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Acetabular component liner exchange with highly crosslinked polyethylene for wear and osteolysis

DOES FIXATION METHOD MATTER?

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Aims

Isolated acetabular liner exchange with a highly crosslinked polyethylene (HXLPE) component is an option to address polyethylene wear and osteolysis following total hip arthroplasty (THA) in the presence of a well-fixed acetabular shell. The liner can be fixed either with the original locking mechanism or by being cemented within the acetabular component. Whether the method used for fixation of the HXLPE liner has any bearing on the long-term outcomes is still unclear.

Methods

Data were retrieved for all patients who underwent isolated acetabular component liner exchange surgery with a HXLPE component in our institute between August 2000 and January 2015. Patients were classified according to the fixation method used (original locking mechanism (n = 36) or cemented (n = 50)). Survival and revision rates were compared. A total of 86 revisions were performed and the mean duration of follow-up was 13 years.

Results

A total of 20 patients (23.3%) had complications, with dislocation alone being the most common (8.1%; 7/86). Ten patients (11.6%) required re-revision surgery. Cementing the HXLPE liner (8.0%; 4/50) had a higher incidence of re-revision due to acetabular component liner-related complications than using the original locking mechanism (0%; 0/36; p = 0.082). Fixation using the original locking mechanism was associated with re-revision due to acetabular component loosening (8.3%; 3/36), compared to cementing (0%; 0/50; p = 0.038). Overall estimated mean survival was 19.2 years. There was no significant difference in the re-revision rate between the original locking mechanism (11.1%; 4/36) and cementing (12.0%; 6/50; p = 0.899). Using Kaplan-Meier survival analysis, the revision-free survival of HXLPE fixed with the original locking mechanism and cementing was 94.1% and 93.2%, respectively, at ten years, and 84.7% and 81.3%, respectively, at 20 years (p = 0.840).

Conclusion

The re-revision rate and the revision-free survival following acetabular component liner exchange revision surgery using the HXLPE liner were not influenced by the fixation technique used. Both techniques were associated with good survival at a mean follow-up of 13 years. Careful patient selection is necessary for isolated acetabular component liner exchange revision surgery in order to achieve the best outcomes.

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Introduction

Isolated acetabular liner component exchange was a common revision arthroplasty procedure to address polyethylene wear prior to the advent of highly crosslinked polyethylene (HXLPE) in patients who have liner component wear and a stable uncemented acetabular prosthesis. HXLPE has been transformative in primary total hip arthroplasty (THA), greatly decreasing wear and reducing osteolysis compared to conventional ultra-high molecular weight polyethylene (UHMWPE).[1,2] Revision-free survival of primary

a

b

Fig. 1

a) Anteroposterior and b) lateral radiograph of the right hip of a 58-year-old male patient 13 years after primary total hip arthroplasty demonstrating the asymmetrical polyethylene wear, an indication for exchange of the acetabular liner.

a

b

Fig. 2

a) Anteroposterior and b) lateral radiograph of the right hip of a 58-year-old male patient one month following revision surgery with highly crosslinked polyethylene acetabular liner fixed with cement.

THA using HXLPE up to 94.5% in 12.8 years has been reported.[3] Isolated acetabular liner exchange with HXLPE has emerged as a frequently performed revision procedure to address polyethylene wear in THA. This targeted approach involves replacing the existing acetabular polyethylene liner of the acetabular component with a new HXLPE liner, which minimizes the invasiveness of the procedure and the risk of complications.

During liner exchange revision surgery, the new liner component can be fixed either using the original locking mechanism or by being cemented into the acetabular component. Cementing the liner is used when compatible liners are not available or when the original locking mechanism has been damaged. Whether the method used for fixation of the HXLPE liner has any bearing on the outcomes ten to 15 years after surgery is still unclear.

This study aimed to determine the ten- to 15-year results after isolated acetabular liner exchange using a HXLPE component, and to ascertain whether the fixation method (original locking mechanism or cemented) has any influence on outcomes after surgery. The secondary outcome of this study was the incidence of complications following liner exchange surgery with HXLPE implants.

Methods

Our institute recently conducted a study focused on the long-term survival of isolated acetabular liner exchange revision surgery using conventional UHMWPE or HXLPE, with fixation options being either cementing or the original locking mechanism.[4] The results of our study revealed that HXLPE components exhibited a significantly lower re-revision rate compared to conventional UHMWPE liners. Notably, conventional UHMWPE liners fixed with the original locking mechanism showed particularly poor performance in terms of re-revision-free survival. Considering the widespread adoption of HXLPE acetabular component liners as the standard in isolated liner exchange revision surgery, we aimed to further investigate the outcomes of this cohort of patients that utilized a HXLPE component in terms of their re-revision-free survival and associated complications.

