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ORIGINAL ARTICLE

Radiological and Clinical Outcomes after Surgical Correction of Thoracolumbar Post-traumatic Kyphosis by Vertebral Column Resection

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Abstract

Background data: posttraumatic kyphosis is a major problem that affects the lifestyle and activity of the patients. We are studying the outcomes of surgical treatment by VCR and whether it benefits the patients clinically or not. This article aimed to determine the degree of spinopelvic parameters correction after PVCR of neglected malunited vertebrae and clinical improvement of the patients postoperatively.

Methods: A retrospective cohort study of a total of 25 patients with posttraumatic kyphosis that was included in this study. The average age was 26.0 ± 8.15 (range 19-40) with 60% females and 40% males. Patients were treated with PVCR. Plain radiography, computed tomography, and MRI were performed on all patients, and the following parameters were measured using the Surgimap (version: 2.2.13) computer program: Thoracic kyphosis (TK), Lumbar lordosis (LL), Pelvic incidence (PI), Sacral slope (SS), Pelvic tilt (PT) and Sagittal vertical axis (SVA). Bony fusion is assessed using postoperative radiograph and/or computed tomography. Visual analog score for pain and the Oswestry Disability Index were assessed preoperatively and at the last follow up.

Results: The average follow-up period was 20.21 ± 7.47 (range 18–24 months). VAS score decreased from (5.80 ± 1.78) preoperatively to (3.0 ± 0.70) postoperatively while the ODI score showed significant decrease from (35.0±11.63) preoperatively to (18.40±2.60) postoperatively. The local kyphotic angle decreased from 54.60±8.76 to 11± 6.97. The mismatch between pelvic incidence and lumbar lordosis declined from 16.40 ± 7.69 to 7.60 ± 2.85. The lumbar lordosis showed significant change from 68.40 ± 13.04 to 51.40 ± 8.76. There were no significant changes in the sacral slope nor the pelvic tilt postoperatively

Conclusion: PVCR provides significant correction of pelvic parameters and clinical functions of patients with fixed posttraumatic deformity

Keywords: Vertebral column resection, Spinopelvic, Kyphosis

INTRODUCTION

Late post-traumatic kyphosis is a complication that can occur after a neglected or maltreated spinal fracture. The residual focal kyphotic deformity can lead to a progressive deformity over the years by increasing the moment arm. The disc damage can also contribute to the deformity either at the time of the initial trauma by adding to the instability at fracture site due to its rupture or because of the degenerative changes that occur over time due to disturbed biomechanics at fracture site **[1].**

Pain is the most common symptom. It may manifest as a dull aching pain either at the apex of the deformity due to muscle spasm and fracture nonunion or at the levels above and below the apex due to compensatory hyperextension with subsequent facet arthritis. Symptoms of neural tissue injury, if present, may range from mild weakness to complete paraplegia and loss of sphincteric control. It may be due to injury from retro pulsed fragments at time of trauma or may develop over time due to compromise of the canal diameter, tenting of the cord over the kyphus, and the development of post-traumatic syringomyelia **[2].**

The thoracolumbar junction is the site most affected then the thoracic then the lower lumbar spine. The lower lumbar spine kyphosis is less well-tolerated than a similar deformity in the thoracic spine due to differences in anatomy and biomechanics. The effect of the location can be measured using the sagittal index, as defined by Farcy et al. This index is calculated by subtracting the normal contour of a corresponding area from the degree of kyphosis, resulting in a positive value in kyphotic areas of the spine and a negative value in lordotic areas **[3].**

There is a strong relation between obtaining a normative spinopelvic parameters and good health related quality of life. This was mentioned by Schwab et al where they concluded that a patient with SVA > 5 cm, PI-LL > 11° and PT > 23° will show more disability and lower health related quality of life. Restoration of the spinopelvic parameters to near normal degrees is strongly associated with better quality of life **[4].**

