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Case Report

Management and Outcomes of Breakage in Polyethylene-Ceramic Composite (Sandwich-type) Liners: Lessons From Long-term Follow-up

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A B S T R A C T

This case series reports the only 3 instances of ceramic liner breakage among patients who underwent total hip arthroplasty (THA) with polyethylene–ceramic composite (sandwich-type) liners at our center between 1999 and 2002. Breakages occurred at approximately 6 (n = 2) and 17 years (n = 1) after the primary THA. Symptoms included audible crepitation, pain, and restricted motion during normal activities. Surgical revisions utilized a polyethylene liner and third-generation alumina ceramic head, with synovectomy and irrigation to remove debris (preventing third-body wear). All patients achieved good long-term outcomes. Although infrequent, the risk of breakage increases over time, and several patients still carry these liners years after THA. This case series underscores the importance of vigilant follow-up, patient education, and timely intervention to manage this infrequent but potentially catastrophic complication.

Introduction

Total hip arthroplasty (THA) using ceramic-on-ceramic (CoC) bearings has progressively evolved over time. Since their introduction in 1970 [1], CoC bearings have been widely adopted, particularly in younger and more active patients, due to their wear outstanding resistance [2-5]. Nonetheless, although ceramics offered a key advantage over other bearing surfaces by minimizing wear debris, early generations remained prone to breakage, making fracture risk a persistent concern for orthopaedic surgeons [2,6].

Although fourth-generation CoC bearings have considerably reduced fracture risk compared to previous generations [7-9], owing to the zirconia-toughened alumina and increased bending strength, this was not always the case [10,11]. However, before these advancements, third-generation (sandwich-type) bearings were developed in an effort to address the persistent risk of ceramic breakage. These bearings integrated third-generation BIOLOX forte alumina ceramic (CeramTec GmbH, Plochingen, Germany) with a thermocompressed ultrahigh-molecular-weight polyethylene (PE) interlayer positioned between the ceramic liner and the metal acetabular cup. This design, marketed as Cerasul Alpha (Zimmer Biomet, Winterthur, Switzerland; Fig. 1), was intended to reduce ceramic fracture risk, as the PE interlayer was designed to dampen impact forces and distribute stress more evenly across the ceramic component [12,13]. However, despite its theoretical advantages,

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Figure 1. An intact Cerasul Alpha insert. paired with a ceramic ball head.

this design ultimately demonstrated higher-than-expected failure rates, leading to its discontinuation [10].

This case series describes the natural history of primary THAs using the sandwich-type liner, focusing on the clinical course leading to revision surgery due to ceramic liner breakage—a failure that is unique to this type of implant. It also complements previously published data provided by our research group [14], offering valuable information on the implant's long-term performance and specific complications.

Patients were informed that data concerning their individual cases would be submitted for publication, and written informed consent was obtained individually from each patient. Institutional review board approval was obtained (PR291/19) and confidentiality was guaranteed according to current Spanish legislation (LOPD 3/2018). This manuscript adheres to the CARE guideline [15].

Case histories

Between January 1999 and December 2002, Cerasul Alpha implants were used in our tertiary hospital for primary THA. A cohort of 54 adult patients (49 men) with 59 CoC implants (5 bilateral cases) was established for periodic follow-up and has been detailed elsewhere [14]. These implants, consisting of a sandwich-type liner housed in a cementless Allofit titanium alloy shell with a ceramic Cerasul ball head and Alloclassic cementless femoral stems (Zimmer, Winterthur, Switzerland) have not been used in our practice since 2002.

In all cases reported below, revision surgery was performed using a posterolateral approach. The acetabular cups and femoral stems were firmly fixed and left in place, while the broken ceramic components were meticulously removed. This required extensive irrigation, synovectomy, and debridement to eliminate ceramic debris embedded in the PE liner and surrounding tissues. Long-term follow-up demonstrated good clinical outcomes, with all patients returning to normal daily activities following revision surgery. Case histories are summarized in Table 1.

Case 1

A 55-year-old male patient underwent primary THA for osteonecrosis. The clinical result was excellent until acetabular implant breakage occurred 16 years and 7 months later during normal daily activity following a minor stumble (Fig. 2a-c). Symptoms of the sandwich-type liner breakage included audible crepitation, mild pain, and loss of motion.

