

Case report

Catastrophic failure of tripolar constrained liners due to backside wear: a novel failure mode

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ARTICLE INFO

Article history:

Received 9 March 2018

Received in revised form

16 April 2018

Accepted 17 April 2018

Available online 18 May 2018

Keywords:

Revision total hip arthroplasty

Dislocation

Tripolar constrained liner

Modular dual mobility

ABSTRACT

Constrained acetabular liners have been developed for patients who are at high risk for dislocation or who are undergoing revision surgery for recurrent dislocations. We report on 2 cases of failure of tripolar constrained liners due to severe backside polyethylene wear after dissociation of the outer polyethylene liner without dislocation, a mode of failure not previously reported. The backside of the inserts suffered severe polyethylene deformation, wear, and scratching due to dissociation from the locking mechanism. In patients with tripolar constrained liners, radiographic evidence of eccentric wear should be considered as possible occult dissociation of the polyethylene liner within the shell. Conversion to a modular dual mobility liner appears to be a viable solution in this setting.

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Introduction

Dislocation after primary total hip arthroplasty (THA) remains a significant complication with a reported incidence of 2%–5% [1]. After recurrent dislocation, the success of revision surgery has been reported to be only 61%, demonstrating the inherent complexity in managing this cohort of patients [2]. Current implant options to address instability include large femoral heads, dual mobility bearings, and constrained liners [3]. Constrained acetabular liners are indicated during primary or revision THA for patients who are at high risk for dislocation or who have had recurrent dislocations [4–6]. These constrained components transfer the hip forces that would otherwise lead to dislocation to the locking mechanism, the liner-shell interface, or the bone-prosthesis interface [7]. Multiple commercially available constrained liners exist, each with design-specific nuances such as locking mechanisms, cutouts, or pre-assembled manufacture which influence the method of implantation,

range of motion, and ultimate performance. The Stryker Trident constrained acetabular system (Stryker Ltd., Mahwah, NJ) uses a ring-lock tripolar constrained design, the results of which have been previously reported [8–10].

According to Zywiell et al. [11], tripolar constrained acetabular liners can provide successful outcomes in patients with hip instability, although reliance on a constrained liner alone cannot compensate for other correctable factors such as component positioning. According to Levine et al. [9], a tripolar construct is effective in eliminating or preventing instability in 93% of the complex cases treated. In a systematic review encompassing 1199 THAs in 1148 patients with a total mean follow-up of 51 months, the rate of dislocation after revision with a constrained liner averaged 10%, and the reoperation rate for reasons other than dislocation averaged 4% [12]. Thus, revision THA for recurrent instability by placing a constrained liner without optimizing other aspects of the reconstruction leads to a high rate of recurrent failure [13]. Other authors have suggested that constrained acetabular liners have failure rates ranging from 4% to 29% at short-term follow-up and up to 42% at long-term follow-up [4,7]. The failure modes of constrained liners have been previously reported and categorized based on the interface that fails [14].

In this article, we present 2 cases of an unusual and previously unreported mode of failure of Trident tripolar constrained liners due to severe backside polyethylene wear after dissociation of the locking mechanism. This mode of failure may initially be

One or more of the authors of this article have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to <https://doi.org/10.1016/j.artd.2018.04.002>.

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<https://doi.org/10.1016/j.artd.2018.04.002>

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asymptomatic and may not present until catastrophic failure, metallosis, and damage to the acetabular shell have occurred. These cases illustrate the importance of the accurate identification of the underlying mechanism causing implant failure and emphasize the importance for performing radiographic surveillance.

Case histories

Case 1

Patient 1, an 81-year-old female with a body mass index of 20.79 kg/m², had a past medical history of breast cancer, hypercholesterolemia, hypothyroidism, and osteoporosis. She underwent bilateral simultaneous primary THAs for osteoarthritis in 2007 with a cemented femoral stem and cementless acetabular cup implanted in both hips (Fig. 1a). Four years after her primary surgery, she had 3 successive dislocations of the right THA, after which she underwent revision surgery using a Trident tripolar constrained liner (Fig. 1b).

