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Staged sacrectomy—an adaptive approach

Clinical article

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Object. Sacral tumors are commonly diagnosed late and therefore present at an advanced stage. The late presentation makes curative surgery technically demanding. Sacrectomy is fraught with a high local recurrence rate and potential complications: deep infection; substantial blood loss; large-bone and soft-tissue defects; bladder, bowel, and sexual dysfunction; spinopelvic nonunion; and gait disturbance. The aim of this study was to analyze the complications and morbidity of sacrectomy and the modifications meant to reduce the morbidity.

Methods. This is a retrospective study of the patients who underwent sacrectomy between February 1997 and September 2008 in the Department of Surgical Oncology, Government Royapettah Hospital, Kilpauk Medical College, in Chennai, Tamilnadu, India. Sacrectomy was performed using 1 of the following approaches: posterior approach, abdominolateral approach, or abdominosacral approach, either as sequential or staged operations. The morbidity rate after the sequential and staged abdominosacral approaches was analyzed. Functional assessment was made based on the Enneking functional scoring system. The results were analyzed and survival analysis was done using the Kaplan-Meier method (with SPSS software).

Results. Nineteen patients underwent sacrectomy, of which 12 operations were partial, 3 were subtotal, and 4 were total sacrectomy. Histological diagnosis included giant cell tumor, chordoma, chondroblastoma, adenocarcinoma of rectum, and retroperitoneal sarcoma. The giant cell tumor was the most common tumor in this series, followed by chordoma. The patients' mean age at diagnosis was 32 years. There were 10 male and 9 female patients. Forty-seven percent of patients had bowel and bladder disturbances postoperatively, and 57.89% of patients had wound complications. The median follow-up duration was 24 months (range 2–140 months). The 5-year overall survival rate was 70.4%, and the 5-year disease-free survival rate was 65% (based on the Kaplan-Meier method). The local recurrence rate (5 cases) was 26.32%. The median duration for first recurrence was 12 months (range 3–17 months). Distant metastasis occurred in 1 patient (5.26%), and 4 patients died, 1 of them due to pulmonary thromboembolism, in the postoperative period. Based on the Enneking system of functional evaluation, 5 patients (26.32%) had excellent outcome, 6 (31.57%) had good outcome, 5 (26.32%) had fair outcome, and 3 (15.78%) had poor outcome. Spinopelvic reconstruction was not performed in any of the patients, and all were ambulatory postoperatively. The staged abdominosacral approach has markedly reduced patient morbidity in terms of reduction of operating time, blood loss, anesthesia complications, and wound complications.

Conclusions. Sacrectomy, a dreaded operation that often results in morbidity, is now feasible with modifications and improvement in surgical technique. The staged abdominosacral approach reduces the immediate postoperative morbidity. Use of a gluteal advancement flap reduces the incidence of wound complications.With modern surgical facilities and postoperative care, sacrectomy is feasible via the staged abdominosacral approach.
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Key Words • sacrectomy • staged abdominosacral approach • sequential abdominosacral approach

Sacral tumors comprise a heterogeneous group of neoplasms ranging from benign, benign aggressive, malignant, to metastatic in origin. Patients presenting with sacral neoplasm range in age from very young with teratomas to very elderly with metastatic disease. The most common primary sacral tumors are chordoma, GCT, chondrosarcoma, and plasmocytoma. Secondary infiltration of the sacrum by rectal carcinoma and retroperitoneal tumor can occur. The most common tumors requiring sacrectomy are primary sacral tumors and rectal carcinoma infiltrating the sacrum. Characteristically, the primary tumors progress slowly to involve adjacent

Abbreviations used in this paper: GCT = giant cell tumor; PNET = primitive neuroectodermal tumor.

This article contains some figures that are displayed in color online but in black and white in the print edition.

structures. Eventually, the sacral nerve roots coursing through the sacrum are invaded, and then cease to function. The symptoms produced by these tumors are often vague, ranging from local pain to ill-defined lower lumbar pain associated with radicular symptoms that are commonly confused with the more common lower lumbar back and nerve root compression syndromes. The symptoms, however, tend to involve both lower extremities and only later produce the commonly expected bowel and bladder dysfunction.

Attempts to resect primary and metastatic lesions of the sacrum have intrigued surgeons for years, as is evident from numerous reports. Sacrectomy was performed by many surgeons, like Bowers[1] in 1948 and MacCarty et al.[8] (at the Mayo Clinic) in 1952. The technique of the 2-position procedure was popularized by Hays[3] in 1952 and by Localio et al.[7] in 1967. In 1978, Stener and Gunterberg[11] described the currently accepted principles and techniques of sacral amputation, and these remain the standard by which other reports on sacral resection are judged.

Methods

A retrospective study of the patients who underwent sacrectomy between February 1997 and September 2008 at the Department of Surgical Oncology, Government Royapettah Hospital, Kilpauk Medical College in Chennai, India was done, and the morbidity after sequential and staged abdominosacral approaches was analyzed. Preoperative imaging with radiography of the pelvis (anteroposterior view), CT scanning of the abdomen and pelvis, and/or MR imaging (Fig. 1) was done in all patients, and the site and extent of the tumor was determined. Distant metastasis was excluded by evaluating appropriate imaging studies. Histological specimens were obtained by Trucut or CT-guided biopsy procedures. After adequate preoperative preparations, sacrectomy was performed using 1 of the following approaches: posterior, abdominolateral, or abdominosacral, either as a sequential or staged operation. The anterior procedure is an intraperitoneal approach that is performed to expose the anterior aspect of the tumor, to gain vascular control, to ligate the internal iliac vessels, to isolate the rectum, and to perform anterior osteotomy. The posterior approach is done to dissect and transect the dural contents, eventually interconnecting the anterior and posterior osteotomies to complete the sacral amputation. Closure is done either primarily or by bilateral gluteal advancement flap. Spinopelvic reconstruction was not done in any of the patients. Postoperative wound complications were managed conservatively, with a split skin graft, or with a gluteal advancement flap. Adjuvant therapy was instituted in appropriate situations.