Intraoperative assessment revealed a stable acetabular cup and femoral stem, with no abnormalities detected in the trunnion. The new PE liner provided by the manufacturer was not fully stable within the metal back. Consequently, a cemented PE liner (Longevity Revision Polyethylene, Zimmer Biomet, Warsaw, IN) was implanted, along with a third-generation alumina head (Fig. 2d). Five years postrevision, the patient continues normal daily activities without complications.

Case 2

A 24-year-old male patient underwent primary THA for osteoarthritis secondary to a childhood condition (Perthes disease). The patient experienced prosthetic hip dislocations at 4 and 60 months postoperatively, both of which were successfully treated with closed reduction under sedation. Five years and 11 months after the primary THA, acetabular implant breakage occurred during normal daily activity (Fig. 3). Symptoms included audible crepitation, mild pain, and loss of motion.

The acetabular cup and femoral stem were firmly fixed and left in place. Following the removal of ceramic fragments, a new PE liner provided by the manufacturer was implanted, along with a

Table 1
Case summary.

Parameter	Case 1	Case 2	Case 3
Age (y)	55	24	52
Sex	Male	Male	Male
BMI (Kg/m^2)	27.5	25.1	27.3
Date of primary THA	January 2003	June 2000	November 2000
Date of breakage	August 2019	March 2006	March 2006
Presentation	Breakage during normal daily-life activity. Audible crepitation, pain, and loss of motion	Breakage during normal daily-life activity. THR instability but no luxation episode forewent the breakage.	Breakage after a little stumble 5 y after the primary THA. Audible crepitation, pain, and loss of motion.
Side	Right	Left	Right
Date of revision surgery	August 2019	March 2006	April 2006
Abduction angle	35°	45°	42°
Anteversion angle	23°	25°	35°
Procedure highlights	The new PE insert provided by the manufacturer was not fully stable in the well-fixed metal back, so a cemented PE insert was implanted instead.	Insert replaced by a PE liner and a third-generation ceramic head (no gross evidence of taper scratches).	Insert replaced by a PE liner and a third-generation ceramic head (no gross evidence of taper scratches).

BMI, body mass index; THR, total hip replacement.

