International Journal of Surgery 7 (2009) 529–533

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.theijs.com

Polyaxial screws for lumbo-iliac fixation after sacral tumor resection: experience with a new technique for an old surgical problem

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ARTICLE INFO

Article history:
Received 6 May 2009
Received in revised form
18 July 2009
Accepted 22 August 2009
Available online 6 September 2009

Keywords:
Polyaxial pedicle screws
Lumbo-iliac fixation
Sacral tumor resection

ABSTRACT

Background: Although numerous reports have been published about various methods for reconstruction after sacrectomies, there are still biomechanical and technical dilemmas that are unaddressed. This report describes the experience at authors' institution of five cases in which polyaxial pedicle screws construct has been successfully used for lumbo-iliac fixation after sacral tumor resection.

Methods: Five cases of sacral tumors, two of Ewing's sarcoma and three of giant cell tumor (GCT) underwent surgical resection and then reconstruction was done with hardware using vertical rods placed alongside the spine bilaterally, transfixing monoaxial and polyaxial pedicle screws in lower lumbar levels and polyaxial screws into the ilium bilaterally. Cross links were also used to connect the two vertical members, thus enhancing biomechanical stability of the construct. Use of autologous bone grafts was relied upon to fill the gap created by sacral resection.

Results: No instrumentation failure was noted and the continuity of the spine and pelvis was well established with the instrumentation and auto grafts. In follow up of these patients (1–3 years), no complications were seen.

Conclusion: Polyaxial pedicle screws fixation is an effective technique to transmit axial load from spine to the appendicular bone and can be used safely in patients in whom sacral integrity is compromised after surgical resection. However, the long term benefits of this technique need to be evaluated.

1. Introduction

Few surgical challenges can be as intimidating and prohibitive as resection of a sacral tumor. Fortunately enough, sacral tumors are one of the rarer tumors faced by a surgeon in clinical practice.[1–3] Chordomas are, by far, the most common sacral tumors followed by giant cell tumors (GCTs).[2–5] Although benign, sacral tumors are extremely aggressive. The frequently encountered large size and closeness to important anatomic structures makes sacral tumor resection a formidable task.[6] Resection of sacral tumors has previously been associated with a high failure rate with local recurrence of up to 75%.[6–8] The high recurrence rate associated with sacral tumors has been linked to the delayed diagnosis, larger tumor volume, poorly defined margins of the lesion, and the surgically inaccessible location of the tumor.[6,9]

Normally, sacral biomechanics is such that the wedge shaped sacrum stabilizes sacroiliac joint and transfers load to the pelvis. The main challenge in resection of a sacral tumor lies in reconstruction of a functional column that is able to transmit the axial load effectively and safely from spinal column to the appendicular skeleton of the lower extremities.[10,11]

Various hardware constructs have been used to achieve this goal. Most commonly used methods for sacro-pelvic attachment are Galveston reconstruction (GR) and modified Galveston reconstruction (MGR).[12,13] Another method involves triangular frame reconstruction (TFR).[14] With these constructs, the pull-out weakness and other hardware failure issues remain a problem. Rigidity is also a crucial element in these reconstructions because of high fusion rates.[15,16]

In the recent years, use of pedicle screw-assisted spinal stabilization has gained popularity worldwide. Numerous studies have advocated the safety and efficacy of pedicle screw fixation for many spinal disorders.[17,18]

In the current report, we describe our experience of using poly axial pedicle screws and connecting rods to transmit the load from the spinal column to the ilium after sacral tumor resection. The construct we have devised is: monoaxial or polyaxial pedicle screws in lower lumbar levels and polyaxial screws into the iliac

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doi:10.1016/j.ijsu.2009.08.007

crest. Use of bone screws is preferable because screws provide 3–dimensional stability. Longitudinal members need to be linked with cross members, which provides a two fold advantage: enhances the rigidity of the construct as well as it's pull out resistance.

