Zagazig University Medical Journal
www.zumj.journals.ekb.eg
https://doi.org/10.21608/zumj.2024.335770.3685 Volume 31, Issue 1, January. 2025
Manuscript ID ZUMJ-2411-3685
DOI 10.21608/zumj.2024.335770.3685
ORIGINAL ARTICLE

Radiological and Clinical Outcomes after Surgical Correction of Post-traumatic Kyphosis by multiple Ponte osteotomies

Mohsen Fawzy Omar, Mohamed Abdallah Esawy, Sherif El-aidy
Orthopedic and traumatology surgery, Faculty of Medicine Zagazig University, Zagazig city, Egypt

***Corresponding author**

Sherif El-aidy

Email:
dr.sherif.aidy2006@gmail.com

Submit Date 18-11-2024
Revise Date 21-11-2024
Accept Date 01-12-2024

ABSTRACT

Background data: Kyphotic spine deformity is a major problem that may affect wellbeing the patients. We are studying the outcomes of surgical treatment by multiple Ponte osteotomies and whether it improves the patients clinically. We aimed to determine the degree of spinopelvic parameters correction after multiple Ponte osteotomies of malunited vertebrae and clinical improvement of the patients postoperatively.

Methods: A retrospective cohort study of a total of 17 patients with posttraumatic kyphosis that were included in this study. The average age was 25.0 ± 7.44 (range 18-38) with 10 females and 7 males. Patients were treated with multiple Ponte osteotomies. 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 21.20 ± 6.37 (range 17–23 months). VAS score decreased from (6.20 ± 1.77) preoperatively to (3.3 ± 0.60) postoperatively while the ODI score showed significant decrease from (34.0±12.03) preoperatively to (19.40±1.90) postoperatively. The local kyphotic angle decreased from 51.60±8.76 to 15.01± 6.97. The mismatch between pelvic incidence and lumbar lordosis declined from 17.30 ± 6.98 to 8.60 ± 2.55. The lumbar lordosis showed significant change from 61.44 ± 14.24 to 47.40 ± 9.16. There were no significant changes in the sacral slope nor the pelvic tilt postoperatively.

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

Keywords: Ponte osteotomy, Spinopelvic, Kyphosis, Deformity

INTRODUCTION

Post-traumatic kyphosis after a neglected or maltreated spinal fracture is a handicapping complication that may affect the patient's life in many ways. Residual focal kyphotic deformity is a significant concern in patients who have experienced spinal injuries. This condition, characterized by an abnormal curvature of the spine, can evolve over time, leading to worsening deformity and increased complications. Central to this progression is the relationship between the deformity and the moment arm, as well as the role of disc damage at the fracture site [1].

Residual focal kyphotic deformity can lead to significant complications that profoundly affect the patient's quality of life. Pain is the most prevalent symptom, often presenting as a dull ache at the apex of the deformity. This discomfort may arise from muscle spasms and fracture nonunion, creating a chronic source of distress. Additionally, compensatory mechanisms such as hyperextension above and below the deformity can lead to facet

arthritis, further exacerbating pain and limiting mobility [2,3].

Moreover, symptoms related to neural tissue injury can emerge, ranging from mild weakness to severe complications like complete paraplegia and loss of sphincteric control. These neurological issues can result from acute injury caused by bony fragments at the time of trauma or may develop progressively due to the narrowing of the spinal canal. The kyphotic curvature can also lead to stretching of the spinal cord over the deformity, increasing the risk of post-traumatic conditions such as syringomyelia, where a fluid-filled cyst forms within the spinal cord, complicating the clinical picture [4,5].

A critical aspect of managing residual focal kyphotic deformity involves the assessment of normative spinopelvic parameters. Research by Schwab et al. highlights a significant correlation between these parameters and health-related quality of life. Specifically, they found that patients with a sagittal vertical axis (SVA) more than 4 cm, a pelvic incidence minus lumbar lordosis (PI-LL) exceeding 11°, and a pelvic tilt (PT) greater than 23° tend to experience greater disability and a lower overall quality of life [6,7].

