Scoops of success: outcomes in a series of 13 patients using a cone cup prosthesis for acetabular reconstruction

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Abstract

Background

Endoprosthetic reconstruction of major pelvic bone loss in oncology and revision arthroplasty surgery is associated with high complication rates. However, comparative data for reconstructive methods are limited. We present short-term clinical, radiological and functional outcomes of the Implantcast MUTARS® LUMiC® prosthesis for acetabular reconstruction after major pelvic bone resection or loss.

Methods

A retrospective folder review was performed from December 2019 to June 2022. The minimum follow-up period was 12 months. The inclusion criterion was all patients who underwent acetabular reconstruction with the Implantcast MUTARS® LUMiC® cone cup prosthesis.

Results

Thirteen patients were included in the study. The indication for pelvic resection was a primary bone tumour in seven patients, metastatic bone disease in three and failed arthroplasty in three. Complications, as classified by the Henderson classification, occurred in 38% and included two patients with dislocation, three with infection, and one of whom had both. Other complications included sciatic nerve neuropraxia, iatrogenic fracture of the greater trochanter, and vascular injury. The median Musculoskeletal Tumor Society Score (MSTS) scores at 12 months assessed in eight patients were 21 of 30 points.

Conclusion

Our results are in agreement with other series, and highlight the problems of instability and deep infection. Patients without complications had an acceptable functional outcome.

Level of evidence: Level 4

Keywords: acetabulum, endoprosthetic replacement, osteosarcoma, chondrosarcoma, metastatic bone disease, limb salvage, amputation, revision arthroplasty, pelvis

Introduction

Reconstruction of the acetabulum and proximal femur is often required after resection of pelvic tumours and for significant bone loss following fractures and revision arthroplasty. Surgical reconstruction of these defects remains challenging due to the complex anatomy of the pelvis, the biomechanical forces at play and limited remaining bone stock.[1-3] Although the indications may differ, the problems of implant fixation, joint stability and infection remain.[4,5]

The reconstructive options after major acetabular bone loss include biological, composites and endoprostheses.[5-8] Currently modular endoprostheses are the preferred option for reconstruction, but because of the rapid development of computer-aided three-dimensional (3D) printing technology, patient-specific implants have become a viable alternative.[9]

All reconstructive options in this field are associated with high rates of complications and there is no standout method, due to the rarity of these tumours as well as the difficulty of these procedures. There are not previous studies of this nature and those found in the literature consist mainly of small case series. Most current investigations are retrospective case series or cohort studies ranging from 9–126 patients (mean 49), and lack comparative data.[10,11]

Our paper aims to develop further data on this topic by studying outcomes and reviewing surgical techniques using the Implantcast MUTARS® LUMiC® cone cup prosthesis.

Methods

A retrospective review was carried out on the medical records and imaging of all patients who underwent pelvic reconstruction with a cone cup prosthesis. The study period was from December 2019 to October 2021 with a minimum follow-up of 12 months. Tumour resection was planned using plain film radiography, computed tomography (CT) and/or magnetic resonance imaging (MRI).

