European Spine Journal (2019) 28:1767–1774
https://doi.org/10.1007/s00586-019-05888-4

ORIGINAL ARTICLE

Anterior instrumentation through posterior approach in neglected congenital kyphosis: a novel technique and case series

Belal Elnady[1] · **Ahmed Shawky Abdelgawaad**[1,2] · **Mohamed El-Meshtawy**[1]

Received: 10 July 2018 / Accepted: 13 January 2019 / Published online: 22 January 2019

Abstract

Purpose To present a novel technique for anterior instrumentation and reconstruction with PVCR for treatment of severe neglected congenital kyphosis through posterior approach.

Methods Between 2010 and 2014, all patients with severe congenital kyphosis more than 90° were included. PVCR augmented with anterior vertebral body instrumentation was done for all patients through the same posterior approach. Cobb angle of the main kyphosis and scoliosis curves, the global sagittal and coronal balance were measured preoperatively, postoperatively and at 2-year follow-up. The functional outcome was assessed using the SRS-22 questionnaire preoperatively and at 2-year follow-up.

Results Fourteen patients with mean age of 19.4 years were included. The mean follow-up period was 38 months. The mean number of resected vertebrae was 2.4 vertebrae per patient. The mean height of the anterior defect after resection was 6.4 cm. The mean preoperative local kyphosis angle was 104.6° that was corrected to a mean of 22.8° at 2-year follow-up. The sagittal vertical axis improved from 62.7 mm preoperatively to 21.4 mm at 2-year follow-up. The mean coronal Cobb angle was 71.2° preoperatively and 25.6° at 2-years follow-up. The mean coronal balance was 32.4 mm preoperatively and 13.6 mm at 2-year follow-up. All patients had significant improvement of the SRS-22 questionnaire at the last follow-up.

Conclusion Addition of anterior instrumentation to PVCR allows controlled gradual correction and more biomechanical stability. This technique should be preserved for high degrees of sagittal plane deformities.

Graphical abstract

These slides can be retrieved under Electronic Supplementary Material.

Keywords Anterior instrumentation · Severe kyphosis · Congenital kyphosis · Posterior approach · Posterior vertebral column resection

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00586-019-05888-4) contains supplementary material, which is available to authorized users.

Extended author information available on the last page of the article

Introduction

Treatment of neglected congenital kyphosis is challenging. Pain, neurologic deficits as well as functional and psychological disabilities are common indications for deformity correction [1–3].

Many surgical options have been described for treatment of such progressive and rigid deformity. Posterior vertebral column resection (PVCR) has been extensively used as a gold standard for treatment of severe deformity. It allows resection of both anterior and posterior elements of the spine, posterior stabilization and anterior column reconstruction through a single approach [4–6].

This study presents a novel technique for anterior instrumentation and reconstruction together with PVCR for treatment of severe neglected congenital kyphosis.

Patients and methods

Between 2010 and 2014, all patients presented to our institution with severe congenital kyphosis more than 90° were included in this study. Patients with intraspinal anomalies or previous posterior surgery were excluded. This study was approved by Internal Review Board, and an informed consent was obtained from all patients before surgery.

Indications for surgery were progressive deformity, pain or neurologic deficits. All patients underwent thorough neurological examination. Full length standing spine anteroposterior (AP), lateral radiographs and whole spine 3D CT scan were done for all patients. MRI was obtained to exclude coincident spinal dysraphism or other intraspinal anomalies. Functional views were done to evaluate flexibility of the deformity.

In the lateral view, the Cobb angle of the main kyphotic curve was measured together with the global sagittal balance assessed from the distance between C7 plumb line and postero-superior corner of S1. In the AP view, Cobb angle of the scoliotic curve was measured. Global coronal balance was measured as the distance between coronal C7 plumb line and central sacral vertical line.

All patients were operated in prone position over a radiolucent table. Standard posterior approach was used exposing the posterior elements of the spine. Pedicle screws were inserted using free-hand technique at least three vertebrae above and below the apex.

A temporary rod was inserted on one side to secure the spine during resection. Laminectomy was done extending at least one lamina above and below the desired resection levels to avoid cord impingement or compression during correction.

