by Engh et al. [1),2)] for cementless stems that are stable without loosening include:<1>no subsidence≥2mm, or if present, that stops within 1 year;<2>radiolucent lines around the stems of≤1.5mm and without progression;<3>no pedestal sign, or if present, no medullary expansion in the distal stem and no progression of radiolucent lines;<4>bone atrophy in the proximal femur; and<5>densification (spot welds) at the distal extent of the porous coating. In the present study, we could not evaluate<5> because of filling with HA granules, but all our cases met criteria<1>to<3>. Regarding<4>, we also observed bone atrophy of the proximal femur in a large number of cases (zone 1, 35 hips [79.5%]; zone 7, 29hips [65.9%]). Our findings confirmed "no definite loosening" of the stems, and to date, repeat surgery has not been required in any hip. Thus, our surgical procedure may contribute to improved stem fixation. However, the mean period of follow-up

has only been 6.4 years, and we have not compared standard techniques with the same implant types. Therefore, we have to reserve a final decision on the results.

We also evaluated whether our surgical procedure increased polyethylene wear. The annual linear wear rate for polyethylene in acetabular components in previous studies (see Table) ranged from 0.07 to 0.21mm.[9),10),11),12),13),14),15),16),17),18)] In our study, the annual linear wear rate measured by computer was 0.18mm (mean). This value was within the range reported in previous studies and comparable as evaluated radiologically with a computer. Thus, increase in polyethylene wear by the use of apatite was not observed. Also, osteolysis of the stem was noted in only 1 hip, which is further indirect evidence of the absence of significant polyethylene wear.

X-ray assessment of the acetabulum was satisfactory. The results were similar to those previously reported for sockets with cementless fixation. 22 Thus, our surgical procedure may have no effect on osteolysis in the acetablum.

New-designed femoral implants, which give sufficient fixation without HA granules, have been developed and came into clinical use nowadays. So, indication of THA using HA granules may be limited in usual surgical treatment of hip disorders, and we do not use this technique at present time. However, for some cases in which femoral shaft has a huge medullary cavity, or unusual shape, and in case of revision THA with structural bone defect, we believe our technique using HA granules is non-invasive to these patient and very useful method to obtain early stability of the stem.

Conclusion

We evaluated the results of using hydroxyapatite granules in cementless THA in 38 patients (44hips).

1) Clinical results were good; there were no significant radiolucent lines around the stems.
2) The use of HA did not increase polyethylene wear of the acetabular component.
3) Therefore, our surgical technique of using HA granules to fill around the femoral stem may improve long-term outcomes in THA.

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ハイドロキシアパタイト顆粒を大腿骨髄腔に充塡使用したセメントレス人工股関節手術の成績

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要　約

当教室では1988年よりハイドロキシアパタイト顆粒を骨髄腔内ステム周囲に充塡使用するセメントレス人工股関節手術を行ってきた。今回平均6.4年経過した38例44股関節（手術時平均63.7歳）についてX線評価と臨床成績の評価を行った。

subsidenceは2股4.5%に認めた。Radiolucent lineはゾーン1,3,4で13.6%～18.2%に認めたが，いずれもステム周囲全周には及ばず，経時的に拡大しなかった。osteolysisは1股のみに認めた。カップのポリエチレンの摩耗は年間0.18±0.14mmであった。JOAスコアは，平均で術前48.8点，最終観察時86.1点であった。

ステム周囲のRadiolucent lineの出現が少なく，臨床成績も良好であった。臼蓋ポリエチレンの摩耗がHAの使用により増加することはなかった。この方法はTHAの長期成績を向上させる可能性がある。

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