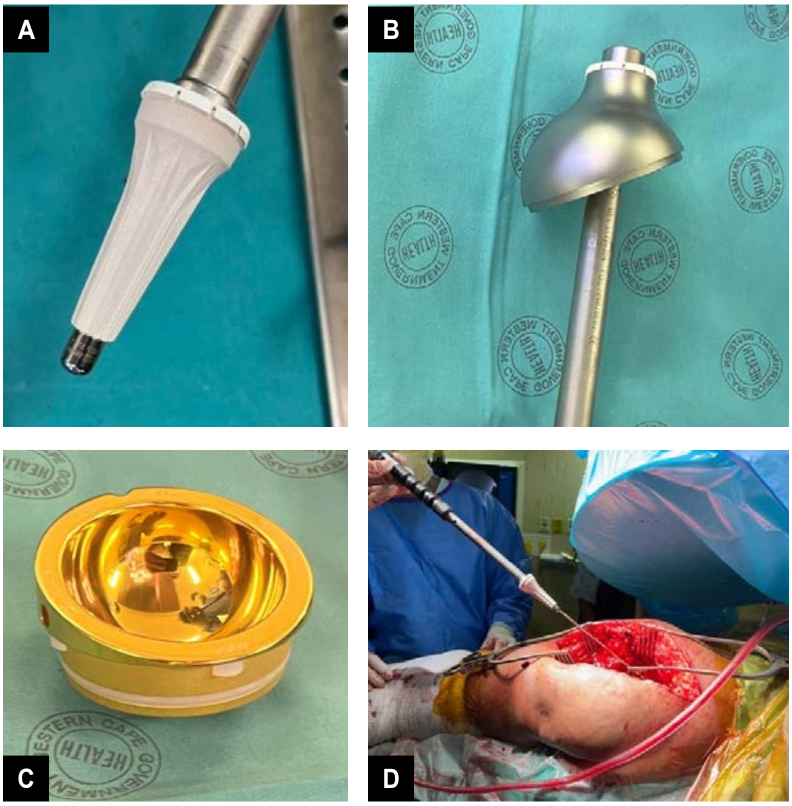


Figure 1. The cone cup prosthesis and its components. A) hydroxyapatite (HA)-coated stem; B) cup; C) cup liner (in this case dual mobility); D) clinical intraoperative picture of stem being implanted

All surgeries were performed by the same primary surgeon who was assisted by a variety of associates and nursing teams. First-generation cephalosporins were given intravenously prior to surgery and additional doses were given for 24 hours after the operation. Patients were instructed not to wear braces, and primary total hip replacement physiotherapy protocols were used to mobilise them after the operation. Musculoskeletal Tumor Society Score (MSTS) scores were obtained for patients 12 months after the procedure.[12]

Surgical technique

The acetabular implant used was the Implantcast MUTARS® LUMiC® cone cup.[13] The stem is designed to fit between the anterior and posterior cortices of the iliac wing, parallel to the sacroiliac joint and above the sciatic notch.[14] The articular design is modular and can be adjusted to achieve the maximum stability desired. Specialised meshed tubing, such as a Trevira tube or an aortic graft, can be added around the construct for additional joint stability (*Figure 1*).[13,15]

The patients were positioned in a lateral decubitus position; bolsters were used to position the patient without obstructing fluoroscopy and to allow access for surgery. Once the pelvic resection had been performed, the guidewire was placed under fluoroscopic imaging. The iliac wing was then reamed and the stem implanted (*Figure 2*).

Results

Patient results

Thirteen patients (nine females) with a mean age of 64 years were identified for inclusion *(Table I)*. Seven patients had metastatic bone disease, three had primary sarcomas, and three were revision arthroplasty patients. At the final 12-month review, eight patients were alive and five had died (four of metastatic disease and one of other medical causes) after a median of six months.

Prosthetic results

The stems of the cone cup prostheses were fixated with cement in ten cases, and three were uncemented. Dual mobility cups were used in 12 of the cases. Five patients required augmentation of the acetabulum with cement and one required cement and Steinmann pin augmentation. The decision about whether to augment was at the discretion of the surgeon, after consideration of how much bone stock remained and how stable the inserted stem was. A Trevira tumour tube was used in two patients. Femoral reconstruction included nine cemented primary stems, two collarless uncemented stems and two proximal femur

