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Case report

Histologic evaluation of the bone-ceramic interface of an alumina ceramic cup arthroplasty retrieved after 25 years in vivo

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ABSTRACT

A 47-year-old man underwent ceramic cup arthroplasty when he was 22 years old. Revision total hip arthroplasty was performed 25 years later because of limited range of motion without implant loosening. Histologic examination revealed that the femoral head and ceramic implant were well fixed through a thin fibrous membrane. The energy-dispersive X-ray analysis indicated that calcium and phosphorus were detected in the same peak pattern as cancellous bone in the bone-ceramic interface.

Introduction

Smith-Petersen [1] first designed the Vitallium mold cup in 1938. Vitallium mold cup arthroplasty had been one of the standard procedures for hip arthroplasty until the appearance of Charnley's low-friction arthroplasty in the 1960s [2]. Despite the popularity of total hip arthroplasty (THA), limited indications for cup arthroplasty still existed in younger patients to preserve bone stock. Only a few articles have reported follow-up studies of cup arthroplasty and revision THA after cup arthroplasty [3-9]. However, all of these articles described the Vitallium mold cup (Howmedica, Inc., Rutherford, NJ). In 1980, the alumina ceramic cup was developed in Japan (Kyocera Corp., Osaka, Japan) and substituted for the Vitallium cup. Unfortunately, this alumina ceramic implant could not be popularized, and only 98 cups were used during quite a short period of usage. In the present case, a well-fixed alumina ceramic cup was revised to THA after 25 years, and the histology of the retrieved bone-ceramic interface was analyzed.

Figure 1. Anteroposterior radiograph of the left hip before revision surgery. Twenty-five years after cup arthroplasty, an alumina ceramic cup (Kyocera Corp.) survived with appropriate cup inclination angle and no varus slipping or shortening of the neck. Severe periarticular heterotypic ossification associated with traumatic brain injury and comminuted pelvic fractures were noted.

This study was approved by the Institutional Review Board of Hyogo College of Medicine, and informed consent was obtained from the patient in the study.

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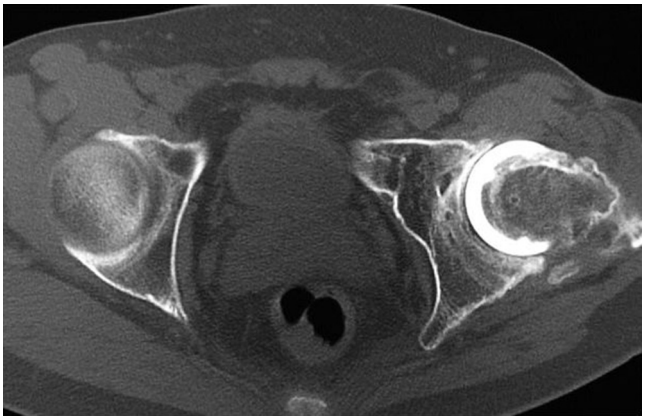

Figure 2. Computed tomography image of the hip joint. The axial image demonstrates that the femoral head and ceramic cup are void of significant gaps.

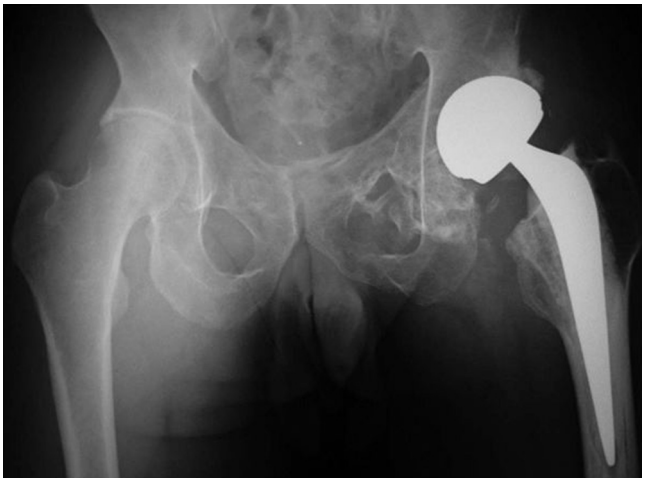

Figure 3. Postoperative anteroposterior radiograph of the left hip. Hybrid revision THA has been performed.