She enjoyed excellent function for 5 years with no recurrent instability. Her family noted a slight change in her gait, and the patient noted progressive shortening of her right leg with gradual development of mild anterior groin pain. Comparison radiographs demonstrated significant eccentric wear of the polyethylene liner with contact of the intermediary metal head with the inner surface of the metallic acetabular component (Fig. 1c). Baseline investigations excluded infection, and metal ion levels were not elevated (chromium < 1.0 µg/L and cobalt = 1.0 µg/L). At the time of revision THA, moderate metallosis within the synovial capsule was noted without

pseudotumor formation. The acetabular and femoral components were well fixed with minimal bone loss other than mild calcar resorption that is typical of metallosis. The tripolar lining was noted to be completely worn out at the apex due to backside wear; however, the locking mechanism and acetabular component were relatively preserved. A Trident modular dual mobility liner was securely seated into the acetabular shell, and after reduction, it was stable throughout a functional range of motion (Fig. 1d). Postoperatively, the patient could ambulate without pain almost immediately and was discharged from the hospital on postoperative day 2 making an uneventful recovery. At most recent follow-up (1 year), she had had no further episodes of instability.

Case 2

Patient 2, a 71-year-old female with a body mass index of 19.84 kg/m², had a complex past medical history with common variable immunodeficiency, systemic lupus erythematosus, hypertension, degenerative scoliosis, chronic kidney disease, and gout. She underwent right THA in 2005 after steroid-induced avascular necrosis and subsequent rapid joint degeneration. A cementless stem (ProxiLock; Implex Ltd.) was used together with a cementless Trident tripolar constrained liner because of hyperlaxity and gross soft tissue laxity (Fig. 2a). The patient enjoyed excellent pain-free function for 12 years after her primary arthroplasty until a fall onto the right hip. Radiographs showed a broken and displaced constraining ring with eccentric polyethylene wear (Fig. 2b). On examination, she complained of progressively worsening anterior

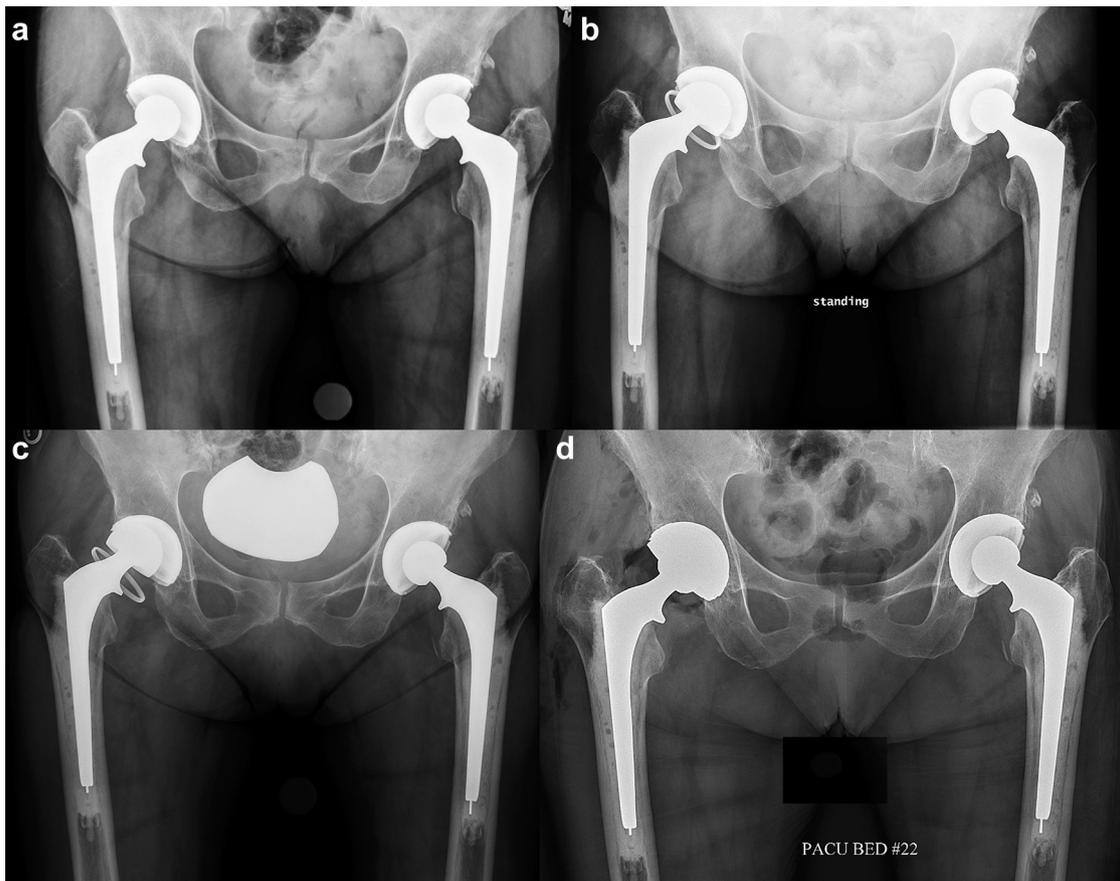


Figure 1. (a) Simultaneous bilateral THA with cemented stem and cementless cup. (b) Revision of the right hip to a tripolar constrained acetabular liner after multiple dislocations. (c) High degree of eccentric polyethylene wear with contact of the intermediary metal head with the inner surface of the acetabular component. (d) Final revision with a modular dual mobility (MDM) liner.

