Landmarks for Sacral Debridement in Sacral Pressure Sores

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Introduction: Most cases of sacral osteomyelitis arising in the setting of sacral pressure ulcers require minimal cortical debridement. When faced with advanced bony involvement, the surgeon is often unclear about how much can safely be resected. Unfamiliarity with sacral anatomy can lead to concerns of inadvertent entry into the dural space and compromise of future flap options.
Materials and Methods: A cadaveric study (n = 6), in which a wide posterior dissection of the sacrum, was performed. Relationships of the dural sac to bony landmarks of the posterior pelvis were noted.
Results: The termination of the dural sac was found in our study to occur at the junction of S2/S3 vertebral bodies, which was located at a mean distance of 0.38 ± 0.16 cm distal to the inferior-most extent of the posterior superior iliac spine (PSIS). The mean thickness of the posterior table of sacrum at this level was 1.7 cm at the midline and 0.5 cm at the sacral foramina.
Conclusions: The PSIS is a reliable landmark for localizing the S2/S3 junction and the termination of the dural sac. Sacral debridement medial to the sacral foramina above the level of PSIS must be conservative whenever possible. If aggressive debridement is necessary above this level, the surgeon must be alert to the possibility of dural involvement.

Key Words: sacral osteomyelitis, CSF complications sacral pressure sores, sacral anatomy

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The human sacrum is a wedge-shaped bone formed by the fusion of 5 vertebrae along the intervening intervertebral discs. The process of fusion begins at the age of 18 years and is completed by the third or fourth decade. This process, however, is dependent on the load placed on the sacrum, in following with Wolfe law. The unique shape of the sacrum, which articulates with the lumbar spine and the pelvis as well as the coccyx, allows it to function as a load-bearing keystone,[1] while various supporting ligaments allow a degree of mobility.

In the adult, the sacrum has 2 surfaces, a concave pelvic surface (facies pelvina), and a convex dorsal surface (facies dorsalis). The dorsal surface of the sacrum is a thin shelf of mainly medullary bone. Along its length run longitudinal crests of bone formed by the rudimentary spinous processes and the paired articular processes of the fused vertebrae (median sacral crest and intermediate crests, respectively). Immediately deep to this thin shelf is the dural sac. Lateral to the intermediate crests are the neural foramina. The sacrum is unique in that the anterior and posterior divisions of the sacral nerves exit through separate foramina. The anterior divisions or ventral rami of the sacral nerves are mixed nerves that exit through the anterior foramina and provide sensory and motor innervation of the pelvic girdle and lower extremities (eg, sciatic nerve).[2] The posterior divisions, or the dorsal rami, provide the cutaneous innervation of the back and the motor innervation of the back muscles, including the multifidus, sacrospinalis, and erector spinae muscles.[1]

When viewed from the posterior surface, certain landmarks are immediately palpable and/or visible. These include the tip of the coccyx near the anus and the broad base of the sacrum as it articulates with the posterior superior iliac spine (PSIS) (sacral dimple, or dimple of Venus). Deep to the skin, a thick fascial layer is visible. The posterior sacrococcygeal ligaments, which run along the median sacral crest and are fused with the posterior sacroiliac ligaments, form a thick fascial sheath that invests both the sacrum and the coccyx. The posterior sacral foramina, through which exit the posterior divisions (dorsal rami) of the sacral nerves, can be appreciated deep to the investing fascia. In a patient with a large sacral decubitus ulcer, these nerves are often compromised, either by the patient's premorbid condition (spinal cord injury) or as a consequence of the pressure sore itself.

Little has been written in the plastic surgery literature regarding the surgical anatomy of the sacrum, despite the fact that sacral pressure sores can result in extensive involvement of bone and adjacent soft tissue. To our knowledge, no detailed anatomic study of sacral anatomy relevant to the surgical treatment of sacral pressure sores has been performed. An anatomic study of the sacrum was performed to provide a safe and anatomically based approach to sacral pressure sores when radical debridement of bone and soft tissue is necessary.