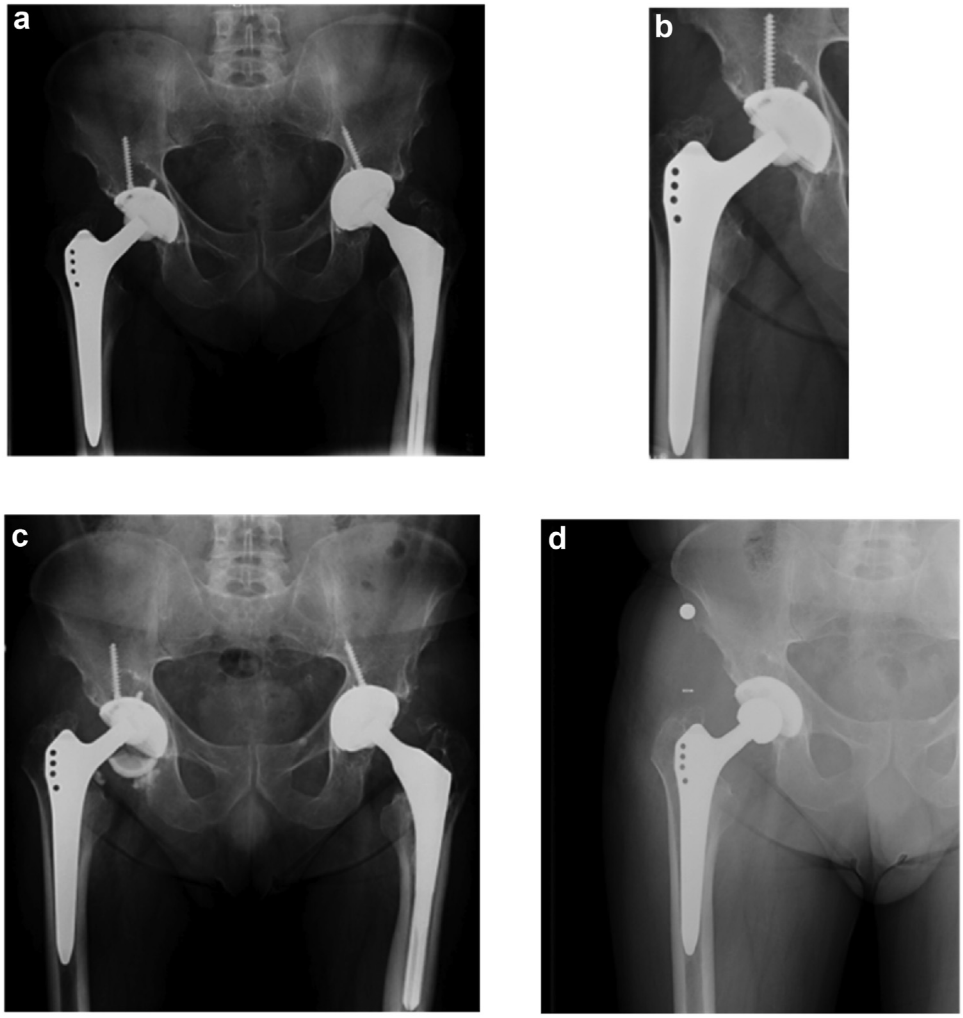

Figure 2. Anteroposterior radiographs of the pelvis performed (a) 10 years after primary THA surgery; (b) approximately 2 years before breakage (showing a dissociation between the ceramic and the polyethylene liner); (c) immediately after the breakage (approximately 17 years after the primary total hip arthroplasty); and (d) after the revision surgery.

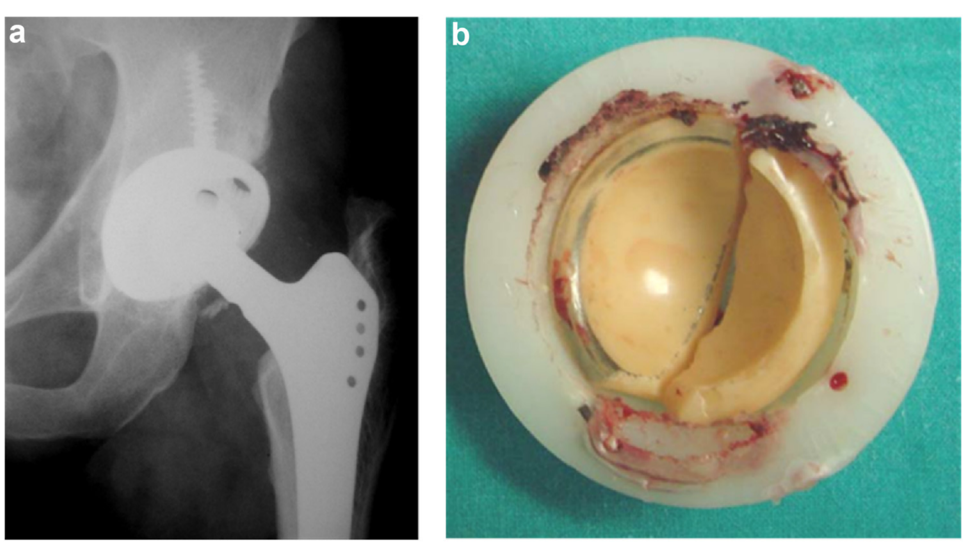

Figure 3. (a) Anteroposterior radiograph performed on the day of breakage and (b) an image of the broken ceramic insert removed.

third-generation alumina head. As in *Case 1*, no gross evidence of taper scratches was observed. Eighteen years postrevision, the patient continues to perform normal daily activities without further complications.

Case 3

A 52-year-old male patient underwent primary THA for osteoarthritis. Acetabular implant breakage occurred 5 years and 6 months postoperatively during normal daily activity (Fig. 4). Symptoms included audible crepitation, moderate pain, and loss of motion.

Intraoperative findings showed a firmly fixed acetabular cup and femoral stem, which were left in place. The broken insert was replaced with a PE liner provided by the manufacturer and a third-generation alumina head, as no gross taper scratches were detected. Eighteen years postrevision, the patient continues to perform normal daily activities without further complications.