After facetectomy, the dorsal nerve roots in the resection levels were identified, ligated and cut unless they were indispensable. The heads of ribs as well as the transverse processes were resected exposing the lateral wall of the vertebrae planned for resection. A careful sub-periosteal dissection of the lateral wall of the vertebrae was done till the most anterior part. Utmost care was given not to injure the parietal pleura. Bleeding from segmental vessels was managed using bipolar diathermy and local haemostatics. A blunt spatula was positioned anterior to the anterior longitudinal ligament to protect the anterior structures and the great vessels. Excision of the pedicles, lateral wall, body and disks was done using different rongeurs and osteotomes. A thin shell of bone just anterior to the dura together with the posterior longitudinal ligament was kept to prevent undue redundancy and kinking of the dural sac during correction. Another temporary rod was inserted on the opposite side, and the same procedure was repeated from the other side until complete resection of the desired levels.

The anterior pedicle screws were inserted into the vertebral bodies just above and below the desired area for resection. The entry point started on the lateral wall of the body, and the screw was directed toward the opposite lateral wall with slight anterior inclination to avoid violation of the canal. Usually, one screw above and one below the resected area were sufficient. A rod with adequate length was connected to those anterior screws.

A spreader was positioned and secured between the two end plates above and below the resected area from the other side of the anterior screws to prevent collapse of the spine after resection of the kyphus. Then, deformity correction was done gradually by simultaneous anterior distraction over the two anterior screws as a fulcrum and in situ bending of the posterior rods.

Utmost care was given to prevent undue kinking or stretch of the cord. As adequate correction was achieved, the rod connected to the anterior screws was secured to maintain the correction and a wake-up test was done. After confirming neural integrity, a mesh cage with suitable length filled with autogenous bone graft was inserted and its position was secured by gentle compression over the anterior screws. The posterior temporary rods were changed one by one, and the posterior pedicle screws were checked for loosening after such manipulations. Loose screws were changed by larger diameter screws, and the final rod was inserted. Final compression over the posterior pedicle screws secured the cage in position. The final position was checked by intraoperative radiographs, and the wound was closed in layers over a suction drain (Figs. 1, 2, 3).

The operative time, blood loss, blood transfusion as well as any intraoperative complications were documented for all patients.