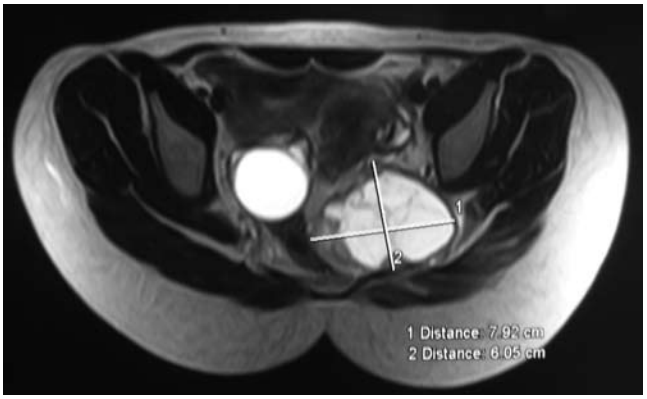

Fig. 1. Axial MR image demonstrating sacral tumor and its extent.

Fig. 2. Follow-up CT scan obtained in a patient who underwent sacrectomy (*arrow* designates absent sacrum).

Fig. 3. Follow-up sagittal MR image obtained in a patient who underwent sacrectomy (*arrow* points to the absence of sacrum below S-1).

TABLE 1: Pathological findings in 19 patients with sacral tumors

Finding	No. of Patients
primary sacral tumor	16
rectal carcinoma infiltrating sacrum	1
retroperitoneal sarcoma infiltrating ilium & sacrum	1
ilium tumor involving sacrum	1
total	19

TABLE 2: Types of sacrectomy in 19 patients with sacral tumors

Sacrectomy Type	No. of Patients
total	3
subtotal	3
partial	9
partial w/ Type 1 pelvic resection	2
composite pelvic exenteration (w/ partial sacrectomy)	1
composite pelvic exenteration (w/ total sacrectomy)	1
total	19

Patients were discharged after complete wound healing, bladder and bowel training, and regaining ambulatory status with or without assisting devices. Patients were followed up at 3-month intervals for the first 3 years and at 6-month intervals subsequently. The imaging studies obtained at the follow-up visit of a patient who underwent sacrectomy are shown in Figs. 2 and 3. Functional assessment was made based on the Enneking functional scoring system. The results were analyzed and survival analysis was done using the Kaplan-Meier method (with SPSS software). The mean operating time, amount of blood replaced, postoperative recovery, and wound complications after the sequential and staged abdominosacral approach were analyzed.

Results

Nineteen patients underwent sacrectomy: 10 were male (52.63%) and 9 were female (47.36%). There were 16 cases of primary sacral tumors (84.21%) and 3 cases of other primary tumors infiltrating the sacrum (15.79%), of which 1 was a recurrent rectal carcinoma infiltrating sacrum, 1 was a retroperitoneal sarcoma infiltrating the ilium, and 1 was a right ilium tumor infiltrating the sacrum (Table 1). The average patient age at diagnosis was 32 years (range 13–65 years). The GCT was the most common tumor in our series (7 lesions), followed by chordoma (6), and the other primary sacral tumors were chondroblastoma, myxopapillary ependymoma, and PNET (Fig. 4).

In this series, 12 patients underwent partial sacrectomy, 3 underwent subtotal sacrectomy, and 4 underwent total sacrectomy (Table 2). One patient with a GCT of the sacrum infiltrating the rectum underwent composite pelvic exenteration, including total sacrectomy and colostomy. One patient with recurrent rectal adenocarcinoma infiltrating the urinary bladder and sacrum underwent composite pelvic exenteration including partial sacrectomy and urinary diversion with colonic conduit. One patient with retroperitoneal sarcoma (malignant fibrous histiocytoma) infiltrating the ilium and sacrum and 1 patient with right ilium tumor (hemangioendothelioma) infiltrating the sacrum underwent internal hemipelvectomy with partial sacrectomy (Type 4 pelvic resection). The patient details are given in Table 3.

