Total Sacrectomy Without Spinopelvic Reconstruction

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5.1 Introduction

Total sacrectomy is an extensive procedure often required when primary malignant bone tumor involves the upper sacrum. After total sacrectomy, there will be impairments of bladder, bowel, sexual, lower limb functions, and spinopelvic stability due to spinal nerve roots sacrifice and the discontinuity between the spinal column and the pelvis. Various methods of spinopelvic reconstruction have been proposed for creating bony stability after total sacrectomy with good outcomes, although some implant-related complications have been reported [1, 2].

We classify iliosacral resection into two types based on the location of the iliosacral resection [3]. *Type I resections* go medial to or through or lateral but close to the sacroiliac joint. *Type II resections* are far lateral (more than 3 cm from the posterior iliac spine) to the sacroiliac joint (Fig. 5.1). We believe that if the iliosacral resection is not too lateral from the sacroiliac joint (within 3 cm from the posterior iliac spine), the spinopelvic stability can be gradually self-created with time. After the spinal column shifts down to the level of the pelvis, the transverse processes which are close to the remaining sacroiliac joints or ilia can form bony auto-fusion (Fig. 5.2) or can form thick fibrotic scarring, without evidence of fusion, that are strong enough to give spinopelvic stability for the patient (Fig. 5.3). Total sacrectomy without spinopelvic reconstruction is indicated in patients who undergo bilateral Type I resection or Type I on one side and Type II on the contralateral side.

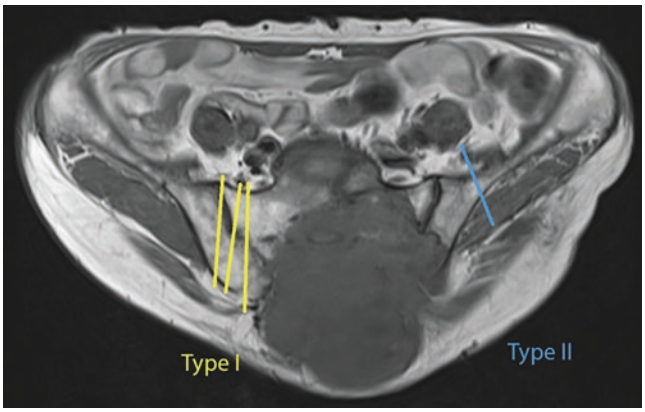

Fig. 5.1 **Type I iliosacral resection** refers to a resection medial to or through or lateral but close to (less than 3 cm from posterior iliac spine) the sacroiliac joint. **Type II iliosacral resection** refers to a resection through the ilium far lateral to the sacroiliac joint (more than 3 cm from the posterior iliac spine)

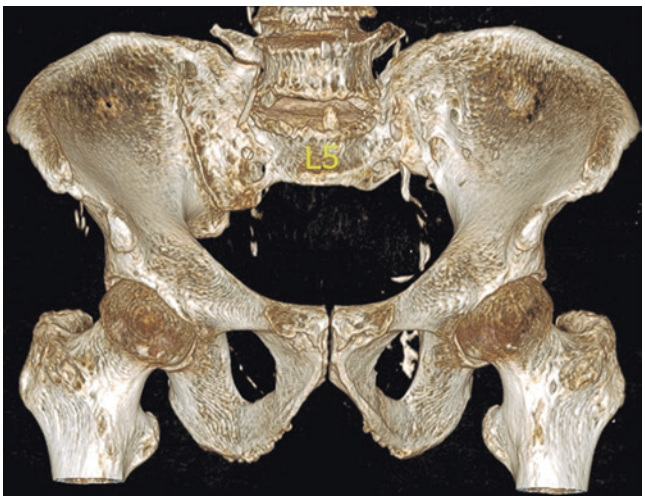

Fig. 5.2 3-D CT scan of the pelvis at 2.5 years after total sacrectomy shows bony auto-fusion between transverse processes, body of L5 and the remaining bilateral sacral ala. The patient can walk with cane, independently

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Fig. 5.3 3-D CT scan of the pelvis at 3 years after total sacrectomy, posterior view, shows no bony fusion between the transverse processes of L5 or L4 and the remaining left sacral ala and the right ilium. Since the patient can walk independently with cane, we believe there should be some fibrotic scar to support and create some spinopelvic stability

Herein we present the case of a patient with sacral chordoma involving the entire sacrum who underwent bilateral Type I total sacrectomy without spinopelvic reconstruction with his functional outcomes after surgery. At 2 years follow-up, the patient was able to walk independently without walking aid while his spinal column shifted down without bony fusion between the transverse processes and the remaining sacroiliac joints.