If the spinopelvic parameters exceed the values mentioned by Schwab et al and the patient reports disturbed functions combined with cosmetic self-dissatisfaction, surgery is typically indicated. Disturbed functions that favor surgery are pain out of patient's indurance, progressive neurological deficit and forward leaning of the trunk during standing or walking with positive sagittal vertical axis (SVA) > 5 cm to the degree that the patient's gaze may be affected **[5].**

There are different surgical techniques to deal with a given kyphotic deformity of the spine according to the degree of the deformity ranging from partial facetectomy to complete vertebral bodies excision. In posttraumatic kyphosis the deformity is usually a focal deformity requiring at least pedicle or partial body resection to balance the deformity and in larger degrees > 40°, the deformity needs resection of a single or multiple vertebrae vertebra to be corrected **[6].**

Since first introduced by Suk et al, vertebral column resection (VCR) has gained more popularity over the years. It involves the complete resection of one or more vertebral segments and to offer controlled manipulation of both the anterior and posterior columns with active reconstruction. It allows for massive correction up to 45 degrees for single level osteotomy. However, it is the osteotomy most associated with complications such as: dural tears, plural tears, nerve roots tears and vascular injuries as segmental arteries, epidural vessels or the catastrophic Aortic injury **[7].**

This study aims at assessing the radiological and clinical outcomes after surgical correction of posttraumatic kyphosis by VCR. Our hypothesis is that the restoration of spinopelvic parameters, by correction the thoracolumbar posttraumatic deformities by VCR, is associated with better health related quality of life of the patients.

METHODS

A total of 25 patients were included in this retrospective study. All of the patients were diagnosed with posttraumatic kyphosis based on clinical as well as radiological investigations. **Informed consent has been obtained from all patients where appropriate and the Institutional Review Board of Faculty of Medicine at Zagazig University has given approval to our work.** Written informed consent was obtained from all participants. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

20 patients were treated conservatively before eventually developing posttraumatic kyphosis. 5 patients had a failure of the surgical correction; three of them due to inadequate reduction, the remaining 2 cases were due to missed extended posterior ligamentous complex injury above the level of the upper instrumented vertebra. All patients were neurologically intact. The fracture level was T11 in 10 cases, T12 in 6 cases, L1 in 9 cases.

Inclusion criteria: Patients presented with symptoms such as stooping forwards, agonizing back pain not responsive to medical treatment, and cosmetic self-dissatisfaction due to gibbus deformity. Radiological findings included thoracolumbar angle from T10- L2 > 25 degrees and local kyphotic deformity more than 40 degrees. **Exclusion criteria:** patients refusing to participate and presence of vertebral congenital anomaly at thoracic or lumbar spine, active infection and spondyloarthropathy diseases

Radiographic analysis: Longstanding whole spine X-rays with arms on the clavicle position were performed to all the cases. These radiographs were obtained preoperatively, 1 month, 3, 6, 12, 18, 24 months postoperatively. CT and MRI were done for all the cases preoperative to prepare a good plan.

The sagittal parameters examined in this study included: Thoracic kyphosis (TK), Lumbar lordosis (LL), Thoracolumbar kyphosis (TLK), Local kyphotic angle (LKA), Pelvic incidence (PI), Sacral slope (SS), Pelvic tilt (PT) and Sagittal vertical axis (SVA).

Clinical analysis: Patients were clinically evaluated preoperatively and postoperatively using the Oswestry disability index (ODI) and visual analogue scale (VAS) score for back pain.