Data from all patients who had undergone isolated acetabular liner exchange revision surgery with HXLPE component in a single institute between August 2000 and January 2015 were retrieved from hard-copy and electronic medical records on the Clinical Management System of the Hospital Authority, Hong Kong. Patients who underwent concurrent femoral or acetabular component revision, those who underwent acetabular liner component exchange for periprosthetic joint infection (PJI), as well as patients who had less than five years of follow-up, were excluded from this study. A total of 24 procedures were excluded: 16 due to inadequate follow-up, seven because femoral or acetabular component revision was performed concurrently with the liner exchange surgery, and one because the liner exchange revision procedure was performed for PJI.

During the liner exchange revision procedure, and following removing the old acetabular liner component, the new HXPLE component was either fixed using the original locking mechanism or cemented, depending on the surgeon's preference or judgement and the availability of compatible HXLPE components with the same locking mechanism. Two common indications for cementing were the unavailability of HXLPE components for some older acetabular implants and a damaged original locking mechanism. All primary and revision procedures used the posterior approach to the hip. Before cementing the new HXLPE liner into the acetabular shell, a metal-cutting high-speed burr was used to score the inner surface of the retained acetabular component, to create radial and horizontal grooves on the backside of the HXLPE liner. A 1 mm to 2 mm cement mantle was created to secure the new liner. If the original locking mechanism was to be used, the liner was fixed using the existing locking mechanism. The original acetabular implants used with the original locking mechanism for fixation were either Duraloc (DePuy Synthes, USA) (n = 18) or

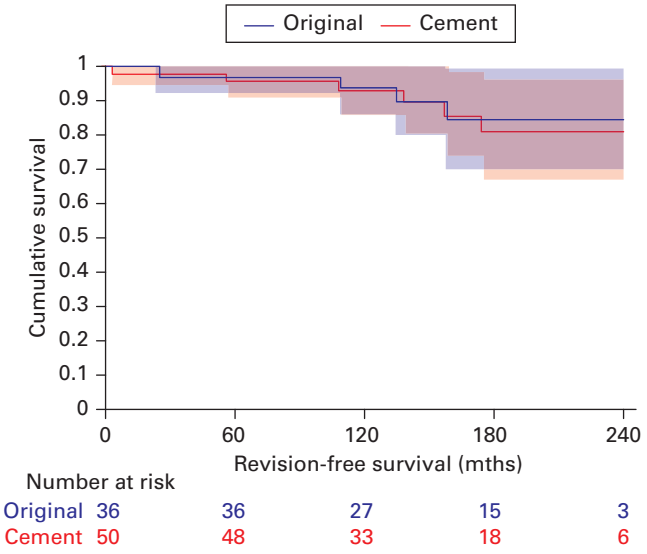

Fig. 3

Kaplan-Meier survival analysis showing the overall revision-free survivals following isolated highly crosslinked polyethylene acetabular liner exchange revision surgery.

Omnifit HA (Osteonics; Stryker, USA) (n = 18). For component exchanges using a Duraloc liner, the locking ring was replaced before inserting the new HXLPE liner, while it was retained for Omnifit HA. If bone defects related to osteolysis were encountered intraoperatively, attempts to fill the defect with synthetic bone substitute such as calcium phosphate were made.

Demographic data, including age at operation, sex, primary diagnosis, details of the index hip arthroplasty surgery, details of the acetabular liner component exchange revision surgery, survival status, and postoperative complications, were collected.

A total of 86 isolated acetabular liner component exchanges with or without femoral head component revision were performed in 78 patients during the study period. The mean duration of follow-up was 13 years (5 to 22). There were 39 male and 39 female patients, with a mean age at operation of 57 years (27 to 83). There were eight patients who had bilateral liner exchange revision procedures. A total of 79 procedures involved revision of both the acetabular liner and the modular femoral head, and six involved only exchange of the acetabular liner component. The reasons for not revising the femoral head were documented for two patients, one being a monoblock femoral component and the other being that the modular femoral head could not be uncoupled from the femoral shaft component during the revision procedure. The mode of the femoral head size used in revision surgery surgery was 28 (range 22 to 36; median 28). Data for the femoral head size used at the index primary THA were not available.