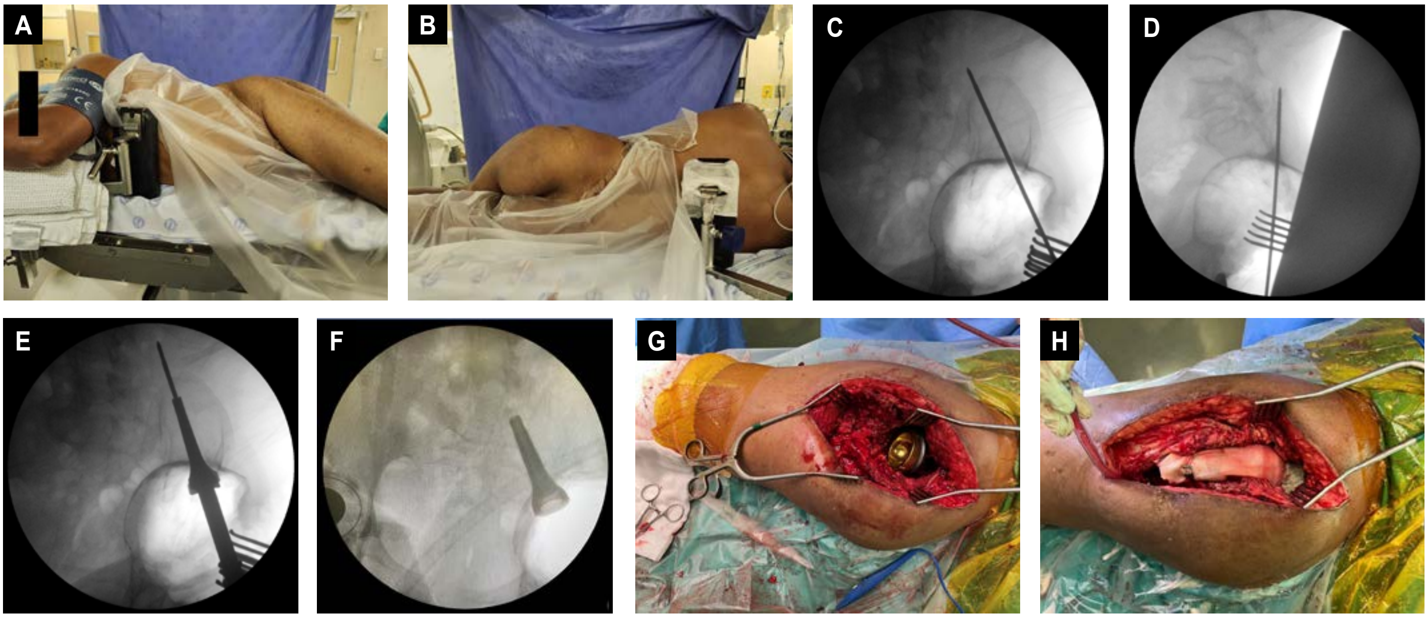


Figure 2. Intraoperative images of stem placement technique. A and B) patient positioning; C and D) guidewire placement; E) reaming; F) stem implantation; G) clinical picture of cone cup in pelvis; H) post-procedure implant with Trevira tube

Table I: Basic demographics, follow-up and indications for surgery

Variable	n = 13
Age (years)	
n	13
Mean	63
Median (IQR)	67 (50, 75)
Range	30–84
Sex	
Male	4
Female	9
Comorbidities	2
Chronic kidney disease	1
HIV	2
Hypertension	4
None	6
Pacemaker for arrhythmia	1
BMI	
< 35	10
> 35	3
ASA	
2	13
Diagnosis	
Breast carcinoma	3
Vulva carcinoma	1
Cervix carcinoma	1
Multiple myeloma	2
Primary chondrosarcoma	2
Synovial sarcoma	1
Failed arthroplasty	3
Indication	
Acetabular primary sarcomatous lesion	3
Acetabular metastases	7
Failed arthroplasty	3
Primary/revision	
Primary	9
Revision	4

HIV: human immunodeficiency virus; BMI: body mass index; ASA: American Society of Anaesthesiologists

megaprostheses. Examples of preoperative and postoperative imaging of the implanted prosthesis can be seen in *Figure 3*. In *Figure 4* one can appreciate a dislocation, highlighting one of the main complications, which is stability.