Case history

A 47-year-old man suffered a traffic accident when he was 21 years old. He sustained a dislocation of the left hip with comminuted pelvic fractures and brain injury. He underwent cup arthroplasty with an alumina ceramic cup (Kyocera Corp.) because of posttraumatic osteoarthritis 1 year after the traffic accident. The partial left hemiplegia and spastic gait remained because of brain injury.

Both medical reports and radiographs at the time of injury and primary operation have been lost; however, we were able to interview the original. Surgery was performed with the Smith-Peterson approach. The femoral head was reamed until the subchondral bone was exposed, and the circumference of the head-neck junction was cut cylindrically. After this procedure, the ceramic cup was press-fit to the femoral head. A rehabilitation program was progressed carefully to stabilize the ceramic cup, and a 1-month nonweight-bearing period was followed after surgery.

The patient could cope with daily life without left hip pain after cup arthroplasty despite partial hemiplegia. Twenty-five years after cup arthroplasty, the patient was referred to our institute because of limited range of motion (ROM) of the left hip. During daily living activities, he could walk without left hip pain; however, difficulties such as standing up from the floor due to severely limited ROM of the hip were encountered. Physical examination found stiffness of the left hip, and passive ROM was −30° in extension and 60° in flexion.

Anterior-posterior radiograph (Fig. 1) and computed tomography (Fig. 2) revealed appropriate cup alignment and stable fixation of the ceramic cup. Additionally, severe heterotopic ossification associated with previous comminuted pelvic fracture and traumatic brain injury was revealed around the left hip joint. However, negative radiographic findings, such as varus slipping, sinking and shortening of the femoral neck, were not noted with cup arthroplasty although it had been 25 years since surgery.

Hybrid THA was performed to improve activities of daily life (Fig. 3).

The Hardinge approach and anterior dislocation were used at revision surgery. Dislocation was difficult because of the adhesive scar tissues and heterotopic ossification, which was removed as much as possible. During the revision THA procedure, the ceramic cup was well fixed to the femoral head and it could not be separated by hand. After surgery, ROM improved −10° and 90° in extension and flexion, respectively.

On analysis of the retrieval, a sagittal section with the femoral head and ceramic implant showed a good fixation between the bone and ceramic (Fig. 4). Sections with higher magnification demonstrated tight contact between the fibrous membrane and the adjacent bone because of the presence of an uneven surface (Fig. 5). In the scanning electron microscope (S-3400; Hitachi, Tokyo, Japan) analysis, there was a fibrous membrane with a thickness of 50-300 μm and no direct contact between the bone and the ceramic. Cancellous bone, consisting of the trabecular pattern

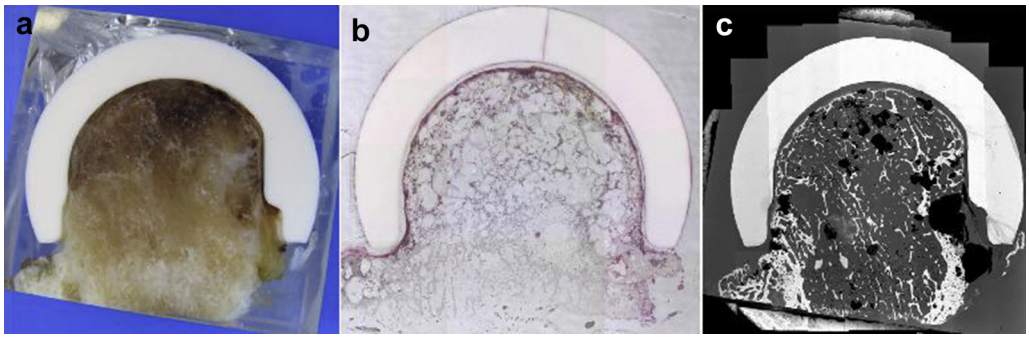

Figure 4. Gross sagittal section of the femoral head and ceramic implant. The femoral head and ceramic implant show good fixation between the bone and ceramic. (a) Gross finding, (b) section of low magnification with hematoxylin and eosin staining, and (c) the scanning electron microscope (S-3400; Hitachi) analysis with low magnification.

