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Research Article

Posterior Vertebral Column Resection in Clinical Practice

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Abstract: **Background:** Our objectives are to share our experience, go over the side effects, and evaluate the long-term results of posterior vertebral column resection (PVCR) with deformity resulting from different causes. **Materials and Methods::** A retrospective analysis of 12 patients who had PVCR between 2012 and 2016 was conducted. Posttraumatic deformity in six patients, rigid kyphotic deformity in two patients, metastasis in two patients, Pott's disease in one patient; and osteoporotic fracture in one patient. We analysed surgical characteristics, complications, and the need for revision procedures. **Results:** The mean follow-up period was 6.18 years. The mean operative time was 315.83minutes. The estimated blood loss was 1591.67m/L. No patient has required revision surgery for any hemopneumothorax, hematoma, dural tear, vascular injury, wound problem, infection, and recurrence of deformity. We have not seen any additional neurological deficits related to the surgical procedure. One patient developed a radiological pseudoarthrosis and was not reoperated. There was a breakage of the rod in one patient, and this patient reoperated. One patient developed arachnoiditis ossificans and reoperated. Conclusion: Although PVCR is a highly risk of blood loss and complications, it is an effective surgery. Surgical experience is very important to prevent operation-related complications.

Keywords: posterior vertebral column resection, Deformity, metastasis, Pott's disease, osteoporotic fracture.

INTRODUCTION

Among the various types of osteotomies, resection of the posterior vertebral column resection (PVCR) provides the most amount of correction, and it is typically used for a severe deformity (congenital or idiopathic) that is not suitable for correction with a less invasive osteotomy[1-6].Other indications for PVCR include osteoporotic fractures with neurologically threatening symptoms [1,7], postinfectious kyphosis, including healed tuberculosis [1, 3, 8], posttraumatic deformity [1,9], congenital, early onset, and adult kyphosis, scoliosis, or kyphoscoliosis [1-5,10-13], lumbosacral spondylectomies [14], primary or metastatic spinal tumors [13, 15, 16]. Seeing the clinical and radiological long-term outcomes of PVCR was the goal of this retrospective investigation.

MATERIAL AND METHODS

Twelve patients who had PVCRs at the İzmir Tepecik Research and Training Hospital between January 2012 and January 2016 were found using this search. The patients eligible for this study were adults aged 18 years or older who were diagnosed with severe spinal deformities requiring posterior vertebral column resection (PVCR). These conditions included posttraumatic deformities, kyphotic deformities, metastatic spinal lesions, Pott's disease, or osteoporotic fractures. Eligibility was further determined based on clinical evaluations and imaging studies, and only patients who were capable of providing informed consent or had consent obtained through a legal guardian were included.

Additionally, the exclusion criteria were clearly defined. Patients were excluded if they had severe comorbidities, such as advanced cardiac or pulmonary conditions, which posed a high surgical risk. We also excluded patients who had undergone prior spinal surgeries that made PVCR infeasible or those who were unable to comply with follow-up and postoperative care due to geographic, social, or economic factors. Furthermore, patients with non-correctable medical contraindications to anesthesia or surgery were not considered for this study. Neurological deficits were classified using standard grading scales based on their severity, while pseudoarthrosis was defined by radiographic evidence of non-union at the surgical site. Arachnoiditis ossificans was identified through MRI findings and associated clinical symptoms, such as worsening neurological function or pain.

The Tınaztepe University's Ethics Institution Committee (022022/16082022) reviewed this study application, which was carried out in accordance with the 1964 Declaration of Helsinki and its subsequent amendments. Every patient who was enrolled gave their written approval to take part in

the research. The Strengthening the Reporting of Observational Studies in Epidemiology (**STROBE**) criteria were used to grade this study. All patient information has been de-identified, and clinical data has been kept private. The senior author, NÖ, acted as the second author and performed and oversaw all surgical procedures for the patients. During the procedure, intraoperative neuromonitoring was not carried out. After the deformity was corrected, wake-up tests were conducted.