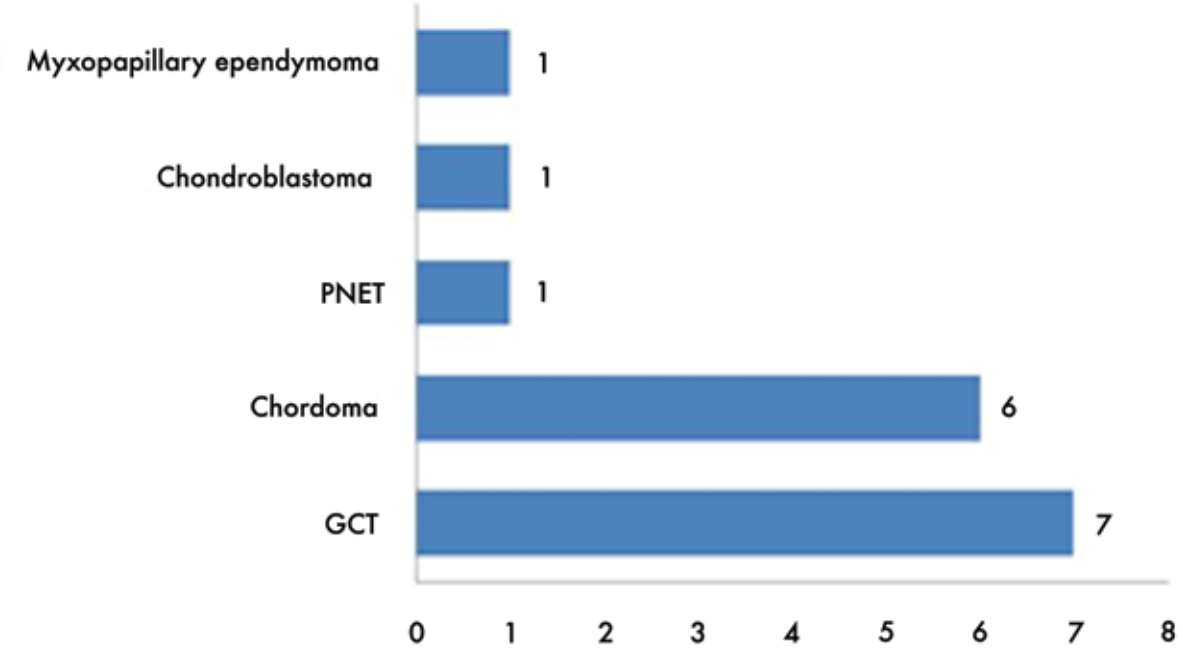

FIG. 4. Graph showing pathological findings in primary sacral tumors in the series. Numbers on the x axis represent the number of patients.

TABLE 3: Characteristics of 19 patients with sacral tumors*

Case No.	Age (yrs), Sex	Tumor Dx	Op	Approach	Tumor Site (upper limit)	Amputation Level	Highest-Level Nerve Root Cut	Nerve Root Preserved	Current Status
1	20, M	sacral: GCT	total sacrectomy	seq ant & pst	body of S-1, bilat sacral alae	lower border of L-5 vertebra	bilat S-1	bilat L-5	NED
2	19, M	sacral: chordoma	partial sacrectomy	pst	S-2	through S-2 sacral foramina, preserving S-2 nerve root	bilat S-3	bilat S-2	LTF
3	15, F	sacral: GCT	partial sacrectomy & curettage	seq ant & pst	junction btwn S-2 & S-3	upper border of S-2	ipsilat S-2	bilat S-1, contralat S-2	LR after 3 mos, died after 24 mos
4	52, F	sacral: chordoma	partial sacrectomy	seq ant & pst	S-3	lower border of S-2 VB & below S-2 sacral foramina	bilat S-3	bilat S-2	LTF
5	35, M	sacral: GCT	total sacrectomy	seq ant & pst	S-1	L5/S1 disc	bilat S-1	bilat L-5	NED
6	39, F	sacral: GCT	partial sacrectomy	seq ant & pst	junction btwn S- 2 & S-3	through S-2 sacral foramina, preserving S-2 nerve root	bilat S-3	bilat S-2	LTF
7	15, M	sacral: GCT	partial sacrectomy & curettage	seq ant & pst	junction btwn S-2 & S-3	through S-2 sacral foramina, preserving S-2 nerve root	bilat S-3	bilat S-2	NED
8	21, M	recurrent rectal CA	composite pelvic exenteration (partial sacrectomy) & colonic conduit	seq ant & pst	S-3	lower border of S-2 VB & below S-2 sacral foramina	bilat S-3	bilat S-2	LR after 17 mos, died after 24 mos
9	33, F	sacral: GCT	partial sacrectomy	seq ant & pst	S2–4, extending to rt sacroiliac joint & involving rt S-2 root	S-2 vertebra	rt S-2	lt S-2	LR after 12 mos, op; NED now
10	22, M	sacral: myxopapillary ependymoma	partial sacrectomy	seq ant & pst	S-2	upper border of S-2 vertebra; rt side above S-2 foramina, & lt side below S-2 foramina	rt S-2	lt S-2	LR after 12 mos, op; NED now
11	30, F	sacral: chondroblastoma	partial sacrectomy	pst	S-3	S-2, lower border	bilat S-3	bilat S-2	NED
12	13, M	ilium: hemangioendothelioma	Type 4 pelvic resection	abdominolat†	rt ilium tumor infiltrating sacral alae	lower border of S-1 VB & below S-1 sacral foramina (hemisacrum)	rt S-2	rt S-1 & all nerve roots on lt	LTF
13	20, M	retroperitoneal sarcoma: MFH	Type 4 pelvic resection	abdominolat†	sarcoma infiltrating half of sacrum	hemisacrum	ipsilat S-1 & S-2	contralat S-1 & S-2	LTF
14	61, F	sacral: chordoma	total sacrectomy	staged ant & pst	S-1	L5/S1 disc	bilat S-1	bilat L-5	LTF
15	29, M	sacral: GCT	composite pelvic exenteration (total sacrectomy) & colostomy	staged ant & pst	S-1	L5/S1 disc	bilat S-1	bilat L-5	died in postop period, w/in 2 mos

(continued)

TABLE 3: Characteristics of 19 patients with sacral tumors* *(continued)*

Case No.	Age (yrs), Sex	Tumor Dx	Op	Approach	Tumor Site (upper limit)	Amputation Level	Highest-Level Nerve Root Cut	Nerve Root Preserved	Current Status
16	20, F	sacral: PNET	partial sacrectomy (lt hemisacrectomy)	staged ant & pst	lt hemisacrum	L5/S1 disc & middle of sacrum (lt hemisacrum)	all sacral nerve roots on lt	all sacral nerve roots on rt	died after 12 mos
17	48, M	sacral: chordoma	subtotal sacrectomy	staged ant & pst	S-2	lower border of S-1 VB & below S-1 sacral foramina	bilat S-2	bilat S-1	LR & DM after 17 mos; alive w/ disease
18	50, F	sacral: chordoma	subtotal sacrectomy	staged ant & pst	S-1	upper border of S-1 VB	rt S-1	lt S-1	NED
19	65, F	sacral: chordoma	subtotal sacrectomy	staged ant & pst	S-1	upper border of S-1 VB; rt side above S-1 foramina, & lt side below S-1 foramina	rt S-1	rt L-5, lt S-1 & S-2	NED

* ant = anterior; CA = carcinoma; DM = distant metastasis; LR = local recurrence; LTF = lost to follow-up; MFH = malignant fibrous histiocytoma; NED = no evidence of disease; pst = posterior; seq = sequential; VB = vertebral body.