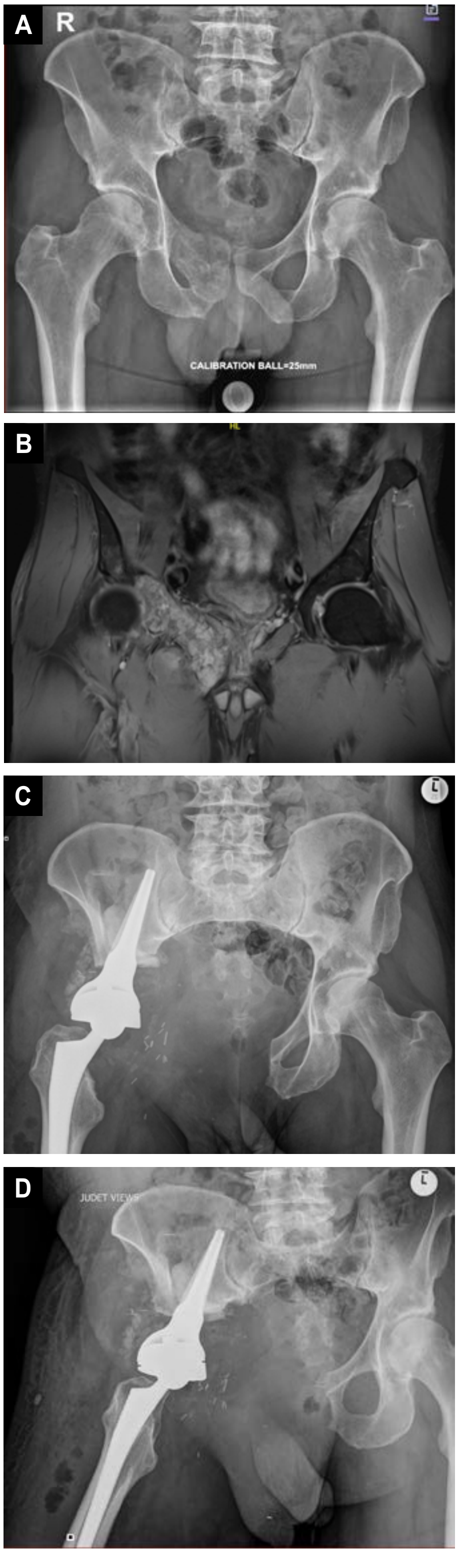


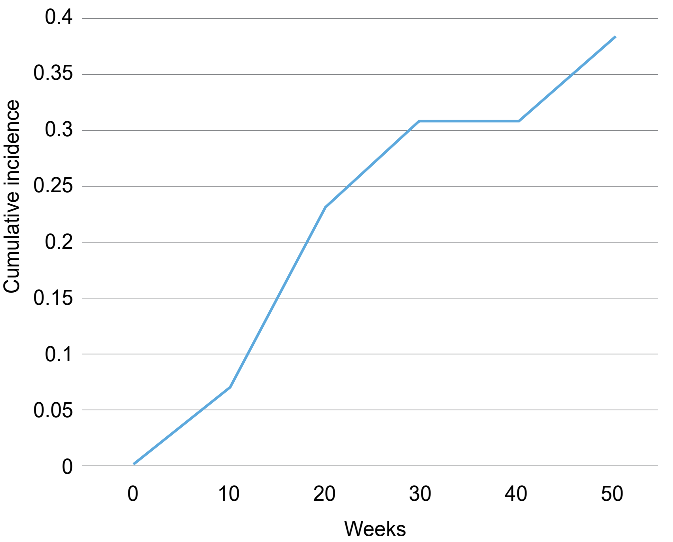
Figure 3. Pre- and postoperative imaging of a patient with acetabular metastatic disease. A) preoperative AP pelvis X-ray; B) preoperative MRI showing extent of pelvic tumour; C) postoperative AP pelvis X-ray showing pelvic resection and implanted cone cup prosthesis; D) postoperative iliac oblique view X-ray showing pelvic resection and implanted cone cup prosthesis