Different brands of acetabular components were used in the primary THA in this cohort, including Porous Coated Anatomic (PCA; Howmedica, USA) (n = 18), Acetabular Cup System (ACS; DePuy) (n = 19), Duraloc (DePuy) (n = 22), Asian (Zimmer Biomet) (n = 7), and Omnifit HA (Stryker) (n = 20).

Diagnosis at the time of primary THA were as follows: ankylosing spondylitis (n = 18), osteonecrosis secondary to corticosteroids use (n = 17), idiopathic osteonecrosis (n = 14), alcohol-associated osteonecrosis (n = 12), traumatic osteonecrosis (n = 7), primary osteoarthritis (OA) (n = 5), developmental dysplasia of hip (n = 4), OA secondary to trauma (n = 3), juvenile rheumatoid arthritis (n = 1), tuberculosis (n = 1), OA secondary to cerebral palsy (n = 1), hemiarthroplasty protrusio (n = 1), pigmented villonodular synovitis (PVNS) (n = 1), and hip fracture (n = 1). The diagnosis at the time of primary THA did not influence the choice of HXLPE liner fixation technique at revision surgery.

The mean time between the primary THA and revision surgery was 15 years (5 to 28). The acetabular component was noted to be malaligned, being too vertical (open) in one patient with evidence of osteolysis at six years after primary THA.

Overall, 60 hips were noted to have osteolysis on preoperative radiographs as an indication to undertake revision THA surgery. A total of 21 of these hips were documented to have intraoperative evidence of massive osteolysis, 31 hips had mild osteolysis, and the remaining hips the extent of osteolysis was not documented. The other 26 hips showed evidence of excessive asymmetric polyethylene wear (Figure 1).

Hips were classified according to the mode of fixation (original locking mechanism or cemented): 50 hips had the new HXLPE acetabular liner fixed by cement (Figure 2) and for the other 36 hips the original locking mechanism was used to secure the new liner component.

Statistical analysis. Chi-squared tests were applied to compare the re-revision rates for the two modes of acetabular liner fixation. Kaplan-Meier survival analyses and log-rank tests were used to compare the survival of the two groups. Secondary outcomes of our study included postoperative complications. Independent-samples *t*-tests were employed to compare the mean of the femoral head size of the hips with post-revision dislocation and that of the hips without dislocation. Statistical significance was set at the 5% level. Statistical analyses were conducted using SPSS v. 27.0 (IBM, USA).

Results

Re-revision rate. Ten hips (11.6%) in this study required a re-revision following HXLPE acetabular liner exchange surgery. The mean time to re-revision was 9.0 years (0.4 to 14.7) following revision surgery. Four of the 36 hips (11.1%) using the original locking mechanism required re-revision after the surgery, while six of the 50 hips (12.0%) with a cemented HXLPE liner required re-revision; this difference was not significant (p = 0.899, chi-squared test).

Survival. Overall estimated mean survival of acetabular liner exchange revision surgery with the HXLPE liner was 19.2 years (95% confidence interval (CI) 18.1 to 20.3). Using the Kaplan-Meier survival analysis, the overall revision-free survivals were 96.5% (95% CI 92.6 to 100), 93.6% (95% CI 88.1 to 99.1), and 82.7% (95% CI 72.3 to 93.1) at five, ten, and 20 years following HXLPE acetabular liner exchange, respectively (Figure 3). The revision-free survival of HXLPE liner fixed with the original locking mechanism or with cement were 94.1% (95% CI 86.1 to 100) and 93.2% (95% CI 85.6 to 100), respectively, at ten years, and were 84.7% (95% CI 70.4 to 99.0) and 81.3% (95% CI 67.0 to 95.6), respectively, at 20 years. There was no

Table I. Details of all the patients who had re-revision performed.

Age at liner exchange surgery	Sex	Time from liner exchange surgery, mths	Indication for re-revision surgery	Fixation technique used in liner exchange surgery	Re-revision operation performed	Remarks
70	M	5	Septic dislocation	Cemented	Revision total hip arthroplasty	-
62	F	25	Acetabular component loosening	Original locking mechanism	Revision total hip arthroplasty	Osteolysis present
48	F	58	Wearing of liner	Cemented	Further acetabular liner exchange	Eccentric placement of liner
62	M	109	Recurrent dislocation	Original locking mechanism	Revision total hip arthroplasty	-
83	F	110	Recurrent dislocation	Cemented	Excisional arthroplasty	-
56	M	135	Dislocation and acetabular component loosening	Original locking mechanism	Acetabular component revision	Chronic alcoholic
57	F	140	Dislocation and liner fracture	Cemented	Acetabular component revision	
43	F	158	Acetabular component loosening	Original locking mechanism	Revision total hip arthroplasty	Osteolysis present
56	M	159	Wearing of liner and recurrent dislocation	Cemented	Further acetabular liner exchange	Cup opening angle 63°
54	M	176	Dislocation and liner dislocation	Cemented	Further acetabular liner exchange	-

significant difference in the revision-free survival between the two groups (p = 0.840, log-rank test).