Operative technique:

Patients were operated on the prone position under general endotracheal hypotensive anesthesia. Foley catheterization, preoperative IV antibiotics, neuromonitoring somatosensory and motor evoked potentials were used. The spine was exposed by standard posterior midline skin incision with subperiosteal posterior and posterolateral exposure up to the tips of the transverse processes exposing three levels above and below the kyphotic apex. The costovertebral junctions at the level of the apex are exposed. Bilateral decompressive laminectomy, facetectomy, and total foraminal unroofing at the apex level was performed exposing the neural elements. Rib osteotomies were done to remove the head of the rib. Periosteum is elevated from the vertebral bodies with the parietal pleura with it from the sides till the anterior. At this stage, the nerve root at the deformity level can be sacrificed to facilitate the osteotomy may be done. We prefer to sacrifice nerve roots, if needed, from T5 to T11 as the T4 root carries sensation from the nipple and the T12 root may share in the lumbosacral plexus. At this stage, a temporary rod is first applied to one side of the spine for stability during the remaining osteotomy. The pedicle of one side is then removed with most of the vertebral body. Then, another rod is put on the other side before removing the first one. This is done to prevent leaving the unstable spine without any fixation during the osteotomy. By applying the second rod before removing the first one, the spine remains stable during the entire procedure. The other pedicle is then removed and the remaining part of the body is removed piece by piece using Rongeurs and pituitary forceps. Lastly, the posterior wall of the body is broken and excised. At last, the disc above and below are removed. Bleeding from the epidural vessels and soft tissues was controlled using bipolar cautery and absorbable gelatin sponge (Gelfoam). A good sized pyramesh was inserted into the osteotomy gap from posterior. This is much easier if the root on this site is ligated and sacrificed as it provides a capacious space. So, this is easier in the thoracic region where you can scarify roots unlike in the lumbar regions where it is not allowed. In the lumbar region it is a tighter space between the precious roots so, the cage must be inserted with caution. It may be inserted obliquely and flipped in the gap in front of the dura after passing the roots. Then the definitive rods are applied with the correction degree required. After closure of the osteotomy, the dura was inspected and palpated for any buckling or kinking below edges of the cephalic and caudal laminae. If this occurs, further partial laminectomy should be performed. The wound was closed in layers over suction drains.

Postoperative care:

The drain was removed when blood collection was less than 50 ml/24 h, usually on the third or fourth postoperative day. A routine neurological examination was done every 12 hours for the first 3 days to detect any neurological deterioration. Patients were discharged in the 4^{rd} day postoperative if there were no complications like postoperative anemia or neurological complications.

Follow up:

Patients were followed in the outpatient clinic at 1, 3, 6, 12, 18 -and 24 months postoperative. Full neurological examination and longstanding whole spine x-rays were done at each visit.

STATISTICAL ANALYSIS

Data collected throughout history, basic clinical examination, laboratory investigations and outcome measures coded, entered and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) (Statistical Package for the Social Sciences) software for analysis. According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD, the following tests were used to test differences for significance. Differences between quantitative paired groups by paired t test, correlation by Pearson's correlation or Spearman's. P value was set at <0.05 for significant results & <0.001 for high significant result.

Data were collected and submitted to statistical analysis. The following statistical tests and parameters were used:

1- Mean: $\bar{x} = \sum x / n$

($\sum x$) is the sum of the values.

(n) is the number of subjects.

2- Standard deviation (SD): $SD = \sqrt{\frac{\sum (x-\bar{x})^2}{n-1}}$

$\sum (x-\bar{x})^2$ is the sum of the square of the differences of each observation from the mean.

RESULTS

The average follow-up period was 24.21 ± 2.47 (range 23–26 months). The average age was 26.0 ± 8.15 (range 19-40) with 60% females and 40% males. The average operative time was 312.25 ± 9.47 (range 135–180 min). The average amount of blood loss was 864.58 ± 84.03 ml (700–1000 ml).

At the last follow up, all the patients showed significant improvement of back pain and decrease in intensity postoperatively. VAS score decreased from 5.80±1.78 preoperatively to 3.0±0.70 postoperatively. Regarding the ODI score, it showed significant decrease from 35.0±11.63 preoperatively to 18.40±2.60 postoperatively **(Table 1**).

