

## 수산화 인회석 피복 비구컵의 조기 방사선학적 해리 소견

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**목적:** 수산화 인회석 피복 비구컵을 이용한 인공 고관절 전치환술 후 실패를 조기에 판단할 수 있는 방사선학적 및 임상적 소견을 알아보기 위하여 이 연구를 하였다.

**대상 및 방법:** 1992년 4월부터 1996년 11월까지 수산화 인회석 피복 비구컵을 이용하여 인공 고관절 전치환술을 시행한 204예 중 재치환술을 시행한 41예를 연구 대상으로 하였다. 재치환술을 실시한 41예의 방사선사진에서 비구컵 주위 방사선 투과성선, 비구컵 각도 변화를 관찰하였다. 비구컵의 해리는 방사선 사진에서 2 mm이상의 전위나 5도 이상의 각 변화가 있을 때 또 수술 소견상 비구컵의 움직임이 있을 때로 정의하였다.

**결과:** 41예 중 12예에서 비구컵 주위 방사선 투과성선이 관찰되었으며, 술 후 평균 55.4개월에 제 3영역에서 가장 많이 관찰되었다. 방사선 투과성선이 관찰된 12예 중 8예는 방사선 추시상 해리가 발생하였으며, 4예는 수술 소견상 해리이었다. 방사선학적 해리는 방사선 투과성선이 처음 관찰된 후 평균 28.8개월에 발생하였다. 서혜부 동통은 비구컵 해리로 재치환술을 실시한 19예 중 18예에서 관찰되었다.

**결론:** 비구컵 주위 진행성 방사선 투과성선은 수산화 인회석 피복 비구컵의 실패를 조기에 판단 할 수 있는 가장 중요한 방사선학적 소견이었다.

**색인 단어:** 인공 고관절 전치환술, 수산화 인회석 피복 비구컵, 해리, 조기 방사선학적 소견

### INTRODUCTION

Hydroxyapatite (HA) was initially utilized in total hip arthroplasty (THA) because of its osteoconductivity and biocompatibility<sup>1,2,5)</sup>. When HA coating is used on prosthesis, bone apposition occurs quickly without the formation of a fibrous interface<sup>4,13)</sup>.

Tonino<sup>4)</sup> reported that all of the HA-coated cups showed bone ongrowth, with a mean bone-implant contact of  $36.5\% \pm 13.5\%$  using histological and histomorphometric analysis of the six cups retrieved at autopsy. But clinical results of HA coated acetabular cups varied depending on the surface texture, properties of HA, and the thickness of the coating. The results of the

microstructure surface HA-coated acetabular cup were disappointing<sup>8)</sup>. A high rate of debonding and failure of a grit-blasted acetabular cup were reported<sup>11)</sup>. We have experienced a high rate of early revision of HA-coated cups. The purpose of our study is to evaluate radiographic findings and clinical signs of the failed microstructure surface HA-coated acetabular cup.

### MATERIALS AND METHODS

From April 1992 to November 1996, 204 primary total hip arthroplasties were performed in our hospital, with 142 hips available for post-operative follow-up examinations. This study included 41 revisions of THA. The cause of THA of the 41 revised hips were avascular necrosis in 31 hips, primary osteoarthritis in 8 hips, traumatic osteoarthritis in 1 hip and tuberculous coxitis in 1 hip. All THAs used HA-coated cups from ABG (Anatomical Benoist Giraud, Howmedica, UK).