5.2 Brief Clinical History

A 31-year-old man who had had pain and swelling at the right buttock for 2 years was diagnosed as non-metastatic chordoma of the entire sacrum. The patient had been unable to control his urination and defecation for 2 months prior to the diagnosis. A rectal examination found a palpable mass at the presacral area with free rectal mucosa.

5.3 Preoperative Clinical Photos and Radiographs

See Figs. 5.4, 5.5.

Fig. 5.4 AP plain radiograph of the patient's pelvis showing an osteolytic lesion at the sacrum

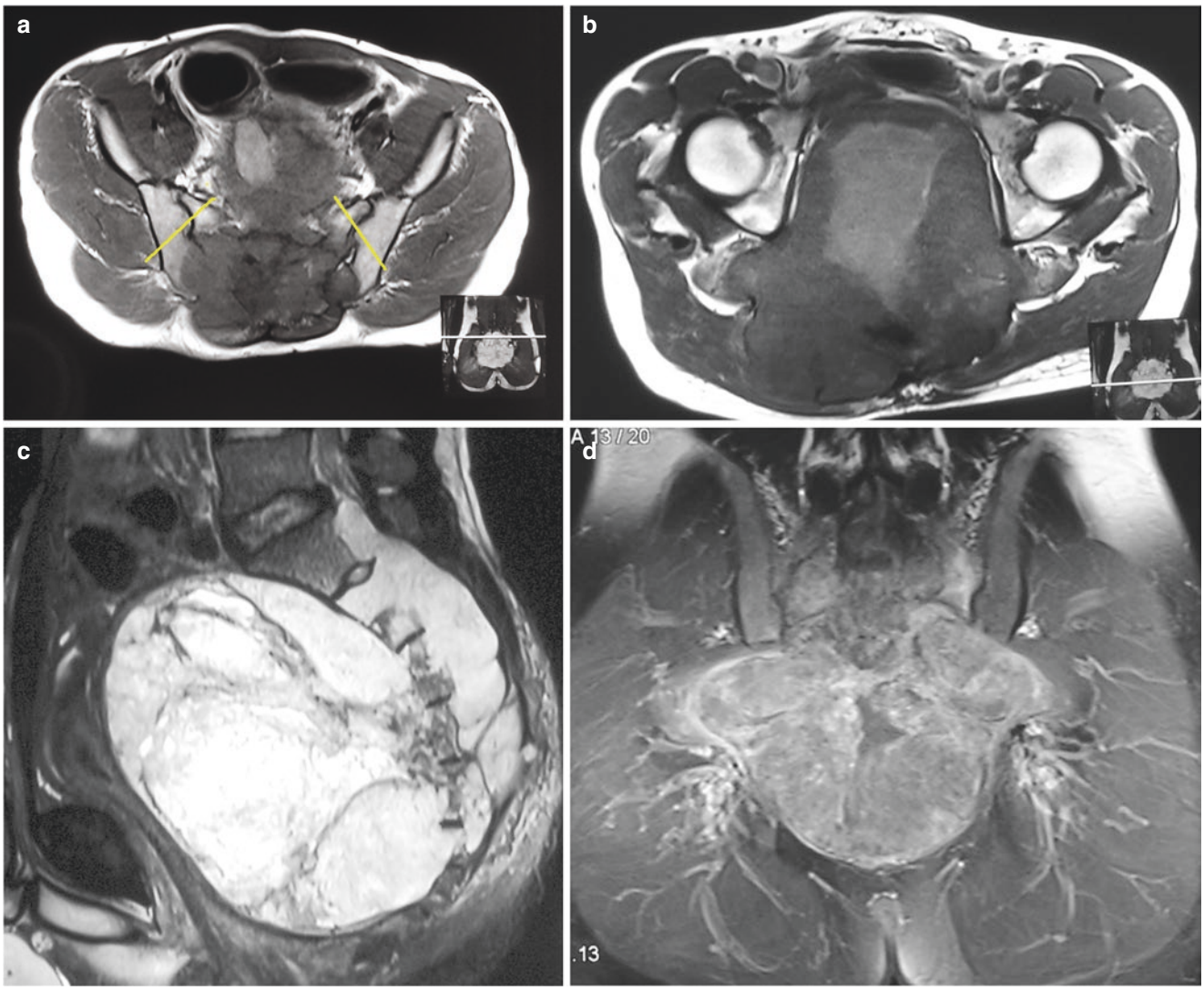

Fig. 5.5 (**a**) T1 axial at the S1 level. (**b**) T1 axial at the mid-sacral level. (**c**) T2 sagittal. (**d**) T1 with Gadolinium magnetic resonance imaging (MRI) revealing a large mass involving the sacrum from S1 to S5 causing spinal canal and sacral foramen compromise. The tumor extends to the bilateral sacroiliac joints, the posterior ilia, the piriformis, the right ischial spine and extends anteriorly causing a pressure effect on the rectum

5.4 Preoperative Problem List

(a) A large chordoma involving the whole sacrum extending beyond both sacroiliac joints to both posterior ilia causing a buttock pain, and inability to control urination and defecation.
(b) Need to remove the tumor as well as the entire sacrum while preserving the uninvolved neurovascular structures, muscles, and tendons.
(c) Spinopelvic stability after a total sacrectomy.

5.5 Treatment Strategy and Considerations

(a) Surgery to completely remove the tumor en bloc with wide margin is the main treatment for sacral chordoma which, in this patient, indicated a wide total sacrectomy. The use of adjuvant radiation therapy is not routinely recommended since it is not associated with improved rate of local recurrence, metastatic disease, or disease-specific survival [4]. The adjuvant high dose radiation

therapy should be used for patients undergoing surgery for primary chordomas when surgical margins are concerning, and all recurrent chordomas [5]. The use of carbon ion radiotherapy or proton beam therapy is another alternative effective treatment which is worth considering if facility provided [6, 7].

(b) A total sacrectomy is also usually indicated in primary malignant bone tumors involving the S1 sacrum and below which need wide margin for local control such as chordoma, chondrosarcoma, osteosarcoma as well as in aggressive benign bone tumors such as giant cell tumor.