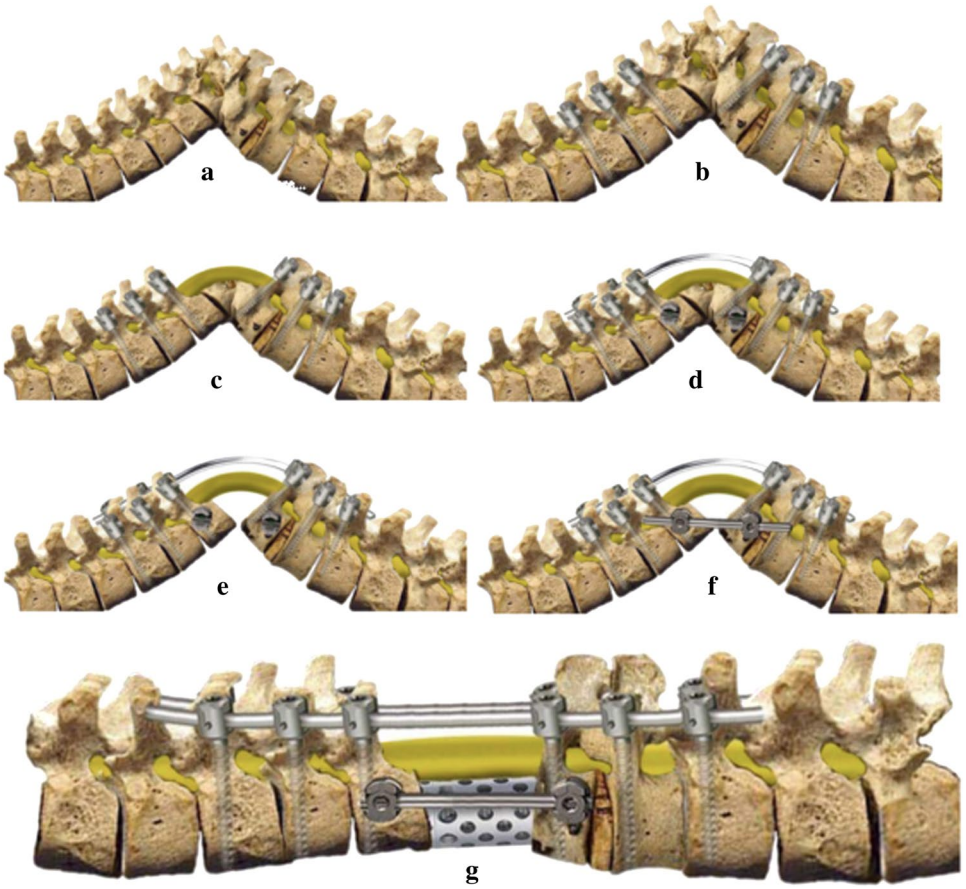

Fig. 1 Illustration of the operative steps: **a** sub-periosteal dissection exposing the posterior and lateral elements of the spine. **b** Insertion of pedicle screws above and below the kyphus. **c** Wide laminectomy extending at least one lamina cranial and caudal to the kyphus. **d** Insertion of 2 anterior screws into the body of the vertebra above and below the kyphus and insertion of posterior temporary rod. **e** Kyphectomy with excision of the whole bodies and disks in the kyphus. **f** Connecting a rod to the anterior screws with gradual distraction to correct the deformity. **g** Insertion of the mesh cage filled with bone chips and the final rod

Postoperatively, early weight bearing was allowed as tolerated with a thoracolumbar brace. Follow-up visits were planned at 2 weeks, 2, 6, 12 months and then every year. Radiological evaluation was done for both coronal and sagittal parameters in each follow-up visit. Fusion was judged by the stability of the construct and the presence of crossing bone around the mesh cage. The functional outcome was assessed using the SRS-22 questionnaire preoperatively and at the last follow-up.

Results

This study included 14 patients: 9 females and 5 males. The mean age at surgery was 19.4 ± 6.43 years with a mean follow-up period of 38 ± 17.2 months.

Indications for surgery were painful progressive deformity in all patients. Two patients had neurologic symptoms in the form of lower limb numbness and sphincteric disturbances. One patient had previous failed anterior surgery for epiphysiodesis.

The mean operative time was 407.8 min, with a mean blood loss of 1662.4 mL. The mean blood transfusion was four units per patient (Table 1).

The mean number of resected vertebrae was 2.4 vertebrae per patient. Titanium mesh cage was used in all patients with a mean length of 6.4 cm to reconstruct the anterior defect. The apex of kyphosis was located in the thoracolumbar junction (T_{10}–L_2) in 12 patients while thoracic (T8, 9) in 2 patients.

The mean preoperative local kyphosis angle was 104.6° that was corrected to a mean of 22.8° at 2-year follow-up. The sagittal vertical axis improved from 62.7 mm anterior to S1 promontory preoperatively to 21.4 mm at 2-year follow-up.

In the coronal plane, all patients had associated scoliosis except one (Fig. 4). The mean Cobb angle of the main curve was 71.2° preoperatively and 25.6° at 2-year follow-up achieving 64% deformity correction. The mean coronal balance was 32.4 mm preoperatively and 13.6 mm at 2-year follow-up (Table 2).

No cases of neurologic deteriorations or cage dislodgment occurred in this study. One patient had intraoperative dural tear. Repair was done with no postoperative CSF leak (Fig. 5). One patient had proximal junctional kyphosis (PJK) 1 year postoperatively and he was counseled for revision surgery; however, he refused (Fig. 6).