2. Clinical materials and methods

2.1. Operative technique

After sacral tumor resection, monoaxial or polyaxial pedicle screws of 6.5 × 65 mm size were placed in lower lumbar level(s) bilaterally along with two polyaxial screws of same size in iliac bone on both sides. The two vertical rods alongside the spine, after bending, were also connected to the polyaxial screws placed into the ilium. A transverse rod connecting the vertical bars was also placed. To achieve satisfactory bony fusion, use of autologous bone graft was relied upon. Patients were placed in brace soon after surgery and were mobilized as soon as possible. Pre-operative treatment included angiographic embolization or chemotherapy and radiotherapy depending upon the kind of sacral tumor.

2.2. Patient population & characteristics

Between September 2004 and December 2007, five patients were chosen to undergo surgical resection and then reconstruction with hardware using polyaxial pedicle screws in the ilium. Inclusion criteria was those sacral tumors which had a life expectancy of more than one year, age of the patient less than 45 years, no other serious pre-morbid condition that may put the patient in ASA grade II, and absence of any metabolic bone disorder. Informed consent was obtained. These patients (four females and one male, mean age 24 years, range 14–43 years) all presented with a common complaint of lower back pain. All patients had tumors restricted to the sacrum. The case summary of each patient is given below.

2.2.1. Case 1

A 16 years old female presented with complaint of low back pain radiating to left buttock and leg for past three months. Straight leg raising (SLR) test was restricted to 30 degrees on left side and 45 degrees on right side. Sensations were decreased in L5 and S1 dermatome. Power was 4/5 in left lower limb. After radiographic examination, a biopsy of the lesion was performed which revealed Ewing's Sarcoma. Six cycles of chemotherapy were given prior to surgery. Tumor was excised from the left upper portion of sacrum in pieces and a total sacrectomy was done. Bilaterally L3–L5 vertebrae and iliac bones were fixed using monoaxial steel screws in the spine, polyaxial titanium screws in the ilium, and fixating rods. Autologous bone grafts taken from L3 to L5 spines were meshed and spread in the raw area for grafting.

2.2.2. Case 2

A 21 years old female presented with a 4 year history of severe backache. She was bedridden due to this problem for the past 1 year. She developed bladder and bowel incontinence 1 year back. After initial radiologic work up, a pre-operative embolization of tumor was performed 24 h prior to the surgery. After excision of tumor, an upper sacrectomy was performed; monoaxial steel screws in the spine (L2–L4) and polyaxial titanium screws in ilium were used for lumbo-iliac fixation. Instrumentation was done by posterior approach. The post-operative histopathology report showed giant cell tumor (GCT).

2.2.3. Case 3

A 25 years old married male, known case of giant cell tumor (GCT) presented with a 1 month history of lower backache radiating to legs bilaterally up to ankle associated with numbness. The patient also had a 3 weeks history of perianal numbness. The patient had developed urinary and fecal incontinence and limping gait for past 3 to 4 days. On examination, there was decreased sensation on dorsum of feet bilaterally. There was loss of sensation on perianal area as well as decreased anal tone. The patient had an excision of tumor done at another hospital 6 months back. Repeated MRI showed mass lesion at S1 and S2, extending to epidural space, 6.0 × 3.2 × 5.8 cm in size. A pre-operative angiographic embolization was performed. Left upper half of the sacrum and right one fourth of the sacroiliac joint were removed. Bilateral spinal fixation was done using polyaxial pedicle screws, rods and cross links in L4, L5, S1 and sacral ala. Autologous bone grafts from iliac crest and fibula were used.

2.2.4. Case 4

A 43 years old female presented with 4 years history of low back pain radiating bilaterally to lateral side of thigh and back of calf associated with numbness. On examination, SLR was reduced to 60 degrees on the left side. Power was 4/5 in the left lower limb. There were decreased sensations in L4, L5, and S1 dermatomes. A pre-operative angiographic embolization of the tumor was performed. Sacral tumor was removed, but a thin sheath of cortex was left in situ for mechanical stability. Bilateral spinal fixation was done using polyaxial pedicle screws, rods, and cross links in L4, L5, S1, and S2 vertebrae. The post-operative histopathology report showed giant cell tumor (GCT). The patient developed deep wound infection post-operatively, which was debrided.