(c) A total sacrectomy is usually difficult to perform because of the complex anatomy of the sacrum and the pelvis, the usually large-sized tumor involved, and the proximity of such tumors to vital organs such as the rectum, the urologic structures, the spinal nerve roots, the sciatic nerve and the iliac vessels which can lead to major complications.

(d) Depending on the extent of the tumor, a total sacrectomy is usually performed at the L5–S1 level which requires removal of the S1 body and will cause spinopelvic instability from the discontinuity between L5 and the pelvic bone, requiring ligation of the L5–S1 dural sac and ligations of the bilateral S1 nerve roots and below causing significant bowel, bladder and sexual function deficits. Furthermore, the large cavity left after the surgery can be susceptible to hematoma and infection.

(e) Spinopelvic reconstruction, which is mainly based on the Galveston and modified Galveston techniques, has been recommended by several authors [8–11] for the treatment of spinopelvic instability, as this procedure is more likely to result in early ambulation and less risk of walking disabilities. However systematic reviews have suggested that rates of patient ambulation are similar in patients with and without spinopelvic reconstruction [12, 13].

(f) Although without spinopelvic reconstruction, the patient needs longer hospitalization, more pain control, and more rehabilitation for ambulation, it has several advantages such as no implant failure, no implant-related pain, shorter operative time, lower risk of infection, and easier postoperative monitoring for recurrence using MRI due to no implant artifacts.

5.6 Basic Principles

(a) Preoperative MRI imaging should include oblique (true) coronal sections of the sacrum for best visualization of the sacral nerves. Preoperative embolization should be performed within 24 h prior to the surgery to reduce intraoperative blood loss through selective vascular embolism using embolic material to the internal iliac arteries and their main branches to the tumor. Preoperative mechanical bowel preparation with polyethylene glycol combined with oral nonabsorbable luminal antibiotics such as erythromycin and neomycin is recommended for reducing the surgical site infection if there is injury to the rectum during the operation [14].

(b) During a total sacrectomy massive bleeding from the epidural venous plexus or injury to the internal iliac vessels and other complex complications can occur, so a multidisciplinary team should be prepared beforehand and be ready to join the surgery if required. The team should include a vascular and colorectal surgeon, a urologist, a spine surgeon, an anesthesiologist, and/or a gynecologist.

