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Results of Posterior Vertebral Column Resection: Surgical Modification of Suk Technique

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Abstract

Study Design: Consecutive, retrospective review.

Objectives: To evaluate and report a modified posterior vertebral column technique.

Methods: We present a retrospective analysis of 20 patients. Patients having severe 3-dimensional deformity with flexibility less than 20% and managed by posterior vertebral body resection (PVCR) between 2011 and 2014 were included in this study. There were 12 female and 8 male patients, with a mean age of 18 year (range = 3-63 years).

Results: The average follow-up was 3.5 years (2-5 years). The preoperative coronal plane deformity was 84° (70° to 120°) and corrected to 42° (28° to 68°), showing 60% scoliosis correction. Average preoperative local kyphotic angle was 92° (82° to 110°). Correction rate for kyphosis was 62%. All patients after surgery showed their baseline neurological status, and no complications were encountered. The mean estimated blood loss was 1072 mL (350-2000 mL). Thirty-nine percent (33% to 50%) of total blood loss occurred after vertebral body resection, and 61% (50% to 67%) blood loss occurred after the removal of posterior elements. The ratio of estimated blood loss to estimated body blood volume was 26% (range = 19% to 52%).

Conclusion: We found that 60% of total bleeding occurs during and after posterior bone resection. Spinal cord is open to possible iatrogenic direct spinal cord injury with surgical instruments for a much shorter period of time compared with the original technique.

Keywords

severe deformity, posterior vertebral column resection

High degree and rigid spinal deformities always present challenges for treatment. The goals of surgical treatment are to establish an acceptable balance both in sagittal and coronal planes as well as relief of pain and durable fusion. Since severe rigid deformities cannot be treated by standard methods, different types of osteotomies become inevitable. The indication for osteotomies arise when the deformity cannot be corrected by only instrumentation with or without a posterior release. Posterior angular osteotomies such as Ponte, Smith-Peterson osteotomy, pedicule subtraction osteotomy, and bone-disc-bone osteotomies are defined, but they have a limited correctional effect in severe deformities. Amount of correction provided by these osteotomies are 9.3° to 10.7°, 30° to 40°, and 35° to 60°, respectively.[1] However, angular osteotomies do not permit displacement of spine, whereas vertebral column resection (VCR) is the only possibility for desirable correction while allowing spinal translation.

A combined sagittal and coronal spinal imbalance with a high degree of fixed deformity can generally be addressed only by a VCR. Common indications include multiplanar or sharp angulated deformities, hemivertebra resections, tumors,

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trauma, or spondyloptosis. VCR combines the osteotomy of 3 columns of spine and involves resection of posterior elements and adjacent discs, which permits translation and shortening required to correct multiplanar deformities. First introduced by MacLennan[2] in 1922, VCR used a posterior approach to excise the apex of scoliosis. Posterior resection and anterior decancellation followed by spinal shortening using segmental instrumentation was done by Luque in 1982.[3] The circumferential VCR was initially reported by Leatherman,[4] but it was extensively used by Bradford in the 1980s.[5] Bradford and Tribus[6] reported new series of patients in 1997. The general conclusion of Bradford's research showed an acceptable correction (greater than 50°, taking into account a correction rate over 50%). Execution of both anterior and posterior VCR at the same time led to a reported operation duration of more than 12 hours, with an accompanying blood loss of more than 5500 mL with high risk of complications (~50%).[6,7]

A 2-stage combined anterior-posterior technique may yield satisfactory outcomes; however, the operation time is long and poses risk to visceral and anterior vascular structures.[6-8] Suk et al introduced a single-step, all-posterior VCR to reduce operational time and complications of technically difficult combined anterior-posterior VCR.[9,10] This was later popularized by Lenke et al[11] in the treatment of severe and rigid spinal column deformities. This approach allows both rotational and translational corrections of spinal column and enables the manipulation of anterior and posterior columns at the same time.

Originally, the Suk surgical technique starts with posterior exposure, posterior instrumentation, in situ one side posterior stabilization, and apical posterior bony element resection. A wide laminectomy and undercutting should be done to avoid neural impingement. After costotransversectomy, the lateral wall of the vertebral body is exposed. With blunt finger dissection, the anterior wall of the vertebral body and main vascular structures were separated. Segmental artery and vein were ligated and cut. Malleable retractors were placed between vascular structures and the anterior wall of the vertebral body. Under direct visualization, vertebral body and pedicles are removed by osteotomes, curette, or high-speed burrs. The posterior wall remain intact at this point. A new security rod is inserted from the resected side and the first rod is removed. The remaining bony structures is removed from the other side. By removing the posterior wall, all necessary bone resection is completed. Under direct visualization of the neural tube, deformity is corrected using in situ countering, necessary compression, and distraction forces. Rods were replaced with new countered rods sequentially. İf there is remaining anterior gap, anterior support is also placed under compression.