Discussion

Alumina ceramic bearings offer numerous advantages, including superior geometric form, a wettable surface, and enhanced hardness, which collectively maintain lubrication and increase resistance to third-body wear. Compared to metal-on-metal and metal-on-PE joint configurations, CoC bearings feature lower wear rates, minimal osteolysis, reduced revision rates, and improved long-term prosthetic survival [4,12,16]. However, the brittle nature of ceramics—characterized by limited tensile strength—remains a significant drawback, with mechanical failure posing an ongoing concern since their introduction. Advances in manufacturing techniques have led to newer generations of alumina ceramics with remarkably lower fracture rates [17]. Nevertheless, the stiffness mismatch between the ceramic liner and metal socket renders the liner susceptible to abrupt or abnormal forces, which can result in cracking. The sandwich-type liner was designed with a PE interlayer to act as a shock absorber, theoretically reducing the ceramic fracture rate. Despite its promise, this composite liner has demonstrated significantly higher failure rates than its conventional ceramic counterparts [6,18-20].

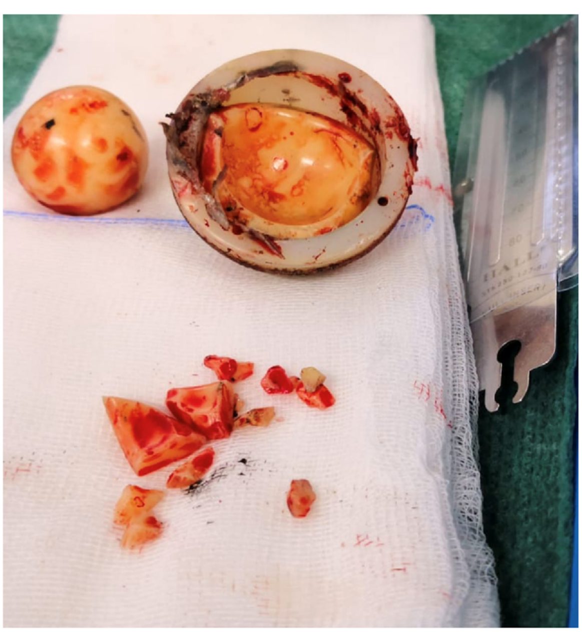

Figure 4. Broken ceramic insert.

Several factors contribute to sandwich-type liner failure, such as patient demographics, activity levels, trauma history, and surgical factors. For instance, younger age, overweight/obesity, high activity levels, and certain body positions, such as squatting or sitting cross-legged have been implicated [6,16,18-21]. In contrast, none of the 3 cases herein reported featured overweight or high activity levels nor reported adopting these positions.

Surgical factors, particularly cup positioning, are critical in determining stress distribution across the acetabular cup and femoral head. Optimal positioning is generally defined as <45° inclination and 10°-15° anteversion [10,13]. Excessive anteversion, such as a mean angle of 25.8° observed in one study's failure group, has been associated with increased risk of fracture [22]. However, results from a cohort study conducted by our group indicated that both the fracture and nonfracture groups had anteversion angles exceeding these thresholds, which speaks against a direct relationship between cup position and liner fracture [14]. Additionally, repeated ceramic head slippage from the liner can overload the edges, leading to localized stress, cracking, and eventual catastrophic failure [23]. *Case 1* in our series showed evidence of ceramic slippage on plain radiography before breakage (Fig. 2b). Notably, Table 2 presents a summary of the available data on ceramic fractures, comparing our series with previously published cases.

The quality and design of the sandwich liner itself are important factors. At 4 mm, the ceramic component of these liners is thinner than conventional designs, raising concerns about its brittleness [6,19,20,25]. Small ceramic head diameters and reduced oscillation angles further exacerbate issues by increasing the frequency of impingement, subluxation, or dislocation. Additionally, the mismatch between the hydrophilic ceramic and the hydrophobic PE in an aqueous environment may promote water interposition, creating a gap that predisposes to liner dissociation and fracture [18-20,22].