2.2.5. Case 5

A 14 years old female presented with a 1 year history of lower back pain. After initial radiographic examination, a biopsy of the lesion was done which revealed Ewing's Sarcoma. Six cycles of chemotherapy were given prior to surgery. An upper sacrectomy was performed and lumbo-iliac fixation was done using polyaxial titanium screws in the spine and ilium.

Figs. 1–3 show the post-operative X-rays of cases 2, 3, and 4 respectively.

3. Results

As mentioned above, the five cases consisted of giant cell tumor (3 cases) and Ewing's sarcoma (2 cases). Pre-operatively, three out of five patients were developing cauda equina syndrome including bowel and bladder incontinence and distal lower extremity weakness. Post-operatively, all five patients were effectively mobilized, and within three month's time all the patients were able to walk without any support. Bowel and bladder incontinence improved in two out of three patients. Male patient ($n = 1$) did not have any erectile dysfunction. In follow up of these patients (range, 1–3 years), we did not see any evidence of hardware failure or erosion at the hardware bone interface. The bony fusion of the grafted material was also accomplished satisfactorily.

4. Discussion

Sacral tumors are difficult to diagnose at an early stage because signs and symptoms are mild and often non specific. The lesions are mostly large and thus present a challenge to the surgeon.[10] Wide excision is the only curative treatment of choice for some very aggressive benign and all malignant sacral tumors.[3,19] With intra lesional or marginal excision, there always remains the risk of local

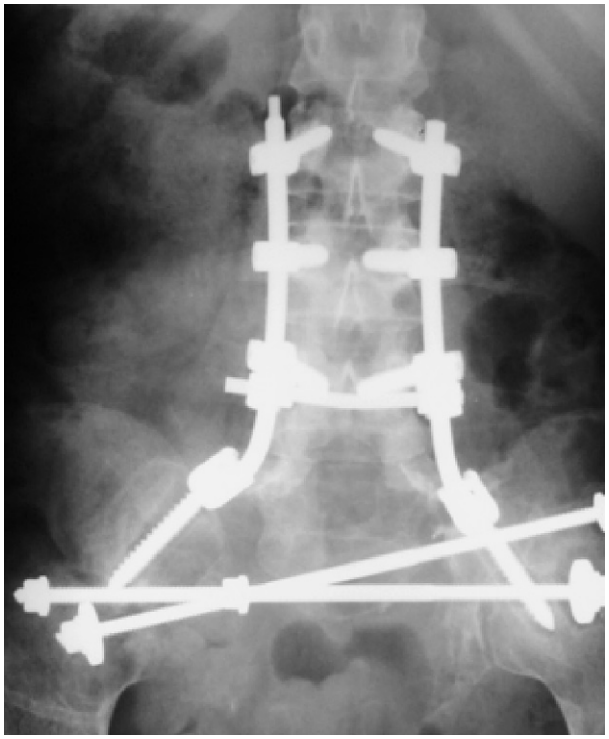

Fig. 1. The post-operative X- ray lumbo-sacral spine (antero-posterior view) of case 2 showing two vertical rods with monoaxial pedicle screws transfixing lower lumbar levels (L2–L4) bilaterally along with two polyaxial screws in iliac bone on both sides. The cross links are also evident. This patient had a giant cell tumor (GCT) of the sacrum.

recurrence. Total en bloc sacrectomy is quite challenging, considering the magnitude of the intervention and the associated risk of complications. Total sacrectomy, however, remains the most effective treatment for both benign and malignant tumors despite the unavoidable neurologic deficits associated with it.[20,21] The sacrifice of the S3 nerve root causes sexual dysfunction; and of the bilateral S2 nerve roots, cause loss of normal urogenital and rectal functions.[22]

Preservation of sacroiliac joint to maintain the stability between the spine and the pelvis after sacral tumor resection is a major issue. Gunterberg et al.[23] reported their findings of the analysis of pelvic strength after major amputation of the sacrum in cadavers and found that the pelvis was weakened by nearly 30% after resection of the sacrum between S_1 and S_2. When the resection was done 1 cm below the sacral promontory, this instability increased to 50%. In clinical practice, patients in whom at least one half of the first sacral body has been preserved do not demonstrate instability.[24] However, total sacrectomy results in vertical and rotational instability plus a great bony and soft tissue defect. It has thus been suggested to re-establish spino-pelvic stability by reconstruction.[23,25,26]

Some surgeons, however, do not consider the reconstruction of the osseous defect after total sacrectomy a fruitful procedure because of the risk of major wound complications.[27,28] The risk of post-operative infection is high because of the large space created by the excision of sacrum, the use of instrumentation, and the relatively longer operative time.[11] Additionally, surgeons belonging to this school of thought believe that stabilization with or without grafting does not improve the ambulation of the patient.