When spinopelvic parameters exceed the thresholds identified by Schwab et al., and patients report functional disturbances alongside cosmetic dissatisfaction, surgical intervention is often warranted. Key indicators for surgery include pain that exceeds the patient's endurance threshold, progressive neurological deficits, and significant forward leaning of the trunk during standing or walking. Specifically, a positive sagittal vertical axis (SVA) greater than 5 cm can lead to functional impairments so severe that the patient's gaze is affected, which can impact daily activities and overall quality of life [8,9].

The best method to deal with a certain kyphotic deformity depends mainly on the degree and rigidity of that deformity. The more rigid larger deformities require more aggressive solutions. It was always stated that large kyphotic deformities above 30 degrees require 3 columns osteotomies. This has changed recently with more surgeons going to multiple posterior columns only osteotomies to avoid the major complications of the 3 column osteotomies such as dural tears, plural tears, nerve roots tears and vascular injuries such. This of course may leave a residual deformity, but clinically may not affect the patient either functionally or cosmetically [10,11].

Since first introduced by Alberto Ponte, Ponte osteotomy has gained more popularity over the years. It involves a closing wedge osteotomy per level, in which the posterior ligament complex and the facets with the inferior part of the lamina are excised and the deformity correction fulcrum is at the mobile anterior disc is which gives a 9 degrees correction per level. **(Figure 1)** [12].

Our hypothesis is that the restoration of spinopelvic parameters, by correcting the thoracolumbar posttraumatic deformities by multiple Ponte osteotomies, is associated with better health-related quality of life of the patients. This study aims to assess the radiological and clinical outcomes after surgical correction of posttraumatic kyphosis by multiple Ponte osteotomies.

METHODS

Seventeen (17) patients were included in this retrospective cohort study. All were diagnosed with posttraumatic kyphosis according to clinical and radiological investigations. The patients were admitted to our point from January 2018 to December 2021 with a minimum follow up of 18 months. **Informed consent has been obtained from all patients where appropriate and the Institutional Review Board of the Faculty of Medicine at Zagazig University has approved to our work (ZU-IRB # 669/10, January 2022).** 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.

Fourteen (14) patients were treated conservatively before eventually developing posttraumatic kyphosis. Three (3) patients had a failure of the surgical correction; one patient was due to inadequate reduction, and 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.

Inclusion criteria: Patients presented with symptoms such as back pain not responsive to medical treatment, and cosmetic disappointment due to the deformity. As for the radiological parameters, the patients had the angle from T10-L2 > 20 degrees and local kyphotic angle > 30 degrees. **Exclusion criteria:** patients refusing to participate, presence of thoracic or lumbar spine congenital anomaly, active infection and inflammatory diseases.

Radiographic analysis: Longstanding whole spine X-rays with arms on the clavicle position were performed in all the cases. These radiographs were obtained preoperatively, 1 month, 6, 18 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 pre and postoperatively by visual analogue scale (VAS) score for back pain and the Oswestry disability index (ODI).

Operative technique:

Patients were operated on the prone position under general endotracheal hypotensive anesthesia. Foley catheterization, preoperative IV antibiotics, neuromonitoring were used. A standard posterior midline skin incision with subperiosteal posterior and posterolateral exposure was done to expose the spine then the pedicle screws are inserted into the planned levels. The inferior part of the lamina with attached supraspinous ligaments were removed. This exposes the ligamentum flavum centrally. The ligamentum flavum was removed with care with the cord directly underneath it. Then we went laterally removing the facets and deroofing the foramens. This was repeated at many levels above and below the apex as the deformity degree and rigidity dictate. The rods are then applied sequentially with the desired correction. In situ correction of the rods was tried if more correction was desired putting in mind to stop at the point any of the screws start to pull out. The wound was closed in layers fascia, subcutaneous and skin.

Postoperative care:

When blood collection was less than 80 ml/24 h, the drain was removed. This was mainly at the second postoperative day. Patients were discharged on the second day postoperative if there were no complications like postoperative anemia or neurological complications.

Follow up:

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

Statistical analysis

Data collected by history, clinical examination and laboratory investigations. The outcome measures coded and analyzed by Microsoft Excel 2016 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.

