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The Friedman-Eilber Resection Arthroplasty of the Pelvis

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Abstract It has been argued that internal hemipelvectomy without reconstruction of the pelvic ring leads to poor ambulation and inferior patient acceptance. To determine the accuracy of this contention, we posed the following questions: First, how effectively does a typical patient ambulate following this procedure? Second, what is the typical functional capacity of a patient following internal hemipelvectomy? In the spring of 2006, we obtained video documentation of eight patients who had undergone resection arthroplasty of the hemipelvis seen in our clinic during routine clinical followup. The minimum followup in 2006 was 1.1 years (mean, 8.2 years; range, 1.1–22.7 years); at the time of last followup in 2008 the minimum followup was 2.9 years (mean, 9.8 years; range, 2.9–24.5 years). At last followup seven of the eight patients were without pain, and were able to walk without supports. The remaining patient used narcotic medication and a cane or crutch only occasionally. The mean MSTS score at the time of most

recent followup was 73.3% of normal (range 53.3–80.0%; mean raw score was 22.0; range 16–24). All eight patients ultimately returned to gainful employment. These observations demonstrate independent painless ambulation and acceptable function is possible following resection arthroplasty of the hemipelvis.

Level of Evidence: Level IV, case series. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Resection arthroplasty of the pelvis is the complete removal of the innominate bone along with the femoral head and neck. It is commonly referred to as an “internal hemipelvectomy,” or “flail hip,” as the limb is retained [9, 11, 13, 18, 29, 30]. While Theodore Kocher is credited as the first surgeon to perform this procedure in the late 19th century [33], in 1979 Eilber et al. described a modification of that technique [18].

Instability of the residual limb following resection of the innominate bone reportedly leads to poor ambulation and inferior patient acceptance [10, 12, 14, 23, 24, 28]. As a result, most authors currently advocate replacement of the resected bone using a prosthetic device, allograft, or other means to reconstruct the pelvic ring [3–5, 7, 10, 17, 44–46]. We previously reported the clinical and functional results following internal hemipelvectomy without reconstruction, which has been our preferred technique since 1979 [18, 26, 40]. The prolonged rehabilitation course following this procedure as well as the consistent improvement in ambulation over time was emphasized in our previous study. Following resection arthroplasty of the hemipelvis, patients typically require ambulatory supports for at least

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Each author certifies that his or her institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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one year, and are eventually able to transition to aid-free ambulation [26].

The purpose of this paper is to provide video evidence of the functional outcomes that are possible with resection arthroplasty of the hemipelvis. We posed the following questions: (1) How effectively does a typical patient ambulate following this procedure? (2) What is the typical functional capacity of a patient following internal hemipelvectomy? The accompanying video may serve as a useful reference for both patient and surgeon during the pre- and postoperative stages of primary pelvic sarcoma management. (Supplemental materials are available with the online version of CORR.)

Materials and Methods

From August 1984 to May 2006, we treated 46 patients with wide resection of portions of the innominate bone for pelvic malignancy. In the spring of 2006, one of the authors (PK) obtained video documentation for all patients who were seen in our clinic for routine followup following resection arthroplasty of the hemi-pelvis (Table 1). This included eight patients seen at a mean of 8.2 years (range, 1.1–22.7 years) following their index resection arthroplasty. The diagnosis was chondrosarcoma in four, Ewing's sarcoma in two, malignant giant cell tumor in one, and osteosarcoma in one. Six patients presented with localized disease, while two had metastatic lesions upon initial presentation. We had prior institutional board approval for the study (UCLA IRB#G07-04-082-01) and all patients were informed that the video documentation would be used for publication, and all patients gave written consent.

All patients underwent resection arthroplasty according to the technique described by Eilber et al. [18]. Critical to the success of this particular technique is the meticulous reconstruction of the soft tissues surrounding the hemipelvis. Following resection, the remaining abductors

and gluteal muscles are sutured in multiple layers to the abdominal muscles. If the anterior resection is through the symphysis, it is frequently necessary to place a prosthetic mesh to facilitate repair of the adductor musculature to the abdominal wall to help prevent herniation of the pelvic contents anteriorly. The femoral head and neck were routinely resected to avoid protrusion of the proximal femur into the pelvis. The posterior osteotomy was performed through the lateral sacrum or by disarticulation of the sacroiliac joint. Six of eight anterior osteotomies were performed through the superior and inferior pubic ramus, while the remaining two were performed through the pubic symphysis.