(c) A wide surgical margin is particularly important to achieve local control and cure the disease, especially in patients with a primary malignant tumor.

(d) In our institution, we routinely perform a total sacrectomy in one-stage using a combined anterior and posterior approach. The anterior approach is used to mobilize the bilateral iliac vessels, ligate branches of the internal iliac vessels that going into the tumor, dissect and mobilize the lumbosacral trunk, and dissect the rectum and soft-tissue from the anterior part of the sacral tumor. The posterior approach is used to ligate the sacral nerve roots and the dural sac, perform a bilateral iliosacral osteotomy, and transverse osteotomy at the L5–S1 disc depending on the tumor and remove the whole sacrum.

(e) In this case, the anterior approach was performed via a midline abdominal incision to expose the anterior part of the tumor, the iliac vessels, and the lumbosacral trunks. The rectosigmoid colon was dissected from the presacral fascia at the anterior part of the tumor. The median sacral vessels, both internal iliac vessels and their branches that going to the tumor were ligated, while both external iliac vessels were preserved. The anterior sacroiliac ligament, the anterior longitudinal ligament, and the L5–S1 disc were partially transected as planned based on the MRI. However, it can be difficult to perform in patients with a large anterior tumor that obscures the location of osteotomy, vessels, and nerves. We do not perform colostomy routinely unless the tumor involves the rectum. Noted that, postoperatively, if no colostomy performed, the surgical wound should be closed with an antimicrobial drape that adheres securely to the skin to reduce the risk of drape lift which can lead to wound contamination and infection. Alternatively, temporary loop colostomy is a useful procedure to avoid infectious complications due to proximity of the surgical site to the anus.

(f) After completing the anterior procedure, the posterior approach was initiated via a three-limbed or inverted-Y incision at the lower back (Fig. 5.6). In cases in which a tumor extension in the coronal plane is not lateral to the lateral border of the sacrum, midline longitudinal incision can be used to expose the sacrum. The gluteus and paraspinal muscles which were not involved by the tumor were dissected and retracted laterally. In cases in which a tumor

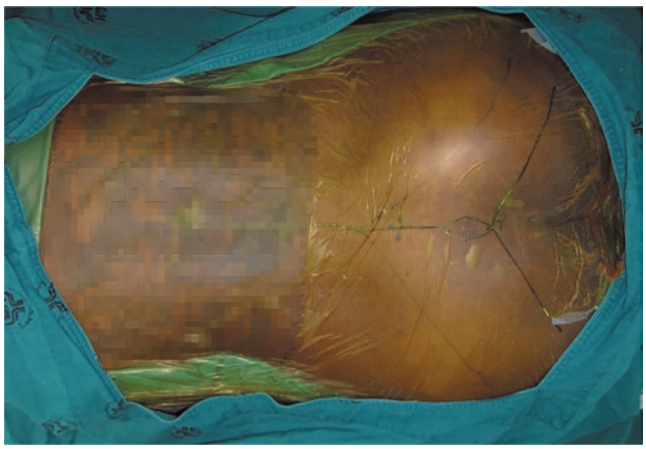

Fig. 5.6 Intraoperative picture after preparation and draping of the skin for posterior approach. A three-limbed or inverted-Y incision at the lower back was marked

involves the piriformis as in this patient, these muscles should be excised more to the lateral side as the tumor is easy to break off at this area. In this case, the right ischial spine was resected since it was close to the tumor. Bilateral sciatic nerves were identified and protected. The lower sacral roots were ligated and transected at the lateral border of sacrum. Bilateral sacrotuberous, left sacrospinous and sacrococcygeal ligaments were resected. The rectum was dissected from the anterior surface of the tumor as much as possible; the remaining part that attached will be later dissected after the osteotomies. Laminectomy was performed to identify the bilateral L5 and or L4 nerve roots which we intended to preserve. The dural sac was ligated caudal to the L5 nerve roots. Next, bilateral iliosacral resections and L5–S1 resection were performed as planned from the preoperative MRI by using multiple sharp osteotomes. Prior to performing the iliosacral resections, gauze was packed into the space anterior to the bilateral sacroiliac joints to protect the anterior structures. However, this packing is sometimes not possible in patients who had a large anterior part of tumor which extended to the lateral aspects. Attention should be paid to not exceeding the osteotomes beyond the anterior edge of the bone which could injure soft-tissue structures anterior to the bone. Computer-assisted navigation can help reconfirm the location and the depth of the iliosacral resection which we routinely use in our institution. After the sacrum was able to mobilize, the remaining parts of the soft-tissue, the rectum, the vessels, and the lumbosacral trunk (the L4–5 nerve roots) were gently dissected from the anterior part of the tumor and the whole sacrum with tumor was removed en bloc.