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The acetabular cup is hemispherical and made of titanium alloy coated with HA. The HA coating was applied with a vacuum plasma-spray torch on pure titanium. The HA coating had the following characteristics: >75% crystallinity, <10% porosity and 60micron( $\pm 20$ ) thickness (Fig. 1). Cobalt chrome femoral heads were 28mm in 39hips and 22mm in two hips. Postelateral approach was used in all patients. Thirty-four hips achieved initial mechanical stability by line to line fixation, but seven hips required screws to achieve stability. Partial weight bearing was allowed immediately postoperatively with crutches. All patients were evaluated postoperatively at 3, 6, 12 months and then once year. Clinical results were evaluated using Harris hip score and inguinal pain. Immediate postoperative radiographs showed an average of 2.1mm gap between cup and bone in 25 hips. This gap appeared most commonly in Delee and Charnley<sup>3)</sup> zone I. The gap had almost disappeared 3~6 months postoperatively. Acetabular cup loosening was defined as migration of more than 2mm or change in the cup angle by more than 5 degrees as determined by serial radiographs. Radiolucent line was defined as a line appearing around the acetabular cup where no gap was initially noted or after the initial gap had disappeared. The radiolucent line was defined as progression when the line extended into another zone and/or an increased in width as determined by serial radiographs. The width of the initial gap and radiolucent line was measured using



Fig. 1. The ABG hydroxyapatite-coated cup.

digimatic calipers (Mitutoyo, Tokyo, Japan). Osteolysis was identified according to the three zones described by Delee and Charnley<sup>3)</sup>. Polyethylene wear was measured using the Livermore method<sup>7)</sup>.

Until January 2002, forty-one microstructure acetabular ABG<sup>®</sup> cups were revised. Twenty cups were revised for polyethylene wear and osteolysis, 19 cups for loosening, and 2 for recurrent dislocation. Revision occurred at an average of 68.8 months (21-115 months) after primary operation. Every socket was checked for stability of fixation before removal. Intraoperatively, the acetabular cup was defined as loosening if any movement occurred at the bone and socket interface by manual rotation and extension force. The HA-coated acetabular cups were removed by applying outward blows with a sliding mallet without difficulty. Even when the cups were fixed by bone ongrowth, removal was easily accomplished and required no special instruments. The revised cups were evaluated for bone ongrowth, resorption of HA and back side deformity of the polyethylene liner.

We performed statistical analysis using the chi-square test.  $P < 0.05$  was considered significant.

## RESULTS

Loosening occurred in 11 of 25 hips with an initial gap, but it was not significantly associated with loosening ( $P > 0.05$ ).

Inguinal pain was noted in 18 of the 19 hips revised for loosening, and also in all 12 hips where radiolucent lines were observed on radiographs around the acetabular cup. Loosening occurred after acute onset of inguinal pain in 4 hips where no loosening was noted on radiographs during follow-up examinations.

The radiolucent line was observed in 12 of the 41 hips at an average of 55.4 months postoperatively. Ten of 12 radiolucent lines were located in zone III and two in zone II. The 12 hips showing radiolucent lines were classified as loosening by radiographs in 8 hips and intraoperatively in 4 hips. Radiographically detected loosening occurred at average of 28.8

months after the appearance of a radiolucent line. A radiolucent line around the acetabular cup had a high correlation with cup loosening ( $P=0.0001$ ).

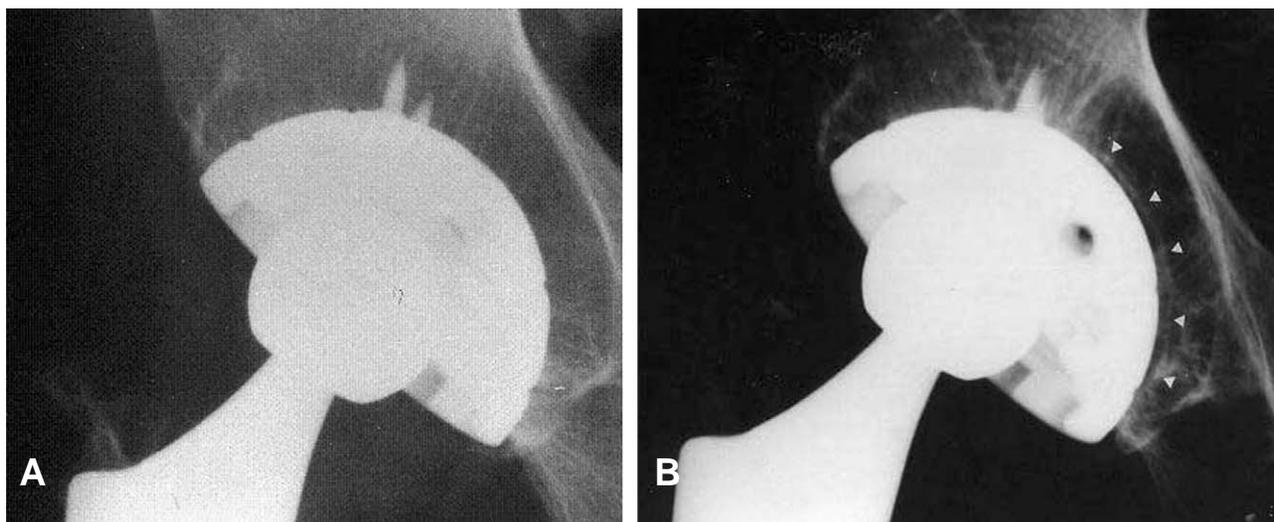
Osteolysis was noted in 28 of 41 hips and was located most commonly in zone II. Polyethylene liner wear was an average of 0.38mm/year. Backside deformity was seen in all retrieved polyethylene.