On the contrary, other surgeons have used a variety of operative methods in past for preservation of spino-pelvic continuity after sacral tumor resection. Improvements in instrumentation have led to the development of various reconstruction techniques. The common goal in a great majority of these techniques is to achieve stabilization of spine by employing a solid ilio-lumbar fusion. This has been done via the use of a number of combinations of screws, wires, bars, and plates.[6,29]

Early spino-pelvic reconstructions done in 1980s used Harrington rod technology and combinations of hooks and wires.[13] Techniques further changed in 1990s and the use of Luque-Galveston iliac fixation and spinal attachment by hooks, Luque wires, and pedicle screws became popular.[6] Even with these innovations, proximal iliac fixation was difficult and stability was cumbersome to achieve. The current generation of instrumentation used in

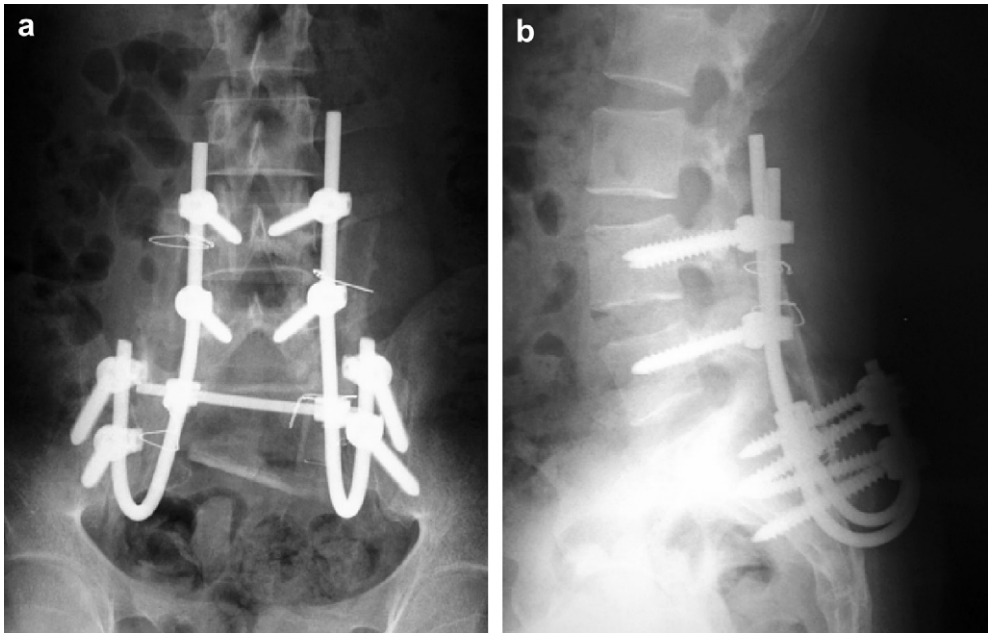

Fig. 2. (a & b): The post-operative X- ray lumbo-sacral spine (antero-posterior and lateral views) of case 3 showing bilateral spinal fixation with two vertical rods transfixing poly axial pedicle screws in L4, L5, S1, sacral ala, and ilium after excision of giant cell tumor (GCT). A cross link is placed between the two vertical bars.

