



# Ceramic Liner Fracture Caused by an Impingement between the Stem Shoulder and the Ceramic Liner

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Mechanisms of ceramic liner fractures have not yet been fully elucidated. Impingement between a stem and ceramic liner is a proposed cause of ceramic liner fractures. We experienced a case of ceramic liner fracture caused by direct impingement between the stem shoulder and the ceramic liner. This type of impingement, unlike impingements with a stem neck, has not been previously reported. While we assume that certain characteristics of the stem contributed to the impingement, we report this case to note that caution may be needed when using certain stem designs.

**Key Words:** Hip, Arthroplasty, Ceramics

Total hip arthroplasty (THA) using ceramic-on-ceramic (CoC) articulation has proven successful at achieving favorable mid-to-long-term outcomes<sup>1,2)</sup>. Ceramic fractures, although rare, remain the most common cause of failure in CoC THA<sup>3,4)</sup>. While the use of the 4<sup>th</sup> generation alumina, BIOLOX<sup>®</sup> *delta* (CeramTec, Plochingen, Germany), has led to a decrease in the incidence of ceramic head fractures, this benefit has not translated as effectively to the occurrence of ceramic liner fractures<sup>5,6)</sup>.

The exact mechanisms of ceramic liner fracture have not

been clarified, however, impingement, edge loading, and malseating have been proposed as possible mechanisms<sup>7-9)</sup>. We experienced a case of ceramic liner fracture assumed to be caused by impingement between the ceramic liner and the shoulder of the stem. This type of fracture has not been reported and may be related to the design of the stem. We report this case to note that caution may be needed when using a stem of certain design.

## CASE REPORT

A 32-year-old man underwent primary THA for osteonecrosis of the femoral head. The patient was 1.72 m in height and 68 kg in weight (body mass index, 22.91 kg/m<sup>2</sup>). He had been under steroid therapy for 10 years because of dermatomyositis. This patient was informed that data from the case would be submitted for publication, and he gave his consent.

Staged THAs were performed with an interval of one month. The components used for the right hip were PLASMACUP SC<sup>®</sup> 56 mm (Aesculap, Tuttlingen, Germany), 3<sup>rd</sup> generation BIOLOX<sup>®</sup> *forte* liner (CeramTec), 3<sup>rd</sup> generation BIOLOX<sup>®</sup> *forte* 28 mm head with short neck, and BiCONTACT<sup>®</sup> (Aesculap) SD type stem of size 16. The components used

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for the left hip were PLASMACUP SC<sup>®</sup> 54 mm, BIOLOX<sup>®</sup> forte liner, BIOLOX<sup>®</sup> forte 28 mm head with medium neck, and BiCONTACT<sup>®</sup> SD type stem of size 17. There were no intra- or postoperative complications. On the right side, the inclination of the cup was 40.3° and the anteversion

of the cup by the method of Bachhal et al.<sup>10)</sup> was 20.0°. On the left side, the inclination of the cup was 30.1° and the anteversion of the cup was 20.9°. The patient had been under annual routine follow-up with satisfactory clinical results. There was no overt negative symptoms, including squeaking.

At 14 years after surgery, the patient heard a pop in his right hip while pulling heavy luggage and visited the emergency room because of sustained pain and a clicking sound. Plain radiographs revealed a ceramic head fracture (Fig. 1). Revision surgery through trans-trochanteric approach was performed. During the revision surgery, ceramic liner fractures at multiple sites of its outer edge were identified in addition to the ceramic head fracture (Fig. 2). After meticulous removal of the fractured ceramic fragments, the remaining main body of the ceramic liner was extracted. After copious irrigation, a new ceramic liner and a 32 mm head with short neck were inserted. Both were made with the 4<sup>th</sup> generation alumina, BIOLOX<sup>®</sup> delta, and the head was coupled with a metal sleeve.

Postoperatively, the patient returned to normal activity after using crutches for eight weeks. At approximately 10 weeks after the operation, the patient experienced remarkable pain in his right hip immediately after falling resulting from a sudden forceful crush by a stranger while sitting in the squat position. The crushing force caused the right hip in the squatting position to be more flexed and abducted. He experienced persistent pain and crepitus in the right hip and visited the outpatient clinic at postoperative 12 weeks. Simple radiographs revealed multiple ceramic fragments presumed to be from the ceramic liner (Fig. 3). Re-revision surgery to exchange the ceramic head and liner with new ones was performed. During the operation, eight fractured segments and multiple smaller flakes of ceramic



Fig. 1. Simple radiograph reveals the ceramic head fracture.