Surgical results

The pelvic resections were type 2 in eight patients and type 2–3 in two patients, according to the Enneking and Dunham classification.[16] Surgical margins were adequate in all patients, depending on the pathology. In patients with primary sarcoma, wide margin tissue resection of the tumour was performed. In cases with metastatic bone disease, pelvic resection was performed as required, based on assessment of preoperative imaging and intraoperative findings. The three patients (23%) who had revision arthroplasty had pelvic discontinuity rather than hemipelvectomy resections.

Skin incisions used were lateral in 11 cases and extended Kocher-Langenbeck in two. The surgical approach to the hip was anterolateral in ten patients and posterior in two patients.

Complications were classified according to the Henderson classification *(Table II)*.[17] There were five Henderson-type



At risk	13	10	10	7	7	7
Events	0	3	3	4	4	4

Figure 4. Graph showing cumulative incidence of first complication

complications (38%), two mechanical and three non-mechanical complications (*Table III*).

Two patients experienced one or more mechanical complications (type 1 and type 3). A single dislocation (*Figure 5*) occurred in two patients within 28 days, and in one of these the cup also cut out (type 3). These two patients underwent revision surgery: one required explantation and excision arthroplasty due to an unsalvageable joint; the other was converted to an acetabular cage with a captured cup. Deep infection (type 4) occurred in three patients, two early in the postoperative period and one after 11 months. One patient was successfully treated with surgical debridement, implant retention and intravenous antibiotics (DAIR). The two other patients died soon after developing infection and first-stage revision surgery, due to a combination of primary malignant disease and perioperative complications.

Other complications included internal iliac artery occlusion likely due to traction of the artery. This was attended to by the vascular surgery team and treated successfully with embolectomy alone. One patient had a sciatic nerve neuropraxia postoperatively, which resolved spontaneously after six weeks. This was thought to be due to a thermal injury when augmenting the cup. In one patient, an iatrogenic fracture of the greater trochanter was caused

Table II: Henderson classification of segmental endoprosthetic failure

Type of failure	Mode of failure	Description
Mechanical		
1	Soft tissue failure	Instability/dislocation, tendon rupture or aseptic wound dehiscence
2	Aseptic loosening	Clinical and radiological evidence of loosening
3	Structural failure	Periprosthetic or prosthetic fracture or deficient osseous supporting structure
Non-mechanical		
4	Infection	Infection of endoprosthesis necessitating removal of device
5	Tumour progression	Recurrence or progression of tumour with contamination of endoprosthesis

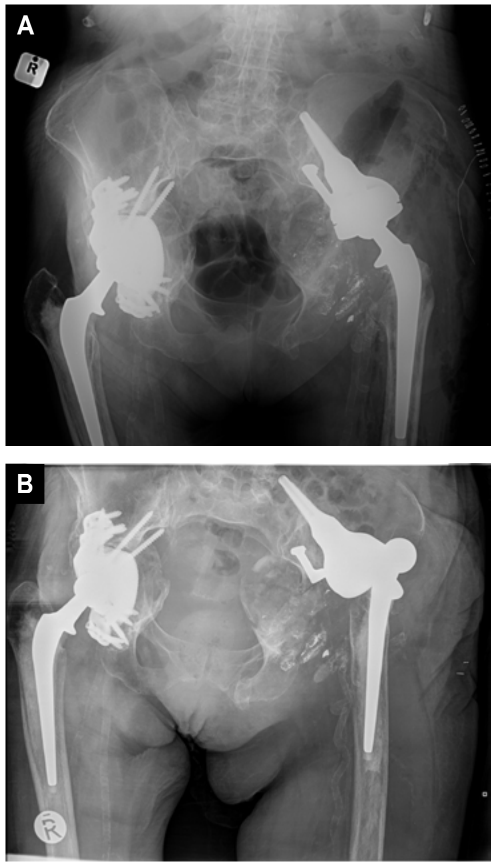


Figure 5. AP X-rays of pelvis in the same patient showing an example of a cone cup dislocation. A) postop; B) at time of dislocation