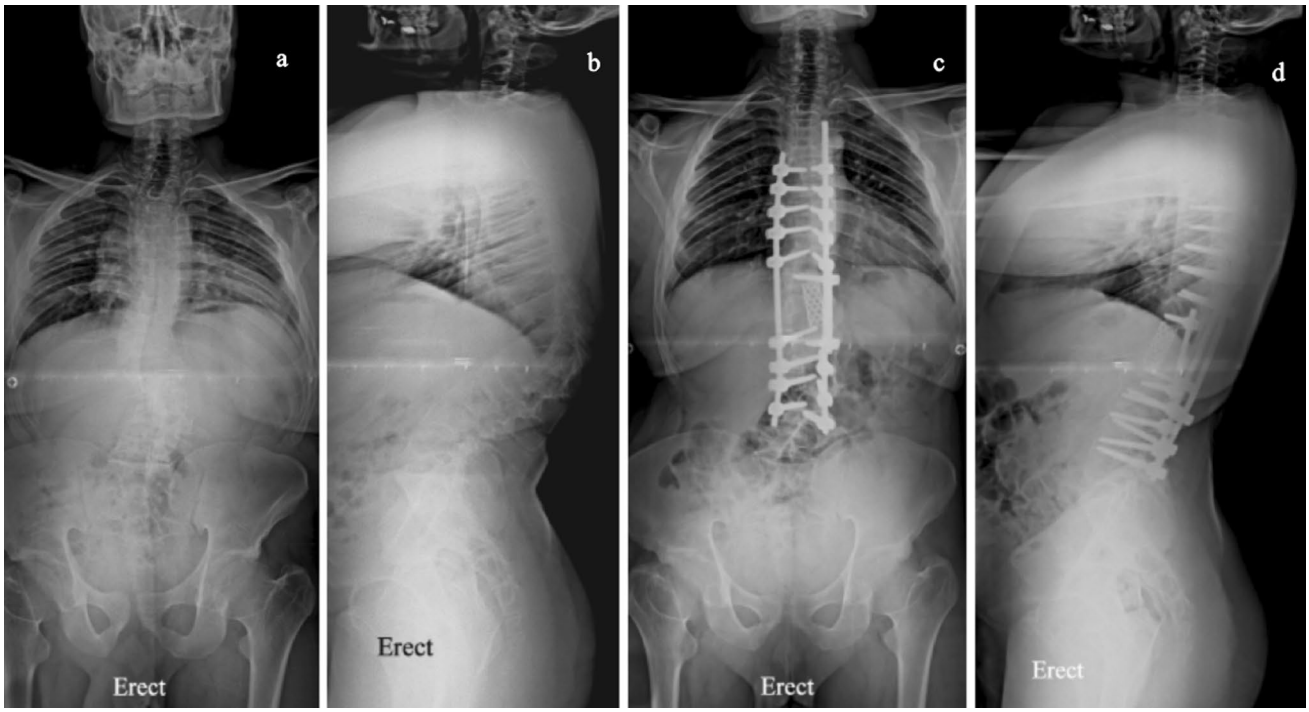

Fig. 2 Male patient 27 years old with neglected congenital kyphoscoliosis: **a**, **b** preoperative AP and lateral whole spine radiograph showing scoliosis measuring 28° and thoracolumbar kyphosis with LKA of 93°. **c**, **d** Postoperative AP and lateral whole spine radiograph after correction of the LKA to 8°