MATERIALS AND METHODS

A total of 6 (3 men, 3 women) fresh cadaveric specimens with a mean age of 60 years were dissected to delineate the bony and soft tissue anatomy of the sacral region. Each cadaver was placed in a prone position. The sacrum was dissected from a posterior approach, dissecting the adjacent soft tissue and muscular anatomy as far lateral as the most lateral aspect of the posterior superior iliac crest. Coccygectomy and ostectomy of the posterior table of the sacrum was performed to the base of the sacrum to reveal the underlying dural sac and the spinal roots before exiting the vertebral foramina. The location of the termination of the dural sac was noted in relation to bony landmarks of the posterior pelvis. Several measurements were obtained (see Table 1). The termination point of the dural sac, both in absolute measurements and in relation to the sacral vertebral levels and superficial bony landmarks, was measured (Fig. 1). Using a sliding vernier caliper, the thickness of the posterior table of the sacrum was measured at the level of the PSIS in the sagittal and parasagittal plane immediately medial to the posterior foramina (Fig. 2). The locations of the piriformis muscle and the superior and inferior gluteal arteries were measured (Fig. 3).

RESULTS

Cadaveric dissection demonstrated that the termination of the dural sac was closest to the S2 foramina (junction between S2 and S3) in all cases, and was on average 0.38 cm (standard deviation 0.16 cm, standard error 0.07) distal the to the PSIS (Table 1). Based on these findings, 95% confidence interval for the true distance was 0.25 to 0.51. The small sample size limited the comparisons between the samples separated by sex, but there was no statistically significant differences comparing male and female cadavers ($P < 0.50$). The mean thickness of the posterior table of the sacrum (facies dorsalis) at this level was 1.72 at the midline sagittal crest and 0.5 cm at the parasagittal plane. Careful dissection of the periostium of the posterior table revealed a paucity of cortical bone, which could not be accurately measured. The mean vertical distance from this point to the tip of the coccyx was 11.67 cm. The mean width of the sacrum at its widest point (PSIS) was 9.75 cm. The terminal extent of the dural sac was approximately 11.23 cm cephalad to the tip of the coccyx. Thus, the caudal-most extent of the PSIS

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TABLE 1. Sacral Measurements (in cm)

Sex	A	B	C	D	E	F	G	H	I	F/E	G/E
M	4	15	2.1	0.8	15	5.5	8.5	14.9	0.1	0.37	0.57
M	3	12	1.5	0.5	14	4	7	11.5	0.5	0.29	0.5
M	3	13	2.5	0.6	13	2	7	12.6	0.4	0.15	0.54
F	2.5	10	1.3	0.5	11	2	6	9.5	0.5	0.18	0.55
F	2.7	11	1.2	0.4	12	1.75	4.5	10.2	0.5	0.15	0.38
F	3	9	1.7	0.2	10.5	2.8	4.5	8.7	0.3	0.27	0.43
Mean (M)	3.33	13.33	2.03	0.63	14	3.83	7.5	13	0.33	0.27	0.54
Mean (F)	2.73	10	1.4	0.37	11.17	2.18	5	9.47	0.43	0.2	0.45
Mean (All)	3.03	11.67	1.72	0.5	12.58	3.01	6.25	11.23	0.38	0.23	0.49
SD	0.52	2.16	0.50	0.20	1.74	1.47	1.57	2.27	0.16	0.09	0.08
SE									0.07		

(A) Interforaminal distance at PSIS, (B) vertical distance from PSIS to coccyx, (C) sagittal thickness of sacrum at PSIS, (D) parasagittal thickness of sacrum at PSIS, (E) length of lateral edge of sacrum from PSIS to coccyx, (F) distance from PSIS to SGA, (G) distance of PSIS to IGA, (H) distance between dural sac and tip of coccyx, (I) distance between PSIS to termination of dural sac.

proved to be an important landmark for the caudal-most extent of the dural sac. Using a line drawn from the posterior iliac spine to the tip of the coccyx, the inferior gluteal artery and the sciatic nerve was found to lie at the caudal edge of the piriformis at approximately the halfway point (see Fig. 2) between these 2 structures (ratio, 0.49). The ratio of the location of the superior gluteal artery along this line was found to be 0.23.