Impingement and edge loading are frequently cited mechanisms of ceramic failure [20,26-29]. Edge loading occurs when the ceramic head contacts the liner's rim in a subluxated state, resulting in striped wear patterns and localized stress propagation under compromised lubrication [19,21,22]. This process generates high torque and microseparations, contributing to rim wear, liner dissociation, and eventual breakage [30]. Notably, *case 1* in our series featured dissociation between the ceramic head and PE liner without instability before fracture. In contrast, the impingement mechanism—particularly relevant in patients with habits such as cross-legged sitting [6,17]—was not evident in our patients, as no black staining or other impingement-related signs were found on their liners.

Treatment strategies for ceramic liner fractures remain diverse and debatable. Common options include metal-on-PE, CoC, or ceramic-on-PE articulations. Given concerns about third-body wear, we advocate for revising to CoC or ceramic-on-PE bearings whenever feasible, while avoiding metal-on-PE bearings [31,32]. Additionally, several precautions are necessary when addressing ceramic fractures. Immediate immobilization is essential to prevent further damage to surrounding components. Intraoperatively, meticulous synovectomy and extensive irrigation are critical to remove ceramic particles, which can otherwise lead to third-body wear and early failure of the revision device [24,31-33].

Taper damage is another critical consideration. Placing a new ceramic head on a deformed taper can result in uneven stress distribution, leading to subsequent cracking and failure [13]. While cup removal may be necessary for small-diameter cups, most authors discourage removing an otherwise intact acetabular cup or

Table 2
Summary of the available evidence on acetabular ceramic fractures.

Study	Hips intervened	Fractures, n (%)	Time-to-fracture, mean (y)	Implant manufacturer	Revision bearing type	Cause
Kircher *et al.* [16]	50	9 (18)	2.5	Keramed	CoP	Impingement
Park *et al.* [6]	357	4 (1.1)	3.1	Lima	CoC	Impingement
Ha *et al.* [17]	144	5 (3.5)	3.0	Lima	Unspecified	Impingement and anteversion
Poggie *et al.* [19]	315	14 (4.4)	2.0	Implex	Unspecified	Weight and subluxations
Iwakiri *et al.* [18]	82	4 (4.9)	5.6	Kyocera	Unspecified	Impingement
Park *et al.* [21]	102	2 (2.0)	8.0	Lima	Unspecified	Impingement
Szymansky *et al.* [24]	132	7 (5.3)	2.7	Fourniture Hospitalieres	Unspecified	Impingement and inclination
Viste *et al.* [10]	124	5 (4.0)	7.0	Zimmer	CoC	Activity and inclination
Lopes *et al.* [22]	353	7 (0.2)	4.3	Zimmer	Unspecified	Impingement
Shin *et al.* [12]	243	6 (2.5)	8.7	Zimmer	CoP	Unspecified
Andeol *et al.* [25]	125	4 (3.2)	12.5	Zimmer	CoC	Unspecified
He *et al.* [3]	300	5 (1.6)	7.6	Lima	CoC	Impingement
Bellvitge University Hospital	59	3 (5.1)	9.3	Zimmer	CoP	Unspecified

CoP, Polyethylene-on-ceramic.

femoral stem due to the potential for complications and bone damage. Ultimately, the decision rests with the surgeon's intraoperative assessment.

Two of the fractures in our series occurred approximately 6 years after the primary THA, while the third occurred around 17 years after implantation. This highlights a potential concern for increased failure rates as these implants age. No single factor emerged as a definitive cause of failure in our patients, underscoring the multifactorial nature of sandwich-type liner fractures. It is crucial to educate patients still using these prostheses on potential red flags and failure-prone activities to facilitate early recognition and intervention. To our knowledge, the implant was discontinued in all hip surgery departments following the recognition of its failure; however, no official recall was issued.

Summary

Despite a fracture rate of approximately 5% for PE-ceramic composite (sandwich-type) liners placed before 2003, many patients still retain these implants 2 decades later. Implant fractures remain a major complication with potentially catastrophic outcomes. Factors such as obesity, high activity levels, trauma history, and surgical issues like cup positioning have been linked to failures, though their roles are debated. Fracture frequency may increase over time, emphasizing the need for vigilance. Suspected fractures require immediate immobilization prompt revision surgery, including meticulous synovectomy and irrigation to remove ceramic debris, which, otherwise, can cause third-body wear. Revision strategies using a PE liner and third-generation alumina head are effective in managing these cases.