(g) We did not perform spinopelvic reconstruction and muscle flap. After a copious irrigation and adequate hemostasis, 4–5 large-cores drains were placed. The paraspinal and gluteal muscles were sutured. In general, if the gluteal muscles are not able to be sutured together over the defect due to tension, wound dehiscence is usually occur in the next couple of days and vacuum-assisted dressing will be usually required after the patient's condition is stabilized. Alternatively, the vertical rectus abdominis myocutaneous (VRAM) flap can be performed as it is beneficial for wound closure and to avoid the prolonged use of vacuum-assisted dressing.

(h) Adequate pain control is important. Postoperatively, we usually use continuous intravenous analgesia, continuous epidural analgesia, and patient-controlled analgesia if required while turning the patient to the side every 3–4 h to prevent pressure ulcers. As soon as possible, the patient is encouraged to do in-bed exercises and practice turning from side to side with the help of a physical therapist. Generally, postoperative pain decreases day by day and is notably improved at 2 weeks, although pain when turning to the side can be severe until as much as a month, postoperatively. As soon as the pain is tolerable, the patient is encouraged to gradually practice sitting, standing, and walking.

(i) A lumbar-sacral corset is recommended for ambulation and walking as it decreases lumbar-sacral motion by one-third compared with the range of motion of the spine without the orthosis and supports the abdomen, reduces the load on the lumbosacral spine, and reduces excessive lumbar lordosis to provide a straighter and more comfortable low back [15–17].

5.7 Images During Treatment

See Figs. 5.7, 5.8.

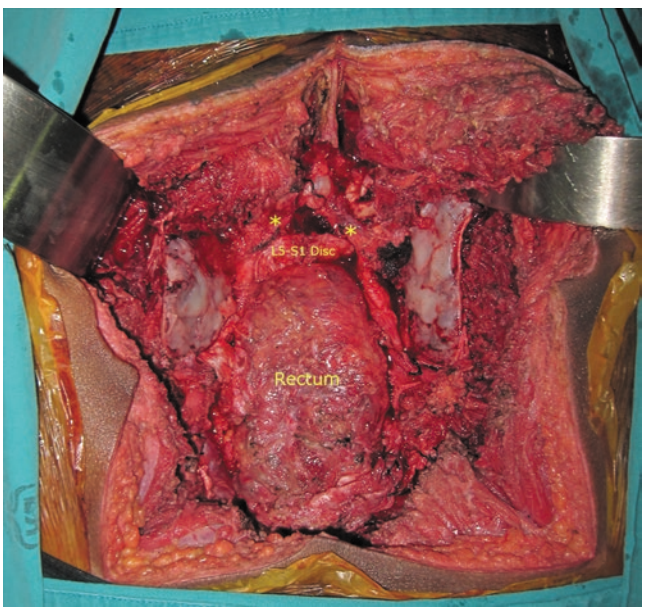

Fig. 5.7 Intraoperative picture after the tumor and the sacrum was removed. Stars (*) indicate the lumbosacral trunk (the L4–5 nerve roots)