There are 2 major concerns with posterior vertebral body resection (PVCR). One is major bleeding during surgery and the other is the possibility of neurological deficit. Neurological deficit may be due to direct injury during the surgery or due to other reasons of deformity correction such as spinal column subluxation, dural buckling, or compression of the spinal cord by residual bone or soft tissues in the canal. Meticulous technique and neuromonitoring would be helpful to prevent some but not all of these complications. Another problem with the technique would be excessive bleeding during the surgery.

Driven by the aforementioned problems with the original technique, we modified the said procedure by changing the order of bone resection and starting with vertebral body resection first. By keeping the neural arch intact until the completion of anterior vertebral body resection, we postpone the bleeding associated with epidural veins, bleeding from the resected bone surfaces, as well as minimizing the risk of possible iatrogenic injury to the spinal cord.

Materials and Methods

This is a retrospective analysis of 20 patients. Patients having severe 3-dimensional deformity with the flexibility less than 20% and managed by PVCR between 2011 and 2014 were included in this study. The patients were 12 females and 8 males. Their average age was 18 years (range = 3-63 years). Fourteen of them had congenital kyphoscoliosis, 4 had neuromuscular scoliosis, 1 patient had deformity due to neurofibromatosis and 1 patient had posttraumatic kyphosis.

Demographic data, operating time, average blood loss before and after laminectomy, and intraoperative transfusions were noted. Also estimated blood loss and estimated body blood volume ratio were calculated. We did not used hemostatic matrix (thrombin) during surgery. The curve magnitude was determined from anteroposterior and lateral radiographs. Coronal curve was measured by the Cobb method. Local kyphotic angle was also measured. Preoperative and postoperative neurological examinations were also noted.

Surgical Technique

Motor-evoked potential monitoring was used throughout the surgery. After the spine was exposed posteriorly, pedicle screws were applied according to the deformity, excluding the segment to be later resected. Intraoperative posteroanterior and lateral C-arm were used for localization. In situ countered rod was applied on one side for stability during resections. Bilateral costotransversectomy was performed at the apex of the deformity. Intersegmental nerves and vessels are dissected, ligated, and cut. Following a gentle pleura push-down maneuver, the vertebral body was exposed. Malleable retractors were placed under the vertebral body while protecting the great vessels. Intersegmental arteries and veins were explored, ligated, and cut (Figure 1A). Vertebral body was resected using osteotomes, curettes, or burrs (Figure 1B). The adjacent discs were removed. The posterior wall of the vertebral body and pedicles were kept intact during resection. After resection of the vertebral body, all posterior bony elements were removed including lamina, facets, and pedicles. Undercutting of adjacent levels of lamina of the resected side is one of the crucial steps in this surgery, to prevent posterior compression of the spinal cord after correction (Figure 1C). Posterior vertebral body wall was removed with reversed curettes at the end. Correction was done

