Clin Orthop Relat Res (2017) 475:735–741
DOI 10.1007/s11999-016-4747-x

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

SYMPOSIUM: 2015 MEETINGS OF THE MUSCULOSKELETAL TUMOR SOCIETY AND THE INTERNATIONAL SOCIETY OF LIMB SALVAGE

Reconstruction After Hemipelvectomy With the Ice-Cream Cone Prosthesis: What Are the Short-term Clinical Results?

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Published online: 16 February 2016

Abstract

Background Reconstruction after internal hemipelvectomy resection likely provides better function than hindquarter amputation. However, many reconstruction methods have been used, complications with these approaches are common, and function often is poor; because of these issues, it seems important to investigate alternative implants and surgical techniques.

Questions/purposes The purposes of this study were (1) to identify the frequency of surgical site complications and infection associated with the use of the Ice-Cream Cone prosthesis for reconstruction after hemipelvectomy for oncological indications; (2) to evaluate the Musculoskeletal Tumor Society (MSTS) outcomes scores in a small group of patients treated with this implant in the short term; and (3) to quantify the surgical margins and frequency of local recurrence in the short term in this group of patients.

Methods Between 2008 and 2013, one center performed a total of 27 internal hemipelvectomies for oncological indications. Of those, 23 (85%) were treated with reconstruction. Our general indications for reconstruction were patients whose pelvic stability was affected by the resection and whose general condition was sufficiently strong to tolerate the reconstructive procedure. Of those patients undergoing reconstruction, 14 (61%) were treated with an Ice-Cream Cone-style implant (Coned®; Stanmore Worldwide Ltd, Elstree, UK; and Socincer® custom-made implant for the pelvis, Gijón, Spain), whereas nine others were treated with other implants or allografts. The indications during this time for using the Ice-Cream Cone implant were pelvic tumors affecting the periacetabular area without iliac wing involvement. Of those 14, 10 were available for followup at a minimum of 2 years (median, 3 years; range, 2–5 years) unless a study endpoint (wound complication, infection, or local recurrence) was observed earlier. Study endpoints were ascertained by chart review performed by one of the authors.

Results Local wound complication occurred in five of the 10 of the patients and two developed deep infection. None of them had to be removed. Median MSTS score was 19 out of 30 when 0 is the worst possible result and 30 a perfect function and emotional status. Five of seven primary tumors had wide margin surgery and three of seven developed local recurrences by the end of the followup.

Conclusions Pelvic reconstruction with the Ice-Cream Cone prosthesis yielded fair functional results at short-term followup. Longer term surveillance is called for to see whether this implant will represent an improvement over available reconstructive alternatives such as allograft, custom-made implants, and saddle prostheses. We are

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cautiously optimistic and continue to use this implant when we need to reconstruct the periacetabular area in patients without Enneking Zone 1 involvement.
Level of Evidence Level IV, therapeutic study.

Introduction

Patients who undergo hemipelvectomies for treatment of bone and soft tissue tumors are left with profound disability if no reconstruction is performed [4, 28, 31]. However, the reconstructions are difficult and prone to mechanical failures, dislocations, and infections [1–3, 5, 9, 10, 19–21, 26, 29, 31, 35]. Numerous reconstructive options have been tried, including autograft (vascularized or not) allograft, composite and saddle, custom-made, or modular prostheses. However, all seem to result in a high likelihood of early failure, and none is clearly superior [1–3, 7, 9, 13–18, 21, 23, 25, 33, 34, 36]. For this reason, alternative devices should be considered and explored.

The Ice-Cream Cone prosthesis is one such plausible alternative. This prosthesis is based on the McKnee-Farrar prosthesis and has been used for patients with severe periacetabular bone loss reconstruction since 2003. The stability is obtained with a stem introduced into the iliac wing and cementation of the space between the osteotomy and the cup. With this study we seek to confirm the results of earlier work that has evaluated the performance of the Ice-Cream Cone prosthesis device for oncological indications [14].

