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Pedicle Subtraction Osteotomy in Local Kyphotic Deformity: An Institutional Study

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Abstract: ***Kyphotic deformity of spine is a debilitating condition of the spine occurring most commonly as a consequence of traumatic spinal injury. In developing countries, Pott's spine also accounts for kyphosis in significant number of patients. Kyphosis is a growing concern for treatment to the patient either due to the progressive neurological deficit or mechanical back pain due to altered spinal biomechanics. Dorsal spinal ostetotomies can readily attend to these treatment goals with the added advantage of being a single approach to both the anterior and posterior compartments and lack of dependency on an anterior device. We present our experience with pedicle subtraction osteotomies in our institution in this study.45 patients with kyphotic deformity were addressed with this procedure, along - with posterior fusion and were assessed in regards to the degree of correction of kyphotic deformity, neurological improvement and post - operative complications. We conclude that with proper anatomic, functional and biomechanical knowledge of the spine, this procedure could provide a one - step solution to all sorts of kyphotic deformities with limited complications.***

Keywords: Kyphosis, PSO, Pedicle Subtraction Osteotomy, Ponte Osteotomy, Posterior fixation, Spinal Osteotomies, Trauma, Spinal Fusion

1. Introduction

Kyphosis is defined as an abnormal excessive posterior convexity of the spine. There are multiple techniques for the correction of kyphotic deformity, which includes the Smith - Petersen or Ponte osteotomy [1], pedicle subtraction osteotomy and thevertebral column resection. It is considered that a Smith - Petersen osteotomy can correct 10° persegment, a pedicle subtraction osteotomy 15 - 25°, and a vertebral column resection, 30 - 40°, or more, each having its own precise indications and respective complications, which together with improvement of alignment, make them useful procedures [2].

The aim of this prospective study of 45 patients was to illustrate the technique of pedicle subtraction osteotomy in management of local thoraco - lumbar kyphotic deformities and the evaluate the post - operative clinical and radiological outcomes of the patients treated using this technique.

2. Materials and Methods

Patients with dorso - lumbar local kyphotic deformity who presented to the Neurosurgery Department of our Institute were assessed clinically using the Frankel's Grading and radiologically with a MRI and X - rays of the involved spinal segment. Degree of kyphosis was measured on X - rays using the Cobb's method. Decision for surgical intervention was taken on the basis of the Iowa algorithm [3].

Surgical Technique

The patient was positioned prone under general anaesthesia on transversely placed bolsters followed by localisation of the deformed spinal segment by C - arm. A midline incision centering the respective segment was placed, extending upwards and downwards up to the desired level of construct. After subperiosteal dissection of the spinal segments, transpedicular screws were applied. Intraoperative antero - posterior and lateral radiographic films were obtained to precisely located the pedicle of the deformed vertebra.

The pedicle of the deformed vertebra was entered by limited osteotomy. Beginning with smaller curettes, decancellation was begun. Gradually larger curettes and rongeurs were used. Once the vertebral body was decompressed on one side, the medial wall of the pedicle was excised, exposing the lateral aspect of the dural sac. A portion of the residual pedicle wall was removed as necessary for further decompression. The procedure was repeated on the opposite side such that only a thin piece of retropulsed bone impinging on the dura was left behind. This bony rim was removed carefully with a dissector after separating from the dural sac. Down biting curettes and impactors were then used to fracture the cortical rim anteriorly and to evacuate the cancellous bone and fractured fragments completely. A final assessment was done using a Penfield to confirm the integrity of the cortical rim. Connecting rods were then placed and loosely fixed with the screw locking system.

Hyperextension of the operating table and distraction of the adjacent segments was used to correct the deformity, which was correlated with a lateral radiographic image. During this closing procedure, the dura and nerve roots were carefully elevated to prevent entrapment in the wedge. The locking system was firmly tightened. Posterior elements were not routinely removed in our patients. Comminuated fragments were excised, but laminar arch fractures with minimal comminuation were left in situ as a possible scaffold for bony fusion. Any dural injury with neural herniation was repaired with 4 - 0 Mersilk. Autogenous bone graft was laid laterally.

A drain was placed, and the wound closed in layers. Patient was fitted with custom moulded orthosis and ambulation allowed from fourth day.