There was a significant reduction in the thoracolumbar kyphosis postoperatively from 44.60±18.96 to 14.20±7.96. The local kyphotic angle decreased from 54.60±8.76 to 11± 6.97. There was also a significant reduction in the mismatch between pelvic incidence and lumbar lordosis from 16.40 ± 7.69 to 7.60 ± 2.85. The lumbar lordosis showed a significant change from 68.40 ± 13.04 to 51.40 ± 8.76. There were no significant changes in the sacral slope or the pelvic tilt postoperatively **(Table 2).** There was a positive correlation between the decrease of thoracolumbar kyphosis from preoperative to postoperative with improvement of ODI and VAS scores **(Table 3).**

There was no patient with neurological deterioration. One patient developed superficial wound infection and was treated with antibiotics without recurrence. No patient required ICU admission, and there were no postoperative mortality cases. Only one patient showed PJK and treated by extension of the fusion to upper thoracic levels **(figure 1).**

At the last follow up, there was no patient with deep infection, hardware failure, or progression of kyphosis. Fusion was evident in all cases with bridging bone at the osteotomy level filling the mesh cage with insignificant loss of correction at the final follow-up **(figure 2).**

Table 1: change assessment of clinical parameters

	Pre	Post	Paired t	P
ODI	**35.0±11.63**	**18.40±2.60**	**3.106**	**0.036***
VAS	**5.80±1.78**	**3.0±0.70**	**4.221**	**0.013***

Table 2: change assessment of radiological parameters

	Pre	Post	Paired t	P
PI	**46.80±7.39**	**46.80±7.39**	**-------**	**--------**
SS	**26.60±8.96**	**29.60±5.68**	**1.430**	**0.226**
PT	**19.80±6.87**	**17.0±5.70**	**1.376**	**0.241**
LL	**68.40±13.04**	**51.40±8.76**	**6.940**	**0.002***
TLK	**44.60±18.96**	**14.20±7.96**	**4.865**	**0.008***
TK	**53.60±18.96**	**50.40±7.70**	**0.297**	**0.781**
PI - LL	**16.40±7.69**	**7.60±2.85**	**3.433**	**0.025***
Sagittal imbalance	**3.30±1.36**	**2.60±1.1**	**0.564**	**0.603**

Table 3: Correlations between clinical and radiological

		ODI pre	ODI Post	VAS pre	VAS post
PI pre	**r**	**.365**	**.301**	**.110**	**.239**
	P	**.073**	**.081**	**.602**	**.250**
PI post	**r**	**.365**	**.301**	**.110**	**.239**
	P	**.073**	**.081**	**.602**	**.250**
SS _pre	**r**	**.017**	**.312**	**-.338-**	**-.596-****
	P	**.935**	**.129**	**.098**	**.002**
SS post	**r**	**-.138-**	**.182**	**-.477-***	**-.560-****

	P	.511	.383	.016	.004
PT pre	r	.399*	.225	.604**	.994**
	P	.048	.278	.001	.000
PT post	r	.663**	.639**	.662**	.868**
	P	.000	.001	.000	.000
LL pre	r	-.785-**	-.579-**	-.874-**	-.217-
	P	.000	.002	.000	.298
LL post	r	-.622-**	-.337-	-.807-**	-.323-
	P	.001	.100	.000	.116
TLK pre	r	-.431-*	-.390-	-.314-	-.473-*
	P	.032	.054	.126	.017
TLK post	r	.411*	.358	.421*	.847**
	P	.041	.079	.036	.000
TK pre	r	-.541-**	-.741-**	-.246-	.434*
	P	.005	.000	.237	.030
TK post	r	-.565-**	-.383-	-.501-*	.046
	P	.003	.058	.011	.827
PI LL pre	r	-.339-	-.439-*	-.398-*	-.414-*
	P	.098	.028	.049	.040
PI LL post	r	-.845-**	-.637-**	-.872-**	-.563-**
	P	.000	.001	.000	.003
Sagittal imbalance pre	r	-.014-	.169	-.051-	-.368-
	P	.949	.418	.809	.071
Sagittal imbalance post	r	.620**	.683**	.516**	.699**
	P	.001	.000	.008	.000