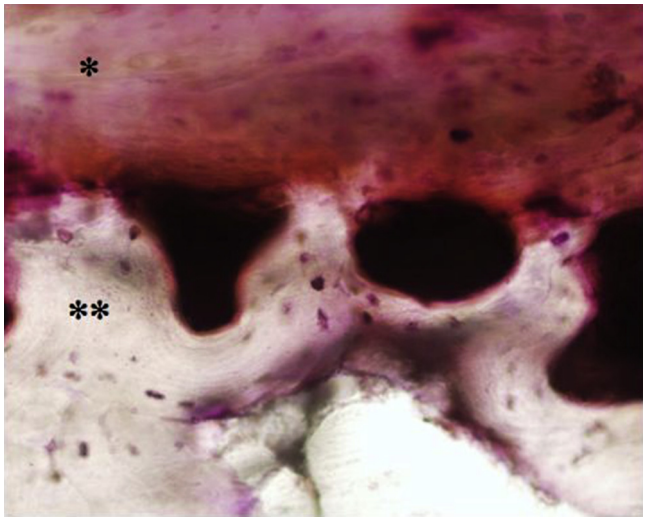

Figure 5. Sections of higher magnification with hematoxylin and eosin staining. The bone-ceramic interface showed a thin fibrous membrane in the red area (*). A section was showing tight contact between the fibrous membrane and adjacent bone (**) because of the presence of an uneven surface.

associated with osteocytes, was seen along the medial side of the fibrous membrane. There was no clear border between the fibrous membrane and bone. However, there was also a white area in the border, which did not include a trabecular pattern (Fig. 6a).

Despite the absence of a trabecular pattern, the energy-dispersive X-ray (EDAX) analysis (Genesis; EDAX, Mahwah, NJ, USA) indicated that calcium and phosphorus were detected to be in the same pattern as that of the cancellous bone (Fig. 6b).

Discussion

Cup arthroplasty was gradually discontinued after the introduction of low-friction arthroplasty by Charnley [2] in the 1960s. However, limited indications for cup arthroplasty continued until the 1990s in Japan. Owing to this, cup arthroplasty was considered to be the bone-conserving procedure, which was the appropriate procedure for younger, active patients with severe hip arthritis.

Only a few articles have reported long-term survivorship of cup arthroplasty [3-8]. Northover and Maqsood [6], Anderson and Gluck [7], and Baker et al.[8] reported the ultra-long-term follow-up of 58, 57, and 62 years for Vitallium mold cup arthroplasty (Howmedica, Inc.). Pan et al. [5] described the long-term survivorship of 77 Vitallium mold cups. They reported that survivorship analysis showed a long-term outcome with a survival rate of 81.6% at 20 years and 59.1% at 30 years. However, negative radiographic findings revealed varus slipping, proximal migration of the cup, and shortening of the femoral neck, which resulted in groin pain and limited ROM in the Vitallium mold cup. On the other hand, there have been no articles describing follow-up studies about alumina ceramic cup arthroplasty.

