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Research Article

# Clinical Outcomes of V-Shaped Lamina Osteotomy in Correction of Spinal Deformities: A Technical Report

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## Abstract

**Background:** Multiple osteotomy techniques have been developed to manage spinal deformities by alleviating symptoms, restoring spinal alignment, and halting progression. Techniques such as Smith-Petersen osteotomy (SPO), pedicle subtraction osteotomy (PSO), bone-disc-bone osteotomy (BDBO), and vertebral column resection (VCR) vary in invasiveness and efficacy. Greater correction generally requires more extensive bone and soft tissue resection, which increases surgical complexity and the risk of complications. The V-shaped lamina osteotomy is a modified grade 1 posterior column osteotomy (PCO) designed to address multilevel deformities with reduced morbidity. This study evaluates its clinical safety and effectiveness.
**Methods:** In this retrospective analysis, 28 patients underwent multilevel V-shaped lamina osteotomy from 2005 to 2015. Diagnoses included idiopathic scoliosis (n = 7), degenerative scoliosis (n = 7), Scheuermann's kyphosis (n = 4), and iatrogenic deformity (n = 10). Patients under 10 or over 80 years of age and those with traumatic, infectious, or malignant deformities were excluded.
**Results:** No intraoperative deaths, neurologic injuries, or major complications occurred. Two patients experienced superficial wound infections, which were resolved with debridement and antibiotics. All patients demonstrated significant sagittal and coronal alignment improvement. Mean blood loss was higher in patients undergoing four (or more)-segment osteotomies (350-500 ml) compared to those with two or three segments (200-300 ml). Surgical time ranged from approximately 4 hours for fewer segments to up to 6 hours for extensive procedures.
**Conclusion:** V-shaped lamina osteotomy is a safe, efficient technique for correcting multilevel spinal deformities. It offers comparable results to more invasive procedures while minimizing complications, making it suitable for long, smooth deformities.

*Keywords:* Osteotomy; Deformities; Kyphosis; Scoliosis

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## Background

Spinal deformities such as kyphosis and scoliosis in both pediatric and adult populations may originate from congenital, idiopathic, developmental, or acquired causes, including degenerative, inflammatory, or post-traumatic changes (1-12). These deformities often result in cosmetic concerns, pain, gait disturbance, and neurologic deficits, significantly impairing quality of life (4-6, 11, 12). Treatment decisions depend on deformity severity, progression, and the patient's neurological and general health status. Nonoperative approaches –including physical therapy, anti-inflammatory medications, and bracing –may be effective for individuals with minimal symptoms and preserved spinal alignment (13, 14). In contrast, surgical intervention is typically indicated for progressive deformities, neurological compromise, or disabling symptoms (3, 5, 6, 8, 9, 12, 15-23). Operative goals include restoring sagittal and coronal alignment, achieving solid fusion, relieving pain, and preventing further deformity (1-3, 5).

Accurate preoperative assessment using full-length spinal radiographs, magnetic resonance imaging (MRI), and computed tomography (CT) is essential. These modalities assist in evaluating spinopelvic parameters, joint degeneration, deformity characteristics, and neural compression. Based on flexibility, deformities are categorized as flexible, semi-flexible, or rigid (5-10, 23, 24). Osteotomies are generally considered for rigid curves that do not reduce below 70° on dynamic imaging (12, 15-22, 25-31). Common techniques include Chevron, Smith-Petersen, Ponte, pedicle subtraction, eggshell, and vertebral column resection (VCR). In 2014, Schwab et al. introduced a six-grade classification system based on the degree of bone resection and destabilization (7). While higher-grade osteotomies allow greater correction, they carry increased risks of bleeding, infection, and neurological complications (1, 2, 32).

Grade 1 osteotomy, which involves resecting the inferior articular process, allows 5° to 10° correction per level and can achieve greater realignment when performed across multiple segments (7, 33). Among its modifications, the V-shaped lamina osteotomy offers a less invasive option. This technique preserves facet joints while enabling correction via posterior column shortening through V-shaped laminar cuts. It reduces operative duration and minimizes risks associated with facet injury. When applied to continuous vertebral levels in the thoracic and lumbar regions, it facilitates harmonious correction.