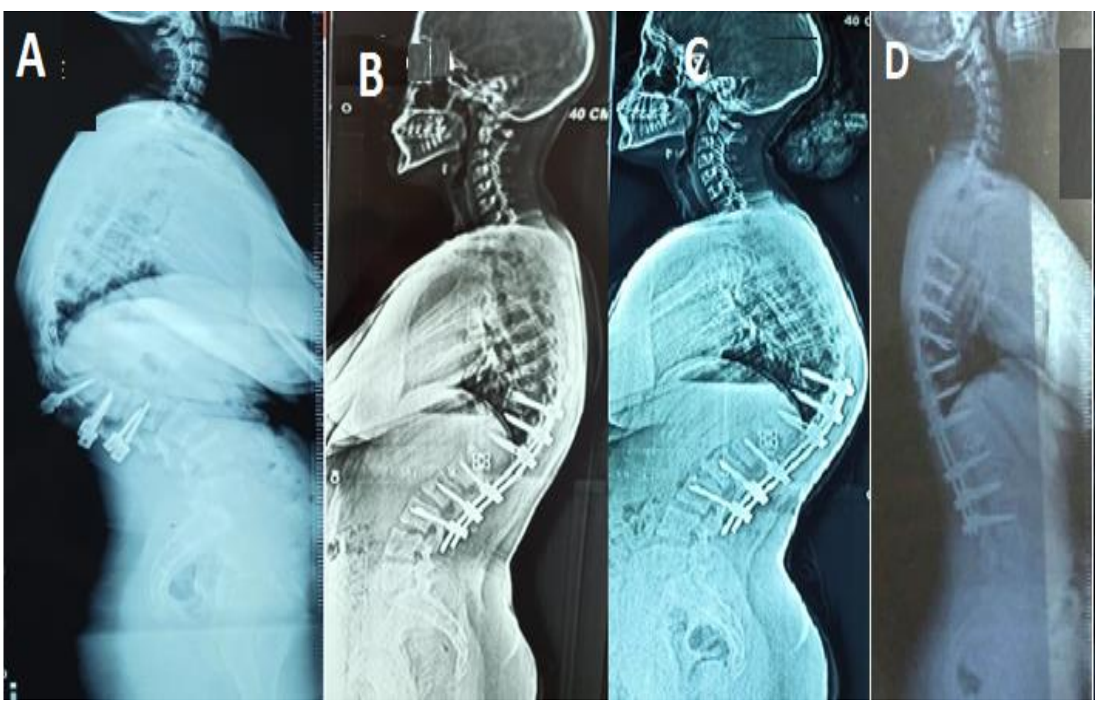

Fig (1): **(A):** longstanding X-ray 12 months after surgical fixation of L1 fracture and 6 months after rod removal due to infection at another center, **(B):** longstanding X-ray 1 months after the VCR **(C):** longstanding X-ray 6 months after the VCR showing progressive PJK, **(D):** Longstanding X-ray 12 months after extension of fusion.