RESULTS

The average follow-up period was 21.20 ± 6.37 (range 18–23 months). The average operative time was 170.34 ± 8.91 (range 135–180 min). The average amount of blood loss was 567.48 ± 73.13 ml (400–700 ml).

At the last follow up, all the patients showed significant improvement of back pain and decrease in intensity postoperatively. Visual analogue scale score decreased from (6.20 ± 1.77) preoperatively to (3.3 ± 0.60). Regarding the ODI score, there was a significant decrease from (34.0±12.03) preoperatively to (19.40±1.90) **(Table 1).**

There was a significant reduction in the thoracolumbar kyphosis postoperatively from 38.70±14.96 to 15.20±6.96. The local kyphotic angle decreased from 51.60±8.76 to 15.01± 6.97. The pelvic incidence and lumbar lordosis mismatch declined from 17.3 ± 6.9 to 8.6 ± 2.5. The lumbar lordosis showed significant change from 61.44 ± 14.24 to 47.40 ± 9.16. There were no significant changes in the sacral slope nor 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.

There was no patient with neurological deterioration. No patient developed superficial wound infection. No patient required ICU admission, and there were no postoperative mortality cases.

At the last follow up, there was no patient with deep infection, hardware failure, or progression of kyphosis. **(Figures 2,3,4)**

Table 1: Change assessment of clinical parameters

	Pre	Post	Paired t	P
ODI	34.0±12.03	19.40±1.90	3.106	0.036*
VAS	6.20 ± 1.77	3.3 ± 0.60	4.221	0.013*

Table 2: Change assessment of radiological parameters

	Pre	Post	Paired t	P
PI	48.80±6.39	48.80±6.39	-------	--------
SS	28.10±8.59	29.66±6.28	1.480	0.324
PT	19.33±6.51	18.10±6.1	1.476	0.349
LL	61.44 ± 14.24	47.40 ± 9.16	8.943	0.00**
TLK	44.60±18.96	17.20±7.96	7.882	0.00**
TK	53.60±18.96	50.40±7.70	0.874	0.408
PI LL	17.30 ± 6.98	8.60 ± 2.55	5.874	0.00**
SVA	3.19±1.11	2.92±0.89	1.412	0.191