† Approach described by Localio et al., 1980.

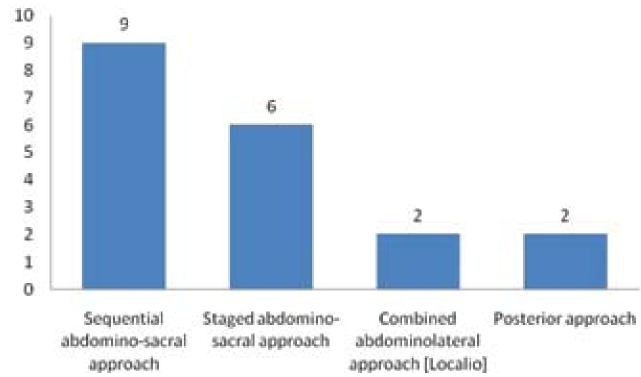

Fig. 5. Bar graph showing various approaches used for sacrectomy in the series. Numbers on the y axis represent the number of patients who underwent the particular operation.

A sequential abdominosacral approach was used in 9 patients; a staged abdominosacral approach was used in 6; a posterior approach in 2; and a combined abdominolateral approach (Localio approach) in 2 (Fig. 5). The mean operating time was 7 hours (range 5–13 hours). The mean amount of blood transfused was 7.5 U (range 3–23 U). Eleven patients had wound complications, of which 5 were managed conservatively, 4 with split skin graft, 1 with secondary suturing, and 1 with gluteal advancement flap. One patient developed rectal herniation through the sacral defect, which was then managed with repair and a gluteal advancement flap. Details of the complications and management are given in Table 4. Major wound dehiscence was observed to be due to extensive soft-tissue resection, prolonged duration of surgery, closure of the wound without a gluteal advancement flap, need to ligate superior gluteal vessels, associated comorbid conditions in the patient, and prior radiation.

Bilateral gluteal advancement flaps were used in 5 cases: 3 at the same stage, 1 in the postoperative period for management of wound dehiscence, and 1 for the management of rectal herniation through the sacral defect. Nine patients (47%) had urinary incontinence, which was managed either with diapers or intermittent self-catheterization, and defecation problems, which were managed with enemas. Adjuvant chemotherapy was given in 2 patients, 1 with hemangioendothelioma and the other with PNET. Adjuvant radiotherapy was not used in any patients.

The average postoperative hospital stay was 46 days (range 20–65 days). The median follow-up duration was 24 months (range 2–140 months). The results were analyzed using the Kaplan-Meier method. The 5-year overall survival rate was 70.4% (Fig. 6 *left*) and the 5-year disease-free survival rate was 65% (Fig. 6 *right*). The local recurrence rate was 26.32% (5 patients). Of the 5 patients who developed local recurrence, 2 patients (Cases 9 and 10) underwent resection and were disease free at follow-up. One patient (Case 3) was treated with radiotherapy, 1 patient (Case 8) with palliative chemotherapy, and 1 patient (Case 17) with symptomatic care. The median duration for the first recurrence was 12 months (range 3–17 months). Vertebral and liver metastases occurred after 17 months in 1 patient with chordoma (5.26%). Four patients

TABLE 4: Wound complications and management in 19 patients with sacral tumors*

Case No.	Type of Flap	Duration of Op (hrs)	Wound Comps	Wound Comp Management	Postop Stay (days)
1	ND	13	none	NA	50
2	ND	6	none	NA	46
3	ND	8	none	NA	40
4	ND	7	wound dehiscence	SSG	60
5	ND	9	wound dehiscence & pst defect rectal hernia	bilat gluteal advancement flap	60
6	ND	8	wound dehiscence	SSG	45
7	ND	6	wound dehiscence	SSG	65
8	OT into defect	7	wound dehiscence	gluteal advancement flap & SSG	60
9	ND	6	wound dehiscence	conservative	55
10	OT into defect	8	wound dehiscence	conservative	50
11	ND	5	none	NA	30
12	ND	6	wound dehiscence	conservative	45
13	ND	7	none	NA	30
14	ND	7	wound dehiscence	SSG	60
15	ND	7	wound dehiscence	conservative	60
16	ND	6	wound dehiscence	secondary suturing	38
17	OT & gluteal advancement flap	5	none	NA	30
18	gluteal advancement flap	6	none	NA	30
19	gluteal advancement flap	5	none	NA	20

* Comp = complication; NA = not applicable; ND = not done; OT = omental transposition; SSG = split skin graft.

died, 1 of them due to pulmonary thromboembolism in the postoperative period.