Complications. Complications were reported in 20 hips (23.3%), with dislocation being the most common (8.1%; n = 7). Ten hips (12.6%) required re-revision surgery, in which four (4.7%) had complications related to the HXLPE liner (wearing of liner (n = 2), liner fracture (n = 1), liner dissociation (n = 1)), and three (3.5%) hips had complications related to the loosening of the retained acetabular component (Table I). The other three re-revisions were performed for instability alone (n = 2) or infection (n = 1). The mean time to re-revision surgery in these ten cases was nine years (five months to 15 years).

Regarding the four hips with acetabular liner-related complications that required re-revision, one patient had evidence of significant polyethylene wear at approximately five years after the liner revision requiring re-revision. Radiological review revealed that the HXLPE liner was eccentrically placed during the liner exchange procedure. The other three patients experienced wear, liner fracture, or liner dissociation associated with hip instability between 11 years and 15 years following surgery. For one patient who had excess wear and dislocation, the acetabular component opening angle was 62°. All four cases used cementing as the liner fixation method. However, the difference in the incidence of re-revision due to liner associated complications between the two fixation techniques did not reach statistical significance (p = 0.082, chi-squared test).

Three patients (3.5%) had loosening of the acetabular component following liner exchange surgery and required re-revision. These three patients experienced loosening of the retained acetabular shell at varying timepoints following their surgery, at two, 11, and 13 years after surgery. All three patients retained the original locking mechanism as the liner fixation method, and all had evidence of osteolysis preoperatively or intraoperatively at re-revision. Fixation using the original locking mechanism was associated with a statistically significantly higher incidence of re-revision due to acetabular component loosening compared to cementing (p = 0.038, chi-squared test).

Infection occurred in one patient, who required removal of the prosthesis and insertion of an antibiotic-loaded cement spacer three months after the liner exchange. Second-stage reimplantation surgery was performed five months after the initial liner exchange surgery.

There were ten postoperative complications that did not require re-revision. These complications included hip dislocation without liner problems in five patients, periprosthetic fracture in two patients with evidence of massive osteolysis, heterotopic ossification in one patient, femoral component loosening in one patient, and acetabular component loosening with protrusio migration in one patient.

A total of 11 hips (12.8%) suffered a dislocation with or without liner-related complications or implant loosening after liner exchange revision surgery. Six required re-revision surgery. Out of these six re-revision cases, three were related to liner-related complications, two were due to instability alone, and one was associated with loosening of the acetabular component. Five cases of dislocation not associated with other complications were treated nonoperatively. Eight cases (16.0%) of dislocation used cementing as the liner fixation method, while three (8.3%) used the original locking mechanism (p = 0.294, chi-squared test). Hips complicated by dislocation after HXLPE liner exchanged showed no difference in mean femoral head diameter (28 mm (SD 0.0); mode 28 (28 to 28)) vs 28.2 mm (SD 1.7); mode 28 (22 to 36)) (p = 0.674, independent-samples *t*-test).

Discussion

To our knowledge, this is the largest study with the longest follow-up looking at the effects of fixation technique on long-term outcomes following acetabular component liner exchange revision surgery with a HXLPE component. The majority of liner exchange procedures were performed in primary THA

patients with a diagnosis of osteonecrosis of the hip, while only five were for primary OA. In most reports, the commonest indication for primary THA is OA of the hip. Osteonecrosis of the hip accounts for 41.2% of primary THAs in Chinese patients in our locality, whereas only 12.5% of arthroplasties were performed for primary OA.[5,6]

This study demonstrated excellent survival (93.6%) after acetabular liner exchange revision THA with the HXLPE component at mean of 13 years' follow-up. This is in close agreement with other similar studies.[7–11] In 2014, Adelani et al[7] conducted a study to compare the outcomes of the two fixation techniques in 100 acetabular liner exchange revision THAs. Of the 56 cases that used HXLPE, two required re-revision surgery, resulting in a survival of 96% at a mean follow-up of 6.6 years.[7] However, the study did not provide information on the proportion of cases in which each fixation method was used when using the HXLPE liner.