Specifically, we sought to (1) identify the frequency of surgical site complications and infection associated with the use of the Ice-Cream Cone prosthesis for reconstruction after internal hemipelvectomy for oncological indications; (2) evaluate the Musculoskeletal Tumor Society (MSTS) outcomes scores in a small group of patients treated with this implant in the short term; and (3) quantify the surgical margins and frequency of local recurrence over the short term in this group of patients.

Patients and Methods

Between 2008 and 2013, one center performed a total of 27 internal hemipelvectomies for oncological indications. Of those, 23 (85%) were treated with reconstruction. Our general indications for reconstruction were patients with enough remaining bone and general condition that balance the risk of the implant. Of those patients undergoing reconstruction, 14 (61%) were treated with an Ice-Cream Cone-style implant (Coned®; Stanmore Worldwide Ltd, Elmstree, UK; and Socincer® custom-made implant for the pelvis, Gijón, Spain), whereas nine others were treated with other implants or allografts. The general indications during this time for using the cone-style implant were pelvis tumor affecting the periacetabular area without iliac wing involvement. Of those, 10 of 14 were available for followup at a minimum of 2 years (median, 37 months; range, 24–54 months), unless a study endpoint (wound complication, infection, or local recurrence) was observed earlier. Study endpoints were ascertained by chart review performed by the one of the authors (IB-R).

Of the 10 patients in this group, seven had sarcomas, two were metastatic carcinomas, and one was an expansive hematoma. Four were women and six were men. Median age was 56 years (range, 33–77 years). All seven primary tumors were Stage IIB according to the Enneking classification. Every patient was examined in the team's multidisciplinary weekly meeting before the biopsy and the surgery [30]. The indication of surgery and other adjuvant treatments was individually discussed.

The preoperative planning included angio-CT (when vessel involvement was suspected), colonic preparation, and embolization of the superior gluteal artery and of the additional tumor vascularization. Intraoperative antibiotherapy included 2 g cefazolin at the start of surgery and 1 gram more every 4 hours as well as a single dose of 500 mg metronidazole. All patients had a preoperative MRI to evaluate the soft tissue mass and three-dimensional CT reconstruction was useful in five patients to understand the complex anatomy of the pelvis and its relationship with the sarcoma. The resections were planned according to the Enneking and Durham classification (Fig. 1A–B).

Surgical Technique

Patients were positioned in decubitus supine with a bump according to the zone that we were planning to resect. Resection in Zone III needed a more supine position and resections in Zone II were positioned in a nearly lateral position. The incision started at the superior border of the sacroiliac joint and progressed over the superior iliac wing to the anterosuperior iliac spine (ASIS). The approach turned to the pubis in a curved line to finish distally as an iliofemoral approach (Fig. 2).

The neurovascular bundle was identified and isolated for the mobilization together with the psoas. The sartorius and anterior rectus were reflected distally and the femoral insertion of the major gluteus was resected to develop the posterior flap. The posterior flap was reflected to visualize the sciatic notch. Before we performed the osteotomies, we measured the distance from ASIS to the superior border to the acetabulum; we used this information to avoid limb length discrepancy when the prosthesis was implanted (Coned®, Stanmore; and Socinser®). We used the CONED® implant in the first cases. We used in the last

