

TYPE IV ACETABULAR DEFECT TREATMENT – TREATMENT WITH A PARTIAL PELVIC REPLACEMENT RING

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ABSTRACT

Reconstruction of severe pelvic discontinuity and acetabular defects is a challenging condition in hip revision surgery. Between October 2018 and July 2023, 5 hip revisions due to traumatic periacetabular osteolysis, primary osteoarthritis, or revised total hip arthroplasty (rTHA) underwent acetabular revision using partial pelvic replacement (PPR). There were 3 female and 2 male patients. The age range was between 35 and 77 years (median, 56 years). Considering the acetabular bone defects, as classified by the American Academy of Orthopedic Surgeons (AAOS), 3 cases were classified as grade III and 2 cases as grade IV. All patients underwent complete clinical and radiographic follow-up for 30 months $\pm$ 2 (minimum 16 and maximum 36 months). For all causes, none of the implants required revision. No patients developed heterotypic ossification or osteolysis at the last X-ray. Before surgery, the average pain was around VAS = 8/10, which reduced to 2/10 following surgery. After surgery, patients had an average limb length discrepancy of 15 millimeters (range, 0-20 millimeters), which was assessed both clinically and radiologically. An improvement in quality of life was observed in all patients. The overall survival of PPR was 100% at 30 months of follow-up. High overall survival rates, pain control, and limb length are achieved by reporting favorable pelvic biomechanics and intermediate-term outcomes in cases of extensive acetabular defects with pelvic discontinuity, through the use of the LINK Endo-Model PPR prosthesis.

KEYWORDS: *acetabular reconstruction, cage device, partial pelvic replacement, bone defect, dual mobility*

INTRODUCTION

Total hip arthroplasty (THA) is the operation of the century, and in view of its rising numbers, its sequelae as revision THA (rTHA) are inevitable and present important bone defects that should be managed.

Pelvic discontinuity and acetabular defects in revision arthroplasty complicate total hip arthroplasty. Such conditions, often encountered after infectious or traumatic events, still represent a challenge for orthopedic surgeons. Acetabular reconstruction is essential for a stable and lasting fixation, as well as to establish the center of rotation, and whenever possible, to restore bone stock (1). In this context, accurately evaluating the extent of acetabular defects is crucial in selecting the appropriate implants.

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Literature provides numerous classifications to evaluate pelvic discontinuity and acetabular defects. According to the American Academy of Orthopedic Surgeons (AAOS), acetabular defects are classified into five grades: Type I Segmental defects, Type II Cavitary defects, Type III Combined defects, Type IV Pelvic Discontinuity, and Type V Arthrodesis (2). This classification was consequently expanded by Berry et al. (3), by Paprosky (4), and finally by the Italian Group for Re-prosthesis (G.I.R.) (5).

The leading causes of THA revisions are loosening due to partial osteointegration (6), bone deformities that require reconstruction, and postoperative implant instability (7). Numerous conditions may result in extensive pelvic defects: tumors, fractures, rheumatoid arthritis, or poor bone stock due to primary hip replacement implants and biological fixation methods, which may delay weight-bearing and reduce osteointegration (8, 9).

Revision of the acetabular component exhibiting bone loss aims to achieve a reconstitution of periprosthetic bone stock and to obtain primary stability. Smaller cavitary bone defects <30% of the acetabulum may be successfully managed with porous-coated hemispherical cups and bone grafting. In cases of significant bone defects where the acetabular cavity is unable to accommodate the prosthetic components, and the rotational center and joint biomechanics are compromised, the use of agents that promote osseointegration, such as porous titanium or tantalum, is recommended. It is often mandatory to use bone grafts to support cemented implants (10, 11).

Literature addressed graft resorption and technical failures resulting from defect filling using massive allografts. Large defects are often ineffectively treated with structural allografts, and their optimal management remains controversial (12-16). Consequently, alternatives to structural allografts that support the acetabular cup surface involved ileo-ischial devices (17-19).

The definitive extent of any bone defect must be confirmed intraoperatively, following hardware, cement, and pathological tissue removal; generally consisting of fibrous tissue and metal or polyethylene debris. The explant itself and the surgical maneuvers may worsen a pre-existing bone defect considerably (20).

Due to the challenging nature of large acetabular defects, we present our case series in which THA revision surgery was performed using a rigid greater-flange surface area with ischial screw fixation: partial pelvic cage (LINK, Hamburg, Germany). In the present report, partial pelvic replacement (PPR) proves to be an effective treatment option with successful middle-term outcomes through immediate bridging mechanical fixation, whilst restoring the rotation center of the hip (21-25).

