Partial Sacrectomy for Sacral Chordomas: A Surgical Perspective

Satish Rudrappa, Venkata R Tukkapuram, Ramachandran Govindasamy, Swaroop Gopal, Dheeraj Masapu

ABSTRACT
Sacral chordomas are locally aggressive tumors that grow slowly and often involve the sacral nerve roots leading to bladder disturbances. The treatment of these tumors involves utmost care as it can lead to tumor recurrence and neurological morbidity. We present our experience of 6 patients with sacral chordomas out of 17 patients with sacral lesions, where we have treated them with partial sacrectomies. In all of our cases, we have preserved at least one S2 root and postsurgery 83.33% of patients had intact bowel and bladder function. The lumbopelvic fixation was done in none of the cases as we have preserved the stability of the sacroiliac (SI) joint, as all osteotomy was done below S1. None of the patients had recurrence with an average follow-up of 4.1 years. This study aims at describing the surgical steps in managing a sacral chordoma.

Keywords: Chordoma, Neuromonitoring, Partial sacrectomy, Sacral flaps, Sacral osteotomy.

INTRODUCTION
Sacral chordomas are a rare presentation with subtle symptoms often missed as a diagnosis unless the patient presents with significant clinical symptoms. However, with experience, it can be diagnosed early and surgical excision gives excellent results. Surgery of these tumors aims at complete en bloc excision with decreased morbidity and preventing recurrence. Since sacral tumors are rare, the proper surgical steps are not clearly known by most of the surgeons. Complete tumor removal by en bloc resection with wide margins is the treatment of choice which can be accomplished with partial to total sacrectomy. Sacrectomy is not an easy procedure as the sacrum is a hollow structure with important neural elements for bowel and bladder continence. Hence, surgical steps need preservation of such important neural elements and at least one S2 root is essential to maintain continence. Sacral reconstruction postremoval may not be required if S1 body and SI joints are preserved.

In our experience, we have encountered 17 sacral lesions, for which we have done 10 partial sacrectomies, of which 6 were chordomas. All partial sacrectomies were approached posteriorly in our series, with complete excision of the lesion. This study aims to reiterate standalone posterior approach to all chordomas, to elaborate surgical technique of partial sacrectomy, and to highlight the results of the surgical procedure with respect to excision of sacral chordomas.

MATERIALS AND METHODS
The approach for partial sacrectomy with posterior approach was decided by preoperative radiological investigation (Fig. 1). Tumors were preferred to be removed posteriorly because of ease of approach, better visualization of neural elements, and lesser morbidity. We believe all cases can be done through posterior approach alone, including the larger lesions abutting toward the SI joints. Involvement of the tumor board and multidisciplinary approach (especially the oncosurgeons and plastic surgeons) from planning stage will obviate the need for anterior approaches. All partial sacrectomies were done under neural monitoring with leads placed in plantar flexors, hamstrings, and anal sphincters. In the recent past, we started actively using the neuronavigation in partial sacrectomy which helps significantly during osteotomy of the sacrum.

Surgical Steps for Partial Sacrectomy
All surgeries were done under general anesthesia without muscle relaxants which is essential, especially when using the nerve monitors since preserving S2 nerve roots are paramount. Patients are positioned prone with bolsters placed over the iliac crest to keep the sacrococcygeal surface at the highest point for the ease of surgical approach. Preoperative bowel preparation is mandatory for sacrectomy procedures. Wide area of the skin surface has to be cleaned and draped for proper exposure. The anal sphincter is isolated from the main operative area while draping to avoid contamination. Draping is done in such a way that...
anesthetists and electrophysiologists could be able to see the contracting muscles during the nerve stimulation.

**Skin Incision and Exposure**

If the lesions are involving beyond the third segment of the sacrum and do not give rise to much of the dead space following excision, exposure is done via posterior midline skin incision. When the lesion is wider and involves up to the upper part of the S2 segment with significant anterior bulk, skin incision should be marked by the plastic surgery team since it requires the mobilization of the gluteal structures at the end of the procedure to cover the dead space. Wound is exposed from L5 to the tip of the coccyx and laterally till SI joint, pelvic ligaments (sacrotauberous and sacrospinous), and pyriformis muscles are exposed on both sides (Fig. 2).

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**Figs 1A to D:** Computed tomography and three-dimensional CT images of sacral chordoma. Expansile and osteolytic lesion with anterior extension

**Fig. 2:** Exposure from L5 lamina proximally and till tip of coccyx distally
Care is taken not to incise close to anal sphincters to prevent its damage. Use of monopolar cautery for skin and subcutaneous tissue is to be limited to avoid wound necrosis. Caution to be taken not to breach the tumor capsule to avoid the recurrence by seedling.

Coccygeal Mobilization and Ligament Sectioning

Initially, the sacroccygeal ligaments are to be sectioned on either side and the tip of the coccyx has to be released from the anococcygeal raphe to create a space to insert a finger anterior to coccyx, which will guide further dissection planes. Using bovie on either side of sacropelvic ligaments (sacrotuberous and sacrospinous), lower border of pyriformis muscle is identified and dissected (Fig. 3).