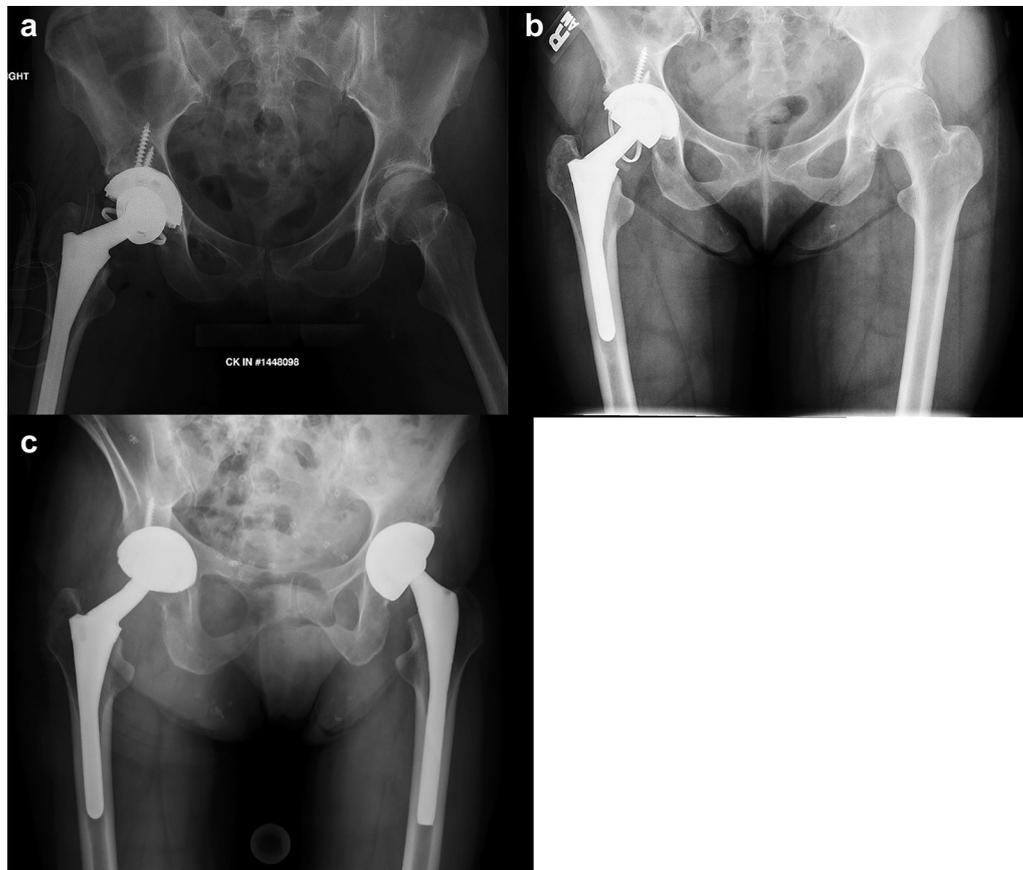


Figure 2. (a) Postoperative radiograph of a primary THA with the use of constrained tripolar liner. (b) Anteroposterior radiograph showing a broken and displaced constraining ring with moderate eccentric polyethylene wear. (c) Final postoperative radiographs after revision to an MDM liner.

groin pain and difficulty in weight bearing. Preoperative baseline investigations excluded infection. After failing initial nonoperative management, the patient underwent revision THA with exchange of the constrained liner. At revision surgery, the constrained liner ring was found to have broken, and the polyethylene liner dissociated within the cup with severe backside wear. Both the acetabular and femoral components were well ingrown and stable with minimal damage to the shell, locking mechanism, or trunnion; therefore, a dual mobility liner was implanted (Fig. 2c). Postoperatively, the patient was rehabilitated as per standard protocols and discharged from the hospital on postoperative day 2. No further episodes of instability have been encountered at most recent follow-up (1 year).