The mean operating time for the sequential abdominosacral approach, which was performed in 9 cases, was 8 hours, compared with 6 hours in the staged abdominosacral approach, which was performed in the last 6

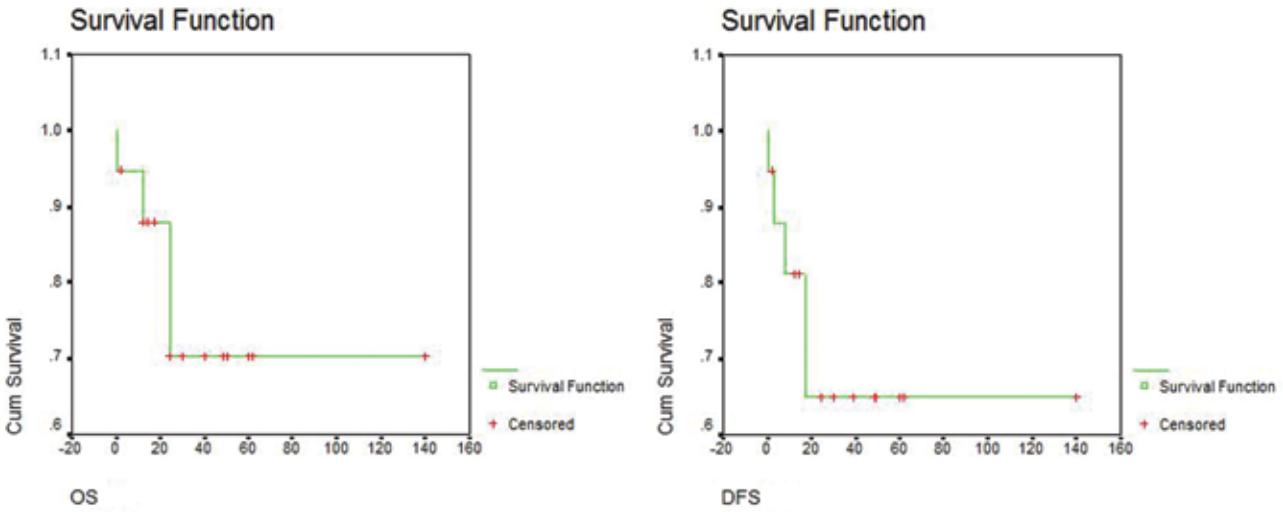

FIG. 6. Graphs showing the overall survival (OS) duration *(left)* and the disease-free survival (DFS, *right*) analysis of 19 patients performed using the Kaplan-Meier method (with SPSS software). The increments on the x axis represent months. Cum = cumulative.

TABLE 5: Comparison of sequential and staged abdominosacral approaches*

Approach	No. of Cases	Mean Op Time (hrs)	Avg Amt of Blood Transfused (U)†	Wound Comp Rate (no. of cases)	Anesthetic Recovery	Avg Postop Stay (days)
seq abdominosacral	9	8	10.2	77.78% (7)	delayed	53.8
staged abdominosacral	6	6	3.3	50% (3)	not affected	40.0

* Avg AMT = average amount.
† One U blood = 350 ml.

cases in our series (Table 5). The average number of units of blood transfused (1 U = 350 ml) was 10.2 U in the sequential abdominosacral approach, but was only 3.3 U in the staged abdominosacral approach. Seven (77.78%) of 9 patients who underwent the sequential approach had wound problems, whereas 3 (50%) of 6 cases in the staged approach group had wound problems. The mean hospital stay in the "sequential" group was 53.8 days, and it was ~ 40 days in the group treated using the staged approach. Based on the Enneking system of functional evaluation, 5 (26.32%) had an excellent outcome (score percentage 75–100%), 6 (31.57%) had a good outcome (score percentage 50–75%), 5 (26.32%) had a fair outcome (score percentage 25–50%), and 3 (15.78%) had a poor outcome (score percentage 0–25%) (Fig. 7).

Discussion

Better understanding of the sacral anatomy and biomechanics of the lumbosacropelvic region is an important factor for a successful surgical and functional outcome. At present, sacrectomy requires teamwork, incorporating a surgical oncologist, neurosurgeon, plastic surgeon, physiotherapist, and oncology nurse for a better surgical and functional outcome. Preoperative counseling with the patient and relatives about the nature of the surgery, long duration of immobility, and functional and surgical outcomes will have a better psychological impact and yield better cooperation.

Preoperative imaging with plain radiographs (pelvis, anteroposterior view), CT scanning of abdomen and pelvis, and/or MR imaging is essential for planning. Involvement of the L-5 level of the spine, extensive sidewall involvement, distant metastatic disease, and poor general condition rule out surgery. Involvement of the rectum necessitates en bloc resection and planning for colostomy also. Therefore, meticulous bowel preparation is advisable preoperatively, along with perioperative antibiotics.

Sacral resection presents a formidable challenge due to the following factors: 1) technical complexity and difficulty, often requiring combined anterior transabdominal and posterior lumbosacral approaches; 2) uncertainties or difficult decisions regarding loss of anorectal and urogenital function and control; and 3) questions regarding weight-bearing stability of retained sacroiliac postural support.

Approaches for Sacrectomy

Various approaches like anterior (transabdominal or

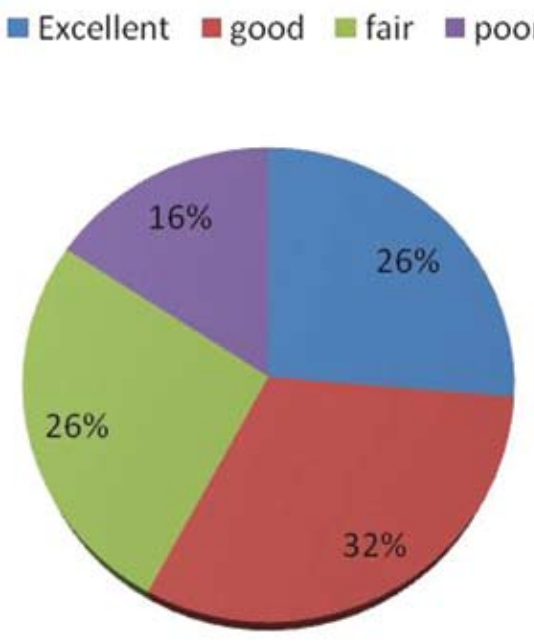

FIG. 7. Pie chart showing functional evaluation score for the 19 patients in the series, based on the Enneking scoring system.