Indications for V-shaped osteotomy include long, smooth curves with mild to moderate imbalance, rigid scoliosis exceeding 75° that fails to correct below 40°, kyphosis that remains over 50° in hyperextension, and sagittal imbalance between 6 and 8 cm (5, 8, 9, 11, 23). Prerequisites include anterior column mobility and unfused discs, making it unsuitable in cases of circumferential fusion (15). Target spinopelvic values include Cobb angle < 20°, sagittal vertical axis (SVA) < 5 cm, pelvic tilt (PT) < 20°, T1 pelvic angle < 20°, central sacral vertical line (CSVL) < 2 cm, pelvic incidence (PI)-lumbar lordosis (LL) mismatch < 9°, and thoracic kyphosis (TK) < 60°, with a composite PI + LL + TK≤45 (5, 6, 9, 12, 16-31, 34). Of these, SVA most strongly correlates with health-related quality of life (HRQOL), and PT < 25° is essential for efficient ambulation.

Despite its advantages, V-shaped osteotomy is limited in addressing severe rigid deformities or those requiring correction beyond 40°. Risks include dural or ligamentum flavum buckling during correction, which may result in neurological compromise. Contraindications include major comorbidities, severe osteoporosis, rigid disc spaces, sagittal imbalance over 10 cm, sharply angulated congenital curves, active spinal infections, and tumors (1-3, 5, 6, 8, 9, 12, 15-31, 34).

This study aims to assess the clinical outcomes and complication profile of V-shaped lamina osteotomy in the surgical correction of spinal deformities. We describe our surgical technique and evaluate its safety and efficacy, particularly for multilevel deformity correction.

## Methods

A total of 28 patients who underwent V-shaped lamina osteotomy for spinal deformity correction were identified retrospectively from the database of Khomeini Hospital, Tehran, Iran, between 2005 and 2015. Patients were categorized into four diagnostic groups: idiopathic scoliosis (n = 7), degenerative scoliosis (n = 7), Scheuermann's kyphosis (n = 4), and iatrogenic deformity (n = 10). All surgical procedures were performed by a single spine surgeon, while an independent spine specialist conducted the clinical and radiographic assessments, data extraction, and analysis.

Osteotomies were performed at the apex of the deformity and distributed by the number of involved segments as follows: 2 segments in 7 patients, 3 segments in 9 patients, 4 segments in 9 patients, 5 segments in 3 patients, and 6 segments in 2 patients. Radiographic evaluations included pre- and postoperative measurements of sagittal and coronal alignment, spinopelvic parameters, and curve flexibility.

Inclusion criteria comprised patients aged 10 to 80 years with rigid spinal deformities requiring multilevel correction. Exclusion criteria included traumatic deformities, spinal infections, malignancies, and age under 10 or over 80 years. Postoperative outcomes were assessed based on radiographic correction, fusion status, pain reduction, and complications. Documented complications included neurologic deficits, dural tears, wound-related issues, thromboembolic events, cardiopulmonary complications, gastrointestinal or renal dysfunction, and postoperative anemia.

***Ethical Considerations:*** All patients verbally consented to the use of their anonymized clinical data and imaging for publication. However, no written consent was obtained, as no identifiable personal information was included.

***Surgical Technique:*** Under general anesthesia, patients were positioned prone on a radiolucent table with all bony prominences adequately padded. Intraoperative neuromonitoring was employed throughout the procedure using transcranial motor evoked potentials (TcMEPs), somatosensory evoked potentials (SEPs), and continuous electromyography (EMG). After sterile preparation and draping, the posterior elements of the spine were exposed through subperiosteal dissection of the paraspinal musculature.

Pedicle screws were inserted using the free-hand technique at the intended vertebral levels. The spinous processes were excised, and a V-shaped osteotomy was initiated at the inferior border of the lamina in the midline and extended in a superolateral direction toward the lateral margin of the pars interarticularis. The same technique was applied to the contralateral side of the posterior vertebral arch. Multilevel osteotomies were performed at predetermined vertebrae based on preoperative radiographic evaluation (Figure 1).