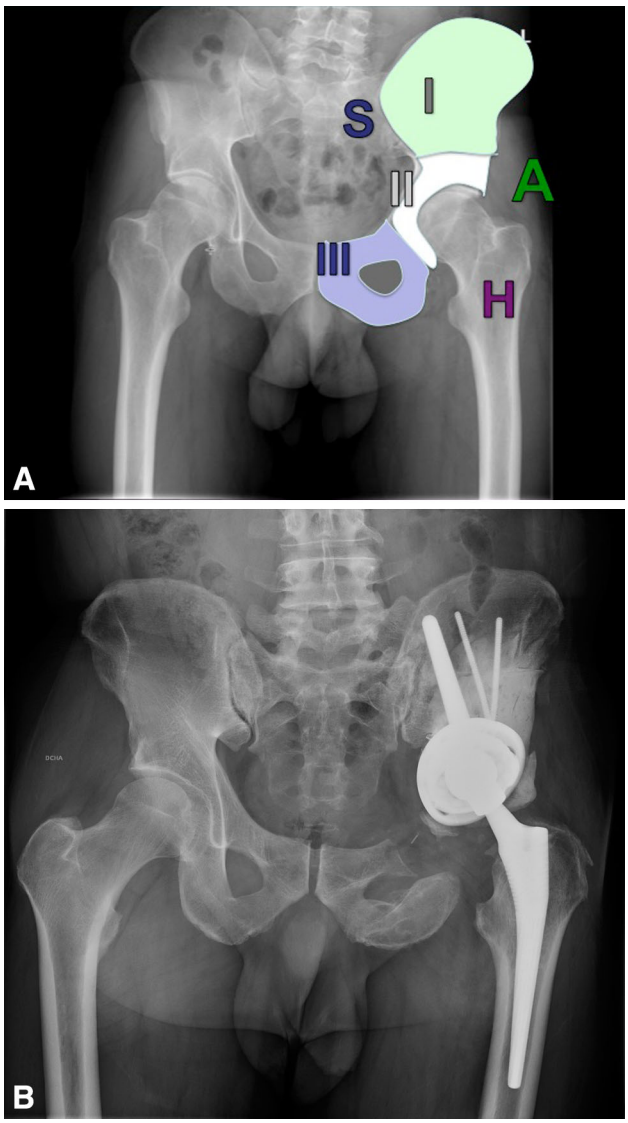

Fig. 1A–B (**A**) This picture shows a pelvic chondrosarcoma radiograph with the Enneking and Durham classification of the pelvic resection zones. H = hip; S = sacrum; A = abductor muscles. (**B**) This is a postoperative radiograph of the same patient showing the Ice-Cream Cone prosthesis that was implanted after an internal hemipelvectomy in a patient with a chondrosarcoma located in the periacetabular area.

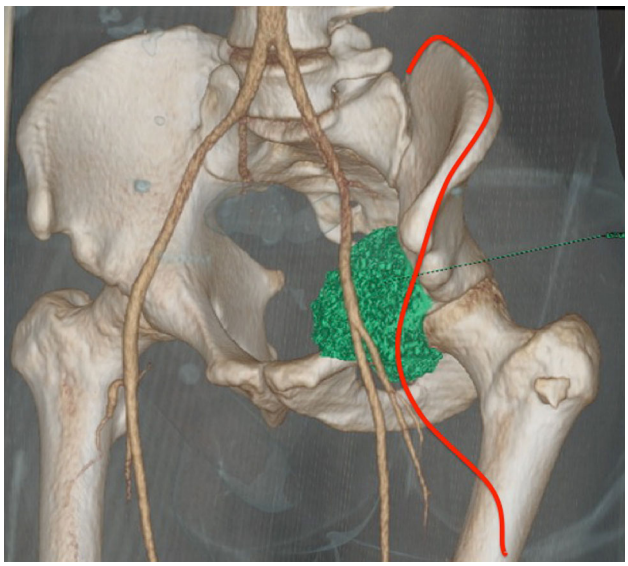

Fig. 2 This image shows a three-dimensional CT reconstruction of a Zone II to III sarcoma. The red line shows the standard approach.

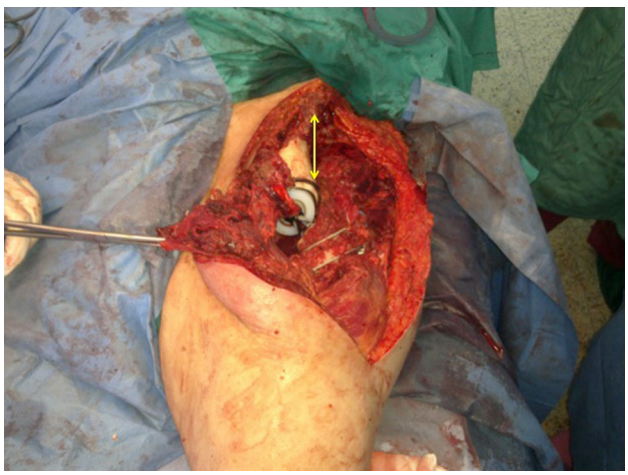

Fig. 3 In this intraoperative picture we can observe an implanted prosthesis with restored limb length. The arrow points to the distance from the ASIS to the border of the acetabulum.