DISCUSSION

The management of sacral osteomyelitis in the setting of sacral pressure sores is not without controversy. Most of the controversy resides in the treatment of confirmed or suspected sacral osteomyelitis. Traditionally, suspected osteomyelitis of the sacrum has been treated with wide debridement of all clinically affected bone and a prolonged course of intravenous antibiotics before definitive closure.[3] However, this approach has been viewed as impractical by those who cite the difficulty of targeted antibiotic therapy (bone cultures are often negative or indeterminate), the difficulty of determining the extent of involvement, the difficulty of confirming resolution, and the equivalent results obtained with conservative decortication and definitive closure at the time of diagnosis.[4]

Furthermore, as several authors have pointed out, the presence of osteomyelitis tends to be overestimated by clinical assessment alone.[2–6] Even with the use of imaging modalities, such as bone scanning and MRI, it is difficult to differentiate periostitis and pressure-induced changes, such as fibrosis, medullary edema, and reactive bone formation that accompany stage 4 sacral ulcers from true cortical bone involvement.[2,6] An autopsy-based histopathologic study of sacral ulcers showed that only half of stage 4 ulcers contained histological evidence of sacral osteomyelitis, and that all of these cases involved the superficial subcortical bone (facies dorsalis) of the sacrum only.[6] Although it is difficult to draw reliable conclusions from this study because the study group included all stage 4 sacral ulcers and not just those with clinical evidence of osteomyelitis, these results nevertheless corroborate what we know clinically, that deep involvement of sacral osteomyelitis is not the norm even for stage 4 sacral pressure ulcers and that radical debridement of bone and soft tissue is usually not necessary.

Nevertheless, neglected sacral pressure ulcers tend to present at an advanced stage and can demonstrate extensive involvement of the soft tissue and the underlying bone. Instances of extensive necrotizing fasciitis in the setting of sacral pressure sores have been reported, as well as cases of extensive sacral and pelvic osteomyelitis necessitating hemicorporectomy. Other complications are bacteremia[7–9] and

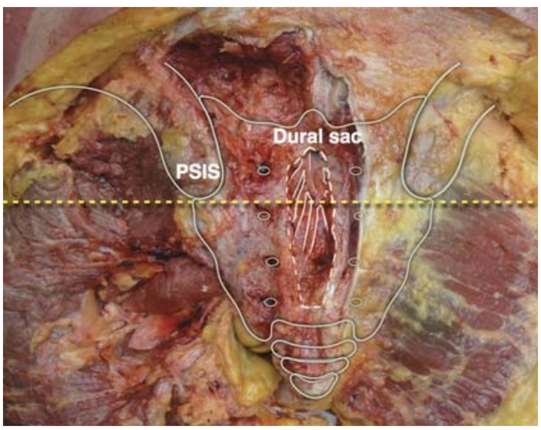

FIGURE 1. The terminal extent of the dural sac lies within 0.4 cm of the caudal-most extent of the PSIS. The dashed line outlines the portion of posterior table unroofed. The dural sac and its filum terminale extensions have also been outlined. The filum terminale fuse at the termination point of the dural sac, as shown here.

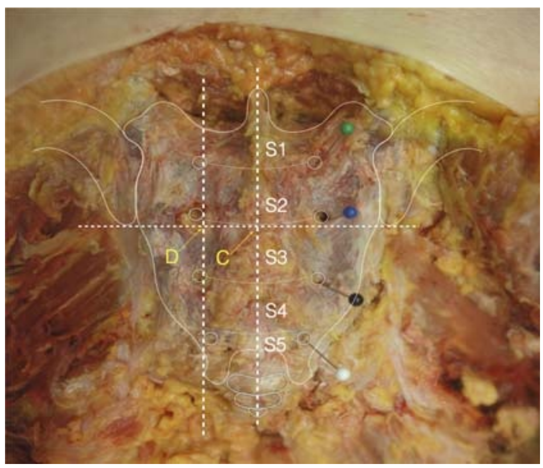

FIGURE 2. Dashed lines showing the points at which the thickness of the posterior table was measured: C, sagittal plane at PSIS and D, parasagittal plane at PSIS.