OPERATIVE TECHNIQUE

Following the induction of general anesthesia, the patient is placed prone over bilateral chest rools. The lesion at the index vertebra was in the center of the incision, which was done in a straight line down the middle. Next, the target area's paraspinal muscles were primed. The patient was fixed with pedicle screws free-hand following preoperative imaging and surgical planning. Usually, two vertebral bodies above and two below the index vertebra are subjected to this procedure. First, a makeshift rod was placed in place on one side. Following the temporary stabilizing rod, laminectomy, facetectomy, and pediculectomy were carried out. The transverse processes on either side were osteotomized at the thoracic levels, and approximately 3 cm of the rib next to them were chopped off. The thoracic region's nerve roots were not severed or ligated. The intervening discs and vertebral bodies were removed using rongeurs, curettes, and a high-speed drill. Normally, one might pass from underneath the posterior vertebral wall, which was still present at this point, to the contralateral half. Following the removal of all the bone on one side, the process was repeated with the addition of a temporary rod to the opposite side. The area of bone immediately ventral to the cord, known as the posterior vertebral wall, was removed last using reverse-angled curettes, Kerrison rongeurs, or posterior wall impactors. Following the effective preparation of the vertebral body and both neighboring intervertebral discs, fusion was facilitated by the insertion of a titanium cage containing bone replacement. patients were mobilized with a thoracolumbosacral orthosis the following day, and the orthosis was maintained for three months. The wound was bandaged in layers over a drain, and the cage was clamped tightly between adjacent vertebrae by subsequent dorsal compression to achieve a hyperkyphotic deformity.

RESULTS

There were 12 patients in total who underwent a PVCR. The details of these are summarized in Table 1. Six patients had a posttraumatic deformity,

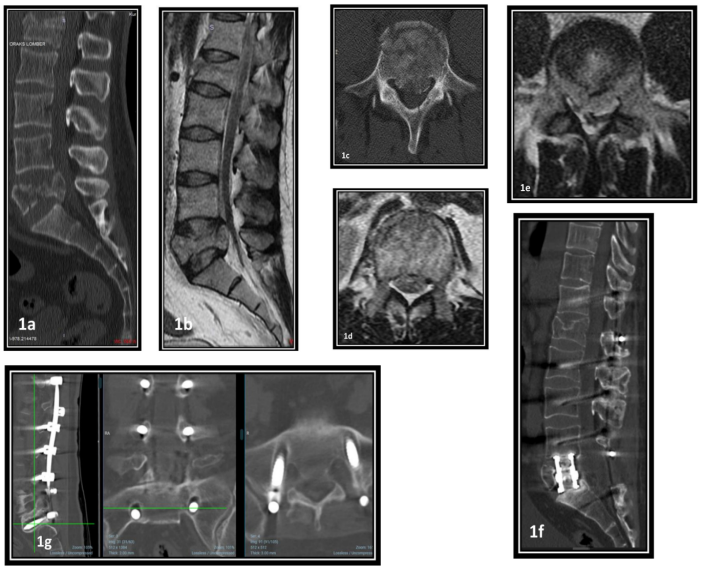

Figure 1. A 39-year-old male with posttraumatic deformity. A-B-C-D-E. Preoperative sagittal and axial CT with MRI demonstrated that L1 and L5 fractures. L5 axial T2 weighted section showed that dural sac compression by fragment. A L5 PVCR with T12-L2-L3-L4-S1 instrumentation was performed. F-G. The patient had radiological pseudoarthrosis with no clinical complaints in bilateral S1 screws 4 years after surgery. The patient who had a 6-year follow-up did not need reoperation.