cases the Socinser® implant because it provides the Kirschner wire guidance that in our hands is a helpful tool for positioning.

One Kirschner wire or reamer was placed parallel to the sacroiliac joint under control with intraoperative radiography before drilling. Using an intraoperative radiograph, we carefully evaluated the wire position before starting to ream to avoid violation of the sacroiliac joint. The prosthesis has different lengths and widths of the stem to accommodate it to the patient. In young people with strong bone, the stem was inserted press-fit, whereas older patients may require a cemented stem to ensure the soundness of the system.

The cup was reinforced with two to five screws or Steinmann pins from the implant to the iliac wing and the entire construct was cemented together (Fig. 3). At that time, a metallic cup was cemented in the Ice-Cream Cone implant to correct the defects of the cup position and a femoral stem (VerSys®; LD/Fx cemented and press fit prosthesis; Zimmer®, Warsaw, IN, USA) dual-mobility nonconstrained polyethylene and chrome-cobalt head were implanted to restore the joint.

Dead space must be avoided to diminish postoperative complications. We preserved the flap consisting of the

gluteus maximus and medius during the approach and they were reattached to the iliac wing after the procedure. Two cases had a proximal femur resection; in these patients the major gluteus was used as soft tissue coverture of the implant. Sartorius, anterior femoral rectus, and tensor of the fascia were also reattached. We do not use any kind of mesh to reconstruct the capsule. The patients in the study did not have any soft tissue reconstruction at first and we observed that a high proportion of them developed local wound complications. Now, we use a rectus abdominis myocutaneous (VRAM) flap as a standard of treatment in the patients with prosthesis reconstruction in the pelvis [22].

We maintained patients on strict bedrest for 1 week. Surgical drains were removed as soon as the debit was less than 30 cc per 24 hours and we maintained the antobiotherapy until the drains were out. In postoperative care, we used 1 g cefazolin intravenously each 8 hours. In people who are allergic to penicillin, we used 500 mg vancomycin intravenously every 12 hours with blood drug control every 2 days. Sitting was allowed after the seventh day. Patients were asked to walk with crutches and an abduction orthosis 2 weeks after surgery.

Wound complications, intraoperative bleeding, transfusions, surgery time, infection, and functional status according to the MSTS scale were recorded. Intraoperative data (bleeding, transfusions, and surgery time) were obtained from the anesthetic intraoperative chart. This scale uses a range of 0 to 30, in which 0 is the worst possible result and 30 the best functional and emotional status. Study endpoints were ascertained by chart review, which was performed by one of the authors (IB-R, MP-P, EJO-C). Tumor volume was measured in cubed centimeters and obtained multiplying the three diameters of the mass.

The patient was reviewed as an outpatient every 3 months. In each visit the functional and oncological status was recorded. Radiological evaluation of the implant was performed by one of the authors postoperatively. The distance between the sacroiliac joint and the end of the stem, the AP cup angle, and limb length discrepancy were also recorded.