Implant analysis

The retrieved Stryker Trident constrained liners were cleaned and analyzed using a Keyence VHX digital microscope (Keyence Corp., Itasca, IL). The backside of the inserts exhibited severe polyethylene deformation, wear, and scratches. Case 1 demonstrated catastrophic wear in the medial and posterior region of the backside of the liner (Fig. 3a). Case 2 showed severe deformation and scratching that spanned the total area of the backside of the component (Fig. 3b). This damage pattern suggests that the liner was dissociated from the locking mechanism of the metal shell for some time and thus was not behaving with “tripolar” functionality. This likely impeded the implant’s range of motion, causing the observed accelerated wear, as the implant is not designed to articulate between the backside of the constrained insert and the metal shell.

Discussion

The use of a constrained component remains an appropriate strategy for recurrent dislocation caused by soft tissue insufficiency after a THA [7]. In our high-volume primary and revision arthroplasty center, we employ approximately 50 tripolar constrained liners annually. This number has remained constant despite an increase in the overall volume of surgeries; this represents a relative decrease due to the increasing use of dual mobility liners in the majority of instability cases. The Stryker Trident tripolar design has been used in both the primary and revision setting, resulting in a 96%–98% stability rate at 5-year follow-up [8]. Goetz et al. [15] followed up 101 THAs for an average of 5 years and had a 4% rate of instability, whereas Shapiro et al. [16] reported a 98% stability rate in 87 hips over a 5-year follow-up. Shrader et al. [17] evaluated 110 hips at an average of 3-year follow-up and reported a 98% stability rate. Although proven effective in reducing instability, concerns have been raised regarding the longevity of constrained liners primarily because of a restricted range of motion leading to impingement [18,19]. In constrained acetabular components, impingement forces are dissipated through the locking mechanism and the liner-shell and shell-bone interfaces so that stability is maintained [10,18]. The dissipation of these forces can result in early loosening and/or dislocation due to failure of the insert at the insert-shell interface and/or failure of the shell at the shell-bone interface [10,18].

In our first case, the prerevision radiographs demonstrated a high degree of eccentric polyethylene wear that is assumed to be between the tripolar articulation; however, at the time of revision, this was revealed to be backside wear of the polyethylene liner with

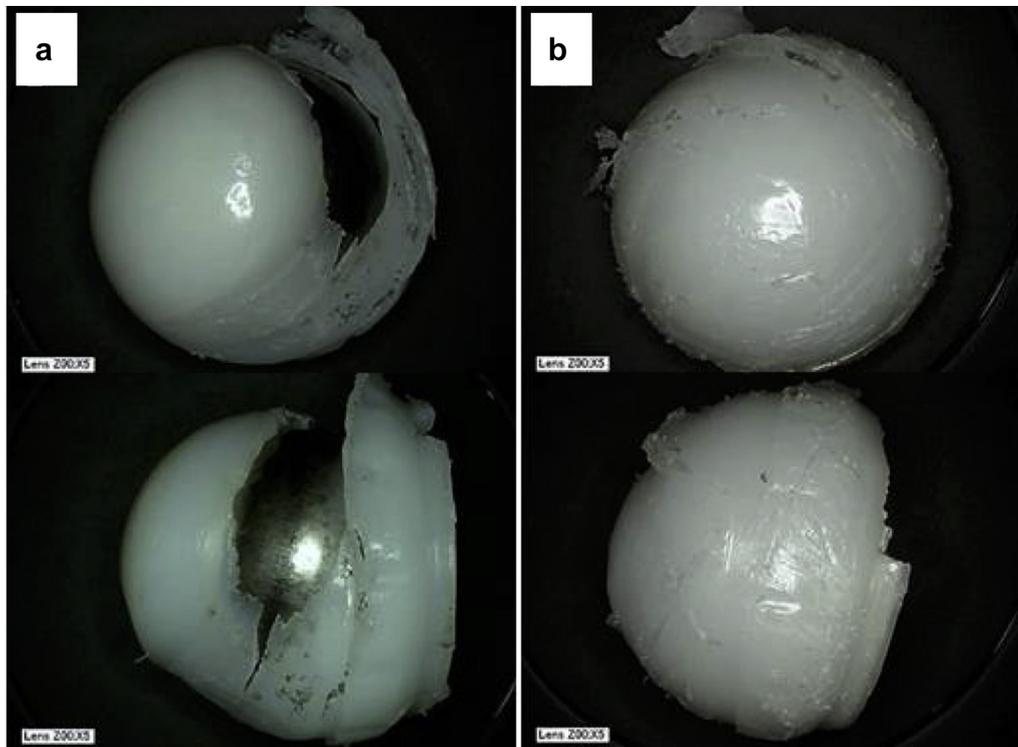


Figure 3. Retrieved constrained liners from (a) case 1 and (b) case 2. Both implants were severely damaged, consistent with failure caused by extreme backside wear.

resulting metallosis and synovitis due to articulation of the metal outer head with the inner surface of the acetabular component. In our second case, the prerevision radiographs showed only mild eccentric wear of the polyethylene liner; however, at the time of revision, the backside damage to the polyethylene was found to be severe. Both cases were effectively managed by conversion of the tripolar liner to a dual mobility liner.