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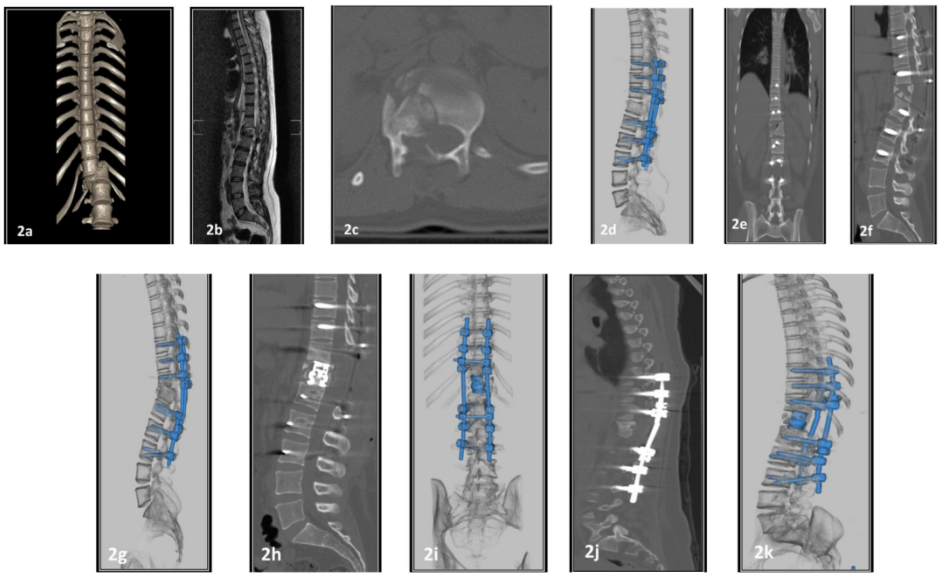

Figure 2. A-B-C-D-E. T9-T10-T11-L2-L3-L4 was applied to a 46-year-old female patient due to T12-L1 fracture dislocation after an in-vehicle traffic accident. F-G. After 14 months, the rods were broken on both sides over L1, which caused kyphosis. H-I. Upon this, changing rods was applied with T12 PVCR. J-K.10 months after PVCR, this time the right T11 rod was broken. She had back pain, and sagittal balance measurements were normal. The broken titanium rods were replaced with chrome cobalt rods. The follow-up period of the patient is 8 years and she has no problems.