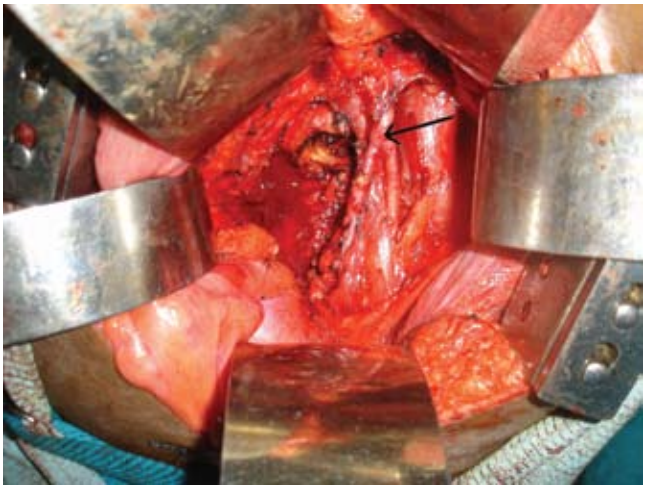

FIG. 8. Intraoperative photograph obtained on the 1st day of the operation, showing the anterior approach and vascular isolation of iliac vessels (designated by the *arrow*).

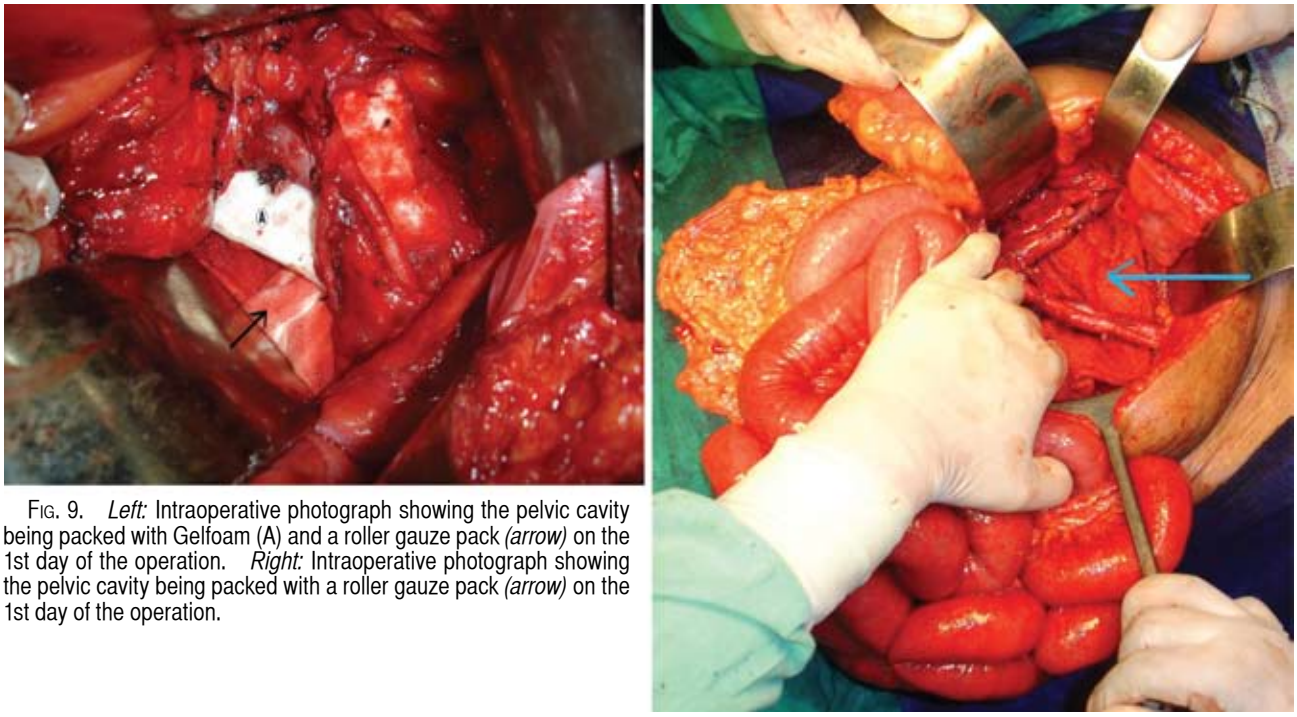

FIG. 9. *Left:* Intraoperative photograph showing the pelvic cavity being packed with Gelfoam (A) and a roller gauze pack *(arrow)* on the 1st day of the operation. *Right:* Intraoperative photograph showing the pelvic cavity being packed with a roller gauze pack *(arrow)* on the 1st day of the operation.

retroperitoneal); posterior that involves sacral laminectomy; sequential anterior and posterior (Bowers);[1] synchronous abdominolateral (Localio et al.)[6] with lateral decubitus position; sequential anterior and posterior with myocutaneous flap (Stener and Gunterberg);[11] and perineal approach are described for sacrectomy. Wanebo and Marcove[12] described a 2-stage approach, beginning with an anterior procedure, and followed by a posterior procedure after 1 or 2 days.

A sequential anterior and posterior approach, which is indicated in tumors with anterior extension and significant involvement of the S-1 and S-2 segments, is commonly used. Tumors below the sacroiliac joint can be approached posteriorly.

The major advantages of the posterior transsacral approach are its familiarity, wide access to the intraspinal and intradural compartments, and clear differentiation between tumor and neural tissue. It is the procedure of choice for the removal of intraspinal tumors with little or no presacral extension. Incisional biopsy sampling or intralesional curettage of sacral body tumors is also easily performed posteriorly. Any significant presacral extension is not adequately exposed for marginal resection from this approach and will require either a staged or simultaneous anterior procedure.