Very limited bone ongrowth was observed in 29 of 41 revised cups. No bone or soft tissue ongrowth was observed in 12 of the 19 hips revised for loosening. All retrieved cups showed HA absorption.

## DISCUSSION

We performed 204 primary THAs from 1992 to 1996 and followed up 142 hips. We revised 41(28.8%) of the 142 acetabular cups for a variety of reasons. We revised 19 (13%) hips for aseptic loosening. The revision rate of our study (28.8%) is higher than other reports of cementless THA with HA-coated prostheses<sup>6,9,15</sup>. Tonino<sup>15</sup> reported that three cups were revised for technical reasons before the 2-year assessment, but no components required revision after 2 years. Giannikas<sup>6</sup> reported that only one acetabular cup was revised for malposition in an average of 4.8years after implantation. They<sup>6,9</sup>

reported that all components achieved osteointegration and did not revise any for mechanical loosening during medium-term follow-up. But Manley<sup>8</sup> reported that after a minimum follow-up of five-years, 21 (11%) of the 188 HA-coated press-fit cups had been revised because of aseptic loosening. Manley<sup>8</sup> found that the HA-coated press-fit cup could not sustain the tensile stresses that were imposed between the cup and the bone by the daily activity of the patient and suggested that physical interlocking between the cup and the supporting bone may be a prerequisite for long term survival. Also Reikeras and Bunderson<sup>11</sup> reported a high failure rate after THR with HA-coated acetabular cup. We observed that the HA-coated acetabular cup was stabilized by osteointegration within a short period after surgery. But at the last follow-up, loosening occurred even in the cups which showed osteointegration. Also, nineteen cups revised for loosening showed osteointegration on radiographs in an initial period after surgery (Fig. 2). Røkkum<sup>12</sup> reported that HA-coated cup loosening occurred after the cup had functioned painlessly and shown extensive bony ongrowth as demonstrated radiologically. Manley<sup>8</sup> reported that out of the 156 HA-coated press-fit cups, thirteen (8%) were classified as unstable. All of the HA-coated press-fit components that were classified as unstable at the most recent