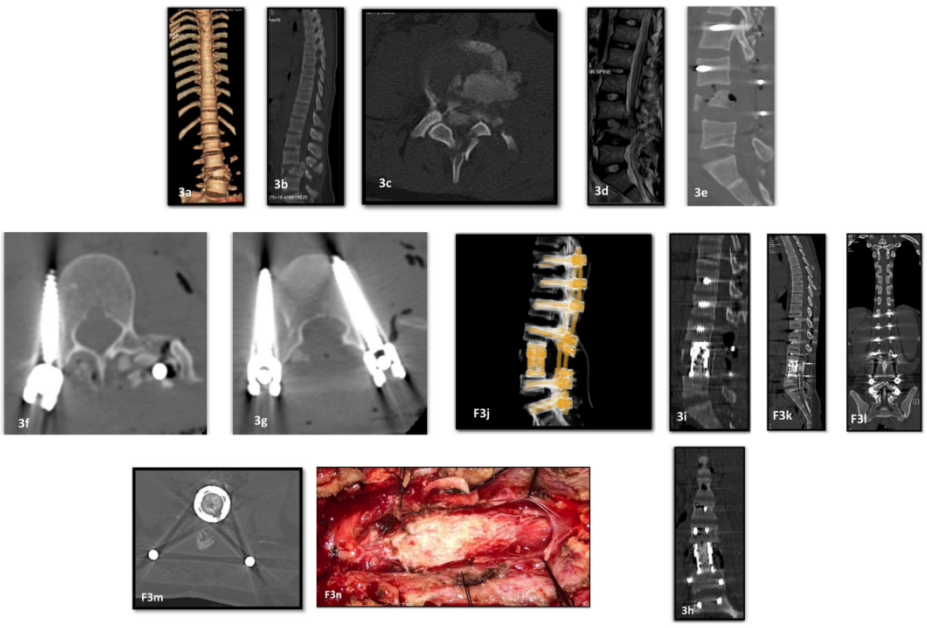

Figure 3. A-B-C-D. Posterior spinal instrumentation was applied to an 18-year-old girl patient due to L4 fracture. She was admitted with a severe neurological deficit. After surgery, her neurological deficit improved. F-G-H-I-J. However, L4 PVCR was performed in the patient who developed posttraumatic deformity due to screw mal-positions. K-L-M-N After the fourth year, her urinary problems worsened. Arachnoiditis ossificans was detected and surgery was performed. The patient's urinary incontinence improved. No additional problems were observed during the 9-year follow-up. two patients had a rigid kyphotic deformity

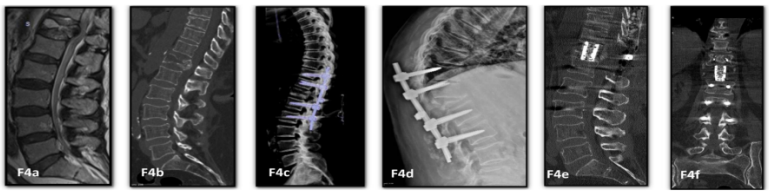

Figure 4. A-B-C-D-E-F. A 75-year-old female patient who underwent posterior spinal instrumentation for a T12 fracture developed a rigid kyphotic deformity. A T12 PVCR with T12-L2-L3-L4-S1 instrumentation was performed. She has no complaints during 8-year follow-up. Two patients had metastases, one patient had a Pott's disease (tuberculous spondylitis) (Figure 5), and one patient had an osteoporotic fracture (Figure 6).

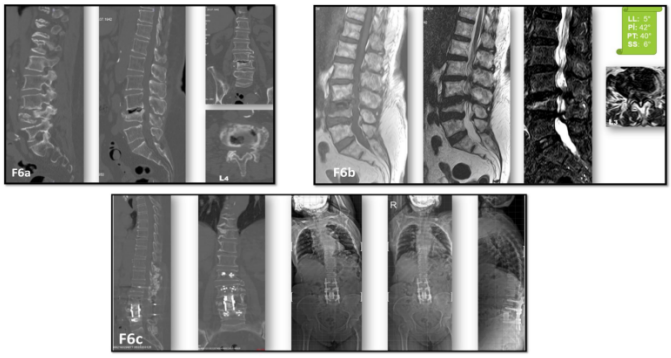

Figure 5. A-B-C-D. CT and MRI of a 47-year-old female patient with spinal tuberculosis that involved the L3-L4 disc and L4 corpus. E-F-G-H. This lumbar site was treated with L4 PVCR with L2-L3-L5-S1 instrumentation. No additional problems were observed in the 6-year follow-up of the patient who received antituberculosis treatment for 1 year.