3. Results

From 2016 to 2019, 63 transpedicular decancellation techniques were performed in our institute for 45 patients presenting with local kyphotic deformity.36 of the 63 lesions were at the thoraco - lumbar junction (D11 - L1). Out of the 45 patients, 30 were post - traumatic and 15 had Pott's

spine.27 patients had a single level of kyphotic deformity, while 18 patients had two level kyphotic deformity. Average age of the patients was 41 years.28 of the patients were male. The angle of kyphotic deformity ranged from 20° to 40° with an average of 30°.

Neurologic assessment of the patients was done in the pre and post - operative period using the Frankel's grading (Fig. I).3 patients were lost to follow up.

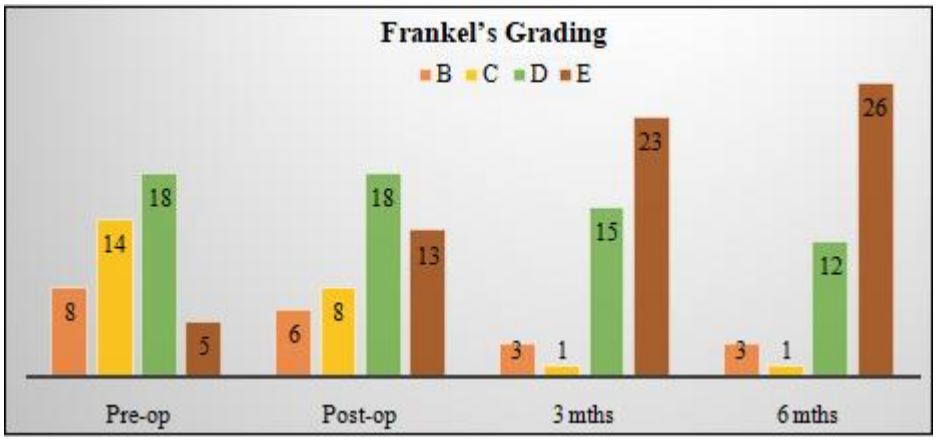

Figure I: Distribution of patients as per Frankel's grading in pre - , post - operative, 3 and 6 month follow up

All patients in our study underwent a transpedicular subtraction osteotomy.18 patients who had two adjacent levels of fractures underwent decompression in both levels, while the rest underwent a single level of decompression. No implant or autograft was used in any patient to fill the anteriorly decompressed space. The number of levels of posterior fusion ranged from four to eight.

Intra - operative complications included injury to the cord structures, nerve root injury or avulsion, dural tears and vascular injury. We encountered a dural leak in 9 patients (20%). Unrecognised dural leak in post - operative period was found in 3 patients. Root injury had occurred in 10 patients. No definite major vascular injury was addressed. There was a neurological deterioration in 2 patients in immediate post - operative period which recovered subsequently.3 patients had some degree of superficial wound infection.

Radiographic analysis of patients taken post - operatively revealed a correction of kyphotic deformity in the range of 12° to 26° (average 18°). Bony fusion was established in all cases during the follow - up period. Only one patient had loosening of the screw locking system with slippage of the rod.