Laminectomy and Identification of Sacral Roots

Midline L5-S1 laminotomy (and if needed L5 laminectomy) is done to identify the dural sac with exiting sacral roots, especially S1 and S2 roots. Lower sacral roots can be thin and sometimes differentiating it can be difficult. The roots are traced down all along its course till its exit at sacral foramina (Fig. 4). Tracing down the nerve roots helps in knowing the status of sacral roots anatomically and physiologically. Nerve roots are stimulated with a bipolar nerve stimulator with 2 mA current, and motor potentials are recorded (Fig. 5). The identified sacral nerve roots are traced further laterally outside the sacral foramen. S2 nerve roots which pass under the pyriformis muscle has to be separated before sectioning. At least one sacral root (S2) has to be preserved for maintaining continence.

Dural sac should be tied with nonabsorbable sutures below the level of S2 roots and sectioned. Cerebrospinal fluid leak to be avoided and confirmed with Valsalva maneuvers.

Three-finger blunt dissection anteriorly is carried out gently on both sides without breaking the tumor capsule, especially in large anterior tumor mass projecting up toward sacral promontory. Further dissection can be done after releasing the sacrum with osteotomy cuts.

Osteotomy

Spinous process clamp is attached to the L4 spinous process and intraoperative fluoroscopy images were loaded into stealth station (Fig. 6). The osteotomy cuts were taken as planned with navigation guidance and confirmed under fluoroscopy (Fig. 7) as depicted in the bone model (Fig. 8). The sacrum will be gently lifted up en masse with hand placing below the plane between a tumor and rectum anteriorly after releasing the adhesions. The removed sacrum with the tumor (Fig. 9) has to be sent for histopathological examination and the sacral bed area postremoval has to be inspected carefully under microscope, especially the pyriformis muscle area to look for tumor residue. Entire wound bed is washed with distilled water to prevent recurrence. The wound was then closed using Prolene mesh (Fig. 10) and dead space by gluteal myocutaneous advancement flap (Fig. 11). Skin is closed in two layers after placing a closed vacuum dressing.
RESULTS

In the present study, we have discussed only sacral chordomas, which constitute 35% (6 cases) of the total sacral lesions (17 cases) treated at our center for which partial sacrectomy was done. Male to female ratio was 1:1 in our group of patients and average age of the patient is 49.5 years. Bowel and bladder disturbances were there in 67% (4 cases) of patients in whom lesions were extending cranially till S2 and 75% (3 cases) of them showed improvement postsurgery. In 33% of the cases where the lesion was below the level of S3, there were no symptoms of bladder disturbances and there was no worsening postsurgery. In all cases, at least one S2 root was preserved. Level of osteotomies was decided based on the tumor extent which was radiologically assessed, and after being confirmed intraoperatively, 67% (4 cases) of the sacral cuts were taken at the S1-S2 junction, 16.5% (1 case) at the S2-S3 level, and 16.5% (1 case) at S3-S4 level. The plastic surgeon was involved in the closure of wound where dead space was present after the sacrectomy in 3 cases, whereas in 2 cases gluteus maximus flap covering and in one case V-Y musculocutaneous advancement flap closure was done. Of the 6 cases, one patient had wound infection and the patient was treated with intravenous (IV) antibiotics. We had a follow-up of
1 to 7 years and the average follow-up period was 4.1 years and none of them had a recurrence of the tumor (Table 1).

DISCUSSION

Chordomas are the most common primary tumors of the sacrum. It accounts for 2 to 4% of all primary tumors of the bone with the age distribution of fourth to seventh decade of life and male to female (M:F) ratio is 2:1. It is derived from notochordal remnant, which explains its midline or paramedian location. It is a slow-growing, indolent tumor that spreads locally and rarely metastases with sacral pain, palpable mass, constipation, incontinence, and...
weakness as the symptoms. In our study M:F ratio is 1:1 and average age distribution was in fourth decade. Most of our patients (67%) presented only after they developed neurological symptoms, especially the sphincter disturbances. Radiological features of chordoma are osteolysis and large destructive lesions with local soft tissue extension with calcification. Computed tomography scan with two-dimensional and three-dimensional reconstructions is useful in deciding the level of osteotomy.

Preoperative contrast magnetic resonance imaging (MRI) with coronal sections will guide the surgeons in identifying the involvements of sacral roots. In cases where the nerve roots are encased completely by the tumor, it needs to be sacrificed. In our study at least one S2 root was saved in all cases. In one patient with a 15 cm large tumor, though MRI was suggestive of the involvement of both S2 roots, preoperatively right S2 could be dissected off the tumor capsule and preserved. In this patient, during follow-up, there are signs of recovery of sphincter function, which was completely lost before surgery.