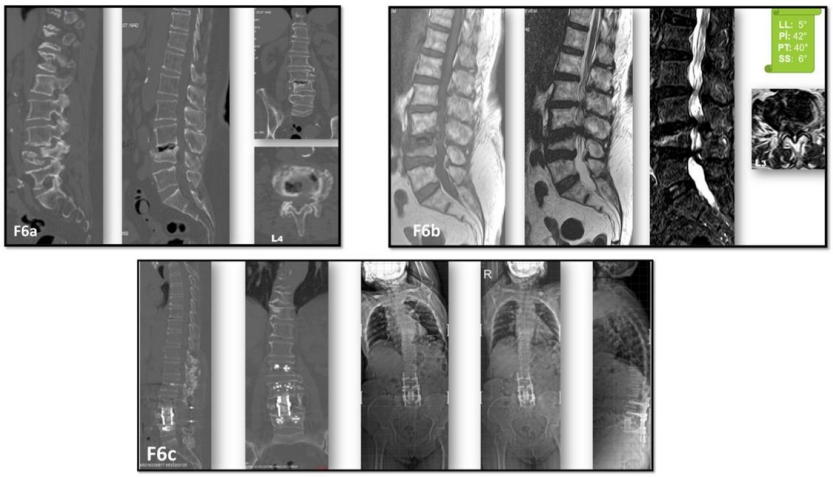

Figure 6. A-B. A 71-year-old female with a L4 osteoporotic fracture and lumbar spinal stenosis.C. A L4 PVCR with L2-L3-L5 instrumentation was performed. No problems were encountered in the control CT after 3 years. The patient died of natural causes 6 years after PVCR.

Table 1: Reported 12 patients for PVCR

Patient	Age, sex	Etiology	Resected vertebral body	Operation time (minutes)	Blood loss (mL)	Hospital stays (days)	Complications	Follow-up (years)
1	39, male	Posttraumatic deformity	L5	340	1300	8	Radiologically bilateral S1 pseudoarthrosis	6
2	66, female	Posttraumatic deformity	T12	380	2100	18	-	6
3	46, female	Posttraumatic deformity	T12	210	700	13	Breakage of rod	8
4	18, female	Posttraumatic deformity	L4	290	1200	19	Arachnoiditis ossificans	9
5	22, male	Posttraumatic deformity	L5	260	1200	16	-	9
6	68, female	Posttraumatic deformity	T8	320	1000	42	-	42 days
7	75, female	Kyphotic deformity	T12	300	1700	21	-	6
8	52, male	Kyphotic deformity	L2	290	3000	26	-	7
9	52, male	Metastasis	L2 and L3	380	2300	14	-	1
10	58, male	Metastasis	L4	390	1000	21	-	10
11	47, female	Pott's disease	L4	300	1300	13	-	6
12	71, female	Osteoporotic fracture	L4	330	2300	34	-	6

Five of the patients were male and seven were female; their ages ranged from 18 to 71, with a mean of 51. Only one case had ankylosing spondylitis (Table 1, patient no. 6). Of the 12 patients, four presented with neurological deficits (Table 1, patient no. 4, 6, 9, 12). Four patients had thoracic involvement, and eight had lumbar involvement. During surgery, one level vertebrae were removed from 11 patients, whereas a two level vertebrectomy was done in one patient (Table 1, patient no. 9). The estimated blood loss for PVCR was 1591.67 mL (SD: 832.45, range: 700–3000 mL, 95% CI: 1200.8–1982.5 mL), and the mean operating time was 315.83 minutes (SD: 45.67, range: 210–390 minutes, 95% CI: 290.4–341.2 minutes). The average hospital stay was 20 days (SD: 10.2, range: 8–42 days, 95% CI: 16.5–23.5 days). Except for one patient who passed away 42 days after PVCR, the average follow-up time was 6.18 years, with a range of 1 to 10 years. This patient who died (Table 1, patient no. 6) in the intensive care unit of the hospital had ankylosing spondylitis and had a severe neurological deficit on admission. The patient who had lung cancer metastasis (Table 1, patient no. 9) died due to the prognosis of the lung cancer after 1 year. The patient with an osteoporotic compression fracture who presented with a neurological deficit (Table 1, patient no. 12) died due to natural causes 6 years after PVCR. There was no death due to surgical procedure in any patient. Besides, none of the patients had any surgery related complications, including the development of additional neurological deficits. No patient has needed revision surgery for a hemopneumothorax, hematoma, dural tear, vascular injury, wound healing issue, infection, recurrence, or progression of deformity. Late complications occurred in 3 patients after PVCR. The patient with a posttraumatic deformity (Table 1, patient no.1) with a 6-year follow-up showed radiological pseudoarthrosis on bilateral S1 screws without any clinical complaints. This patient was not reoperated. (Figure 1). The patient with a posttraumatic deformity (Table 1, patient no.2) with an 8-year follow-up underwent revision surgeries for breakage of rod in two different periods (Figure 2). The patient with posttraumatic deformity presented with severe neurological deficit (Table 1, patient no. 4). After surgery, her neurological deficit improved. After the fourth year, her urinary problems worsened. Arachnoiditis ossificans was considered in the patient, and surgery was performed for this purpose (Figure 3). The patient has had a total of nine years of follow-up and has had neurological improvement with duraplasty.