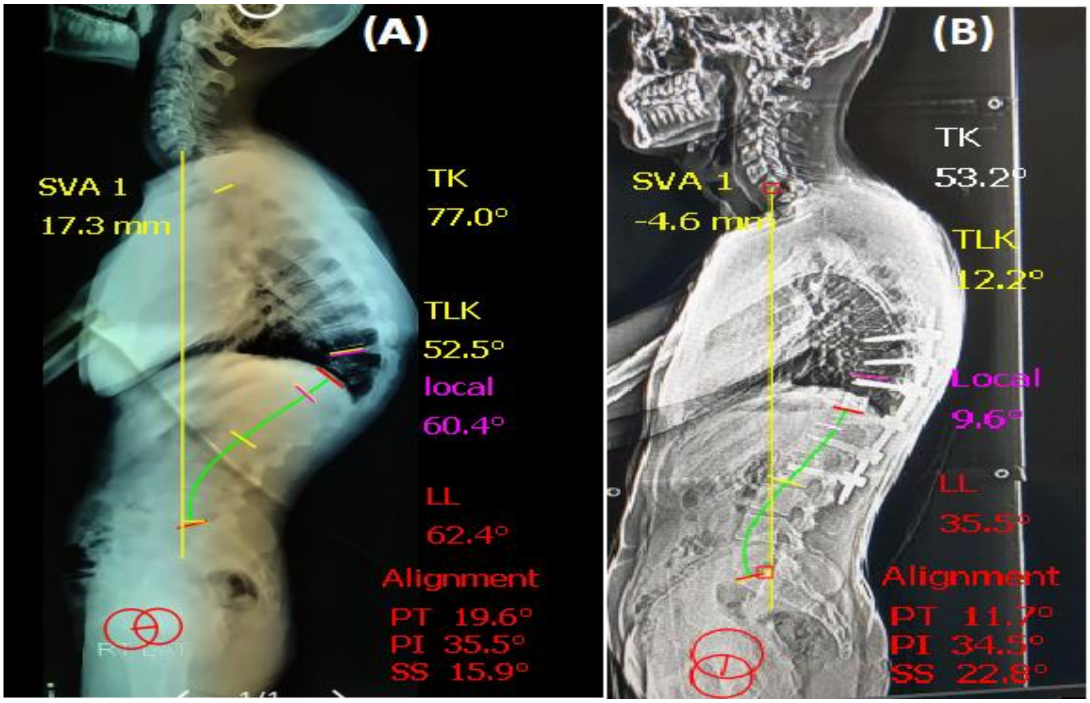

Fig (2): (A) longstanding X-ray sagittal view 18 months after T 11 fracture treated conservatively, (B): longstanding X-ray sagittal view 24 months after T 11 VCR showing sagittal parameters change.

DISCUSSION

Although PTK is defined as a painful kyphotic angulation that can occur anywhere in the spine, asymptomatic PTK can also exist. Deformity of 30° or more has an increased risk of chronic pain or progression. Surgical correction of PTK should be considered in patients presenting with a local kyphotic angle of more than 20° with poor functional tolerance, severe or increasing back pain and disability, angular deformity, nonunion, focal instability, radiculopathy, and/or increasing neurologic deficit. Adjacent painful compensatory deformity such as lumbar hyperlordosis, thoracic hypokyphosis, or lordosis is a further argument for surgery **[8].**

The primary aim of surgical treatment for PTK sharp angular kyphosis is to achieve thorough decompression of the neural elements, removal of all bone fragments from the posterior vertebral body impinging on the cord, correction of angular deformity, and stabilization of the spine for bony fusion. Anterior correction of deformity is often difficult, often hindered by the posterior structures and is associated with higher pseudarthrosis rate and loss of correction. El-Sharkawi MM et al. (2011) reported significant loss of correction in the anterior-only (ACP) group and insignificant loss of correction in the posterior-only PSOS group **[9].**

The posterior approach is more familiar to most spine surgeons. Decompression is easier because the apex of deformity is more accessible and easily approached posteriorly and the neural elements and the wedge fragment compressing it are identified under direct vision and protected early in the procedure. Correction of deformity is facilitated by excising the posterior elements, especially the fused or ankylosed facets, making correction easier **[10].**

Posterior fixation allows better correction, provides stronger fixation for solid bony fusion, and can be extended over many segments as required, especially in junctional areas Although one-stage posterior shortening osteotomy procedure is technically demanding, it has a number of reported advantages over combined procedures. These include shorter operative time, less intraoperative bleeding, diminished postoperative morbidity, which is especially important in patients with less than optimal pulmonary function, more reliable alignment, and solid bony fusion. The ability to work simultaneously anteriorly and posteriorly at the same time through a single approach for anterior reconstruction and graft adjustment is another advantage **[11].**