Surgical margins following the index resection arthroplasty were negative in all eight cases. For the eight patients, mean blood loss at surgery was 1285.7 cc (range, 400–3500 cc) (Table 2). One patient underwent repeat surgery due to postoperative wound dehiscence, likely related to preoperative radiation therapy for his pelvic Ewing's sarcoma (Patient 7). This was managed in a single procedure with irrigation and débridement, followed by wound coverage with a latissimus dorsi rotation flap. Two patients had previously undergone iliac wing resection prior to the index resection arthroplasty. Patient 4 underwent resection of the iliac wing for intermediate-grade chondrosarcoma. Final pathologic evaluation demonstrated a positive surgical margin, and the patient was returned to the operating room within 5 days for definitive index resection arthroplasty. Similarly, Patient 6 underwent iliac wing resection for chondrosarcoma, and experienced a local recurrence 3 years postoperatively. He then underwent his index internal hemipelvectomy procedure.

Video documentation was obtained using a commercially available camcorder device by one of the authors (PK). All patients in the videos were encouraged to ambulate according to their everyday routine, and to use ambulatory aids if these were utilized routinely. Patients were instructed to ambulate approximately 30 feet, turn and return to the starting position. Next, if possible,

Table 1. Demographics

Patient	Age	Diagnosis	Stage	Blood loss	Surgical margins	Metastatic disease
1	17	Ewing's	III	400	Negative	Yes [§]
2	44	Malignant GCT	IIB	600	Negative	No
3	43	Chondrosarcoma	IIB	1000	Negative	Yes*
4	29	Chondrosarcoma	IIB	2500	Negative	Yes [‡]
5	46	Chondrosarcoma	IIB	500	Negative	No
6	22	Chondrosarcoma	IIB	500	Negative	Yes [†]
7	23	Ewing's	IIB	3500	Negative	No
8	28	Osteosarcoma	III	NA	Negative	Yes [§]

GCT = Giant cell tumor; *12 months postoperatively; [†]10 years postoperatively; [‡]3 years postoperatively; [§]At time of presentation.

Table 2. Results

Patient	Length of followup (years)*	Status [†]	Walking aids [†]	Shoe lift (inches) [†]	MSTS score ^{†,#}	Occupation [†]
1	1.1	NED	None	3.5	76.7	College student
2	1.2	CDF	Cane/crutch	2	53.3	Billing specialist
3	1.5	DOD [‡]	None	2	73.3	Executive
4	6.0	DOD [§]	AFO [¶]	2	73.3	Artist
5	10.1	CDF	None	2	76.7	Homemaker
6	10.3	DOD	None	0	76.7	TV reporter
7	12.5	CDF	None	3	80.0	Executive
8	22.7	NED	None	3	76.7	Administrator
Mean	8.2			2.2	73.3	

NED = no evidence of disease following treatment of metastatic lesions; CDF = continuously disease free; DOD = died of disease; AFO = ankle-foot orthosis; MSTS = Musculoskeletal Tumor Society; *At the time of video in 2006; [†]At final followup in 2008; [‡]3.5 years postoperatively; [§]8.6 years postoperatively; ^{||}12.3 years postoperatively; [¶]For nerve palsy related to subsequent spine surgery; [#]reported as percentage of normal (normal = 30 points).

patients were instructed to navigate one flight of stairs according to their everyday routine. Functional outcomes were measured at the time of most recent clinical followup using the revised Musculoskeletal Tumor Society (MSTS) Functional Score described by Enneking et al. [21]. Scores were considered excellent if five of six variables scored five points, good if five variables scored three points or more, fair if five of six factors scored one or more points, and poor if two or more factors scored zero.