MATERIALS AND METHODS

Between October 2018 and July 2023, 5 hips (3 women and 2 men) with peri-acetabular osteolysis for various reasons underwent acetabular revision using partial pelvic replacement (PPR) performed by an experienced, specialized hip surgeon in Italy (San Raffaele Hospital, Milan). Underlying causes of revision surgery were as follows: 2 patients suffered from severe hip osteoarthritis, one patient reported blast trauma with major acetabular involvement, and 2 required re-revision following primary THA-revision failure due to complications. The analysis directly excluded patients whose grade of acetabular defect was under III according to AAOS. The entity of acetabular defects was assessed according to the American Academy of Orthopedic Surgeons (AAOS) classification: 3 patients exhibited grade-III, and the other 2 patients had grade-IV acetabular defects (4).

The average age at the time of operation is 56 years (range: 35-77 years). The average preoperative leg dysmetria was 2.5 centimeters (range, 1.5-3 centimeters), which was assessed clinically and confirmed radiologically. The average preoperative pain was assessed using the Visual Analog Scale and was rated as 8 out of 10. Pelvic discontinuity was considered and defined as a loss of bone in both the anterior and posterior columns of the acetabulum, which disrupted the continuity of the inferior and superior parts of the pelvis (Fig. 1, 2).



Fig. 1. Case 1, X ray pre-op. Marked proximal migration of the previous implant.



Fig. 2. Case2, X ray pre-op. Avascular necrosis of the femoral head with loss of acetabular bone stock.

The same orthopedic surgeon (OM) performed all procedures. A standard lateral approach to the hip was used. Following acetabular exposure, reaming and curettage were performed until cancellous bone was reached, with care taken to avoid breaching the medial wall during the operation. In the current series, we used a cemented LINK partial pelvis replacement cage (LINK, Hamburg, Germany) prosthesis, along with an artificial hip acetabular cup, in cases of extensive bone loss.

The recent LINK Endo-Model® PPR prosthesis can be associated with different LINK hip replacement systems. This implant presents various holes where AO cancellous or cortical screws can be placed and retained. The cage has two cranial flanges and a single caudal flange that allows iliac and ischial fixation.

To achieve primary stability, the acetabular cavities in the loading areas were filled with autografts of morcellized bone, obtained by milling the acetabulum. Once the cage was fixed into the ischium and the ilium, the acetabular defect was filled with polymethylmethacrylate (PMMA) cement. We make sure that the cement completely fills the defect. This is performed using the thinner nozzle of the cement gun to allow penetration through the cage holes into adjacent bone defects. Digital pressure over the remaining defects, combined with the use of an acetabular cement pressurizer, permitted pressurization and cementation.

A dual mobility polyethylene cup was then cemented inside the cage in all patients using a single-stage cementation technique. The preoperative planning aimed to restore the center of rotation, which had been lateralized and proximal, and to achieve limb symmetry. In cases where the defect was more extensive, the new center of rotation may have been limited somewhere between the original and the center of the ileo-sacral joint. The distal flange of the acetabular cage was then inserted into the ischium, and the proximal flange was screwed to the lateral wall of the ilium. Screws directed dorsally and distally prevented displacement in the craniolateral direction.

Postoperatively, weight-bearing on the operated limb was contraindicated for 2 months to allow for osseointegration; however, passive rehabilitation to strengthen muscular trophism was allowed.

The clinical and radiological assessments were conducted postoperatively, at 1 month after the operation, and at the last follow-up, using AP view X-rays of the pelvis and AP and lateral views of the hip.

Attention was given to assess the remodeling of the bone grafts placed behind the concavity of the cage. Oral and written informed consent was obtained from all patients for the surgical intervention, including a statement for the publication of their case reports and any accompanying images.

RESULTS

The mean follow-up of the series was 50 ± 2 months (range, 16-56 months). No acute or midterm complications were observed during the follow-up period. No patient was re-revised for loss of acetabular fixation.

Complete radiological follow-up was available for 5 hips; no patients were lost during follow-up. None of the patients developed symptomatic heterotypic ossification or cases of osteolysis on the last radiographic control (Fig. 3, 4). The mean VAS at the last follow-up was 2/10. All patients reported an improvement in quality of life. After surgery, the patients regained an average of 15 millimeters of limb dysmetria (range 0-20 millimeters), which was evaluated both

clinically and radiologically. At the last checkup, all the patients had abandoned walking aids. The overall survival rate for PPR was 100% after more than 50 months of follow-up (range, 16-56 months).