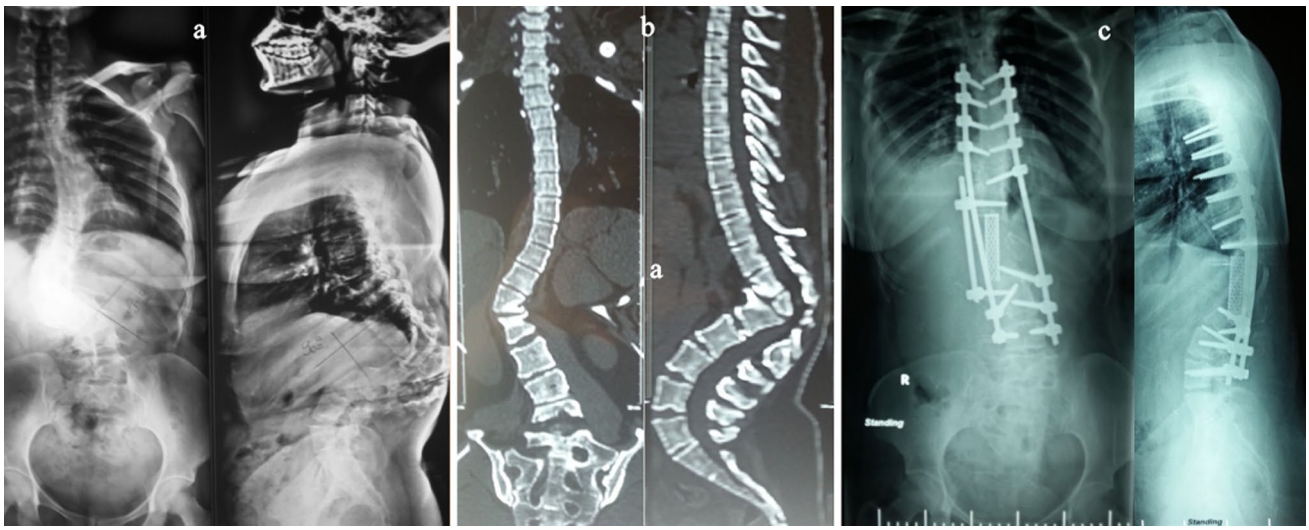

Fig. 3 Female patient 28 years old with neglected congenital kyphoscoliosis: **a** preoperative AP and lateral whole spine radiograph showing scoliosis measuring 65° and thoracolumbar kyphosis with LKA of 104°. **b** Preoperative coronal and sagittal CT scan. **c** Postoperative AP and lateral whole spine radiograph after correction of the LKA to 28° and the scoliosis to 13°

Table 1 Surgical data

	Mean	Range
Operative time	407.8 min	330–620 min
Operative blood loss	1662.4 cc	1100–3200 cc
Blood transfusion	4 units	3–6 units
Number of resected vertebrae	2.4 vertebra/patient	2–3 vertebra/patient
Length of the cage	6.4	4–8 cm

The SRS 22 questionnaire improved significantly from a mean of 2.38 preoperative to 3.92 at last follow-up ($P < 0.001$). Both the total score and the five domains scores improved after surgery.

Discussion

The etiology of congenital kyphosis is obscure despite several theories about environmental, genetics, drugs and chemicals have been postulated [7]. The onset of congenital kyphosis starts as early as the first 8 weeks of the prenatal life [8]. Although a number of cases may be asymptomatic, neglected symptomatic congenital kyphosis usually ends up with severe rigid deformity. This constitutes a big challenge for deformity correction [7]. Moreover, the progression of deformity can cause neurological deterioration that can occur in 10–12% of patients [2, 9, 10].

Several surgical options had been described for treatment of congenital kyphosis including in situ fusion, epiphysiodesis, multiple Ponte or Smith Peterson osteotomies and pedicle subtraction osteotomy. However, the correction achieved by these techniques is limited in patients with neglected severe curves [4].

Vertebral column resection (VCR) is till now the ideal treatment of severe, rigid and complex spinal deformity. Traditionally, VCR was done through combined anterior and posterior approaches [11, 12]. This increases the surgical time, blood loss and anesthetic complications. In addition to the anterior approach-related morbidity, reaching the anterior column through anterior approach is difficult in patients with severe kyphosis [13]. These factors caused the combined anteroposterior VCR to fall out of favor among surgeons nowadays.