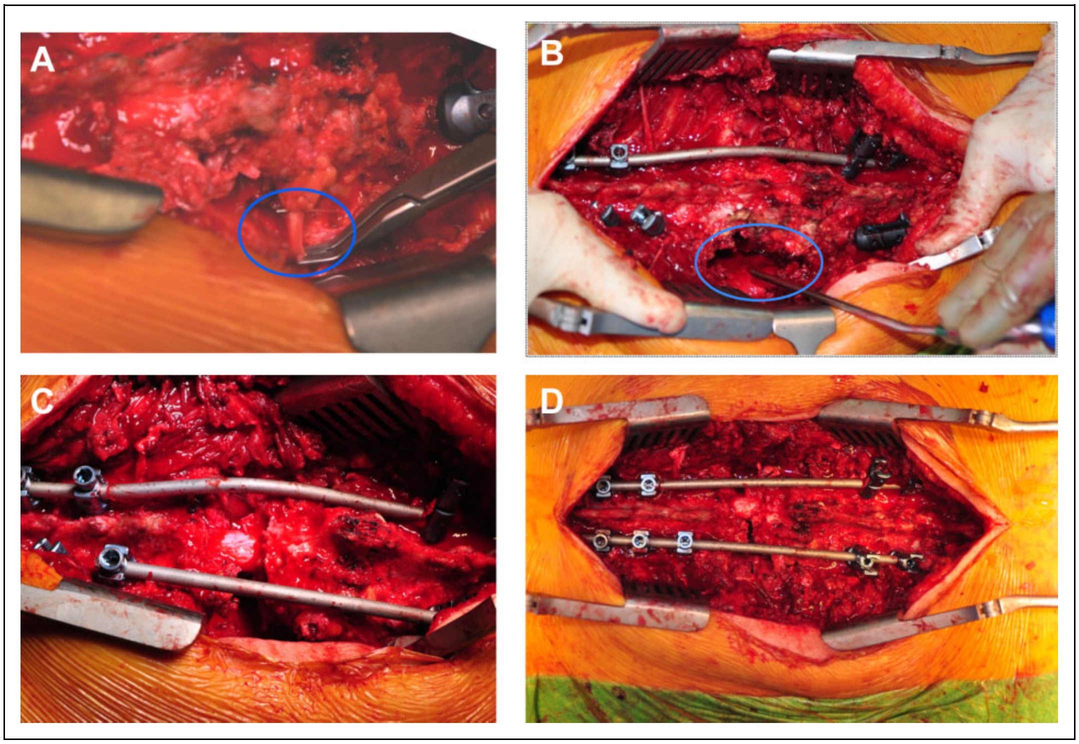

Figure 1. (A) Posterior instrumentation and in situ stabilization on one side and exposure of vertebral body with ligation of intersegmental vessels. (B) Vertebral body resection. (C) Resection of posterior elements. (D) Correction and stabilization with anterior support.

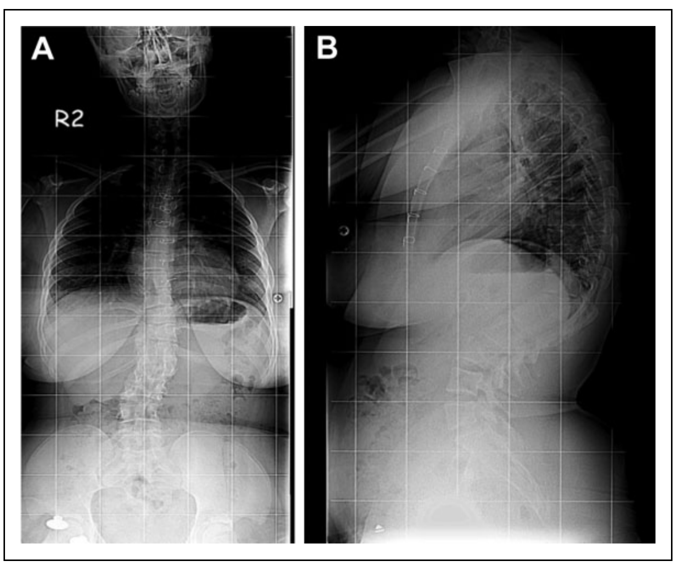

Figure 2. (A) Congenital kyphosis, preoperative PA X-ray. (B) Congenital kyphosis, preoperative lateral X-ray.

using new sagittaly countered rods by using in situ bending-compression and distraction forces (Figure 1D). During the posterior procedure bipolar cautery was used meticulously. Surgicell and spongostan were used for bleeding control. Depending on the deformity, an anterior cage may be used. The cage would prevent the buckling of the cord as an anterior support and also play a pivotal role for deformity correction

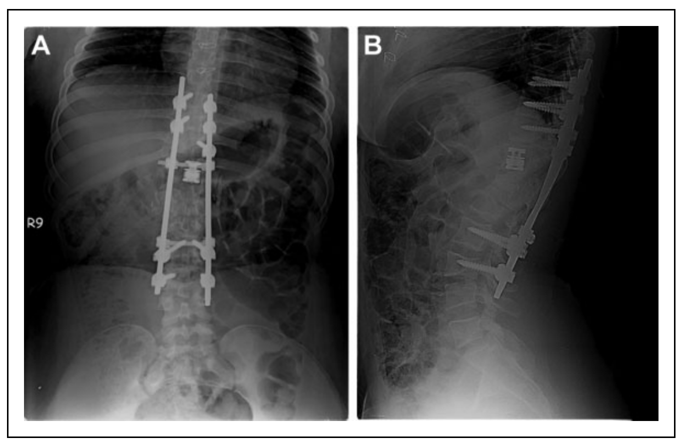

Figure 3. (A) Congenital kyphosis, postoperative standing PA X-ray. (B) Congenital kyphosis, postoperative standing lateral X-ray.

(Figure 2A and B and Figure 3A and B). Exposure and instrumentation were performed under hypotensive anesthesia but the rest of the correction was done with normotensive anesthesia. Motor-evoked potentials were checked throughout the procedure. Correction and instrumentation were rechecked by C-arm, before wound closure.

Results

The average follow-up was 3.5 years (range = 2-5 years). In all patients, one vertebra was resected. The preoperative coronal plane deformity was 84° (70° to 120°) and corrected to 42° (28° to 68°) showing 60% scoliosis correction. Average preoperative local kyphotic angle was 92° (82° to 110°). Correction rate for kyphosis was 62%. All patients after surgery showed their baseline neurological status, and no complications were encountered. The average stay in hospital was 6 days (3-14 days). The mean estimated blood loss was 1072 mL (350-2000 mL). A total of 39.45% (33% to 50%) of total blood loss occurred after vertebral body resection, and 60.91% (50% to 67%) occurred after the removal of posterior elements. The ratio of estimated blood loss to estimated body blood volume was 26% (range = 19% to 52%).