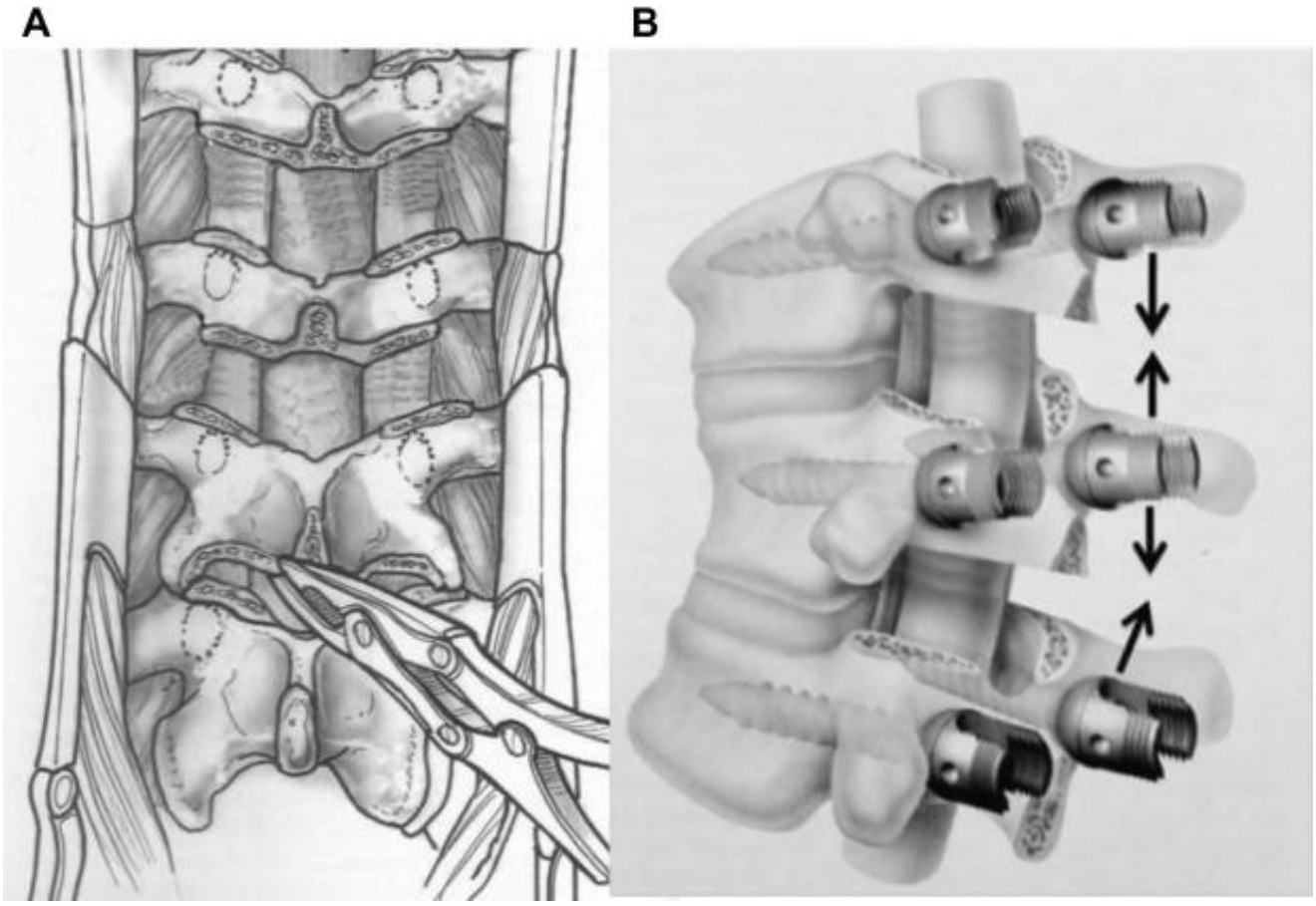

Figure (1): Ponte osteotomy as illustrated by the one who developed it. [12]