DISCUSSION

In standard clinical practice, PVCR is an efficient and secure surgical technique. In the treatment of severe spinal deformity, PVCR is superior to many other osteotomies. It has been shown to be beneficial in terms of short- and medium-term outcomes in many different disease groups [1-16][1]. However, it has the risk of major complications, including spinal cord injury.

The first PVCR was described in 2002 by Suk et al. [4] in 70 patients with spinal deformities (adult scoliosis in 7; congenital kyphoscoliosis in 38; and postinfectious kyphosis in 25), which had been reported in the resection of 9 lumbar or thoracic spinal tumors (metastases in 6; multiple myeloma in 1, aneurysmal bone cyst in 1, and chordoma 1). With a mean blood loss of 4820 mL (range 3200–6300 mL), the operation took 337 minutes. Complications were significant and occurred in 24 out of 70 patients (34.3%), according to Suk's series [4] (mean age 27.4 years with a minimum 2-year follow-up), including 2 patients who sustained complete spinal cord injuries (other complications: hematomas in 6, incomplete nerve root injuries in 4, instrumentation failures in 5, infections in 2, hemopneumothoraxes in 5). Lenke et al. [2] reported 43 severe spinal deformities (26 pediatric, 17 adult) in a 5-year experience. Seven patients had severe scoliosis, twelve had global kyphosis, ten had angular kyphosis, and fourteen had combined kyphoscoliosis. With a mean age of 23.9 years, the follow-up period was two years and two months on average. Between 250 and 3100 mL, the mean estimated blood loss for all patients was 1103 mL. The average operating time ranged from 4 hours, 51 minutes, to 18 hours, 20 minutes, with a mean of 9 hours, 37 minutes. Post-operative neurological complications included five patients who had two reversible spinal cord injuries. One patient experienced a deep wound infection that was treated and recovered. Revision surgery due to instrumentation or fusion complications was not performed. With 102 cases, Hamzaoglu et al. [1] had the largest series. The study includes 12 patients with healed tuberculosis who have severe angular kyphosis, 56 patients with severe spinal deformity (idiopathic, congenital, etc.), and 9 patients with posttraumatic deformity. With a minimum 2-year follow-up, this author underwent PVCR from 1996 to 2007, for a total of 9 years and 3months. At the time of the operation, the average age was 37.6 years. Two patients experienced reversible nerve root injuries; however, the overall complication rate was not disclosed. Forany instrumentation, fusion, or neurological complication, no patient had needed revision surgery. In a retrospective research, Papadopoulos et al. [3] reported a group of 45 patients who underwent PVCR between 2002 and 2009. Congenital kyphosis secondary to fully or partially segmented hemivertebra was linked to the kyphosis in 9 patients, while Pott's disease was linked to it in 26 patients. The mean follow-up period was 2 years and 3 months (from 2 and79 months), with a mean age of 14 years (range, 6-47 years). With an average estimated blood loss of 1265 mL (range, 350-2500 mL), the average operating time was 445 minutes (range,360-600 minutes). There were three patients in this series: one with a spinal cord injury, one with a permanent nerve root injury, and one with a temporary nerve root injury. 10 patients under went revision surgery (wound infection in 4, surgical drainage for tuberculous psoasabscess in 1, myelopathy in 1, pseudoarthrosis in 3, dislodge of proximal hooks in 1). Zeng etal. [9] had published the series with 39 cases of PVCR. A total of 81 patients had posterior osteotomies for focal kyphosis in this study; 39 of them had PVCR (the other approaches used pedicle subtraction osteotomies in 19 cases and posterior osteotomies with anterior opening posterior closing correction in 23 cases). The average operation lasted 6.1 hours, and 2710 mLof blood were lost on average. In this study, PVCR had a higher mean surgical time and blood loss than the other two techniques. Intraoperative complications included 3 patients of dural tear, 5 patients of nerve root injury, 2 patients of transient neurological compromise for PVCR. Titanium mesh loosening of 1 patient and 1 osteotomy segment shifting were early complications for PVCR. In one patient, fixation failure and kyphosis recurrence were found to be late complications of PVCR. 15 patients with severe angular post-tuberculous kyphosis of the thoracolumbar region who received PVCR treatment between 2004 and 2009 were presented by Zhang et al. [8]. At the time of surgery, the average age was 35.8 years (the range was 20–60 years). Follow-up after surgery lasted 36.1±10.7 months (range: 24-62 months). With a mean blood loss of 1653.3±777.9 mL (range 800-3000 mL), the average operating time was 446.0±92.5 minutes (injury range 300-640 minutes). In this series, there were no cases of proximal junctional kyphosis, spinal cord injuries, nerve root injuries, dural tears, vascular complications, pseudoarthrosis, instrumentation breakage and loosening, or kyphosis recurrence. In 76 patients (52 adolescents and 24 adults) between 2004 and 2011, Xie et al. [5] identified risk factors for neurological deficits during PVCR correction. These patients had severe and rigid spinal deformities. The median age was 17.5 years; the range was 10 to 48.The average follow-up period for 52 patients was 48.6 months (the range was 24-72