Results

Three patients who presented with Stage IIB lesions at the time of presentation developed metastatic disease at 12 months, 3 years, and 10 years postoperatively. All three of these patients died of disease in 2008, at 3.5, 8.6, and 12.3 years, respectively, following their resection arthroplasty (Table 2). Functional data for these three patients was obtained at the time of their most recent outpatient clinic visit.

At the time of their last outpatient clinical evaluation, seven of the eight patients walked without walking assists and had no pain related to the index procedure. The remaining patient (Patient 2) used a cane around the house, crutches while outside, and remained on occasional narcotic medication. The mean shoe-lift size was 2.2 inches (range, 0–3.5 inches). One patient chose to ambulate without a shoe lift (Patient 6). In the absence of an ambulatory aid, all eight patients walked with a Trendelenburg gait. All patients ultimately returned to gainful employment.

The mean MSTS score at the time of most recent followup was 73.3% of normal (range, 53.3–80.0%; mean raw score, 22.0; range, 16–24). Scores were rated as good in 7 patients, and fair in 1.

Several key points are emphasized by the video supplement accompanying this report. First, readers should note the improvement in function that occurs as the time from the index procedure increases. Those patients with followup less than 3 years in duration demonstrate inferior ambulatory capacity to those with greater than 3 years' followup. We have found this typical of patients who have undergone resection arthroplasty of the hemipelvis, and patients are generally more accepting of this procedure at longer-term followup. Second, most patients are able to navigate stairs. The two patients who are not seen climbing stairs (Patient 1 and Patient 2) were ultimately able to achieve this capacity with the use of a rail at the time of most recent followup. Finally, readers should note the use of shoe lifts among patients in the recordings, and the function that is possible despite a substantial leg-length discrepancy. Of particular interest is Patient 6 who does not use a shoe lift, and effectively compensates by ambulating with his foot in slight equinus. (Supplemental materials are available with the online version of CORR.)

Discussion

Resection arthroplasty is a well-established procedure for conditions affecting the acromioclavicular, femoroacetabular, proximal radiocarpal, scapulothoracic, and metatarsophalangeal joints, among others [15, 22, 31, 35, 36, 42]. Despite its widespread use elsewhere, most authors decry the use of resection arthroplasty for conditions involving the pelvic girdle, citing poor postoperative function and unacceptable levels of pain. The purpose of this review was to answer the following questions: what is the typical ambulatory status of a patient following this procedure, and what is their typical functional capacity?

The major limitations of this study include the small number of patients, the lack of an appropriately matched control group, and the potential for selection bias. Internal hemipelvectomy is only rarely indicated for pelvic malignancy and, at our institution, we averaged just over two of these procedures annually during the past three decades. With many of these patients having already succumbed to disease, and others living in distant parts of the country, it is exceedingly difficult to amass a large series. While we recognize that our study population is a select cohort, we believe these video recordings provide an accurate sample of the function that is typical following resection arthroplasty of the hemipelvis. Furthermore, the videos may serve as a useful reference for both patient and surgeon as to the typical rehabilitation course, and functional outcomes following this procedure.

All eight patients in this series were able to ambulate without pain, and without the use of walking aids. All patients walked with a Trendelenburg gait, and all but one patient required the use of a shoe-lift. It is our experience that stability of the extremity, and thus ambulation, is improved by utilizing a shoe-lift approximately 50% of the total leg-length discrepancy (eg, a 2.5-inch lift for a 5-inch leg-length discrepancy). This allows the patient to ambulate with the foot in slight equinus. If the lift equals the total leg-length discrepancy, the plantigrade foot rests on an unstable platform, which is less cosmetic and less functional than walking on the ball of the foot. The number of patients seen in this series who ambulate with a Trendelenburg gait and demonstrate a substantial leg length discrepancy is comparable to that seen in the available literature.