The alumina ceramic cup was introduced by Kyocera Japan in 1980. The concept of this implant was different from the Vitallium

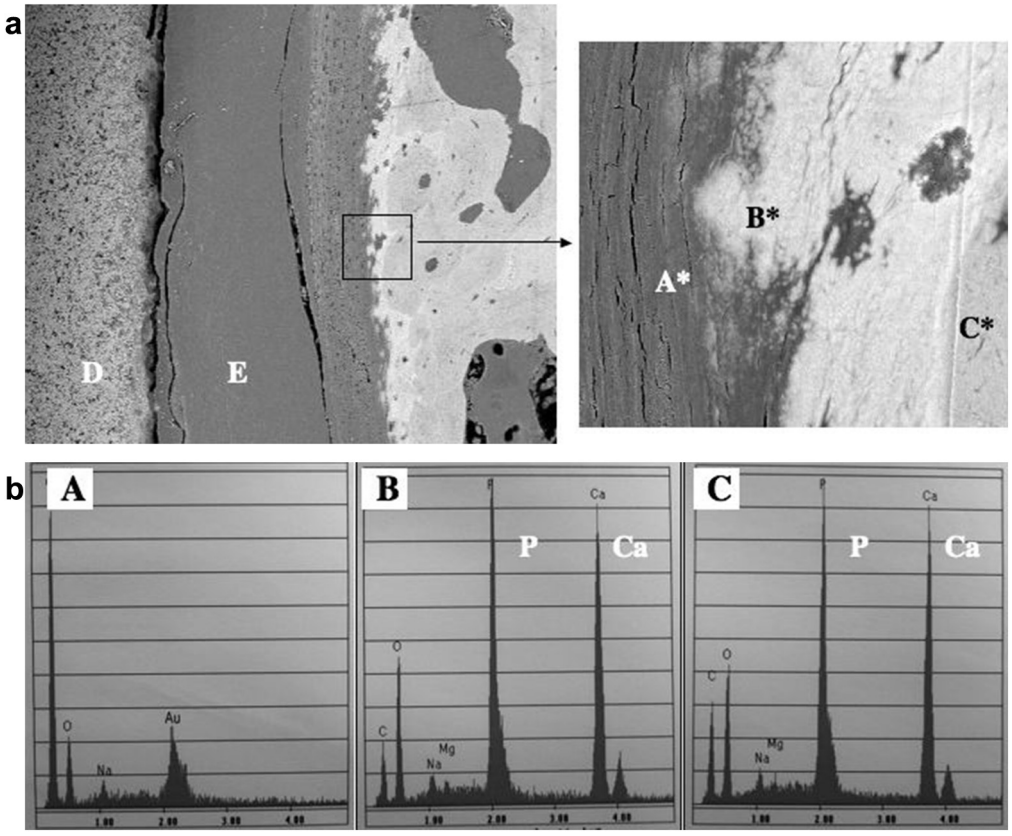

Figure 6. SEM with energy-dispersive X-ray (EDAX) analysis. (a) SEM analysis: there were fibrous membranes with a thickness of 50-300 μm and no direct contact between the bone and ceramic (A*). Cancellous bone, which consisted of the trabecula pattern associated with osteocytes as the biological apatite layer (C*), was seen along with the medial side of the fibrous membranes. There was no clear border between the fibrous membrane and bone, and the fibrous membranes were gradually transferred to the bone. There was a white area in the border, which did not consist of the trabecula pattern (B*). (D) ceramic cup (E) and the space of the artificial slit formation. (b) Energy-dispersive X-ray analysis: the area (B*) indicated that Ca and P were detected to be the same peak pattern as that of the cancellous bone (C*).

cup. The alumina ceramic cup was expected to allow fixation to the femoral head, despite the absence of the hydroxyapatite or porous coating around the implant. The Vitallium cup arthroplasty, on the other hand, was an interposition arthroplasty, which articulated with both the acetabulum and the femoral head. In addition, the Vitallium mold cup was expected to allow mobility on the femoral head [10].

Before the development of the alumina ceramic cup, Kyocera introduced cementless total knee arthroplasty (TKA) with alumina ceramic (KC-1; Kyocera Corp.). This implant consisted of an exclusively alumina ceramic femoral component and ceramic with a high-density polyethylene plate [11]. Ceramic was considered to have excellent osteophilic properties and little tissue reaction [12]; however, sinking and tilting of the tibial plate were reported in short-term results. Tateishi et al. [13] reported 6 cases of revision TKA in 23 rheumatoid arthritis patients who underwent TKA with KC-1. Cementless ceramic TKA could not be popularized because of the poor stability of the bone-ceramic interface. There were inflammatory cells including lymphocytes, macrophage, and osteoclasts in the bone-ceramic interface.