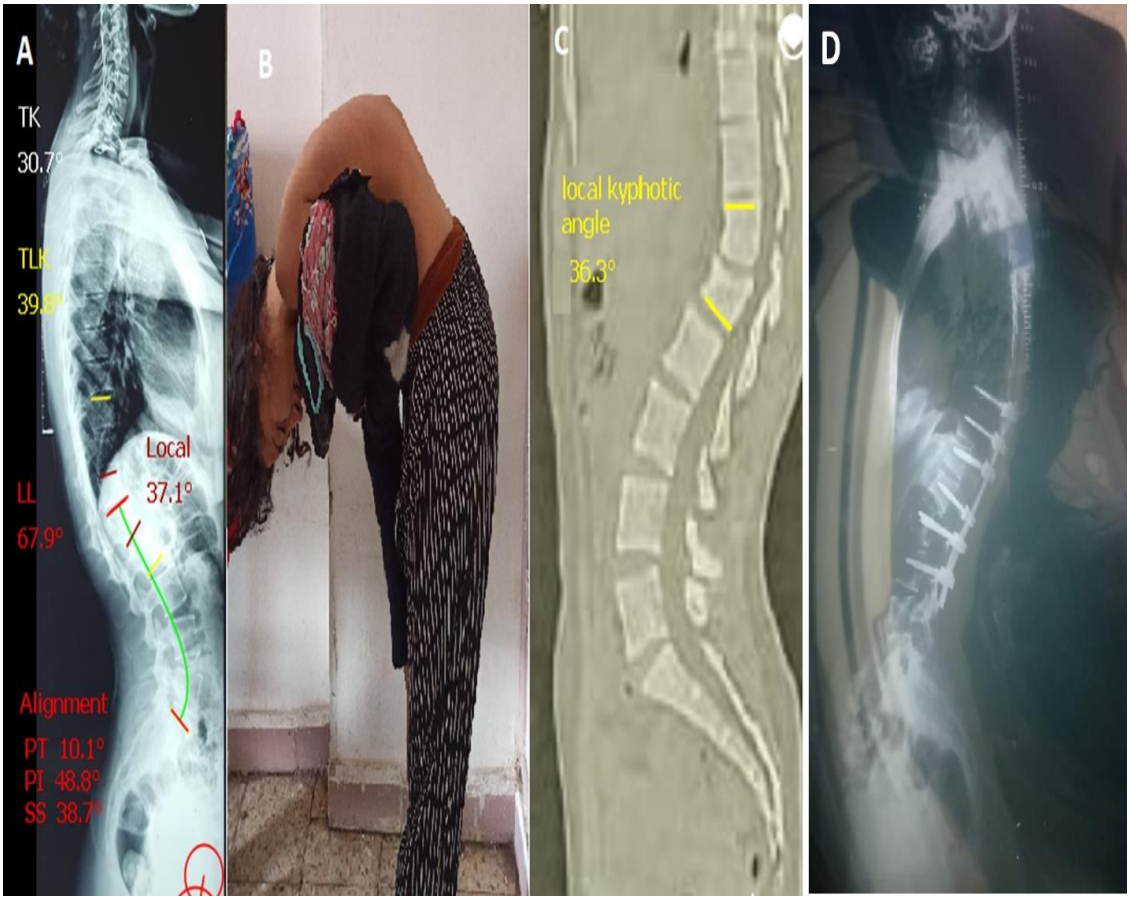

Figure (2): Female patient 20 years old with L1 fracture managed conservatively. A) Sagittal longstanding X-ray preoperative. B) clinical photo preoperative. C) Sagittal cut CT view preoperative. D) One year follow up after 3 Ponte osteotomies with fixation T10-L3.