Conflicts of interest

The authors declare there are no conflicts of interest.
For full disclosure statements refer to https://doi.org/10.1016/j.artd.2025.101698.

Informed patient consent

The authors confirm that written informed consent has been obtained from the involved patients or if appropriate from the parent, guardian, power of attorney of the involved patients; and, they have given approval for this information to be published in this case report.

CRediT authorship contribution statement

Daniel Rodríguez: Writing – review & editing, Supervision, Investigation, Data curation, Conceptualization. **Thiago Carnaval:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Marcos-del-Carmen Rodríguez:** Writing – review & editing, Investigation. **Antonio Coscujuela Maña:** Writing – review & editing, Investigation. **José-Luis Agulló:** Writing – review & editing, Supervision, Investigation, Conceptualization. **Sebastián Videla:** Writing – review & editing, Supervision, Methodology, Conceptualization.

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References

[1] Boutin P. [Total arthroplasty of the hip by fritted aluminum prosthesis. Experimental study and 1st clinical applications]. Rev Chir Orthop Reparatrice Appar Mot 1972;58:229–46.
[2] Hannouche D, Zaoui A, Zadegan F, Sedel L, Nizard R. Thirty years of experience with alumina-on-alumina bearings in total hip arthroplasty. Int Orthop 2011;35:207–13.
[3] He B, Li X, Dong R, Tong P, Sun J. A multi-center retrospective comparative study of third generation Ceramic-on- Ceramic total hip arthroplasty in patients younger than 45 years with or without the sandwich liner: a ten-year minimum. J Orthop Surg (Hong Kong) 2022;30:10225536221109960.
[4] Kress AM, Schmidt R, Holzwarth U, Forst R, Mueller LA. Excellent results with cementless total hip arthroplasty and alumina-on-alumina pairing: minimum ten-year follow-up. Int Orthop 2011;35:195–200.
[5] Park JW, Ko YS, Lee YK, Ha YC, Koo KH. Ten to 13-year results of delta ceramic-on-ceramic total hip arthroplasty in patients less than 30 Years old. J Bone Joint Surg Am 2023;105:789–96.
[6] Park YS, Hwang SK, Choy WS, Kim YS, Moon YW, Lim SJ. Ceramic failure after total hip arthroplasty with an alumina-on-alumina bearing. J Bone Joint Surg Am 2006;88:780–7.
[7] Buttaro MA, Zanotti G, Comba FM, Piccaluga F. Primary total hip arthroplasty with fourth-generation ceramic-on-ceramic: analysis of complications in 939 consecutive cases followed for 2-10 years. J Arthroplasty 2017;32:480–6.
[8] Castagnini F, Bordini B, Tassinari E, Stea S, Ancarani C, Traina F. Delta-on-Delta ceramic bearing surfaces in revision hip arthroplasty. J Arthroplasty 2019;34:2065–71.
[9] Hernigou P, Roubineau F, Bouthors C, Flouzat-Lachaniette CH. What every surgeon should know about Ceramic-on-Ceramic bearings in young patients. EFORT Open Rev 2016;1:107–11.
[10] Viste A, Chouteau J, Desmarchelier R, Fessy MH. Fractures of a sandwich ceramic liner at ten year follow-up. Int Orthop 2012;36:955–60.
[11] Massin P, Lopes R, Masson B, Mainard D, French H, Knee S. Does Biolox Delta ceramic reduce the rate of component fractures in total hip replacement? Orthop Traumatol Surg Res 2014;100:S317–21.

[12] Shin JJ, Shin JS, Kim JH, Hwang SK. Experience with sandwich liner and its high rate of failure. Eur J Orthop Surg Traumatol 2015;25:233–42.

[13] Traina F, De Fine M, Di Martino A, Faldini C. Fracture of ceramic bearing surfaces following total hip replacement: a systematic review. Biomed Res Int 2013;2013:157247.

[14] Rodriguez-Perez D, Carnaval T, Rodriguez MD, Coscujuela-Mana A, Agullo JL, Videla S. Long-term follow-up of total hip arthroplasty using polyethylene-ceramic composite (sandwich) liner. Hip Int 2024;34:467–75.