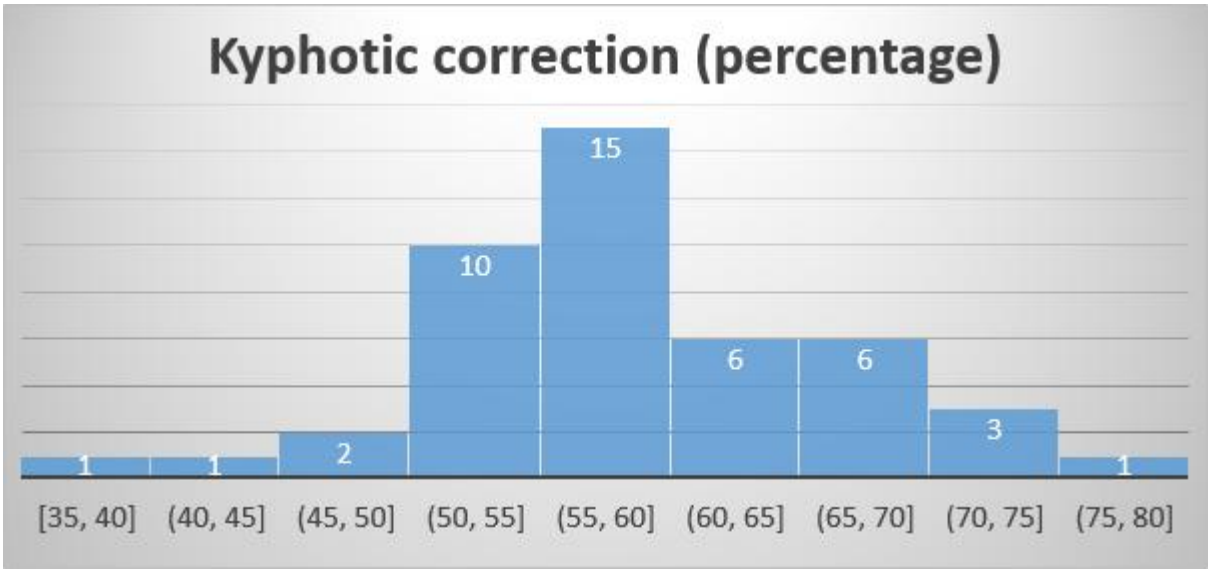

Figure II: Distribution of percentage kyphotic correction in our sample

4. Discussion

Smith - Petersen et al., were the first to treat gibbus secondary to ankylosing spondylitis in 1945, by performing a multilevel "extension" osteotomy procedure [1]. Heinig and Boyd in the 1970s and Thomasen in 1985were the first surgeons to propose a dorsal decancellation orreduction osteotomy, an "eggshell" procedure, to correctkyphosis in patients with ankylosing spondylitis [4]. The technique consists of removing a posteriorly based wedge of bone from the vertebral body, which subsequently produces lordotic correction as the spine is hyperextended. Gertzbein

and Harris has also successfully performed this decancellation "eggshell" procedure in three patients with posttraumatic kyphosis [5]. Danisa et al, also reported their study with posterior decancellation ("eggshell" procedure) in 11 patients of debilitating lumbar kyphosis [6].

Burst fractures result from axial loading of the spine and are often associated with concommitant flexion. These forces result in failure of the anterior and middle columns and are associated with damage of the neural elements, loss of vertebral height and kyphosis. The management of severe thoracolumbar burst fractures has been and remains controversial [7].

Malcolm et al, observed that anterior fusion techniques without instrumentation were associated with high failure rate (>50%), but success rate improved significantly with addition of a posterior fixation technique [8]. Advocates of anterior stabilization considered this technique to provide reliable decompression of the neural canal. However, the authors also observed that realignment of the kyphotic spine may be difficult with this approach. Furthermore, placement of bulky anterior implants or a combined anterior and posterior staged procedure may be required for spinal stabilization [8]. McAfee et al, concluded that anterior decompression and fusion should not be used alone to correct a kyphosis, rather a combined anterior and posterior procedure was necessary [9]. The rationale for combined anterior–posterior procedures was to provide and maintain greater angularcorrection, minimize the number of vertebral levels requiring osteotomy, and to reduce the rate of pseudarthrosis [6]. In lieu of these findings, all patients in our series underwent anterior decompression with posterior fusion procedure.

There has been lot many controversies regarding the exact procedure of PSO. Various authors have different opinion on certain factors like whether the end plate and adjoining disc should be removed or not, whether the cavity should be filled with autologous bone grafts, regarding attachment of a temporary rod on one side during contralateral PSO and whether posterior elements should be preserved or not. [5, 6, 10 - 12] In our study, the end plate and adjoining disc were routinely removed if they were involved in the fracture or they showed evidence of spondylodiscitis. We routinely kept the cavity of the vertebral body empty. No autologous bone graft was used considering the possibility of retropulsionof bone fragments in the spinal canal. Temporary rod was not used during contralateral decancellation. Posterior elements were selectively removed in cases with spinal canal stenosis where augmentation of the canal was necessary.