Localio et al.[6] described the synchronous abdominolateral approach, in which the patient is placed in the lateral decubitus position, which gives both anterior and posterior exposure. There is no need for patient repositioning and less blood loss in this approach, but exposure is limited and the efforts at mechanical stabilization and soft-tissue reconstruction are complicated. This approach allows simultaneous unilateral ventral and dorsal exposure of the sacroiliac joint. It is suited for en bloc resection of malignant tumors such as chondrosarcoma, osteosarcoma, and GCT, which cross the sacroiliac joint to involve both the lateral sacral ala and medial iliac wing.

The abdominosacral approach is the most versatile and widely used of the combined exposures.[9] With the anterior approach, internal iliac vessels are ligated, and common iliac and external iliac vessels are isolated and safeguarded. The rectum is dissected away from the sacrum. Therefore, chances of vessel injury, blood loss, and rectal injury are reduced. Omental flap transposition is possible with this approach, and this approach is mandatory in patients requiring rectal resection. With the posterior approach, sacral and lumbar laminectomy is done and the dural sac is carefully ligated to prevent CSF leakage and potential development of meningitis. However, the patient needs repositioning.

The staged abdominosacral approach was adopted during the most recent years included in our study (6 cases). On Day 1 of operation, with the patient supine, a midline laparotomy was done, and the iliac vessels, rectum, anterior aspect of sacrum, and tumor were defined. Vascular control of iliac vessels was obtained (Fig. 8). The level of amputation was planned and an anterior osteotomy was done. For adequate hemostasis, the pelvic cavity was packed with Gelfoam (Fig. 9 *left*) and a roller gauze pack (Fig. 9 *right*), which is removed the next day during the posterior approach. The abdomen is closed, with a pelvic drain in place. On Day 2 of the operation, with the patient prone, the posterior approach is performed; a lumbosacral laminectomy is done, dura mater identified and ligated, sacral amputation is completed, and the specimen and the pack are removed (Fig. 10). In our series, this method of performing the operation on 2 subsequent days has markedly reduced the patient morbidity in terms

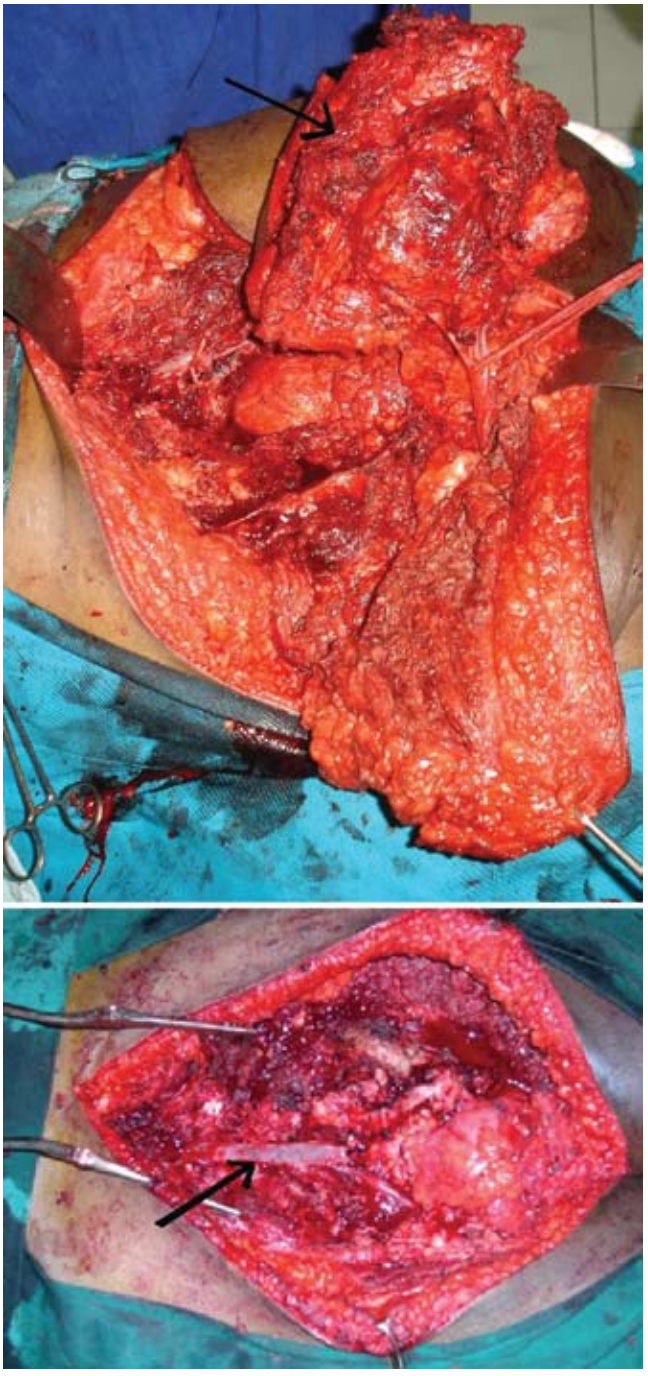

Fig. 10. *Upper:* Intraoperative photograph obtained on the 2nd day of the operation, showing the posterior approach and the sacral tumor being dissected *(arrow)*. *Lower:* Intraoperative photograph obtained on the 2nd day of the operation, showing the posterior approach, with the dura mater indicated by the *arrow*.

of blood loss, reduction of operating time, anesthetic complications, and wound healing, thereby improving the patient's functional outcome and reducing the postoperative hospital stay.

The dura mater is ligated doubly with 2-0 silk and Gelfoam is kept over it, or a muscle cover is done with paraspinal muscles.