months).The average operation lasts 512 minutes, and 4760 mL of blood are lost on average. No patient in this series experienced long-term neurological deficits as a result of a spinal cord or nerve root injury. While there was a change in neurological status in six patients, the preexisting neurological deficit in five of these six patients became more severe. The risk factors for a neurological deficit during PVRC correction of spinal deformity, according to the authors, include pre-existing neurological dysfunction, potential intraspinal and brain stem anomalies, thoracic hyper kyphosis associated with scoliosis, and levels of the vertebral column removed. Despite the long surgical time, high blood loss, and high complication rate, it provides a good correction rate in patients with spinal deformity, considering the large series detailed above for PVCR.

PVCR has also found use in the surgical treatment of spinal tumors (primary or metastatic) as well as spinal deformities. In the literature, this method has frequently been described as an effective fusion with good pain relief and an improved sagittal profile [13, 15,16]. An analysis of 11 cases of spinal metastases treated with PVCR from 2008 to 2010 was published by Jandali al. [15]. The average follow-up period was 14 months (with a 10 to 24 month range). Each surgery took an average of 6.6 hours (range: 4.5–9 hours) and 1618 mL (900–4000 mL) of blood on average. There were no deaths associated with the surgery. Complications included 2 reoperations, 1 delayed hardware failure, and 3 dural tear. Reoperation causes were hematoma and paraparesis that developed after surgery. Cage subsidence and dural tears did not require reoperations. 40 patients who underwent surgery for spinal tumors between 2005 and 2011 were analyzed for PVCR complications, as shown by Fan et These patients ranged in age from 2 to 78 years, with a mean age of 52. 8 years). Thirteen patients had primary tumors, and twenty-seven had metastatic tumors. Ten tumors were discovered in the lumbar region, compared to 30 tumors in the thoracic region. 14 months was the average follow-up (with a 4–78-month range). Two cases survived for about six months, but there were no cases of mortality. The average operation lasted 306 minutes, with 2400 mob blood lost and 2600 mL of blood being transfused, respectively. The majority of the complications were minor enough not to interfere with the patients' ability to recover (cerebrospinal fluid leakage in 2 patients, acute liver dysfunction and renal failure in 1, drainage tube retention in 5, late tracheal extubating in 10, hemothorax in 2 patients, pneumothorax in 1, acute enteritis in 1, transient cardiac ischemia in 1) Major complications were observed in 2 patients, including infective shock in 1 patient and regional recurrence in 1patient. Retrospective analysis of 14 patients who underwent PVCR for 5 plasmacytomas and9 spinal metastases was published by Dreimann et al. [16]. The average follow-up period was12 months, with a 3 to 21 month range. In the range of 51 to 78 years old, the average age at surgery was 63.6. The average operation lasted 282 minutes, with a 200–380-minute range. The range of blood loss was 800-6100 mL, with a mean of 2257 mL. Following surgery or follow-up, there were no signs of a neurological complication, a dural tear, hardware failure, or the need for revision surgery.