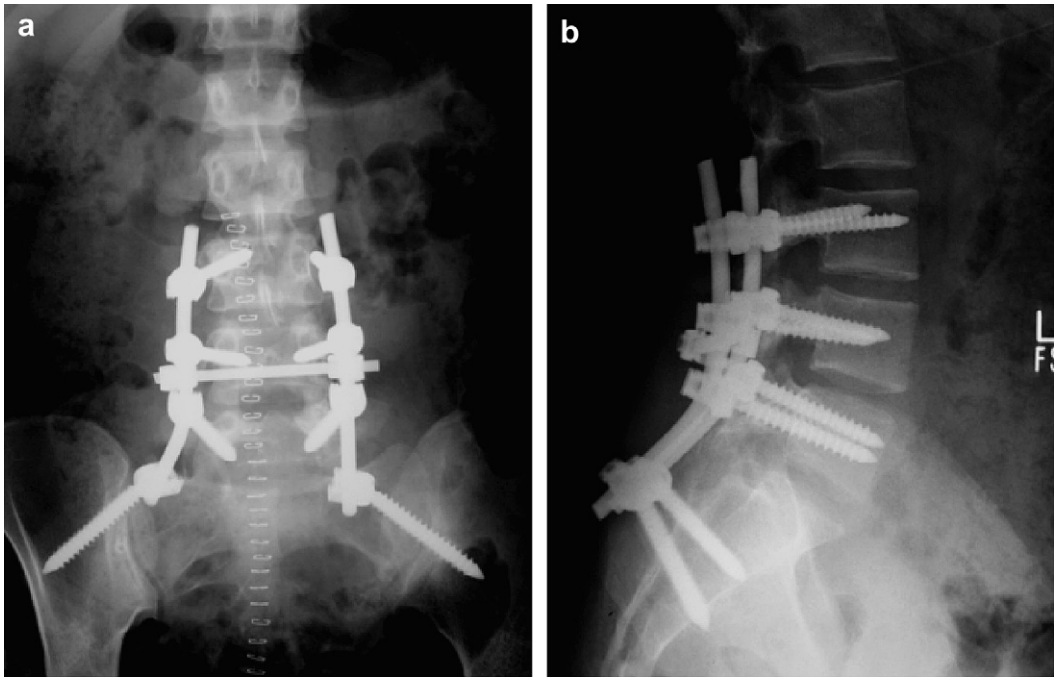

Fig. 3. (a & b): The post-operative X- ray lumbo-sacral spine (antero-posterior and lateral views) of case 4 showing ilio-lumbar fixation with two vertical rods transfixing polyaxial pedicle screws in L4, L5, S1, S2, and ilium along with the connecting bar after excision of giant cell tumor (GCT).

spino-pelvic reconstruction is the pedicle screw-rod construct. This is easier to place, safer, and provides a more rigid fixation in comparison to the constructs used in past.

Based on our experience of these five patients, we consider the polyaxial screws lumbo-iliac fixation to be the optimum reconstructive method after sacrectomy. The polyaxial screws construct that we have used is easier to place safely and the fixation is more rigid than that of previous constructs. Our construct provides a biomechanically stable ilio-lumbar fixation. Our instrumentation is more refined in that the two vertical rods are segmentally fixed bilaterally to the lumbar spine using monoaxial or polyaxial pedicle screws, and each vertical rod, after bending, is also connected to the polyaxial screws placed into the ilium. The obvious advantage of this construct is that the autologous bone graft used between the iliac wings can be compressed by the hooks. Additionally, the transverse rod connecting the two vertical rods provides stability around the horizontal axis of the spine besides preventing rotation around this axis. The major advantage of using polyaxial pedicle screws is the three dimensional stability provided by these screws. Additionally, polyaxial screws provide resistance to pull-out forces, thus decreasing the chances of instrumentation failure.

The good results of the reconstructive method after sacrectomy that we performed are evident by the fact that all five patients' reconstructions were stable at the latest follow up. No instrumentation failure has been noted in our patients so far. However, it is not possible to comment on the long term results of our procedure only on the basis of our series of five patients. We acknowledge this scientific limitation of our paper. We hope that continued application and long term follow up of this technique in sacral tumor patients will more precisely depict its potential merits and limitations.

5. Conclusion

Use of monoaxial or polyaxial pedicle screws inserted into the spine and polyaxial screws in the ilium to transmit axial load from spinal column to the appendicular bone is a safe and efficient method to achieve a satisfactory functional outcome in patients whose sacral integrity is severely compromised after sacral tumor resection.

Conflict of interest
None.

Funding
None.

Ethical approval
Not applicable.

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