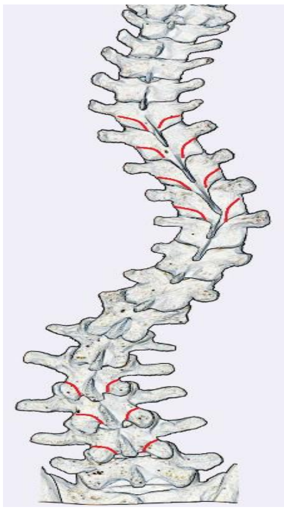

**Figure 1.** Multiple V-shaped osteotomy

This apex-distal V-shaped osteotomy created a posterior bony gap, facilitating the translation and mobilization of spinal elements during correction.

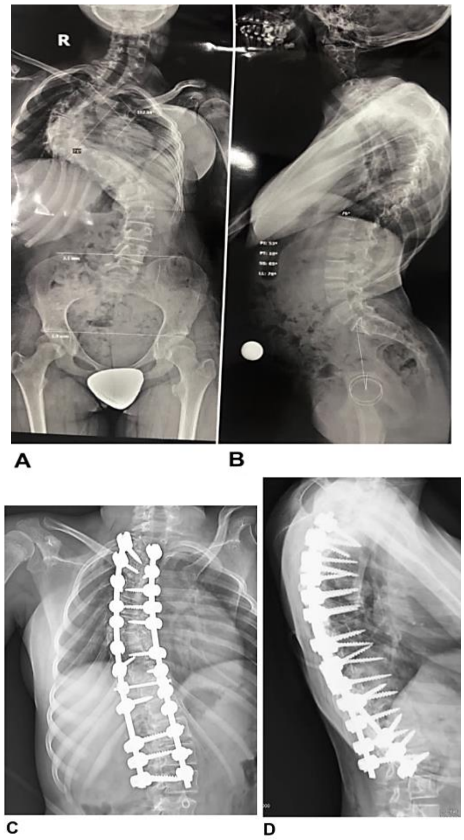


**Figure 2.** Preoperative anteroposterior (AP) and lateral views (A, B) and corresponding postoperative standing radiographs (C, D) of a 13-year-old girl with adolescent idiopathic scoliosis (AIS) treated with V-shaped osteotomy. The preoperative kyphotic angle was 102°, and postoperative imaging demonstrates complete correction.

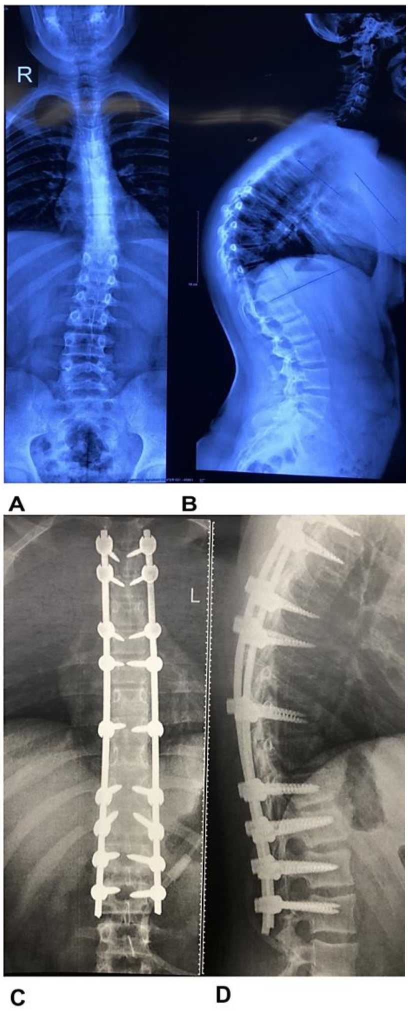


**Figure 3.** Preoperative anteroposterior (AP) and lateral views (A, B) and corresponding postoperative standing radiographs (C, D) of a 14-year-old girl with Scheuermann's kyphosis. The patient underwent V-shaped osteotomy, achieving full correction from an initial kyphotic angle of 80°.

Notably, the superior and inferior articular processes, facet capsules, and ligamentum flavum were preserved. Contoured rods were inserted into the pedicle screws and used to execute correction through posterior column shortening using cantilever forces and compression across osteotomy sites. Closure of the osteotomy site was achieved over mobile intervertebral discs to ensure structural flexibility.

Figure 1 illustrates the schematic representation of the osteotomy, while figures 2 to 5 demonstrate preoperative and postoperative radiographs of selected patients who underwent V-shaped lamina osteotomy.