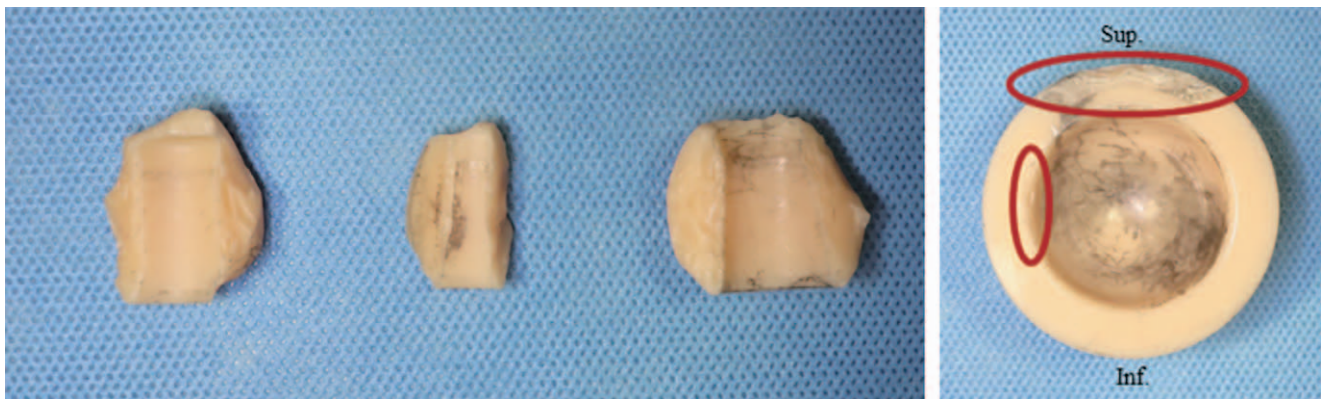
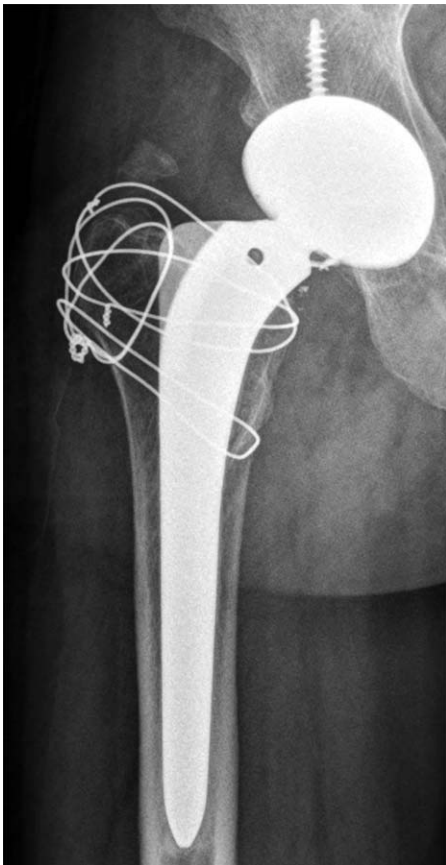


Fig. 2. Fragmented ceramic head fractures (left). The outer edge chip fracture is at the superior (Sup) portion of the liner and inner edge chip fractures are at the Sup and posterior (inferior, Inf) portion of the liner (right).

were identified originating from the edge of the ceramic liner. The fracture site occurred between 8 and 12 o'clock of the liner. When engaging in passive range of motion (ROM) of his right hip joint, impingement between the outer margin of the liner and the shoulder of the stem was observed. A notch on the shoulder-side of the stem was also observed (Fig. 4). All detected fragments were removed and the head and liner were exchanged after copious irrigation. The new head and liner were made of 4<sup>th</sup> generation BIOLOX<sup>®</sup> delta and a long neck head was used to prevent impingement between the stem shoulder and the liner. The patient is currently in satisfactory condition three years after re-revision surgery.

We retrospectively reviewed the patient's serial simple radiographs to detect signs of impingement between the ceramic liner and the stem shoulder. The notch on the medial side of the stem shoulder was continuously observed starting at 5 years after the initial operation (Fig. 5).