Literature also varies in opinion regarding the length of construct to be used for correction of the kyphosis. Posterior spinal fixation following PSO is based on the principle of three - point bending technique of spinal biomechanics. In the absence of any anterior implant in this procedure, there is no tension band fixation. The former fixation principle is known to require a longer construct level than the latter to achieve the same bending moment at the fracture site with similar forces. If a short - segment angular deformity exceeds 20 degrees, it is likely associated with circumferential soft tissue (ligamentous) injury. Short - segment fixators use a short moment arm that may be insufficient to correct or maintain deformity correction. Long - segment fixators may therefore be desirable in such circumstances. [13]Factors deciding levels of construct in our study included the level of pathology, degree of kyphosis, number of motion segments involved and the pathology. [14] Post traumatic fractures spanning the dorso - lumbar transitional zone, a larger kyphotic angle and multi - vertebral involvement favoured a longer construct.

Danisa and colleagues [6] noted that the transpedicular decancellation or reduction procedure performed at a single level was capable of providing angular correction comparable with that obtained using the Smith - Petersen osteotomy. They reported mean correction of 40° isin accordance with such data [4]. Murrey et al, had reported a mean correction of 26° in their study ranging from 14 - 43° [10]. Jo and colleagues reported a mean correction of 29° in their series, ranging from 20 - 41° [15]. The average kyphotic correction in our series was 18°, ranging from 12 - 26°. The relatively lesser degree of correction in our study may be due to the late presentation of the patients which caused fibrotic changes in the surrounding muscle and ligaments, preventing them from returning back to their pre - morbid condition. This theory has been supported by Bohlman et al, who proposed that patients with a fracture history of less than 2 years obtained good therapeutic results after surgery [16]. Murrey et al, also found similar results in their study [10]. On the contrary, Zhang et al. found that among patients with even longer histories of fracture, 58% exhibited improved neurological function after correction and decompression [17]. In our institute, patients are referred from peripheral health centres and hospitals, and often they present very late. The mean duration between the trauma (or infection) and surgery was 2 years in our study.

Whether the angle ofkyphosis is the key factor indicating surgical therapy isundecided. Bedbrook reported that there was no associationbetween kyphosis and pain, and patients reported no paineven when the angle of kyphosis was greater than 40° [18]. However, Gertzbein and Harris considered that when theangle of kyphosis exceeded 30°, the risk of pain increased significantly and surgical correction was necessary [5]. Chenet al. recommended that any kyphosis case with a kyphoticangle of more than 20° requires surgical correction [19]. Pre - operative kyphotic angle ranged from 20° to 40° in our study. The percentage of kyphosis correction in our study ranged from 35 to 75% (average – 59%). Wide range of correction may be due to the fact that chronic, neglected cases with progressive kyphosis who often presented late had considerably lesser degree of correction as compared to those who presented early.

Intra - operative complications include injury to cord structures, dural injury or leak, traversing nerve root avulsion and segmental spinal vessel injury. Hardaker et al [11], stated that dural tears were noted in greater than one third of the cases involving neural arch fractures. In our study, we encountered a dural leak in 9 patients (20%). Unrecognised dural leak in post - operative period was found in 3 patients.10 nerve root injuries occurred in our

series which was a bit higher as compared to the findings of Jo et al, [15] (one out of 13 patients) and Buchowski et al (11.1%) [20].

Murrey et al, in their study reported a 16.9% overall complication rate which included Pulmonary oedema, respiratory failure, implant failure, implant prominence, superficial and deep wound infection, paraparesis and spasticity [10]. In our series, we encountered a complication rate of 11% in the post - operative period. Implant failure (loosening of screw locking system with rod slippage) was encountered in one patient. Superficial wound infection occurred in 3 patients but there were no deep wound infections. All the patients had improved from their pre - operative neurological status in our study except for two patients, who developed transient spinal shock post - operatively which improved subsequently over few days. However, returning to normalcy was not achieved in our series, considering the pre - operative status of these patients, as has also been observed by Murrey et al, in their study. They stated that residual neurologic damage, pain and multi segmental spinal fusion hinder the patient's ability to return to population norms [10].

Danisa et al, noted that transpedicular decompression, although successful in restoring balance is associated with high blood loss and risk of neural injury and hence should be used as a salvage procedure [6].

5. Conclusion

Transpedicular decompression is a very eloquent method of combined anterior - posterior decompression of the thoracolumbar spine, without the need for a separate anterior approach or bulky anterior implants. However, a proper idea of the anatomy and biomechanics of the spine and proper patient selection is mandatory to avoid complications.

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