Discussion

Until the development of extensive osteotomies such as pedicule subtraction and PVCR techniques, correction of severe rigid deformities was not possible. Using monoplanar or biplanar osteotomies, surgeons were able to achieve limited corrections on these patients. Later, with application of vertebra resection using anterior and posterior approach, 3-dimensional corrections became possible. However, prolonged surgical time and unwanted excessive bleeding were 2 major disadvantages of this technique. With the introduction of PVCR, surgeons are able to perform 3-dimensional osteotomy and achieve acceptable corrections in one sitting.

In the original technique of PVCR, posterior total laminectomy, pediculectomy, and facetectomy are performed before vertebral body resection. Therefore, the spinal cord remains unprotected to direct injury during the entire surgery. Because of wide exposed area, osseous bleeding from resected bony surfaces, and bleeding from epidural veins, PVCR is a "bloody" operation. The authors believe that resection of lamina, pedicules, and facets increases the bleeding from epidural veins and also resected bony surfaces. These bleedings will continue during the rest of the operation. Our results clearly showed that, on the average, 60% of total bleeding occurs during and after posterior decompression. Thus, we proposed a modification of the original technique.

Suk et al reported 4820 mL (3200-6300 mL) average blood loss in an adult scoliosis group and 1450 mL (800-2600 mL) in a congenital scoliosis group.[9,10] Lenke et al in 2009 reported that the average estimated blood loss was 691 mL in pediatric patients,[11] and in 2010 estimated blood loss for all patients was 1103 mL (250-3100 mL) but in this article it is not classified as pediatric or adult groups.[12] Xie et al reported estimated blood loss was 6680 mL (3000-24 000 mL) and the ratio of estimated blood loss to estimated body blood volume was 245% (range = 78% to 570%).[13,14] In 2013, Papadopoulos et al reported 45 patients with a mean age of 14 years, and the mean estimated blood loss was 1265 mL (350-2500 mL).[15] In the current study, the blood loss after vertebral body resection, removal of posterior bony elements (laminectomy, pediculectomy, facetectomy), and total blood loss were noted. Thirty-nine percent (33% to 50%) of total blood loss occurred after vertebral body resection, and 61% (50% to67%) occurred after posterior elements removal. Mean estimated blood loss was 1072 mL (350-2000 mL). The ratio of estimated blood loss to estimated body blood volume was 26% (range = 19% to 52%). The mean age was 18 years (3-63 years) in the current study and estimated blood loss seems to be lower than in other studies, but it would be not accurate to compare estimated blood loss in different studies. There are numerous factors affecting the blood loss. Most important ones are patients' age, number of resected vertebras, number of instrumented levels, and the duration of surgery (so the severity of the deformity). Comparing the ratio of estimated blood loss to estimated body blood volume will yield more accurate results.

Neurological complications are major problems in PVCR. Most of the neurological complications are transient nerve palsy. Lenke et al reported 2 patients, one patient with drop foot for 2 weeks and the other one with quadriceps deficit for 6 months.[16,17] Suk et al had reported complete cord injury in 2 patients and 4 root injuries that had recovered without further intervention.[10] Papadopoulos et al reported 1 complete spinal cord injury, 2 patients with isolated nerve root injury, 1 transient left L1 injury and 1 permanent left S1 nerve root injury.[15] Hamzaoglu et al reported motor-evoked potential changes in 6 patients; they all interfered during operation by widening laminectomy and/or by correction of translation.[18] No neurological complications were observed in the current study. In order to prevent nerve injury, neurological monitoring is a must to avoid catastrophic results. Also, performing wide laminectomies, preserving the anterior longitudinal ligament, evaluation of spinal canal after every attempt of correction, filling the gap anteriorly to prevent excessive shortening, and dural buckling will decrease nerve injuries.[19] The authors also believe that preserving the posterior bony element during vertebral body resection protects the spinal cord from direct injuries and augments the role of temporary rod contoured to the shape of the deformity.

The major limitation of this study is the small number of patients involved, and the outcomes such as bleeding, correction amounts, and complications cannot be compared with other studies as the patient groups are not homogeneous.

Conclusions

PVCR is a technically demanding procedure and needs experienced surgeons. There are 2 major concerns during PVCR: excessive bleeding and neurological compromise. We modified the original Suk surgical technique to reduce these complications. Our results show the following:

1. Sixty percent of total bleeding occurs during and after posterior bone resection.
2. Spinal cord is open to possible iatrogenic direct spinal cord injury with surgical instruments for a shorter period of time compared to the original technique.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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