**Fig. 3.** Simple radiograph reveals a ceramic liner fracture and liner particles.

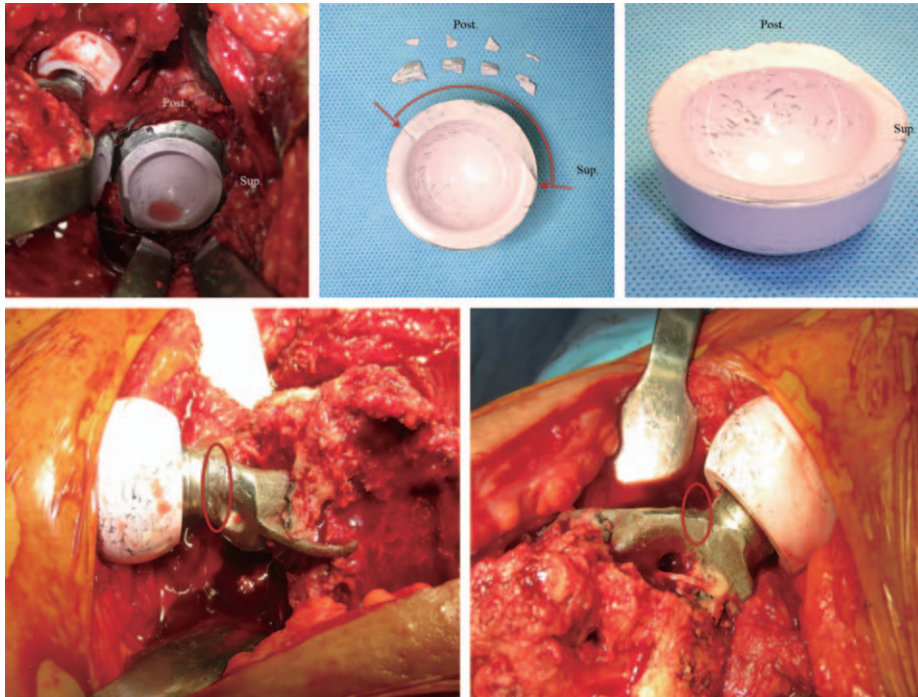
## DISCUSSION

In the first event, the head fracture occurred 14 years after the initial operation while the patient was pulling heavy luggage, though it was not so forceful as to cause fracture of the ceramic head. The 28 mm head with short neck has been known to be a risk for ceramic head fracture. During the operation, chip fractures were identified on the edge of the ceramic liner and the stem neck and shoulder were noted to be damaged. However, the liner fracture and scratches on the stem neck and shoulder were thought to be inevitable results of the head fracture having caused the inter-component impingement. Thus, it was not initially considered that the initial impingement occurred between the stem shoulder and the edge of the ceramic liner.

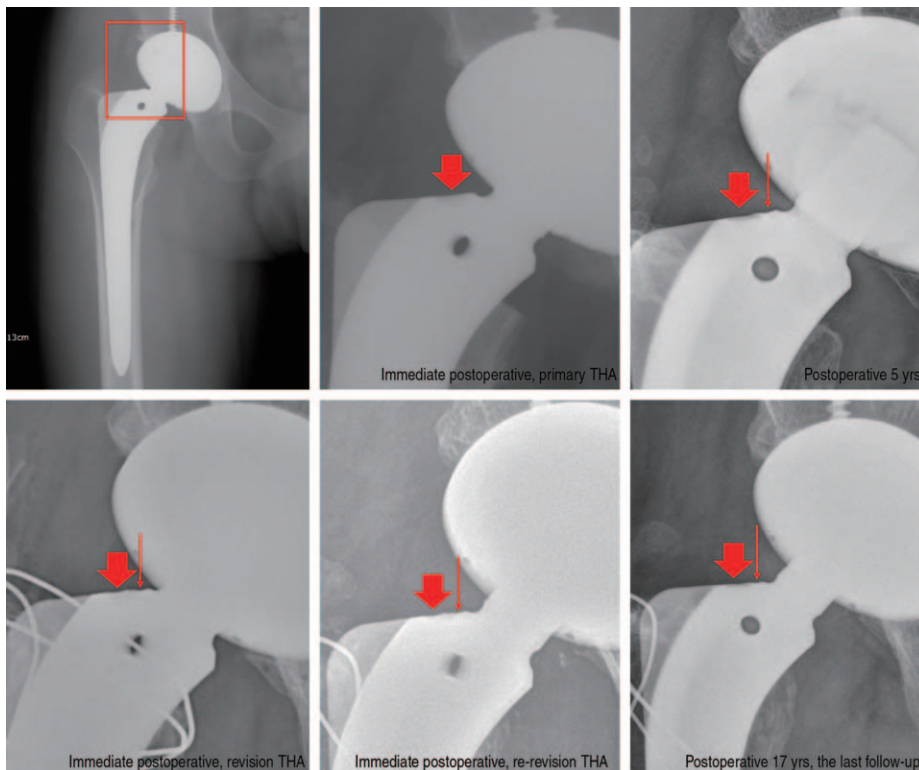
In the second event, the patient's right hip was suddenly flexed and abducted forcefully. Thus, collision between the stem neck and liner edge was first suspected as the cause of the liner fracture. However, no scratch on the stem neck was observed and the fracture site was not at the inner edge of the liner, but rather the outer edge. If the impingement with the stem neck was the cause of the liner fracture, the inner edge of the liner would have been fractured. Based on these findings, we reasoned that impingement between the stem shoulder and the outer edge of the liner had occurred. This type of impingement was confirmed intraoperatively with wide abduction of the hip joint. With wide abduction, the medial end of the impression site for the stem impactor collided with the outer edge of the ceramic liner (Fig. 5). To avoid this impingement, we exchange the short neck ceramic head to the long neck head with an optional metal sleeve. When we combined the BiCONTACT<sup>®</sup> stem with a short neck head, a liner and a cup *ex vivo*, there was a collision between the stem shoulder and outer margin of the liner like the intraoperative findings (Fig. 6).