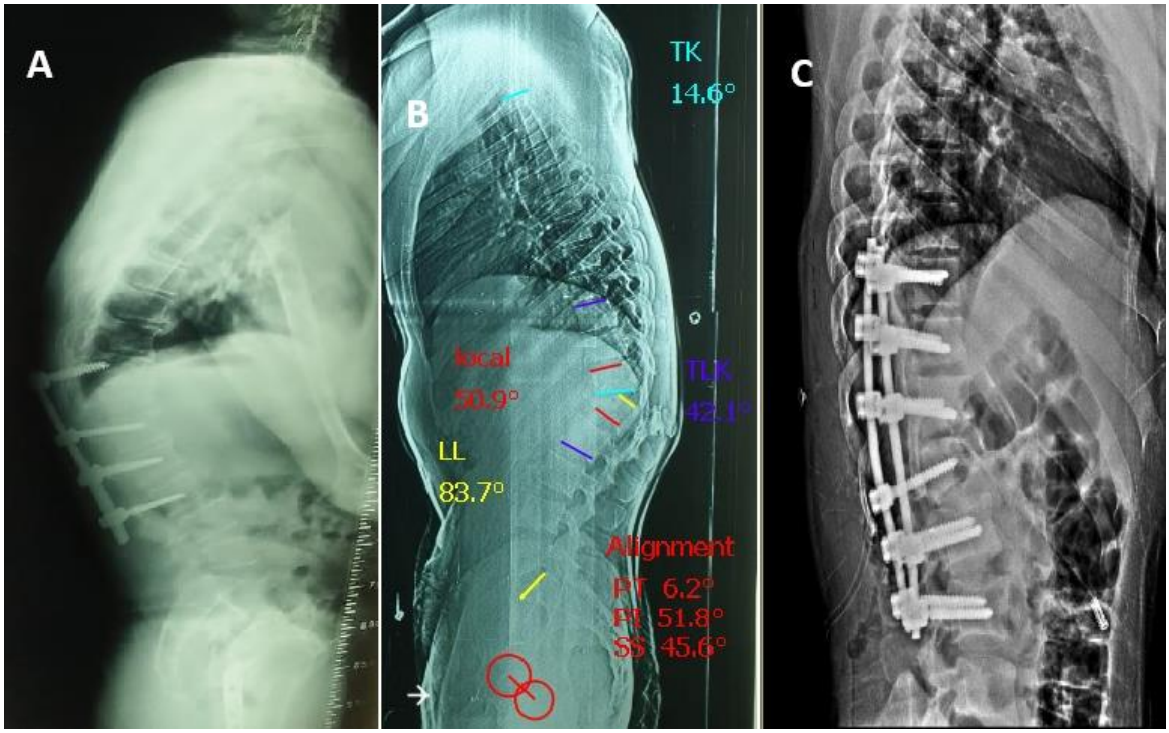

Figure (3): Male patient 35 years old had T12 fracture fixed by one level above and 3 levels below A) 1 month after the first operation, B) 1 week after removing the screws, C) one year after surgical correction by 3 Ponte

osteotomies and T9 to L2 fixation with local kyphosis and TLK improvement to only 15 and 10 degrees respectively.

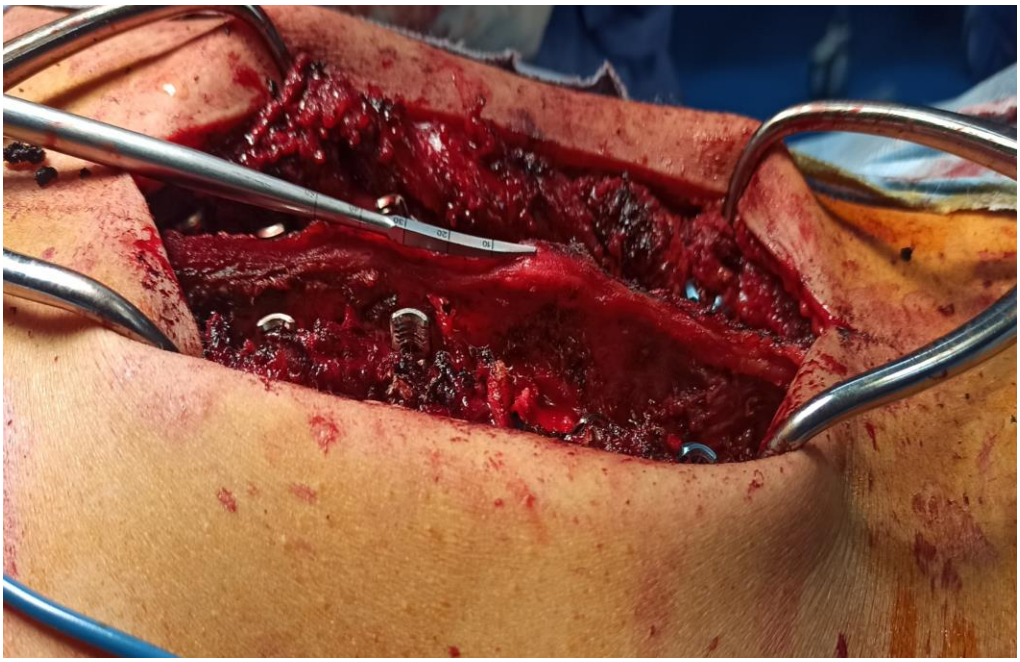

Figure (4): Intraoperative clinical photo of patient in figure (1) shows widened interspinous distance with tear of the supraspinous ligament

DISCUSSION

Posttraumatic kyphotic (PTK) deformity of thirty degrees or more has an increased risk of progression and affecting the patient's life. Surgical correction of post-traumatic kyphosis (PTK) should be carefully considered in patients exhibiting a local kyphotic angle exceeding 20°. Indicators for surgery include poor functional tolerance, severe or escalating back pain, and significant disability. In addition, the presence of angular deformity, nonunion at the fracture site, focal instability, radiculopathy, or worsening neurological deficits are critical factors that support the decision for surgical intervention [13,14].

The main goal of surgical treatment for PTK is to correct the deformity through osteotomy and spinal instrumentation for bony fusion. Correcting the deformity from the anterior approach is often challenging and has a higher rate of pseudarthrosis along with a greater risk of losing the correction. El-Sharkawi et al. found that anterior-only fusion led to a significant loss of correction, while posterior-only fusion showed an insignificant loss of correction [15].