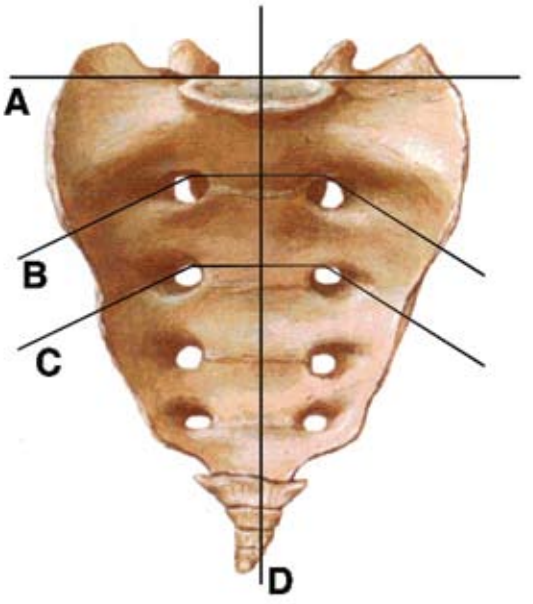

Fig. 11. Drawing representing the levels of amputation. A, total sacrectomy; B, subtotal sacrectomy; C, partial sacrectomy; D, hemisacrectomy.

Low and High Sacrectomy

The level of amputation, if possible, should be 1 sacral segment above the most rostrally involved segment, as determined by preoperative imaging. Low sacrectomy (S-3 or below) is relatively simple because the osteotomy is performed below the sacroiliac joint. It is most easily performed through the sacroperineal route, although more complicated cases, such as those with rectal involvement or operation for recurrent tumor, may require an abdominosacral exposure. Because the S-3 nerve roots can usually be spared with low sacrectomy, urogenital and anorectal function can be preserved.[4]

Progressively higher sacrectomy presents proportionally greater risks of morbidity. Blood loss, particularly during osteotomy of the sacrum and ilium, can be profuse, and the large dead space left by the resected specimen may result in significant wound complications. Because high sacrectomy requires amputation of the dural sac, these complications are compounded if the thecal closure is not watertight. Preservation of S-2, at least unilaterally, will often preserve voluntary uroanal sphincter control. Preservation of the S-2 root should always be attempted, but not at the expense of violating the tumor margin. Lower-limb function is only minimally affected with even total sacral root division, but may be significantly impaired if the nearby lumbosacral trunk, gluteal, or sciatic nerves are injured during the resection.

In our series, we classify the operation as total sacrectomy when the level of amputation is at the L5/S1 disc, with complete removal of sacrum. Even if only the ala on 1 side of the S-1 vertebra is retained and the rest of the sacrum is removed, we consider it to be a total sacrectomy. When the level of amputation is at the body of the

S-1 vertebra, through the level of the S-1 foramina, preserving the S-1 nerve root, and when both the alae of the S-1 vertebra are preserved, we consider it to be a subtotal sacrectomy (spinopelvic continuity is maintained). When the level of amputation is at or below the body of the S-2 vertebra, through the level of the S-2 foramina, preserving the S-2 nerve root, we consider it to be a partial sacrectomy. The level of sacral amputation is represented in Fig. 11. When feasible, we try to preserve the uninvolved nerve roots regardless of the bone cut made.

Spinopelvic Reconstruction

Subtotal resection of the sacrum caudal to the midportion of the S-1 vertebral body does not destabilize the pelvis. Total sacrectomy requires reconstruction of the pelvic ring plus establishment of a bilateral union between the lumbar spine and iliac bone.

Structurally, preserving the upper half of the body of S-1 will retain sufficient bone and continuity of the obliquely positioned sacroiliac joint to permit immediate, unprotected weight bearing. Resections including the entire body of S-1 and preserving only the L-5 nerve root will require posterior pedicle instrumentation, with fixation to both iliac crests and additional bone grafts. These patients should either be immobilized or limited to bed or chair activities until sufficient bone healing is present to permit weight bearing. Sacral rim stability is maintained if the resection line can be kept in the lower half of the S-1 vertebra. Fifty percent of the S-1 should be preserved so long as a tumor-free margin is maintained.

Reconstruction by various methods, like the Galveston reconstruction system, modified Galveston reconstruction system, sacral bar and compression rods, Harrington compression plates, posterior and anterior instrumentations (Yoshida et al., Annual Meeting of Japanese Society for Orthopaedic Biomechanics, 2001), triangular frame reconstruction,[5] and so on, has been described.

In our series, pelvic reconstruction was not done after total sacrectomy. The transverse process of L-5 vertebra and the iliolumbar ligaments were left undisturbed during sacrectomy in our series, and 1 patient in the group that underwent total sacrectomy did not develop major spinal instability.

Management of Sacral Defect After Sacrectomy

Most patients developed wound problems like dehiscence and flap necrosis. This is due to proximity to the anus, extensive resection creating large defects, ligation of internal iliac vessels, and suturing with tension. The rectum may be exposed after wound dehiscence, which may be avoided by covering the rectum with omentum, and by the use of flaps. Meticulous hemostasis, obliteration of dead space, and prophylactic antibiotics will help to prevent infection. Reconstruction of the soft-tissue defect after sacrectomy has been done with a transabdominal vertical rectus abdominis myocutaneous flap (VRAM flap), gluteal advancement flap, or free flaps.[2,10] In our series, gluteal advancement flap was done, which significantly reduced the postoperative wound dehiscence and morbidity.

Conclusions

Sacrectomy, one of the seldom-used and morbidity-producing operations, is feasible now with modified and improved surgical techniques. The staged abdominosacral approach significantly reduces the mean operating time, blood loss, wound complications, and immediate postoperative morbidity. The gluteal advancement flap reduces the incidence of wound dehiscence and necrosis. Although it is a procedure that results in morbidity, sacrectomy with improved surgical techniques improves oncological outcome and patients' quality of life. Sacrectomy performed using the staged abdominosacral approach is feasible with modern surgical facilities and postoperative care.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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