Table 3. Function following internal hemipelvectomy: comparison of the available literature

Author	Year	Number of patients	Duration of followup (mean or range)	Reconstruction type*	Functional outcome†	Comments
Enneking et al. [20]	1978	32	1–17 years	A, E	23G,5P,4F	3 with resection arthroplasty, all with good function
Johnson [27]	1978	2	2–4.5 years	C	n/a	Both ambulate with limb, one with cane
Steel [43]	1978	5	3–6 years	A	n/a	All ambulatory without supports
Nilsonne et al. [38]	1982	7	1.5–10 years	A	n/a	Gait analysis; 1 of 7 uses no support
Nielsen et al. [37]	1985	1	5 years	C	n/a	Pain-free, using crutch, employed
Huth et al. [26]	1988	27	2–14 years	A	n/a	Initial ambulation with supports, eventually independent
Abudu et al. [1]	1997	35	84 months	C	70%	Thirteen of 35 available for MSTS score
Bell et al. [8]	1997	17	7 years	B	70%	Thirteen of 17 available for MSTS score
Renard et al. [41]	1999	15	6 months	C	50%	
Kollender et al. [34]	2000	27	1.5–12 years	A,B,C	6E,17G,3F,1P	Twelve of 27 had no reconstruction
Pant et al. [39]	2000	13	84 months	A,B,C	3G, 1F‡	Six of 13 had no reconstruction; 4 patients alive at follow-up
Wirbel et al. [46]	2001	18	60.5 months	C	3E,7G,6F,3P	
Aljassir et al. [2]	2005	17	45 months	C	51%	
Beadel et al. [6]	2005	21	60 months (min)	B	45%	Six of 21 available for MSTS score
Hoffman et al. [25]	2006	45	69 months	A,B,C	48%	Best function (61%) with “hip transposition”
Kitagawa et al. [32]	2006	8	37 months	C	53%	
Dai et al. [14]	2007	10	21–48 months	C	7G, 2F, 1P	
Dellooye et al. [16]	2007	18	41 months	B, C	68%	
Chang et al. [12]	2008	6	18 months	D	n/a	Mean time to assist-free ambulation was 8 months
Schwartz et al. §	2008	8	8.2 years	A	22; 73.3%	7 Good, 1 Fair; Video documentation provided

* Type of reconstruction: A – None; B – Allograft; C – Endoprosthesis; D – Vascularized Strut Graft; E – Fusion.

† According to system described by Enneking et al. [21], shown as percentage of normal (normal = 30 points), or according to modified score: E: excellent; G: Good; F: Fair; P: Poor.

‡ 4 patients alive at follow-up.

§ Present study.

A lack of standardized reporting, coupled with varied surgical techniques reported throughout the literature makes functional data comparison difficult (Table 3). The system described by Enneking et al. [21] is the most widely employed means of functional reporting following treatment of musculoskeletal malignancy. According to this system, patients are assigned a score between 0 and 5 for pain, function, supports, emotional acceptance, walking ability, and gait. Functional scores are reported as a percentage of normal (the maximum 30 possible points) [21]. An earlier scoring system [19] reported outcomes on a 35-point scale, and encouraged a more subjective terminology (e.g. excellent, good, fair and poor) used in many older series. The results of this series are compared to those reported in the available literature (Table 3). The mean MSTS score at the time of most recent followup was 73.3% of normal (range 53.3–80.0%; mean raw score was 22.0; range 16–24), which is comparable to scores reported throughout the literature. The prolonged rehabilitation course following this procedure, which is a common finding in similar studies, should be discussed with the patient preoperatively. By 3 years, most patients are able to achieve pain-free, independent ambulation without the use of supports.

Resection arthroplasty of the hemipelvis provides an alternative to complex reconstructive procedures that carry high rates of reoperation, infection, implant failure, and amputation. Although the vast majority of patients will demonstrate a considerable leg-length discrepancy, the results of this review demonstrate that independent, painless ambulation is possible following resection of the innominate bone without reconstruction of the pelvic ring. We provide this video documentation as objective evidence for both patient and surgeon of the functional outcomes that are possible following this procedure. A lack of standardized reporting in the available literature makes comparison of the different reconstructive options difficult. In the future, increased uniformity of technique and reporting method among comparable series should be encouraged.

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