The mode of failure encountered in our patients does not correlate well with the patterns of failure of constrained acetabular systems previously described [14,20]. Cooke et al. [20] divided failures into 3 types: type I—at the bone-prosthesis interface; type II—between the polyethylene liner and the acetabular shell when a liner is cemented into a well-fixed acetabular shell; and type III—failure of the femoral head—locking mechanism due to fracture or displacement of the locking ring. In a more recent study, Guyen et al. [14] further classified failure modes into five types: type I—failure at the bone-implant interface; type II—failure at the mechanisms holding the constrained liner to the metal shell; type III—failure of the retaining mechanism of the bipolar component; type IV—dislocation of the prosthetic head at the inner bearing of the bipolar component; type V—infection. We therefore propose that the mode of failure seen in our cases should be considered a modification of both the Cooke and/or Guyen classifications as type IIA—dissociation of the outer liner within the acetabular shell leading to backside wear without dislocation (Table 1).

To the best of our knowledge, backside polyethylene wear of tripolar liners due to dissociation of the outer liner from the acetabular shell is a mode of catastrophic failure not yet reported. Previous case reports have focused on dislocation of the inner and outer liners with or without ring breakage [4,8,18,21,22]. Liner dissociation is a subtle radiographic finding, one with long-term consequences. There are a range of factors that may contribute to this phenomenon, including the method of insertion (occult soft tissue interposition at the time of implantation), the locking mechanism design, and/or possibly neck-liner impingement.

Regardless, the final common pathway is liner dissociation from the shell due to locking mechanism failure. Despite this rare complication, the specific tripolar implant has a relatively good track record in comparison to other options and remains a useful adjunct in situations when a dual mobility construct will not provide sufficient stability.

The authors recommend that any signs of eccentric polyethylene wear in a tripolar liner should prompt consideration of backside wear secondary to locking mechanism dissociation. In our cases, the eccentric polyethylene wear was obvious on plain radiographs (Figs. 1 and 2); however, for more subtle instances, there are many described techniques for assessing polyethylene wear, including those by Livermore or Martell and Berdia [23,24]. Additional imaging with 3-D reconstruction computer tomography, particularly with metal artefact reduction, may also provide visualization of component position and subtle changes in implant interface.

Table 1
Classification of tripolar constrained articulation failure modes.

Type	Cooke et al. [20]	Guyen et al. [14]
Type I	Failure at bone-prosthesis interface	Failure at the bone-implant interface
Type II	Failure between polyethylene liner and acetabular shell when a liner is cemented into a acetabular shell	Failure at the mechanisms holding the constrained liner to the metal shell
Type IIA	Dissociation of the outer liner within the acetabular shell leading to backside wear without dislocation	
Type III	Failure of the locking mechanism due to fracture or displacement of the locking ring	Failure of the retaining mechanism
Type IV	Not reported	Intraprosthetic dislocation of the prosthetic head at the inner bearing of the bipolar component
Type V	Not reported	Infection

In our experience, the exchange of a failed tripolar constrained liner to a dual mobility articulation appears to be a reliable solution; one that combines the benefits of a large femoral head with a wide range of unrestrained motion and improved stability. Dual mobility liners show promising early to mid-term results, with good overall survival and low rate of dislocation in the revision setting [25,26]. In the long term, further follow-up is required to assess the overall survivorship of tripolar liners converted to dual mobility articulations in the revision setting.

Summary

Failure of a tripolar constrained liner due to severe backside wear secondary to outer liner dissociation within the acetabular shell without dislocation is a new mode of failure not previously reported. In patients with long-term implantation of tripolar liners, radiographic evidence of eccentric wear should be considered as possible occult dissociation of the outer polyethylene liner within the acetabular shell. Conversion to a modular dual mobility liner appears to be a viable solution after failure of the constrained acetabular liner in this setting, but long-term follow-up is required.

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