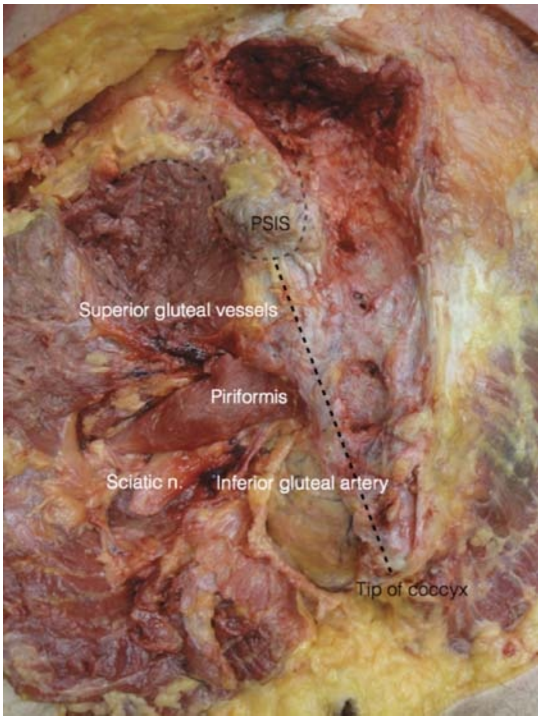

FIGURE 3. Using a line drawn connecting the posterior superior iliac spine to the tip of the coccyx, the approximate locations of the superior and inferior gluteal artery can be estimated. The ratio of the distance between the PSIS and the superior and inferior gluteal arteries and the PSIS to the tip of the coccyx is 0.23 and 0.49, respectively.

malignancy.[10–12] These complications, although relatively rare and based on small case series or case reports, are recognized in the literature and mentioned in most review articles on the subject.[13–15] Although CSF involvement in the form of meningitis, CSF leak/fistula, empyema, and pneumocephalus was also reported in the literature,[16–22] this spectrum of complications appears to be less recognized. All articles were single case reports, and in all cases, direct extension of an adjacent sacral pressure sore was implicated. In 5 of 7 cases, the level of communication with the dural space was determined to be above S2. Only one of the cases was preceded by surgical debridement,[16] though it is impossible to draw conclusions if inadvertent entry into the dural space occurred during the time of debridement. In this group, 3 of the patients either died or were discharged to hospice care.

What these reports show is that clearly there are instances where sacral pressure ulcers extend beyond the superficial cortex of the sacrum and require consideration of possible CSF involvement, particularly when above the level of S2/S3. Conversely, sacral osteomyelitis limited to below this level would not be expected to have a high incidence of CSF involvement.

In our study, we have found that the termination of the dural sac occurs at the S2/S3 junction, for which the caudal-most extent of the PSIS is an accurate and readily palpable landmark. Although such a small sample size increases the probability of sample error, this was mitigated by the small standard deviation observed. Based on our data, the 95% confidence interval was 0.24-0.51 cm, meaning that there was a 95% statistical probability that the true distance between the PSIS and the termination point of the dura fell in the range of 0.24 to 0.51 cm. A larger sample size would be expected to reduce sample error and narrow the 95% confidence interval further. At this level, the posterior surface of the sacrum was found in our study to be 1.7 cm thick at the midline sagittal crest and 0.5 cm at the parasagittal plane medial to the sacral foramina. These findings have important implications, the first being that debridement of the posterior table of the sacrum at or above the level of the PSIS must be conservative and take into account the thickness of the posterior table of the sacrum at this level to avoid inadvertent entry into the dural space. The second implication is that when sacral ulcers involve bone above the level of the PSIS, the surgeon must be alert to the possibility of CSF communication and make every effort to identify and address the complication swiftly.

Lateral to the sacrum and coccyx, the origin of the gluteus maximus can be observed (Fig. 3). The gluteus muscle covers the piriformis and the muscles of the pelvic floor. The coccyx may be removed, revealing the presacral fat and fascia investing the posterior surface of the rectum. With a line drawn connecting the PSIS to the tip of the coccyx, the approximate locations of the superior and inferior gluteal artery can be estimated. Avoidance of injury to these structures is critical if a gluteus myocutaneous flap is to be used as an option for repair. Using the lines drawn in Figure 3, the ratio of the distance between the PSIS and the superior and inferior gluteal arteries and the PSIS to the tip of the coccyx is 0.23 and 0.49, respectively.

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