In this study, we used VCR for correction of sharp angular thoracolumbar posttraumatic kyphosis to get the maximum correction needed to get good radiological parameters and thus good clinical parameters. The local kyphotic angle decreased by nearly 80 % from 54.60±8.76 to 11± 6.97. There was significant reduction in the thoracolumbar kyphosis postoperatively by more than 70 % from 44.60±18.96 to 14.20±7.96. The lumbar lordosis showed significant change from 68.40 ± 13.04 to 51.40 ± 8.76. This change in the lumbar lordosis represents decrease of the hyperextension compensatory mechanism after the correction of the kyphotic deformity. This subsequently leads to significant reduction in the mismatch between pelvic incidence and lumbar lordosis (PI-LL) from 16.40 ± 7.69 to 7.60 ± 2.85, reaching the accepted degrees as listed by Schwab et al, less than 11 degrees, which is associated with more health related quality of life of the patients. This was also evident in our study in the subsequent decreases of VAS and ODI after the reduction in (PI-LL) mismatch.

This highlights the importance of adequate correction of the fixed local deformity of thoracolumbar spine to near normal levels and its effect on all the radiological parameters changes and clinical improvement. The local kyphotic angle deformity correction will lead to a decrease the thoracolumbar kyphotic angle and then a decrease in the compensatory hyperlordosis of the lumbar spine leading eventually to a decrease in the PI-LL mismatch. This local angle correction is correlated to the clinical improvement as there was positive correlation between the decreases of thoracolumbar kyphosis, local kyphotic angle and (PI-LL) mismatch from preoperative to postoperative with improvement of ODI and VAS scores. VAS score decreased from (5.80 ± 1.78) preoperatively to (3.0 ± 0.70) postoperatively and ODI score showed significant decrease from (35.0 ± 11.63) preoperatively to (18.40 ± 2.60) postoperatively.

Our results agree with the results of Lu et al of surgical correction of thoracolumbar sharp kyphotic deformities. They used PVCR to attack the deformity and to reach the needed correction. In their study, the average preoperative local kyphotic deformity was 54.6°±8.0° (range, 45°–68°) and changed into 6.8±1.3° (range, 5°–9°) at the last follow-up. The average preoperative VAS score of 6.1±1.1 (range, 5–8) was reduced to 2.5±0.4 (range, 2–3) at the last follow-up. The mean preoperative ODI of 38.7%±4.8% (range, 31%–48%) was significantly improved to 23.9%±4.5% (range, 16%–29%) at the final follow-up **[12].**

This result resembles the result obtained by El Naggar et al & El-Sharkawy et al. The VAS improved from (6.8±0.9) and (6.56 ± 2.24) to (1.7±0.8) and (1.28 ± 0.74) respectively. The mean ODI improved from (59.8±7.5) and (56.32 ± 21.57) to (11.6±3.4) and (22.71 ± 12.33) respectively. The mean local kyphotic angle improved from (64.1± 6.3o) and (66.38°±28.95) to (8.8±3.4o) (13.69°±19.88) respectively **[13, 14].**

In a study by li et al over clinical and radiological outcomes after correction of surgically failed fractures fixation ending eventually in late thoracolumbar posttraumatic kyphosis, there was a strong correlation between the local kyphotic angle correction and the VAS score improvement. The local kyphotic angle angle improved from preoperative (28.65 ± 11.41) to postoperative (1.14 ± 2.79), VAS score of back pain was improved from preoperative (4.41 ± 1.08) to postoperative (1.5 ± 0.91) at final follow-up**[15].**

This study has some limitations including b-being a retrospective case study with a relatively short follow up period without multicenter research results for more confirmation. The small sample size was another weakness. In future work, we will increase the number of the patients and perform long term follow up to evaluate the clinical results through a prospective multicenter randomized controlled clinical trial.