The HXPLE liner can be secured either with the original locking mechanism or by cementing in the liner, and others have investigated the influence of mode of fixation.[12] A total of 36 cases in this study underwent insert exchange using the original locking mechanism, and four of them required re-revision surgery. With the longer follow-up in our study, we found that the outcomes in terms of re-revision were comparable between original locking mechanism and cemented fixation of HXLPE liner, which is consistent with other reports.[7,8,13–15]

In this study, the revision-free survival rates for the HXLPE liners secured with the original locking mechanism were promising. Some other studies with cohorts that used the original locking mechanism alone, and a mean follow-up of 5.1 years to 6.7 years, have reported poorer survival of 83% to 87%.[9,16] However, the exact proportion of the differing types of liner used in these studies was not clear. It had been shown that the use of conventional UHMWPE components in liner exchange revision surgery is associated with a higher need for re-revision surgery than with the use of a HXLPE liner.[4] As a result, it is possible that the discrepancy in the survival between this study and previous studies could be attributed to the use of conventional UHMWPE components.

Our study also reported good outcomes with cement fixation of HXLPE components, which is consistent with other studies. The ten-year survival in this study was 93.2% for patients who had the HXLPE liner fixed with cement. A study by Lim et al[10] in 2014, involving 36 cases of acetabular liner exchange revision surgery using a HXLPE component fixed with cement, revealed an overall survival of 97% at a mean follow-up of 6.1 years. Other studies that used cementing for the liner fixation with a mean follow-up of between ten years and 11 years have reported a survival of 84% to 90%, although conventional UHMWPE components were used instead of HXLPE.[17,18] Based on the longer follow-up period in this study, the results suggest that the incidence of failure requiring re-revision surgery following cement fixation of a HXLPE liner is low. The complications of cement fixation are not limited to local hip-related complications. There is the rare possibility of bone cement implantation syndrome, which can potentially cause death. No 30-day mortality or cement-related complications are reported in this study. One large-scale study from registry data concluded that there was no significant increase in 30-day mortality with cement fixation in primary hip arthroplasty.[19]

Complications that necessitated re-revision were uncommon in this study. Most were related to complications of the liner. Less common causes included loosening of implants, hip instability, and infection. Liner component-related complications included wear, liner fracture, and liner component dissociation. Liner component dissociation is a well recognized postoperative complication of this type of revision surgery, and occurred in one case. The reported incidence of acetabular component liner dissociation typically ranges from 0% to 3%.[9,16,20] Although all failures (three cases) related to liner-specific complications occurred in hips where cement fixation was undertaken, this did not reach significance, Unlike using the original locking mechanism, cement fixation of the new acetabular liner component is more technically demanding and perhaps more likely to be prone to intraoperative placement issues, which may increase the risk of subsequent liner-related complications. Further study with a larger sample size is warranted to establish the relationship between using cement fixation and postoperative liner-related complications.

The overall incidence of acetabular component loosening requiring re-revision was low at 3.5%. None of the patients with cemented HXLPE liners suffered this complication. Although the incidence was low, the results of this study suggest that acetabular component loosening requiring re-revision surgery following liner exchange revision THA was associated with use of the original locking mechanism. All three cases in our study were associated with the Omnifit HA implants. Previous studies have reported the incidence of acetabular component loosening to be approximately 4% in around five to ten years' time; however, the type of acetabular implant used was not specified.[7,11] However, it has been suggested that the risk of acetabular component loosening is higher in hips with significant osteolysis prior to the liner exchange revision THA.[11] There is some controversy around whether isolated liner exchange revision THA should be performed in the presence of acetabular osteolysis.[11,21] A study with 116 hips that underwent liner exchange revision THA with both conventional UHMWPE and HXLPE components between 1993 and 2004 reported a significant increased risk of aseptic loosening in hips with established acetabular osteolysis in all three DeLee and Charnley acetabular zones, greater than 50% the circumference of the acetabular component, or defects > 600 mm^2.[11] The authors recommended revising the acetabular component in these cases.[11] Revising the acetabular components in hips with extensive osteolysis requires acetabular reconstruction.[12] Other investigators reported a study with 138 hips, with osteolysis and polyethylene wear as the indications for isolated liner exchange revision THA using a crosslinked polyethylene component did not observe an increased re-revision rate.[22] The presence of acetabular osteolysis should not be an absolute contraindication for liner exchange revision THA for some patients with polyethylene wear after primary THA. Preoperative radiological assessment of the extent of osteolysis is necessary to determine the appropriate reconstructive option.