Results

Local wound complication with necrosis was observed in four of 10 patients. Four patients had wound infections; two of them were superficial infections and were managed with irrigation and débridement, a vascularized flap (one VRAM flap and one gluteus flap), and antibiotics with good results. The other two patients had deep infections, One of them, with an *Enterococcus cloacae* infection, was operated on with irrigation and débridement, polyethylene exchange, and a VRAM flap; this patient also developed recurrent dislocation, which was treated in the same surgery with cemented cup repositioning. The other patient with a deep infection was an elderly woman who developed a chronic *Candida albicans* infection, and she is being managed on suppressive antifungal treatment. No patient has undergone Ice-Cream Cone implant removal or amputation. Median intraoperative bleeding was 2585 mL (range, 500–7000 mL) and postoperative drain output was 340 mL (range, 150–400 mL). Transfusions of stored red blood cells were used in all but one patient with a median of 7 units/patient (range, 2–19 units). Median surgery, including resection, and bone and soft tissue reconstruction time were 419 minutes (range, 240–605 minutes).

Median MSTS score was 19 of 30 (range, 11–24 of 30). Five patients are able to perform a stable walk with two crutches, four of them with one crutch, and one of them could walk without aids. All our patients had a Trendelenburg gait. Daily activities (job, housework) were possible in five of 10 patients. Preoperative limb length discrepancy was 7 mm shorter and the postoperative discrepancy of the involved limb was 15 mm shorter (range, 5–30 mm). AP cup angle was 38° (range, 18°–80°). With the numbers available, we did not observe a correlation between the MSTS score and the implant positioning in this series (Table 1).

Five of seven primary tumors had wide margin surgery and three of seven developed local recurrences at the end of the followup. A total of two of the seven patients with primary bone tumors developed metastatic disease (Table 2).

Table 1. Radiological and functional results

Patient number	Age (years)	AP angle (degrees)	Distance to sacroiliac joint (mm)	MSTS score
1	67	47	23	16
2	36	43	7	22
3	65	32	7	23
4	77	18	1	14
5	70	35	8	11
6	50	27	7	11
7	66	20	0	18
8	46	80	Through	15
9	60	47	0	20
10	49	32	0	11
Median	56 (range, 33–77)	38 (range, 18–80)	5 mm (range, 0–23)	19 (range, 11–24)

MSTS = Musculoskeletal Tumor Society.

Table 2. Marginal status and oncological results

Diagnosis	Zones resected	Margins	Tumor size (cm^3)	Local recurrence	Metastases
CHSA	IIB	W	8 × 7 × 5	Not	Not
CHSA	IIB	W	6 × 8 × 6	Not	Not
CHSA	IIB	M	14 × 10 × 7	Yes	Not
Pseudotumor	NA	NA	12 × 6 × 3.5	NA	NA
CHSA	IIB	W	23 × 15 × 10	Yes	Yes
MPNST	IIB	M	8 × 8.5 × 13	Yes	Yes
Thyroid metastasis	III	IL	11 × 7 × 8	Not	Yes
CHSA	IIB	W	6 × 5 × 5	Not	Not
CHSA	IIB	W	4 × 3 × 5	Not	Not
Breast met	III	IL	15 × 10 × 8	Not	Yes

CHSA = chondrosarcoma; Pseudotumor = expansive and destructive not oncological disease; MPNST = malignant peripheral nerve sheath tumor neurofibrosarcoma; Breast met = breast adenocarcinoma bone metastases; NA = not oncological purpose of the procedure.

Discussion

Many attempts have been made to improve the reconstruction of the pelvis after tumor resection. However, complications remain common and survival has not substantially improved when we compare the results in the old series and in more recent reports [1–3, 6, 7, 9, 13–18, 21, 23, 25, 28, 33, 34, 36]. Using an allograft or an allograft-prosthesis composite in pelvic surgery seems a good option in those countries with proper bone banking with severe protocols to avoid disease transmission. Nevertheless, fracture, pseudoarthrosis, and infection are also a concern in these patients. The restoration of the stability with allograft has a 3-year survival rate of 50% that is similar to other pelvic reconstructions but poorer than the outcome of allograft in other locations [23].