during implant insertion, and was managed conservatively. These complications were iatrogenic and not directly related to the implant. If these additional complications are taken into account, along with the complications classified above by the Henderson classification, the overall gross complication rate would be 46%.

The median MSTS score at 12-month follow-up for eight available patients was 20.75 (17–27) out of 30 points.

Table III: Follow-up and complications over a one-year period

Variable	n = 13
MSTS at one year	
Dead before one year	5
17	3
20	2
24	2
27	1
Follow-up at one year	
Dead	5
No complications	6
Type 1 complication: dislocation	2
Type 3 complication: cut out	1
Type 4 complication: PJI	3
Follow-up period in months	
1	1
6	3
9	1
12	8

Discussion

Pelvic reconstruction after tumour excision or failed arthroplasty is a technically challenging procedure with a high risk of complications. There is no current literature to support a single best technique or approach to managing these patients. Here we report our findings using the cone cup implant in all patients.

Historically, Harrington et al. in 1981 described the use of Steinmann pins with cement augmentation to manage acetabular bone defects after tumour excision.[18] Prior to this, there were no other feasible options for reconstructive surgery. Harrington's method was found to have a high risk of complications. The main complication is dislocation due to the difficulty of deciding on the correct placement of the acetabular cup. Stability remains an issue today but since the use of navigation systems, modular prostheses and constrained liners, dislocation rates have decreased.[19,20]

Harrington's techniques are still applied in the management of large pelvic defects and for less invasive procedures, such as percutaneous screw placement or cement augmentation in pelvic metastatic disease. However, advances in modular implants such as the Implantcast MUTARS® LUMiC® cone cup and other endoprostheses, are proving to be valuable solutions for more complex reconstructions.[8,19,21]

Our retrospective observational study examined the short-term outcomes of patients treated with the Implantcast MUTARS® LUMiC® cone cup prosthesis. In patients without complications, the implant provided a relatively simple and functional hip joint, despite the complex pathology and reconstructive requirements. Our MSTS score and complication rate correlates with current literature on cone cup implants and other reconstructive methods.[6,8,15,22-24]

The cone cup is designed to bypass the anterior portion of the pelvic ring and distribute forces through the ilium above the sciatic notch and into the sacroiliac joint, sacrum and spine. The procedure has shown good functional outcomes, but there have been high complication rates.[8] Mechanical complications have been reported in 30% of cases in previous studies, and can include dislocation or implant failure without dislocation, i.e. loosening.[6] Issa et al. reported a 58% complication rate over a period of 8–94 months, with all patients experiencing at least one complication. The main complications in their study were sepsis and dislocation, but the implant survival rates at five years were relatively acceptable at 75%.[22] Comparing the cone cup to other methods, Hipfl et al. reported complications of up to 40% using a stemmed pedestal cup, with deep infection being the most common complication.[24] Tsagozis et al. reported the successful reconstruction of metastatic acetabular defects using a modified Harrington procedure, which involved the placement of modular acetabular cups cemented into the construct with retrograde screws, rather than Steinmann pins.[20] This technique demonstrated a decrease in dislocation rates and improved functional outcomes. Lastly, Volpin et al., in their systematic review, found that regardless of the choice of acetabular implant used to address acetabular bone loss, instability remained the most common reason for revision surgery.[4]