It is known that most spine surgeons like the posterior approach. It allows easier decompression since the deformity's apex is more accessible from the back, enabling direct visualization of the neural elements and the compressing wedge fragment, which can be identified and safeguarded early in the procedure. Additionally, deformity correction is simplified by removing the posterior elements, which facilitates the deformity correction [16].

Posterior fixation offers superior correction, stronger stabilization for solid bony fusion, and can be extended across multiple segments as needed, particularly in junctional areas. Although the one-stage posterior shortening osteotomy is technically challenging, it has several reported benefits compared to combined approaches. These advantages include reduced operative time, less intraoperative blood loss, lower postoperative morbidity which is especially beneficial for patients with compromised pulmonary function more consistent alignment, and robust bony fusion [17].

In this study, we utilized multiple Ponte osteotomies to correct thoracolumbar posttraumatic kyphosis, achieving the maximum correction necessary for favorable radiological parameters, which in turn resulted in improved clinical outcomes. The local kyphotic angle was reduced from 51.6±8.7 to 15.01±6.9. Additionally, lumbar lordosis significantly changed from 61.44±14.24 to 47.40±9.16, indicating a reduction in the compensatory hyperextension mechanism following kyphosis correction. This led to a substantial

decrease in the pelvic incidence and lumbar lordosis mismatch (PI-LL), from 17.30±6.98 to 8.60±2.55, reaching the acceptable threshold of less than 11 degrees as outlined by Schwab et al., which is associated with improved patient quality of life.

Correcting the local kyphotic angle deformity reduces the thoracolumbar kyphotic angle, which subsequently decreases compensatory hyperlordosis in the lumbar spine and ultimately reduces the PI-LL mismatch. There was a positive correlation between the reduction in thoracolumbar kyphosis, local kyphotic angle, and PI-LL mismatch from preoperative to postoperative stages, and improvements in ODI and VAS scores. VAS score decreased from (6.20 ± 1.77) preoperatively to (3.3 ± 0.60) postoperatively while the ODI score showed significant decrease from (34.0±12.03) preoperatively to (19.40±1.90) postoperatively.

Our results agree with the results of Herrero et al of surgical correction of thoracolumbar sharp kyphotic deformities. They used multiple Ponte osteotomies to attack the deformity and to reach correction. In their study, the mean value of the kyphosis was 78.8° ± 7.59° (Cobb) before surgery and 47.5° ± 12.54° at late follow up, with mean correction of 33.9° ± 9.53° and lost correction of 2.2°. [18]

This result resembles the result obtained by Zhang et al. All cases showed significant improvement in focal kyphotic deformity as the deformity degrees reduced from 85.6 ± 19.8° to 36.1 ± 16.7° and 53.9 ± 26.8° to 30.8 ± 18.6°, achieving mean correction rates of 57.7% and 41.2%, respectively. Postoperative coronal and sagittal parameters improved significantly. The average operative time was 267.86 ± 54.49 minutes, with an average blood loss of 838.7 ± 538.9 mL. All clinical function scores of the patients showed significant improvement at the final visit [19].

Our findings are similar to those of Geck et al., who achieved an average correction of 61% in kyphosis across instrumented levels and 49% in the largest Cobb angle. Their study reported significant clinical and radiological improvements, with no cases of reoperation due to pseudarthrosis or instrumentation failure [20].

In a study by Li et al. examining clinical and radiological outcomes following the correction of failed fracture fixations that ultimately resulted in late thoracolumbar posttraumatic kyphosis, a strong correlation was found between the correction of the local kyphotic angle and the improvement in VAS scores. The local kyphotic angle improved from a preoperative value of 28.65 ± 11.41 to a postoperative value of 1.14 ± 2.79. Similarly, the VAS score for back pain decreased from a preoperative score of 4.41 ± 1.08 to a postoperative score of 1.5 ± 0.91 at the final follow-up [21].

This study has some limitations including a retrospective case study with a relatively short follow up period. 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.