This study had a number of limitations. First, this is a case series and we did not compare our result with the Ice-Cream Cone prosthesis with the results of hemipelvectomies with Zone 1 or 4 implications or the periacetabular reconstructions with other devices. Insofar as some of these patients may survive for many years, a study with 2-year minimum followup tells only a small part of the story. Mechanical failures and infections may yet result in revisions or removal of implants in these patients, and longer surveillance is necessary. To compare our results to those of other devices such as custom-made prostheses [26, 33], saddle prostheses [7, 17, 20, 25], or modular prostheses [15, 17, 33, 34, 36], longer term studies are needed, and we continue to follow these patients. Last, as a result of the variety of diagnoses, resection zones implied, and ages, the series has a high degree of heterogeneity. All of those factors and others can make comparing functional results difficult, and the MSTS scale, although validated [8, 11, 12, 27], is a crude tool. Even so, an MSTS score of 19 out of 30 (the median in this series) likely exceeds what is possible in a patient with an internal hemipelvectomy who does not then undergo reconstruction.

A variety of different reconstructive approaches have been used in patients undergoing hemipelvectomies, including as custom-made prostheses [24, 26], saddle prostheses [7, 17, 20, 25], or modular prostheses [15, 17, 33, 34, 36]. In our small series at short-term followup, we believe that the frequency of complications, infections, and reoperations compares favorably to those alternatives; however, longer followup and confirmation in the hands of others certainly are needed. The functional results of the reconstruction with these devices are not usually excellent and the complications are as frequent as with allograft [23]. The Ice-Cream Cone implant has the advantage of a reproducible technique that does not need a perfect match between the patient and implant and it also has the advantage of modularity.

In our series local wound problems were common, but none of the implants had to be removed during our short followup. Prior work about custom-made prostheses suggests they are associated with frequent complications, including infection (25%–32%) and dislocations (2.5%–17%) [24]. Zhou et al. [36] had promising results with a modular endoprosthesis in eight patients without infection or dislocation and good function. However, Witte et al. [33] studied 40 patients with a MUTARS® Implantcast (Buxtehude, Germany) modular prosthesis and found that 75% developed complications, and 3-year survival of the implant was 61%. The saddle prosthesis has the advantage of less surgical time and postoperative pain, but complications seem to be as common as in custom-made prostheses and these have the additional risk of proximal migration and seem to be associated with poorer function (0%–7%) [1, 7, 17, 20, 25]. The custom-made devices [26] had 21% infection, 16% dislocations, and 11% aseptic loosening in the series.

Achieving a high level of function in patients undergoing hemipelvectomy is all but impossible, because the osseous resection is large, and sometimes nerves are sacrificed or injured in the course of these resections. In our series, a median MSTS score of 19 of 30 was achieved at 2 years. This is better than other previous series; however, approximately half of our patients were not able to return to work. The flail hip (resection without reconstruction) with the new position of the femoral head after the resection (may be anterior or posterior to the iliac wing or periacetabular neck) could be a possibility in patients with large tumors who need early recovery of the surgery without complications to start adjuvant therapies; however, such patients should be counseled that a high level of function is seldom achieved with this approach [20, 31]. The function in patients treated with a custom-made implant [24, 26] was 12 to 13 of 30 on the MSTS scale. On the other hand, the function with modular implants has varied from 15 to 20 in the different studies [17, 33, 36]. Other authors have suggested that the distance to the sacroiliac joint may be a predictor of more pain and poor functional results [14]; however, we did not find a clear correlation in our series.

Local recurrences and oncological results in this report are, as expected, comparable to those observed with other reconstructive techniques [7, 17, 18, 20, 24, 26, 32–34, 36]. This is not surprising, because the reconstruction is performed after the resection, and the priority, regardless of the reconstructive approach used, must be an adequate oncological margin. Moreover, surgical margins are more difficult to achieve when the tumors are very large when they are referred.

Complications in our hands with the Ice-Cream Cone prosthesis were common but all the implants were retained at short-term followup. The expected function is fair on the MSTS scale (19 of 30 in our small series). However, the followup was only short term, and the series were small, so further studies are necessary to confirm our findings. We are cautiously optimistic and continue to use this implant when we need to reconstruct the periacetabular area in patients without Enneking Zone 1 involvement.

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