Fig. 3. Case 2, X-ray postop. Link cage partially corrected with the position of the liner.



Fig. 4. Case 1, X-ray postop. Correct placement of the PPR.

DISCUSSION

The main finding of this study is that limb length discrepancy and range of motion, as well as function, can be restored following important bone defects of the pelvis.

To achieve this, primary hip stability and biomechanical restoration are crucial to avoid severe but common complications, such as implant dislocation and loosening (26). Over time, several treatment methods were proposed, including non-cemented oblong or jumbo cups, reinforcement rings, anti-protrusion cages, ileo-ischial cages with modular trabecular metal grafts, and structural and morselized bone grafts (27).

Despite excellent long-term outcomes with 95% survival rates after 15 years being shown in acetabular revisions for small bone stock deficits using conventional uncemented cups with supplementary screw fixation, stable fixation of biological lining using the aforementioned methods in cases of great bone defects is unlikely to be successful. Literature proves that defective bone filling with massive unsupported periacetabular allografts leads to early failure due to graft resorption and cup loosening (28-30).

When a graft supports more than 50% of the acetabular component, a reconstruction system that covers bone defects from the ileum to the ischium should be considered to protect the graft and to provide structural stability (31).

Although the literature provides satisfactory results with the use of the most antiprotrusion cages, they exhibit some non-negligible complications; loss of primary stability in acetabular defects AAOS> III, thus, a stable fixation of the distal flange in the ischium is recommended (32). Secondly, osseointegration deficit is frequent due to the lower quality of the bone stock. Moreover, cement failure is common when considering the middle and long-term survival (33). Antiprotrusion cages aid in the reconstruction of the hip rotation center; however, they are insufficient to reduce the incidence of dislocation of the prosthetic components, with the incidence of dislocation in revision reaching 35%.

Dislocation may arise due to several factors, including muscle insufficiency, aggressive capsulectomies, poor quality and/or quantity of bone stock, age, female sex, type of surgical approach, static or dynamic balance disorders, neuromuscular pathologies, and extreme implant positioning. When considering elderly patients as the main candidates for revision of a hip prosthesis, there are often combined and coexisting risk factors (34, 35). We perceived confidence after adequate ischial fixation with the used implant, considering this to be one of the key factors in fixation compared to other reinforcement rings or cage constructions (36), which allowed us to bypass the areas of pelvic discontinuity.

In a series of 47 hips, Rowell et al. used this implant for lytic bone metastasis of the acetabulum with excellent results. They favored this fixation to allow their patients immediate weight-bearing and to obtain a larger surface area and stress dispersion (37).

High rates of aseptic loosening (from 12-27%) were reported after an average follow-up of 4.1 years, which were encountered following the use of morselized bone grafts (38-40). Similarly, with this PPR, it is crucial to reconstruct an adequate bone stock through bone grafts to ensure primary stability and prevent both short-term and long-term loosening of the prosthetic components.

In our cases, PPR fixed and supported bone grafts from weight bearing through load stress distribution, bypassing the area of bone loss and providing satisfactory hip biomechanics and function, allowing for restoration of the hip rotation center to the anatomic center and the center of the sacro-iliac joint, even in the absence of anatomical landmarks. The use of a dual mobility cup cemented in an acetabular reconstruction cage device limited the risk of instability while permitting acetabular fixation.

This study presents several limitations; firstly, it is limited to the retrospective nature of the analysis. Secondly, the study was conducted on only 5 patients, and a control group was lacking due to the rarity of such cases, where alternative techniques and devices may have been employed. Furthermore, there are numerous confounding variables associated with the patients, including baseline disorders, the reason for revision, and the degree of acetabular disruption. Nevertheless, a single orthopedic surgeon, an expert in hip surgery, performed the same surgical procedure, thereby limiting the potential for controllable biases. The preoperative planning was performed by the same operator and was thoroughly conducted to assess the actual extent of the bone tissue deficit, which was confirmed through a careful intraoperative assessment. The surgeon's experience played a fundamental role in ensuring the correct positioning of the prosthetic components and minimizing any neurovascular and iatrogenic lesions, as most failures are likely related to a poor surgical technique and inadequate application of unstable bone grafts (18). For all causes, we report an overall implant and patient survival rate of 100% at an average follow-up of 50 months.

CONCLUSIONS

High overall survival rates, pain control, and limb length are regained by reporting favorable pelvic biomechanics and intermediate-term outcomes in cases of extensive acetabular defects with pelvic discontinuity, through the implication of the LINK Endo-Model® PPR prosthesis.

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