Sacral chordomas are a low-grade tumor which can cause significant morbidity due to local recurrence and it can be avoided by strictly avoiding tumor wall breach as the spillage leads to tumor recurrence. Complete and wide en bloc surgical resection with a clean bone and soft tissue margins is the treatment of choice as these tumors are radioresistant and chemoresistant. Wide margin removal is difficult in some instances where the tumor is not well demarcated. Kaiser et al reported local failure in surgical tumor margin violation and showed the local recurrence rate of 28% in complete en bloc excision and 64% if the tumor capsule is violated. Five years survival rate in sacral chordoma is 50% and 10 years survival rate is 30% approximately. Unlike other studies we had 0% recurrence rate with long-term follow-up, and we believe it is because of meticulous en bloc excision without tumor capsule violation. Trans-arterial embolization (TAE) reduces intraoperative blood loss and shrinks the tumor which helps to remove the tumor completely. Angiography is also useful in knowing if the chordoma is vascular and to assess the usefulness of TAE in such cases. Trans-arterial embolization is not used in any of our patients.

Using navigation helps in making precise osteotomy cuts where desired without destabilizing the SI joints. It reduces the amount of radiation to the operating room staff and also reduces the operating time. We used neuro-navigation in 3 patients, which significantly helped in identifying the precise sites of the osteotomy and also reduced the time taken for the same.

Neuromonitoring is mandatory during sacrectomy, especially in cases wherein the roots are pushed by the tumor bulk. At least one S2 root has to be preserved for maintaining proper bowel and bladder function.

The intraoperative neuromonitoring during sacral tumor excision consists of mainly motor responses in monitored muscles of the lower limbs along with anal sphincter. Somatosensory evoked potentials from the posterior tibial nerve and triggered electromyography (EMG) from the anal sphincter. The activity of the anal sphincter may be extrapolated to the activity of the external urethral sphincter because both are striated muscles innervated by the pudendal nerve that arises from S-2, S-3, and S-4. Stimulation of these nerves causes contraction of the sphincter muscles, and a wave can be seen in the monitor. Three types of neuromonitoring are utilized: 1. Transcranial motor-evoked responses of the anal sphincter 2. Triggered EMG responses 3. Spontaneous EMG responses

Table 1: Details of the patients with extension of the lesion, level of osteotomy, preserved sacral nerve roots, pre- and post-op bowel and bladder involvement with follow-up in years

<table>
<thead>
<tr>
<th>Age/sex</th>
<th>Extent of lesion</th>
<th>Bowel and bladder involvement</th>
<th>Level of osteotomy</th>
<th>No. of sacral roots preserved</th>
<th>Bowel and bladder function postsurgery</th>
<th>Follow-up (years)</th>
<th>Recurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>36/M</td>
<td>S2–S5</td>
<td>Yes</td>
<td>S1–S2</td>
<td>Left S2 (1)</td>
<td>Improved</td>
<td>5</td>
<td>Nil</td>
</tr>
<tr>
<td>35/M</td>
<td>S2–S5</td>
<td>Yes</td>
<td>S1–S2</td>
<td>Left S2, S3 (2)</td>
<td>Improved</td>
<td>5</td>
<td>Nil</td>
</tr>
<tr>
<td>42/F</td>
<td>S2–S5</td>
<td>Yes</td>
<td>S1–S2</td>
<td>Left S2 (1)</td>
<td>Disturbed</td>
<td>1</td>
<td>Nil</td>
</tr>
<tr>
<td>68/F</td>
<td>S4–S5</td>
<td>No</td>
<td>S3–S4</td>
<td>B/L S2, S3 (4)</td>
<td>Preserved</td>
<td>7</td>
<td>Nil</td>
</tr>
<tr>
<td>71/F</td>
<td>S3–S5</td>
<td>No</td>
<td>S2–S3</td>
<td>B/L S2 (2)</td>
<td>Preserved</td>
<td>5</td>
<td>Nil</td>
</tr>
<tr>
<td>45/M</td>
<td>S2–S5 with muscle involvement</td>
<td>Yes</td>
<td>S1–S2</td>
<td>Right S2 (1)</td>
<td>Improved</td>
<td>2</td>
<td>Nil</td>
</tr>
</tbody>
</table>

Fig. 11: Wound closure with V-Y advancement flap
In triggered EMG, during the surgery, whenever a structure could not be identified clearly, it was stimulated with the disposable electrical stimulator and, if EMG waveform is seen on the monitor (indicating contraction of the anal sphincter), the structure was preserved. The anesthesia maintenance will require no relaxant technique, if possible it has to be maintained on total IV anesthesia and avoiding inhalational anesthetics will give rise to good waveforms.

Sacral chordomas are locally aggressive tumors and require en bloc excision without tumor spillage to achieve good long-term prognosis. With the use of microsurgical approaches, neuronavigation, and neuromonitoring, good results are achievable with standalone posterior procedures. Preserving the anal sphincter function gives satisfactory results from patients’ perspective and preserving at least one S2 during surgery might benefit the patients.

CONCLUSION

Sacral chordomas are locally aggressive tumors and requires en bloc excision without tumor spillage to achieve good long-term prognosis. With the use of microsurgical approaches, neuronavigation, and neuromonitoring, good results are achievable with standalone posterior procedures. Preserving the anal sphincter function gives satisfactory results from patients’ perspective and preserving at least one S2 during surgery might benefit the patients.

REFERENCES