In our study, dislocations were observed in two patients, both occurring early after surgery and among the first patients in the cohort. This was thought to be related to a steep surgical learning curve in prosthetic placement and the need for the use of dual mobility implants. The procedure to insert a LUMiC® cone cup requires a complete understanding of patient setup methods and the use of intraoperative fluoroscopy to ensure accurate implant insertion into good quality bone for stability, and proper orientation of the prosthesis and acetabular cup to maximise stability. Navigation, where available, is a useful tool to aid the surgeon in achieving this, but it is not readily available in all centres. Most resections in our study were type 2 pelvic resections, which involved the removal of all hip stabilising structures, and is believed to be a major contributing factor to instability resulting in possible dislocation. The authors believe that using a standard primary femoral prosthesis over a proximal femoral megaprosthesis, where possible, helps maintain better stability by preserving the large abductor musculature. If concerns about potential dislocation persist, a tumour tube is used.

Infection was another major complication observed both in the current literature and in our patients. Of the total of 13 patients, three became infected, and of these, one was salvaged successfully. The prosthesis was revised in the other two patients, but with poor outcomes. Multiple factors contribute to high infection rates in this patient cohort, including a cancer diagnosis, cancer treatment (chemotherapy and radiotherapy), systemic illness, prolonged surgical time, and blood loss. Patients who require this procedure for failed trauma or arthroplasty have often undergone multiple previous surgeries, which further increases the risk of infection.

The alternatives to reconstruction include iliofemoral arthrodesis, hindquarter amputation, or a 'hanging' hip.[25,26] However, these options often leave patients with poor function and quality of life, disfigurement, significantly shortened leg, and significant psychological impact.[18,27,28] For these reasons, endoprosthetic reconstruction is usually chosen following acetabular resection.[28-30]

When examining functional outcomes, our mean MSTS score was 21 (out of 30). Although this score is not particularly high, the patients in our study experienced improved function and independence compared to their baseline and what they would have had without reconstruction. Preoperative MSTS for comparison is not possible or helpful because the patient still has their hip and pelvis and has relatively good function, with pain often being the cause for their limitation.

The literature has shown that limb-sparing surgery patients generally have higher MSTS scores than amputees.[31] The MSTS scoring system has limitations; it is largely a score of physical function and is usually scored by the clinician rather than the patient, and often does not reflect the patient's general health or mental state.[32,33] The use of a single crutch or assistive walking device significantly decreases the MSTS score. MSTS scores in our patient series could be evaluated more positively considering alternative surgical options that leave the patient with an ablated limb or non-functional joint.

Advancements in CT technology and additive manufacturing have enabled the production of 3D-printed custom prostheses, offering methods for viable defect reconstruction and prosthetic fixation into remaining bone, when standard implants like the cone cup will not suffice.[1,34-36]

The observational retrospective design and small patient cohort limit the accuracy of the data. A multicentred international study is needed to include larger numbers. Longer follow-up is required, although high patient dropout is expected, due to the poor prognosis that is associated with cancer patients. Further follow-up is needed to study late complications such as sepsis, dislocations, implant failure, loosening, and tumour recurrence rates, which would enhance the value of the research.

Conclusion

Reconstruction for large pelvic defects is a high-risk procedure with significant complication rates, regardless of the method of reconstruction. However, successful reconstruction offers better functional outcomes compared to no reconstruction or amputation. Careful planning, precise surgical technique, and infection prevention are crucial in minimising complications. We consider pelvic reconstruction and salvage surgery using the Implantcast MUTARS® LUMiC® cone cup prosthesis to be a viable option. It offers modularity and is readily available as an off-the-shelf item.

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Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

Prior to the commencement of the study ethical approval was obtained from the following ethics review board: University of Cape Town, ethics approval number: HREC 667/2021.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

For this retrospective study, formal consent was not required.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

SWK: study design, data capture, state patient follow-up and scoring, manuscript preparation

TLH: study conceptualisation and involvement in all aspects of this article

HCFB: data analysis, manuscript preparation

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