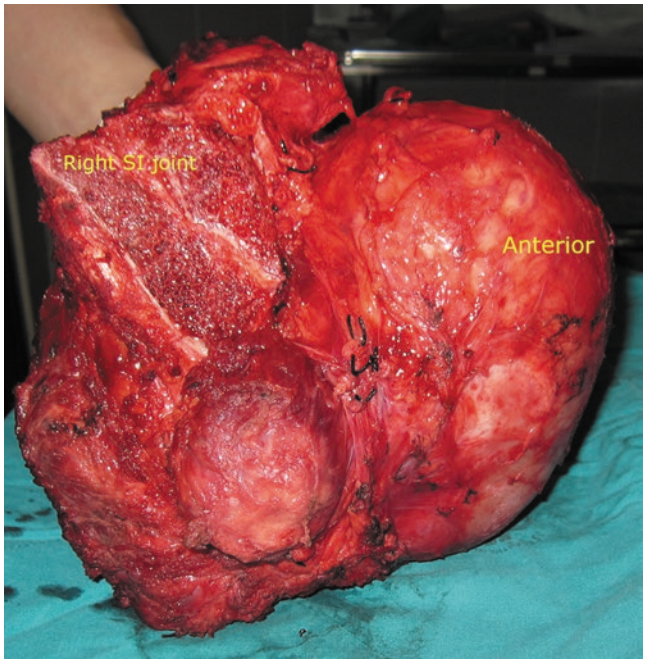

Fig. 5.8 Specimen of the sacrum after total sacrectomy

Fig. 5.9 Radiograph of the pelvis at a 2-year follow-up

5.8 Technical Pearls

After the iliosacral osteotomies and sacrum begins to mobilize, keep in mind that just at the anterior aspect of the sacroiliac joints, there are internal iliac vessels and their branches that go into the sacrum. It is possible that some branches were not tied during an anterior approach, especially if the anterior part of the tumor was large. Gentle dissection at these areas and tied off these branches whenever possible are recommended to avoid injury to them which could lead to massive, difficult to control bleeding.

5.9 Outcomes, Clinical Photos, and Radiographs

This patient was able to sit with support at approximately 1 month, sit without support at 1.5 months, stand at 2.5 months, and practice walking at 3 months after the surgery. At 4 months, the patient was able to walk with a walker without help, although he was still unable to move his right ankle and toes. The patient sometimes used a lumbar-sacral corset while walking but refused to use an ankle-foot orthosis due to its discomfort. At a 2-year follow-up, the patient was able to independently ambulate and walk without walking aid (Video 5.1) (Figs. 5.9 and 5.10).

5.10 Avoiding and Managing Problems

5.10.1 Intraoperative Massive Bleeding

Extensive bleeding is not uncommon in total sacrectomy and has been reported in many studies [18–20] with average intraoperative blood loss greater than 6000 mL, leading to hemorrhagic shock [19, 21]. The causes of such massive bleeding include injury to one or more main branches of the internal iliac vessels, the veins that drain the epidural plexus, larger tumor volume, and excessive tumor blood supply [20]. Other than preoperative selective embolization which has proven to be an effective method for minimizing intraoperative blood loss [22], aortic balloon occlusion is an interesting option which has been reported to be associated with lower intraoperative blood loss and transfusion [11]. Excessive bleeding can cause visual obstruction of the operative field or destabilization of the patient, which in turn can lead to a hurried operation and problems such as positive margin resection or nerve injury.

5.10.2 Recurrence

Local recurrence is common following surgical treatment of chordoma with reports in the literature ranging from 19 to 54% [23]. Wide surgical margin resection is important and is the optimal treatment to decrease local recurrence. Careful