CONCLUSIONS:

Restoration of spinopelvic parameters is associated with better health related quality of life of the thoracolumbar posttraumatic kyphosis patients. PVCR provides significant correction of fixed posttraumatic kyphotic deformities allowing the restoration of the spinopelvic parameters to normal degrees.

Conflict of interests: there is no conflict of interests

Financial Disclosure: None

References:

1. De Gendt EEA, Vercoulen TFG, Joaquim AF, Guo W, Vialle EN, Schroeder GD, et al . The Current Status of Spinal Posttraumatic Deformity: A Systematic Review. *Glob. Spine J.*, 2021 Oct;11(8):1266-80.

2. Been HD, Poolman RW, Ubags LH. Clinical outcome and radiographic results after surgical treatment of post-traumatic thoracolumbar kyphosis. Eur Spine J 2004; 13:101–7

3. Farcy JP, Weidenbaum M, Glassman SD. Sagittal index in management of thoracolumbar burst fractures. Spine; 1990; 15:958–65

4. Schwab F, Blondel B, Bess S, Hostin R, Shaffrey C, Smith J, et al. Radiographical Spinopelvic Parameters and Disability in the Setting of Adult Spinal Deformity: A Prospective Multicenter Analysis. Spine 2013; 38(13):p E803-12,

5. Boehm H, Shousha M and Bahrami R. Corrective osteotomies for posttraumatic misalignment. Trauma Berufskrankh., 2017;19(2):86–96.

6. Schwab F, Blondel B, Chay E, Demakakos J, Lenke L, Tropiano P et al. The comprehensive anatomical spinal osteotomy classification. *Neurosurgery*. 2014 Jan; 74(1):112-20; discussion 120.

7. Saleh MK, Elhewala TA, Alagamy S. Spinopelvic Balance Restoration using Posterior Vertebral Column Resection in Fixed Lumbosacral Deformity Following Pyogenic Spondylodiscitis. *Egypt. Spine J.*, 2022; 41: 99e108

8. Buchowski JM, Kuhns CA, Bridwell KH and Lenke LG. Surgical Management of posttraumatic thoracolumber kyphosis. Spine 2008; 8:666–677.

9. El-Sharkawi MM, Koptan WM, El-Miligui YH, Said GZ. Comparison between pedicle subtraction osteotomy and anterior corpectomy and plating for correcting post-traumatic kyphosis: a multicenter study. Eur Spine J 2011; 20:1434–40.

10. Hao CK, Li WS, Chen ZQ. The height of the osteotomy and the correction of the kyphotic angle in thoracolumbar kyphosis. Chin Med J (Engl) 2008; 121:1906–10.

11. Suk SI, Kim JH, Lee SM, Chung ER, Lee JH. Anterior-posterior surgery versus posterior closing wedge osteotomy in posttraumatic kyphosis with neurologic compromised osteoporotic fracture. Spine (Phila Pa 1976) (2003); 28:2170–5.

12. Lu J, Dai ZH, Li HS, Kang YJ, Chen F. Posterior vertebral column resection for correction of thoracolumbar kyphosis after failed anterior instrumented fusion. Medicine (Baltimore). 2020 Jul 17;99(29).

13. El Naggar, A., Elgawhary, S., ElHewala, T. Posterior Vertebral Column Resection in Management of Severe Post-traumatic Thoracolumbar Kyphosis, *Egypt. Spine J.*, 2018; 28(1): 48-58.

14. El-Sharkawi M, Koptan W, Elmorshidy E, Tammam H, Hasan K, El Miligui Y. Posterior Only Vertebral Column Resection (PVCR) for Fixed Angular Kyphosis (FAK), *Glob. Spine J.*, 2016; 6 (1_suppl):s-0036-1582773

15. Li S, Li Z, Hua W, Wang K, Li S, Zhang Y, Ye Z, Shao Z, et al. Clinical outcome and surgical strategies for late post-traumatic kyphosis after failed thoracolumbar fracture operation: Case report and literature review. Medicine (Baltimore). 2017 Dec;96(49):e8770.

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