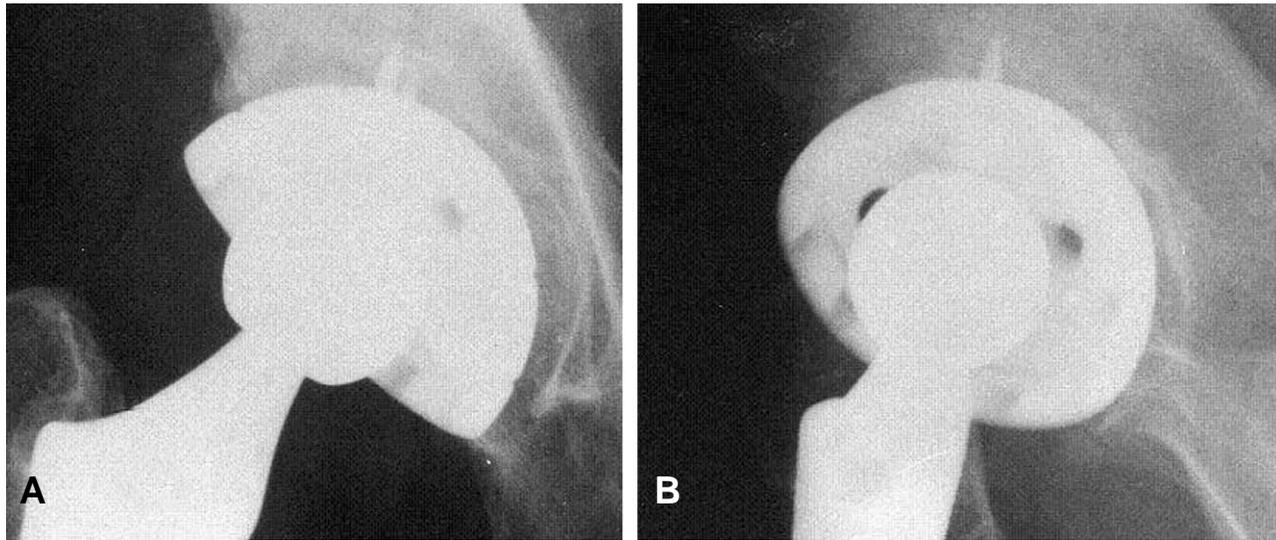
**Fig. 2.** (A) Radiograph at 2 years after total hip arthroplasty for osteonecrosis of the femoral head shows a well osteointegrated cup. (B) At 10 years after surgery, the cup is revised for loosening.

evaluation had been classified as stable with osseous ongrowth at the previous follow-up interval. We think that the HA-coated ABG<sup>®</sup> prosthesis without a mechanical interlock between bone and cups will not survive for long-term follow-up.

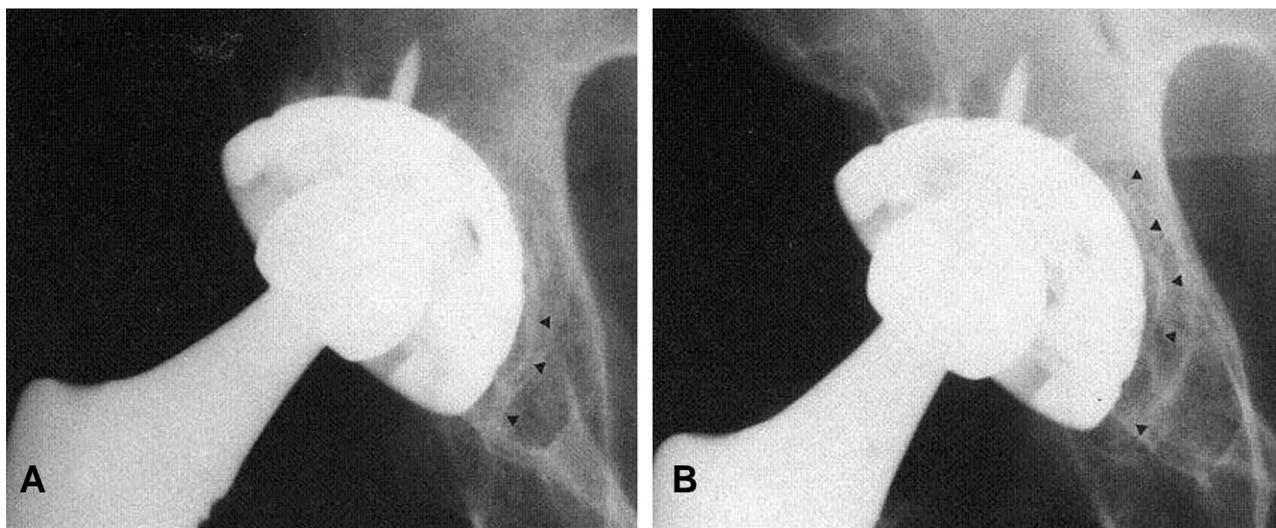
We reviewed the medical records of the revised 41 hips. Eighteen of the 19 hips defined as loosening had inguinal pain, with most of them experiencing chronic inguinal pain. Four hips with acute pain were immediately examined radiographically and found to have loosening. In the report by Reikeras and Gunderson<sup>11)</sup>, sudden

pain was associated with a complete change in position of the cup. In our study, all of the 12 hips seen radiolucent lines on radiographs experienced inguinal pain. If a patient who is pain free for several years after primary THR complains of inguinal pain, we should be concerned about the mechanical loosening and observe the patients closely.