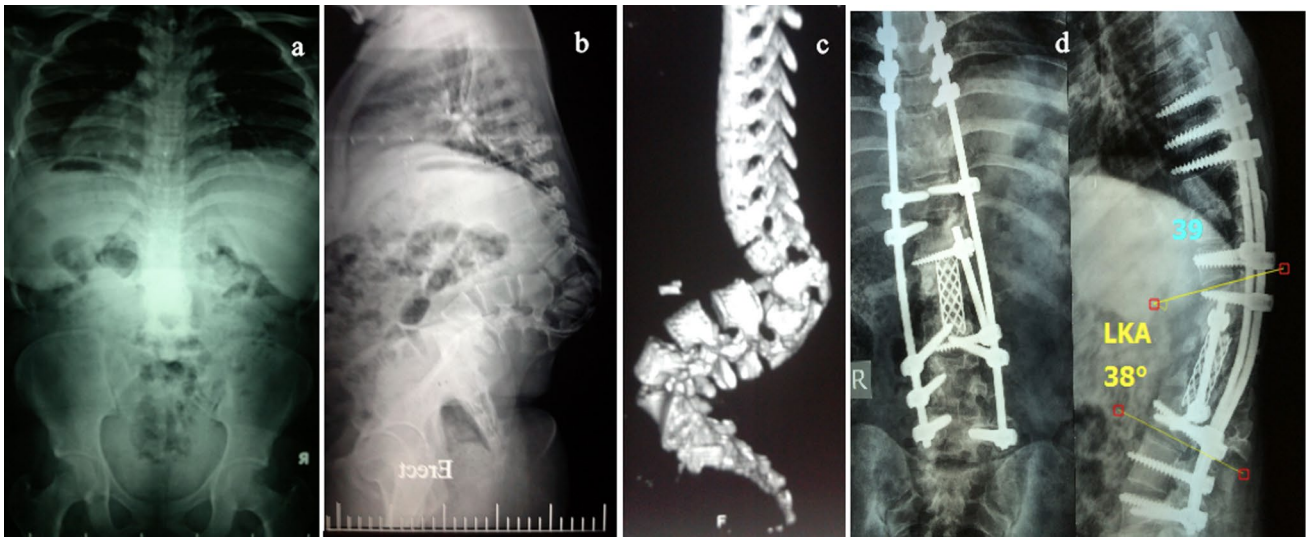

Fig. 4 Female patient 17 years old with neglected congenital kyphosis: **a**, **b** preoperative AP and lateral X-rays showing severe kyphosis with LKA measuring 129°. **c** Preoperative sagittal CT scan. **d** 2-year follow-up AP and lateral X-rays with correction of LKA to 38° with bridging bone around the cage

Table 2 Radiographic data

	Preoperative	2-year follow-up	*P* value
Local kyphotic angle	104.6° ± 19.76° (range 90°–129°)	22.8° ± 15.1° (range 8°–38°)	0.002
Sagittal balance	62.7 mm	21.4 mm	0.01
Main curve Cobb angle	71.2° ± 37.2° (range 28°–102°)	25.6° ± 9.1° (range 15°–33°)	0.001
Coronal balance	32.4 mm	13.6 mm	0.063