CONCLUSION

Restoration of spinopelvic parameters is linked to a better health related quality of life of the thoracolumbar posttraumatic kyphosis patients. Multiple Ponte osteotomies provide significant correction of fixed posttraumatic kyphotic deformities allowing normalization of the spinopelvic parameters.

Disclosure of conflict of interests: there is no conflict of interests

Conflict of interests: No conflict of interests

Financial disclosure: The authors declare that no funds, grants, or other support were received during the preparation of this manuscript

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. Global Spine J. 2021 Oct;11(8):1266-80.

2. Buchowski JM, , Bridwell KH, , Lenke LG, , Kuhns CA, , Lehman RA Jr, & Kim YJ, et al.: Neurologic complications of lumbar pedicle subtraction osteotomy: a 10-year assessment. Spine (Phila Pa 1976) 32:2245–52, 2007

3. Voos K, Boachie-Adjei O, Rawlins B. Multiple Vertebral Osteotomies in the Treatment of Rigid Adult Spine Deformities. Spine (Phila Pa 1976). 2001;26(5):526-33.

4. Dorward IG, Lenke LG. Osteotomies in the posterior-only treatment of complex adult spinal deformity: a comparative review. Neurosurgical Focus FOC. 2010;28(3)

5. Leong JJ, Curtis M, Cartes E, Cowan J, Lehovsky J. Risk neurogical injuries in spinal deformity surgery. Spine (Phila Pa 1976). 2016;41(12):1022-7.

6. 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,
7.Lafage V, Schwab F, Vira S, Patel A, Ungar B, Farcy JP. Spino-pelvic parameters after surgery can be predicted: a preliminary formula and validation of standing alignment. Spine (Phila Pa 1976). 2011;36(13):1037-45.
8. Bridwell KH: Decision making regarding Smith-Petersen vs. pedicle subtraction osteotomy vs. vertebral column resection for spinal deformity. Spine (Phila Pa 1976) 31:19 Suppl 171–78, 2006.
9. Roussouly P, Gollogly S, Berthonnaud E, Dimnet J. Classification of the normal variation in the sagittal alignment of the human lumbar spine and pelvis in the standing position. Spine (Phila Pa 1976). 2005;30(3):346-53
10. 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
11.Lichtblau PO, & Wilson PD: Possible mechanism of aortic rupture in orthopaedic correction of rheumatoid spondylitis. J Bone Joint Surg Am 38-A:123–27, 1956
12. Ponte, A., Orlando, G. & Siccardi, G.L. The True Ponte Osteotomy: By the One Who Developed It. Spine Deform 6, 2–11 (2018)
13. Munting E. Surgical treatment of post-traumatic kyphosis in the toracolumbar spine: indications and technical aspects. Eur Spine J. 2010;19(Suppl 1):69-73.
14. Buchowski JM, Kuhns CA, Bridwell KH and Lenke LG. Surgical Management of posttraumatic thoracolumber kyphosis. Spine 2008; 8:666–77.
15. 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.
16. 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; 1906–10.
17. 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); 2170–75.
18. da Silva Herrero CF, Porto MA, Barbosa MH, Defino HL. Multiple segmental osteotomies to the kyphosis correction. Rev Bras Ortop. 2015 Dec 7;44(6):513-8
19. Zhang Y, Hai Y, Tao L, Yang J, Zhou L, Yin P, et al. Posterior Multiple-Level Asymmetrical Ponte Osteotomies for Rigid Adult Idiopathic Scoliosis. World Neurosurg. 2019,467-73.
20. Geck MJ, Macagno A, , Ponte A, & Shufflebarger HL: The Ponte procedure: posterior only treatment of Scheuermann's kyphosis using segmental posterior shortening and pedicle screw instrumentation. J Spinal Disord Tech 20:586–93, 2007
21. Li S, Li Z, Hua W, Wang K, Li S, Zhang Y, 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.

Citation

Omar, M. F., Esawy, M., El-aidy, S. Radiological and Clinical Outcomes after Surgical Correction of Post-traumatic Kyphosis by multiple Ponte osteotomies. *Zagazig University Medical Journal*, 2025; (446-453): -. doi: 10.21608/zumj.2024.335770.3685