## Results

No intraoperative deaths, major surgical complications, pseudarthrosis, or rod breakage were observed among the 28 patients who underwent V-shaped lamina osteotomy. Two patients experienced superficial wound infections, both of which resolved following local debridement and antibiotic therapy.

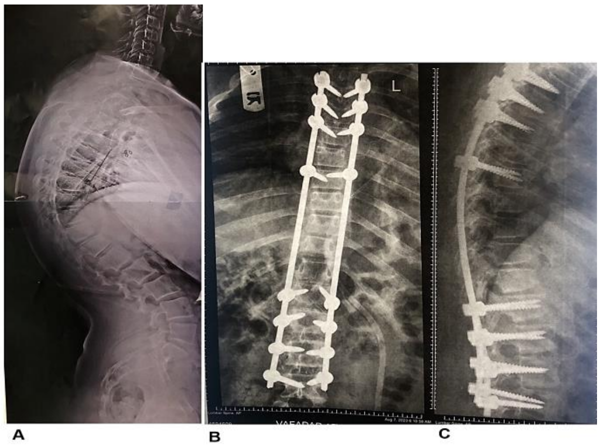


**Figure 4.** Preoperative anteroposterior (AP) (A) and corresponding postoperative standing radiographs (B, C) of a 15-year-old boy with Scheuermann's kyphosis treated with V-shaped osteotomy. The preoperative kyphotic angle measured 80°, with complete radiographic correction achieved postoperatively.

All patients demonstrated radiographic improvement in sagittal and coronal alignment following surgery. Figures 2 to 5 illustrate representative cases showing preoperative deformity and postoperative correction.

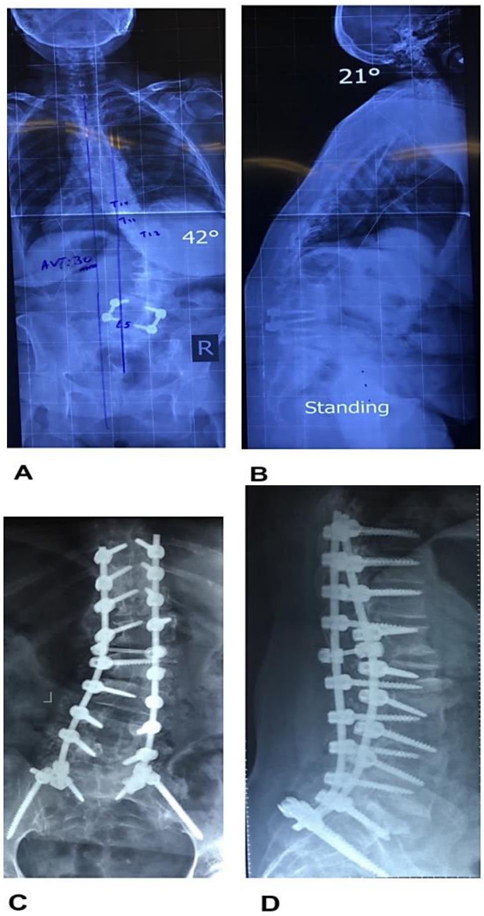


**Figure 5.** Preoperative anteroposterior (AP) and lateral views (A, B) and corresponding postoperative standing radiographs (C, D) of a 58-year-old woman with iatrogenic lumbar kyphosis, proximal junctional kyphosis (PJK) deformity, and sagittal imbalance treated with V-shaped osteotomy

Patients who underwent osteotomies involving four or more segments had higher intraoperative blood loss, ranging from 350 to 500 ml, compared to those with two- or three-segment procedures, whose blood loss ranged from 200 to 300 ml. Similarly, surgical duration increased with the number of osteotomy levels, averaging 4 hours for procedures involving fewer than three segments and extending up to 6 hours for those with three or more segments.

## Discussion

Corrective osteotomies are often required for spinal deformities such as congenital kyphoscoliosis, idiopathic scoliosis, adult degenerative scoliosis, flat back syndrome, and fixed coronal or sagittal imbalance (1-9). These procedures are technically demanding and associated with considerable risk. Selection of the appropriate osteotomy type depends on deformity severity, neurologic status, patient comorbidities, and the surgeon's experience. Grade 1 or 2 osteotomies are often adequate for mild deformities, whereas more severe cases may require grade 3-6 techniques to restore spinal balance and spinopelvic harmony (1-12).