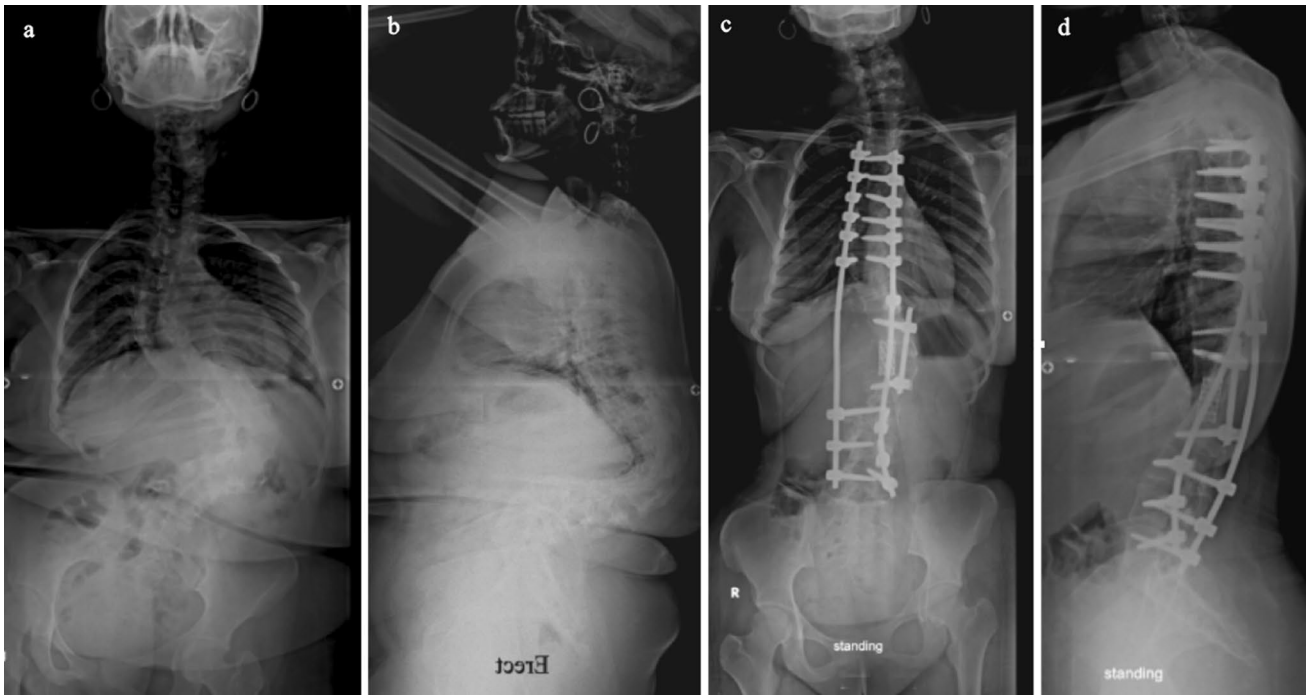

Fig. 5 Female patient 21 years old with neglected congenital kyphoscoliosis: **a**, **b** preoperative AP and lateral whole spine radiograph showing severe scoliosis measuring 102° and thoracolumbar kyphosis with LKA of 107°. **c**, **d** Postoperative AP and lateral whole spine radiograph after correction of the LKA to 26° and correction of the scoliosis to 29°

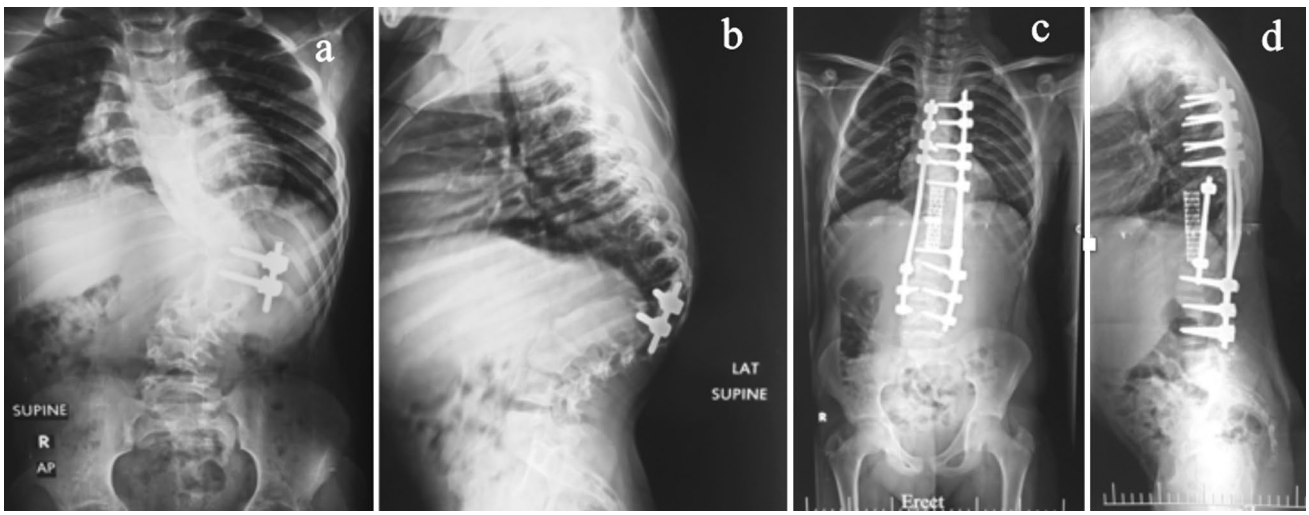

Fig. 6 Male patient 12 years old with neglected congenital kyphoscoliosis with previous surgery for epiphysiodesis: **a**, **b** preoperative AP and lateral whole spine radiograph showing scoliosis measuring 86° and thoracolumbar kyphosis with LKA of 90°. **c**, **d** 1-year follow-up AP and lateral whole spine radiograph after correction of the LKA to 14° and correction of the scoliosis to 20°. However, PJK occurred and the patient is planned for revision surgery

Since Suk et al. [5, 14] described the technique of PVCR, this procedure gained popularity among surgeons for correction of rigid severe deformity [6, 15, 16]. PVCR allows simultaneous manipulation of the anterior and posterior column of the spine through the more familial and less morbid single posterior approach with less operative time and blood loss than the combined approach [9].