[15] Riley DS, Barber MS, Kienle GS, Aronson JK, von Schoen-Angerer T, Tugwell P, et al. CARE guidelines for case reports: explanation and elaboration document. J Clin Epidemiol 2017;89:218–35.

[16] Kircher J, Bader R, Schroeder B, Mittelmeier W. Extremely high fracture rate of a modular acetabular component with a sandwich polyethylene ceramic insertion for THA: a preliminary report. Arch Orthop Trauma Surg 2009;129:1145–50.

[17] Ha YC, Kim SY, Kim HJ, Yoo JJ, Koo KH. Ceramic liner fracture after cementless alumina-on-alumina total hip arthroplasty. Clin Orthop Relat Res 2007;458:106–10.

[18] Iwakiri K, Iwaki H, Minoda Y, Ohashi H, Takaoka K. Alumina inlay failure in cemented polyethylene-backed total hip arthroplasty. Clin Orthop Relat Res 2008;466:1186–92.

[19] Poggie RA, Turgeon TR, Coutts RD. Failure analysis of a ceramic bearing acetabular component. J Bone Joint Surg Am 2007;89:367–75.

[20] Hasegawa M, Sudo A, Hirata H, Uchida A. Ceramic acetabular liner fracture in total hip arthroplasty with a ceramic sandwich cup. J Arthroplasty 2003;18:658–61.

[21] Park YS, Park SJ, Lim SJ. Ten-year results after cementless THA with a sandwich-type alumina ceramic bearing. Orthopedics 2010;33:796.

[22] Lopes R, Philippeau JM, Passuti N, Gouin F. High rate of ceramic sandwich liner fracture. Clin Orthop Relat Res 2012;470:1705–10.

[23] Roo P-JD, Steenbrugge F, Raaijmaakers M. A late dissociation of the ceramic component of a sandwich liner cup in a total hip arthroplasty—case report and review of the literature. Case Rep Clin Med 2013;02:138–40.

[24] Andeol Q, Viste A, Desmarchelier R, et al. Metasul vs Cerasul bearings: a prospective, randomized study at a mean eighteen years. Int Orthop 2020;44: 2545–51.

[25] Min BW, Song KS, Kang CH, et al. Delayed fracture of a ceramic insert with modern ceramic total hip replacement. J Arthroplasty 2007;22: 136–9.

[26] Lee S, Yoo JJ, Kim HJ. Impingement Between the Metal Stem and the Ceramic Liner in Total Hip Arthroplasty: The Neck Is Not the Only Place Where Impingement Occurs. J Bone Joint Surg Am 2021;103:139–45.

[27] Vigdorchik JM, Sharma AK, Madurawe CS, et al. Does Prosthetic or Bony Impingement Occur More Often in Total Hip Arthroplasty: A Dynamic Preoperative Analysis. J Arthroplasty 2020;35:2501–6.

[28] Murali R, Bonar SF, Kirsh G, et al. Osteolysis in third-generation alumina ceramic-on-ceramic hip bearings with severe impingement and titanium metallosis. J Arthroplasty 2008;23:1240. e1213-1249.

[29] Akagi M, Nonaka T, Nishisaka F, et al. Late dissociation of an alumina-on-alumina bearing modular acetabular component. J Arthroplasty 2004;19: 647–51.

[30] Popescu D, Gallart X, Garcia S, et al. Fracture of a ceramic liner in a total hip arthroplasty with a sandwich cup. Arch Orthop Trauma Surg 2008;128: 783–5.

[31] Rambani R, Kepecs DM, Makinen TJ, et al. Revision Total Hip Arthroplasty for Fractured Ceramic Bearings: A Review of Best Practices for Revision Cases. J Arthroplasty 2017;32:1959–64.

[32] Szymanski C, Gueriot S, Boniface O, et al. Sandwich type ceramic liner fracture rate with the Atlas III socket: A study of 144 primary total hip replacements at a mean 74 months' follow-up. Orthop Traumatol Surg Res 2011;97:494–500.

[33] Zagra L, Gallazzi E. Bearing surfaces in primary total hip arthroplasty. EFORT Open Rev 2018;3:217–24.