Spinopelvic radiographic parameters such as SVA, PT, and PI-LL mismatch are well correlated with patient-reported HRQOL scores. Everett and Patel emphasized that even mild positive sagittal imbalance negatively impacted outcomes (13). Schwab et al. (7) and Bess et al. (4) reported that SVA showed the strongest correlation with HRQOL; higher SVA values were associated with decreased physical function. Likewise, lowering PT below 25° improves ambulatory capacity.

Surgical complication rates tend to be lower with grade 1 and 2 osteotomies compared to higher-grade procedures (1, 2, 6-8, 10-12, 15, 16). Reported complications include significant blood loss, neurological injury, durotomy, deep infections, thromboembolic events, pulmonary complications, myocardial infarction (MI), pleural effusion, pseudarthrosis, and hardware failure (2-4, 17). Neurologic deficits can also result from buckling of the ligamentum flavum during osteotomy closure. To mitigate such risks, intraoperative neuromonitoring and maintaining mean arterial pressure above 70-80 mmHg are recommended (1-4, 8, 9, 17-19).

The spectrum of posterior osteotomy techniques ranges from posterior column osteotomies (PCOs) such as Smith-Petersen and Ponte procedures, to pedicle subtraction osteotomy (PSO), and VCR. Smith-Petersen osteotomy (SPO), first introduced in 1945, is technically simpler but offers limited correction and a risk of coronal decompensation (1, 4, 20). Ponte osteotomy, developed in the 1980s, is a modification designed for Scheuermann's kyphosis and involves complete facet removal without anterior longitudinal ligament (ALL) disruption (1, 4, 8, 18-20). SPO poses vascular injury risk due to ALL disruption and posterior pivoting (1-4, 8, 10, 18-20), while Ponte relies on anterior column mobility and uses the posterior disc as the fulcrum (1-4, 6-8, 10, 12, 18-21).

PCOs yield ~10° correction per level and can be effective even in rigid curves when applied over multiple segments (1, 6-8). Voos et al. showed similar correction in multilevel PCO and single-level PSO, though PSO was associated with greater blood loss (22).

V-shaped lamina osteotomy is a less invasive grade 1 modification, well-suited for long-segment deformity corrections. It retains facet joints and ligamentous structures, reducing operative complexity and complications. Unlike SPO and Ponte, this approach preserves anatomical continuity of key stabilizing structures. Correction is achieved by mobilizing osteotomized lamina and adjacent mobile discs, with posterior column shortening and anterior column lengthening at the disc level.

Compared to PSO –which involves wedge resection of the vertebral body and pedicles –and VCR –which entails full vertebral body and adjacent disc resection –V-shaped osteotomy achieves effective correction with lower surgical risk (1, 2, 10, 11). VCR remains the option for the most severe deformities, such as sharp congenital angles, multiplanar deformities, or tumor-related cases (1, 2, 6, 8, 23-25). Though higher-grade osteotomies offer more angular correction, they carry greater risk. Liu et al. reported complication rates of 5-7 percent for grade 1-2 procedures (15, 26), while rates for PSO and three-column osteotomies may reach 60% (28).

Unlike PSO and VCR, the V-shaped approach allows correction with limited bone removal, shorter surgical time, and lower risk of neurovascular injury. This technique achieves ~10° correction per level when anterior disc mobility is preserved. However, its efficacy diminishes in patients with degenerative discs or sharp-angle deformities, for which higher-grade osteotomies may be preferable. Overall, V-shaped lamina osteotomy is a safe, effective alternative, particularly suited for long, smooth deformities in patients with preserved disc mobility.

### *Conclusion*

V-shaped lamina osteotomy represents a less invasive adaptation of grade 1 osteotomy within the Schwab classification system, offering comparable surgical indications and effectiveness. This technique is especially advantageous for long-segment deformity corrections due to its simplicity, preservation of stabilizing structures, and reduced surgical complexity. When applied appropriately, it can shorten operative time and minimize complications, making it a favorable option in selected patients with multilevel, smooth spinal deformities.

## Conflict of Interest

The authors declare no conflict of interest in this study.

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