In the present case, revision THA was performed because of a decline in activities of daily living with limited ROM. Regardless of proper cup alignment, limited ROM occurred because of heterotopic ossification. The stability of ceramic cup was observed at the time of revision surgery. In the radiographic evaluation before revision surgery, cup inclination angle was appropriate and shortening of the neck was not observed. Excellent stability of the cup and femoral head, with an interposed fibrous membrane, was seen in the histologic evaluation. We hypothesized that one of the possible reasons for the excellent stability might be the limited ROM caused by the patient's heterotopic ossification. The cup and femoral head were considered to be placed in proper load-bearing conditions. Additionally, a gross finding of the sagittal section with the femoral head and ceramic implant did not indicate any gaps surrounding the femoral head. It was predicted that the fixation of the implant at the time of the primary operation was excellent.

The present case suggests that a ceramic implant might be possible to induce fibrous stable osteointegration. In addition, long-term survivorship may be expected when the cup and femoral head are placed in the appropriate load-bearing conditions. These findings might provide information to develop new concepts and materials for hip arthroplasty in the future.

Summary

An alumina ceramic cup arthroplasty (Kyocera Corp.) was revised to THA after 25 years. Appropriate alignment and stable fixation of the ceramic cup were noted on radiologic examination, and histologic evaluation confirmed that the femoral head and ceramic implant were well fixed through a thin fibrous membrane.

Acknowledgments

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References

[1] Smith-Petersen MN. Arthroplasty of the hip. A new method. J Bone Joint Surg Am 1939;21:269.
[2] Charnley J. Arthroplasty of the hip: a new operation. Lancet 1961;1:1129.
[3] Aufrac OE. Constructive hip surgery with the vitallium mold: a report on 1000 cases of arthroplasty of the hip over 15-year period. J Bone Joint Surg Am 1957;39:237.
[4] Amustutz HC, Dorey F, O'Carrol PF. THARIES resurfacing arthroplasty: evolution and long-term results. Clin Orthop Relat Res 1986;213:92.
[5] Pan HL, Akiyama H, Kawanabe K, Goto K, So K, Nakamura T. Long-term survivorship analysis of hip arthroplasty with vitallium mold cup. J Orthop Sci 2010;15:459.
[6] Northover JR, Maqsood M. 58-year follow-up of vitallium mold hip arthroplasty: a case report and literature review. Acta Orthop 2008;79:731.
[7] Anderson JT, Gluck JL. Vitallium cup arthroplasty: case report of a 57-year follow-up. Am J Orthop 2007;36:50.
[8] Baker JF, Vioreanu MH, Khan HA. Smith-Petersen Vitallium mold arthroplasty: 62-year follow-up. J Bone Joint Surg Br 2011;93:1285.
[9] Ash SA, Callaghan JJ, Johnston RC, Moines D. Revision total hip arthroplasty with cement after cup arthroplasty. J Bone Joint Surg Am 1996;78:87.
[10] Saadat E, Tiberi JV, Burke DW, Kwon YM. Smith-Petersen vitallium mold arthroplasty. Case report with a fifty-one-year follow-up and histopathologic analysis. JBJS Case Connect 2013;3:e112.
[11] Yamamoto S. Total knee replacement with the Kodama-Yamamoto knee prosthesis. Clin Orthop Relat Res 1979;145:60.
[12] Cooke FW. Ceramic in orthopedic surgery. Clin Orthop Relat Res 1992;276:135.
[13] Tateishi H, Iwata Y, Futani H, et al. Clinical experience of ceramic cementless total knee arthroplasty in RA and histological study of bone ceramic interface in revision cases. Bull Hosp Jt Dis 1993;53:35.