The average surgery time and the amount of blood we estimated to have been lost in our group of patients were comparable to those reported in the literature. For any hemopneumothorax, hematoma, dural tear, vascular injury, problem with the healing of the wound, infection, recurrence, or progression of deformity, no patient has needed additional surgery. Complications could be avoided with careful intraoperative manipulations and good protection of the surrounding tissues. In our series, we haven't seen any more neurological problems that were caused by the surgery. Improvement was observed in 4 patients with preoperative neurologic deficits. But one of the four people who had neurological problems before surgery got worse because of arachnoiditis ossificans in the fourth year after surgery. One patient experienced radiological pseudoarthrosis and was not reoperated on. There was a breakage of the rod in one patient, and this patient reoperated.

We recognize that patient comorbidities, such as diabetes, osteoporosis, and smoking status, could have influenced surgical outcomes and complication rates in this study. These factors are known to impact recovery, bone healing, and overall postoperative risks. However, due to the retrospective nature and limited sample size, this study could not control for these potential confounders. We acknowledge that the follow-up periods in this study were inconsistent, ranging from 42 days to 10 years, primarily due to its retrospective nature. This variability limits the comparability of long-term outcomes across patients and introduces potential bias in assessing the effectiveness of PVCR. Consistent follow-up schedules would improve the accuracy of long-term outcome assessments, facilitate better comparison of results, and ensure a more reliable evaluation of the procedure's impact over time.

There are some limitations to this study:

This study's shortcomings include the fact that it is retrospective in nature. The small size of the sample and the way the patients were chosen may have led to some selection bias. But this study is exploratory in nature, serving as a preliminary analysis to provide foundational insights into PVCR outcomes. While the lack of a control group limits the ability to compare PVCR directly with other interventions, this study was focused on characterizing outcomes and complications specific to PVCR. Intraoperative neuromonitoring, especially motor evoked potential monitoring, is a good way to avoid neurological problems caused by the spinal cord [1-3, 8]. Due to economic and social problems in our country, we were unable to use intraoperative neuromonitoring on our patients. So, information from intraoperative neuromonitoring about how well the nervous system was working was not included in our series. We performed a wake-up test to evaluate neurological function in our patients. No patient awoke with weakness in both lower limbs. We acknowledge that the single-center design of this study limits the generalizability of the findings. Conducting similar research across multiple centers would allow for a more diverse patient population, enhancing the validation and applicability of the findings in broader clinical and geographical settings.

CONCLUSION

Although PVCR carries a high risk of significant complications and excessive blood loss, it is a successful and secure procedure for treating various deformity pathologies. Carefully planned and meticulous surgery results in a favorable outcome. Surgical experience is very important to prevent operation-related complications.

Conflict of Interest Disclosure:

The authors declare no competing financial interests and no sources of funding and support, including any for equipment and medications.

Author's contribution's

Özgür Akan: Literature search, collecting data and writing the manuscript.

Nail Özdemir: Conceiving the idea and editing the manuscript Figures

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