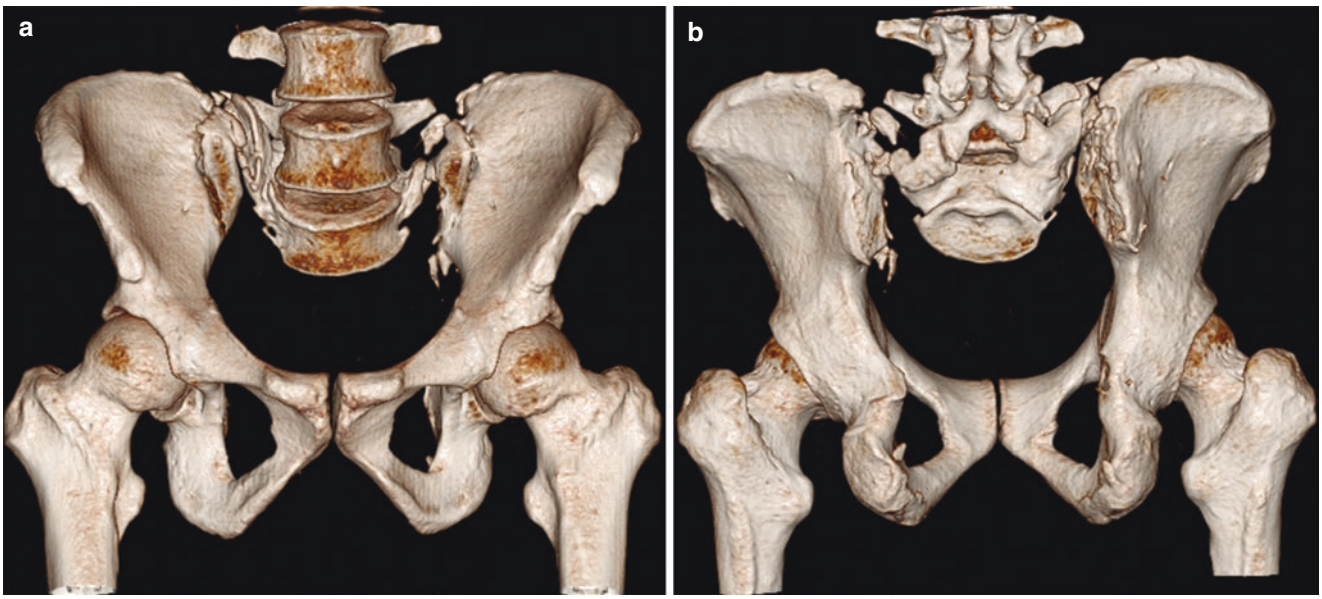

Fig. 5.10 (**a**) Anterior, (**b**) Posterior postoperative CT scan of the pelvis at 2 years after total sacrectomy showing the downward-shifted spinal column and transverse processes of L4, L5 close to the remaining sacroiliac joints. No bony fusion can be seen between the transverse processes and the bone at the sacroiliac joints

planning of the exact location of the resection at both bone and soft-tissue using CT scan and MRI preoperatively is crucial to achieve good surgical margin. In some circumstances that the tumor extends more to the lateral close to the ischial spine, transecting the sacrospinous ligament as lateral as possible or even transecting the ischial spine are recommended. Computer-assisted navigation can help reconfirm the location of the bone resection and the depth of the iliosacral resection which can reduce the incorrect resection. Adjuvant radiation therapy cannot replace the adequate wide margin and should be reserved for those patients with inadequate margins [24].

5.10.3 Nerve Injury

Iatrogenic injury may occur to the L4 and L5 lumbar nerve roots and/or the sciatic nerve during dissection, especially in large sacral tumors when severe bleeding occurs. Careful dissection, intraoperative awareness, and familiarity with related anatomy in this area prior to the surgery can help reduce this complication.

5.10.4 Rectal Injury

Preoperative rectal tube insertion is an option to enable palpation of the rectum intraoperatively which can prevent injury to the rectum during the dissection.

5.10.5 Wound Dehiscence and Infection

Total sacrectomy results in extensive defects or dead space cavities and simple wound closures usually fail [25]. Many soft-tissue reconstruction methods have been proposed to reduce the cavity and risk of infections such as the gluteus maximus flap [26–28] and the vertical rectus abdominis myocutaneous (VRAM) [27] with good results. Vacuum-assisted closure is also recommended for treating spinal wound infection with good results [29]. In our institution, for those patients with wound dehiscence, we have had good results with prolonged use of vacuum-assisted closure and change the dressing every 5–7 days [3]. The wound gradually healed within 1–2 months. The use of mechanical bowel preparation with polyethylene glycol combined with oral nonabsorbable luminal antibiotics is also beneficial for reduce the surgical site infection [14]. Temporary loop colostomy is a useful procedure in order to avoid infectious complications due to the proximity of the surgical site to the anus. Surgical site wound care is important especially for those patients who do not perform colostomy. Antimicrobial drapes that adhere securely to the skin are recommended to reduce the risk of drape lift which can lead to wound contamination and infection.

5.10.6 Pain after Total Sacrectomy

Postoperative pain can be multifactorial such as increasing movement the spine and the ilia, irritation of the residual nerve

roots or the dural sac, vertical weight loading of the surgical area or neuropathic pain, and sometimes it is difficult to identify a specific cause of such pain [17, 30]. The most common type of pain we have found after a total sacrectomy was neuropathic pain occurring the patient at rest. The use of opioids, NSAIDs, and antineuropathic drugs after the sacrectomy to lessen the chance of chronic neuropathic pain has been recommended [30].

5.11 Conclusion

Total sacrectomy without spinopelvic reconstruction is suitable in patients who undergo Type I iliosacral resection on one or both sides as majority of these patients are able to walk independently with or without walking aid. Spinopelvic reconstruction is recommended in patients who undergo bilateral Type II resection.

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