Manley<sup>8)</sup> reported that progressive radiolucet lines seen in zone III adjacent to HA-coated press-fit cups might be the radiographic manifestation of the predicted mode of failure. Conversely, the lack of radiolucent lines in the HA-coated



**Fig. 3.** (A) The radiolucent line is not visible on the anteroposterior radiograph. (B) The radiolucent line can be seen easily on oblique view.



**Fig. 4.** (A) The radiolucent line (arrow heads) shows in zone III at 6 years after operation. (B) The radiolucent line (arrow heads) extended to zone II and increased in width.

threaded cups may mean that mechanical interlocking has prevented such failure. In our study, radiolucent lines adjacent to cups were observed in 12 of the 19 hips defined as loosening. In ten of the 12 hips, radiolucent lines were located in zone III. Radiolucent lines can be observed more easily on oblique views than anteroposterior views (Fig. 3). Radiolucent lines that were not detected on anteroposterior views were clearly seen on an oblique view. So we now routinely check the oblique view. These progressively increased in width and length and extended into the adjacent zone. Most of the radiolucent lines were initially seen in zone III but subsequently extended to zone II (Fig. 4). We think that the appearance of radiolucent lines in zone III marks the beginning of a failure of the HA-coated acetabular cup. Radiological loosening occurred following the appearance of radiolucent lines. A radiolucent line observed adjacent to HA-coated cup demonstrates a debonding between the bone and cup. Debonding that initially occurred in zone III progressed to the adjacent zone and the debonded cup ultimately failed by physiologic load. Rapperport<sup>10)</sup> reported that continued application of physiological loads will cause motion and distraction between the components and the osseous structures beneath it, and that progressive loosening at the interface and failure of fixation may occur. We found that the extent of bone ongrowth of the HA-coated cups was very scant and HA absorption was occurred in all cups. We suppose that scant bone ongrowth and HA absorption may be the main causes of the failed HA-coated acetabular cup, but we need more study to find fundamental causes of a failure of the HA-coated cup.

## CONCLUSION

The progressive radiolucent line was the first most important radiographic finding for detection of a failure of the HA-coated cup. We recommend that very close observation and concern about a revision arthroplasty when progressive radiolucent line is seen on radiographs, especially when

combined with sudden onset inguinal pain.

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ABSTRACT

## Early Radiographic Loosening Findings of the Hydroxyapatite-coated Acetabular Cup

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**Purpose:** The purpose of our study is to examine early radiographic findings and clinical signs of failure of the microstructure surface HA-coated acetabular cup.

**Material and methods:** This study included 41 revisions of 204 THA with hydroxyapatite-coated acetabular cup from April 1992 to November 1996. Radiolucent line around cups, change in the cup angle and osteolysis were evaluated in serial radiographs. Acetabular cup was defined as loosening if any movement occurred at the bone and socket interface by manual rotation and extension force intraoperatively or migration of more than 2 mm and change of the cup angle by more than 5 degrees in radiographs.

**Results:** The radiolucent line was observed in 12 of the 41 hips at an average of 55.4 months postoperatively and was most commonly located in zone III. All of the 12 hips showing radiolucent lines were classified as loosening by radiographically in 8 cases and intraoperatively in 4 cases. Radiographic loosening occurred at an average of 28.8 months after the appearance of a radiolucent line. Inguinal pain was noted in 18 of the 19 cases revised for acetabular cup loosening.

**Conclusion:** The most important radiographic finding for the early diagnosis of loosening was progressive radiolucent lines, which occurred most frequently in zone 3.

**Key Words:** Total hip arthroplasty, Hydroxyapatite-coated cup, Loosening, Early radiographic findings