After surgery, plain radiographs were retrospectively analyzed; no signs suggestive of malseating (e.g., protruded edge) were observed, and a notch at the medial end of the impression site for the stem impactor was first observed at 5 years after the operation. We typically recommend patients avoid squatting or kneeling after THA, however this patient was engaging in stretching exercises to full ROM, sitting cross-legged on the floor and squatting after THA. We advised the patient to avoid excessive ROM after re-revision surgery to help prevent further impingement between the stem shoulder and ceramic liner.

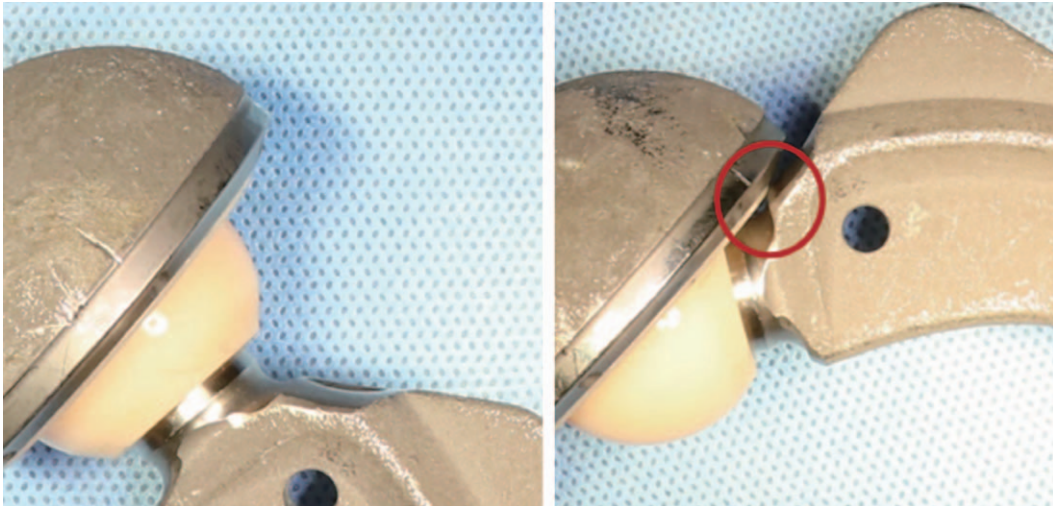
In addition to the patient's excessive ROM of the hip, the design of the BiCONTACT<sup>®</sup> stem is presumed to be



**Fig. 4.** (Upper row) Medical photo reveals a peripheral rim fracture at approximately 8-12 o'clock on the ceramic liner. (Lower row) Intraoperative medical photos reveal a notch on the stem shoulder. Post: posterior, Sup: superior.



**Fig. 5.** Serial postoperative simple radiographs. The lateral shoulder notch (narrow arrow) on the BiCONTACT<sup>®</sup> stem is observed on the medial end of the impression site for stem impactor (broad arrow). THA: total hip arthroplasty.



**Fig. 6.** Impingement occurs between the stem shoulder and outer margin of the ceramic liner. A PLASMACUP SC® and BiCONTACT® stem with a 28 mm short neck head were used in the simulation.

a predisposing factor for subsequent impingement between the stem shoulder and ceramic liner. The BiCONTACT® stem is designed for maximum preservation of the existing bone substance, therefore, the level of neck cutting will be much higher and the length of the stem neck is shorter compared with other implants. Additionally, the neck length is fixed, regardless of the stem size. These attributes make the level of the stem shoulder higher and closer to the edge of the cup as the larger the stem, the closer it is to the cup. These characteristics of BiCONTACT® stem design seem to make the stem vulnerable to impingement on the shoulder site.

This case reveals that impingement between the stem shoulder and ceramic liner can occur, thus leading to liner fracture. This type of impingement should be considered when designing stems. For BiCONTACT® stems, it is recommended that clinicians avoid the use of short-necked heads if possible.

## ACKNOWLEDGEMENTS

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## CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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