Hip dislocation was the most frequent complication observed in this study, noted in 12.8% of the cases. If the dislocation was

associated with liner-specific related complications or acetabular component loosening, re-revision surgery was necessary in all cases. Seven patients suffered dislocation without other associated complications and five of them were managed successfully with closed reduction, while two patients required re-revision due to recurrent instability. Hip dislocation occurred with both fixation methods, and no significant difference was observed between the two techniques. Irrespective of the fixation technique used for securing the liner, during the revision surgery, extensive soft-tissue dissection is required for exposure of the acetabular component, to remove the old liner and allow liner exchange. This is likely to explain the high dislocation rate. Other studies have also reported that dislocation is common and in the region of 16% to 25% of patients after isolated liner exchange revision THA.[11,23,24]

Despite the satisfactory outcomes after isolated liner exchange, it is not without risks, especially if there were already preoperative risk factors that predispose to failure. A review from the New Zealand Joint Registry reported the ten-year revision-free survival of 75.3% in more than 90,000 liner exchange revision procedures, and that nearly half of the re-revisions were due to dislocation and approximately 20% were due to acetabular component loosening.[20] Another review of the Norwegian Arthroplasty Register reported that liner exchange revision THA was associated with an increased risk of complications requiring full acetabular component revision when compared to revising both well-fixed and loose acetabular components.[25] Dislocation was once more the most commonest cause of re-revision.[25] A further study that compared the incidence of re-revision after liner exchange surgery and acetabular component revision also demonstrated that the re-revision rate was lower in patients who had the acetabular component revised.[26] For these reasons, some surgeons advocate that revision THA with complete acetabular component exchange is to be preferred in patients with polyethylene wear after primary THA. However, full acetabular component revision is associated with increased operating time and blood loss when compared to isolated liner exchange.[27] Careful patient selection and detailed preoperative assessment are important to reduce failure in patients undergoing isolated liner exchange revision THA. For successful isolated liner exchange surgery, it is important to preoperatively assess the position of the acetabular component radiologically. A safe zone of inclination of 35° to 55° and anteversion of 5° to 25° has been proposed for predicting success in isolated liner exchange surgery.[7] Failure to identify acetabular component malposition is likely to increase the risk of complications after liner exchange surgery and the requirement for re-revision surgery.

Despite long-term results and a large study group, one limitation of our study is that this is a retrospective case series. There was also significant heterogeneity in the brands of the hip implants and acetabular liners. The study was underpowered to allow comparisons of the incidence of re-revision due to acetabular component loosening and the two fixation methods. Conducting a larger prospective multicentre study would be more likely to provide an answer regarding the association between re-revision due to acetabular component loosening and acetabular liner exchange with the use of the original locking mechanism.

This study has demonstrated that acetabular liner exchange revision THA using HXLPE liners is an excellent option where the acetabular component remains well fixed but liner wear and osteolysis are present, given the encouraging mean 13-year revision-free survival. The re-revision rate and the revision-free survival following liner exchange surgery using HXLPE liners were not affected by the mode of fixation. The overall complication rate was 23.3% (20/86), with dislocation being the most common. In total, 11.6% (10/86) of the patients required re-revision surgery. The use of the original locking mechanism as the fixation method was associated with acetabular component loosening requiring re-revision surgery ($p = 0.038$). Both cement fixation of a HXLPE liner into an acetabular component or using the original locking mechanism for fixation were associated with good survival at 13-year follow-up. Careful patient selection, particularly in the presence of acetabular osteolysis, is necessary to obtain good long-term outcomes and reduce the risk of re-revision when undertaking acetabular liner component revision with a HXLPE component regardless of the surgical technique followed.

Take home message

- The finding of good survival at a mean follow-up of 13 years indicates that liner exchange surgery using highly crosslinked polyethylene (HXLPE) liner can be a viable long-term treatment option for polyethylene wear and osteolysis after total hip arthroplasty.
- The choice of fixation techniques did not affect the re-revision rate after liner exchange operation with HXLPE liner, thus, surgeons can select the most suitable fixation technique based on other factors such as surgical preference, patient characteristics, and available resources.

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