However, PVCR is technically demanding with plenty of complications, especially neurological deficit. This procedure should be done by highly experienced teams.

In this study, anterior instrumentation through posterior approach was added to PVCR. We think that those anterior screws provide immediate stability after resection and prevent collapse or translation of the spine during deformity correction which might cause stretch or buckling of the spinal cord. Also, distraction over these screws together with in situ compression over the posterior rods can provide controlled smooth correction of the deformity that may minimize the risk of neurologic complications. Also, anterior fixation adds to the stability of the construct that may promote healing and decrease the incidence of pseudoarthrosis.

Congenital spinal deformities commonly have both kyphosis and scoliosis components. The described new technique can be applied to all cases where the kyphosis component is the dominant one. The idea behind this technique is that in severe kyphosis, after soft tissue dissection at the hump, surgeon can face the lateral wall of the vertebral body. So, the anterior screws can be easily inserted through the lateral wall. We think the described technique is technically difficult to perform in cases with dominant scoliosis or mild kyphosis.

In this study, no neurological deterioration occurred in any patients. Suk et al. [5] reported 2 complete spinal cord injuries (SCI) out of 70 patients. Papadopoulos reported 1 complete SCI in his study that included 45 patients [15]. Wang et al. reported one incomplete SCI out of 24 patients [9].

Control of blood pressure during osteotomy, stabilization of the spine with temporary rod during resection, careful protection of the neural element together with adequate reconstruction of the height of the anterior column to prevent buckling or stretch of the cord are all essential factors to decrease the incidence of neurologic complications [9]. The addition of anterior column screws may provide additional stability during correction and prevent translation or collapse of the spine with a protective effect on the neural elements.

The complications reported in this study were comparable to those reported in previous studies about PVCR in severe rigid deformity. One patient had PJK that was indicated for revision surgery. The incidence of PJK after spinal deformity correction can reach up to 30% [17]. However, despite this high prevalence, radiographic PJK does not always correlate with poor clinical outcome. Proper selection of the upper instrumented vertebrae, restoration of the sagittal balance and avoiding injury of the facet capsule of the non-fused levels can minimize the incidence of PJK [17].

VCR may be associated with a high rate of rod breakage or screws loosening due to marked instability after resection. Many studies (in vitro and in vivo) reported the importance of using satellite, accessory or multiple rods to prevent mechanical complications after three column osteotomies or complex spinal reconstruction. [18–21] Our technique has the advantages of having another anchor point and being in the load sharing anterior column of the spine. We suppose this might be biomechanically advantageous over accessory or satellite rods; however, a biomechanical study to compare these different fixation techniques is needed.

Implant failure can occur in up to 9% in previous studies. [9] This can result in cage dislodgment which may cause catastrophic injuries of the cord. Our technique provides direct stabilization to the cage that may decrease the incidence of cage dislodgment.

Conclusion

PVCR augmented with anterior instrumentation is a powerful, safe and effective method for correction of severe congenital kyphoscoliosis. Up to our knowledge, this is the first report to describe anterior instrumentation through posterior approach in correction of severe kyphosis. The addition of anterior screws through the same posterior approach provides additional stability to the spine and would minimize mechanical complications and rod breakage. This technique allows resection of the rigid kyphus as well as stabilization of both anterior and posterior columns of the spine simultaneously through the traditional posterior approach. This saves the patient the anterior surgery with its morbidity. Up to 100° of sagittal plane correction can be achieved in a single posterior surgery.

Compliance with ethical standards

Conflict of interest We have no conflicts of interest, and we have not received any funding or payments.

References

1. McMaster MJ, Ohtsuka K (1982) The natural history of congenital scoliosis. A study of two hundred and fifty-one patients. JBJS 64(8):1128–1147
2. McMaster MJ, Singh H (1999) Natural history of congenital kyphosis and kyphoscoliosis. A study of one hundred and twelve patients. J Bone Joint Surg Am 81(10):1367–1383
3. Nasca RJ, Stilling F, Stell H (1975) Progression of congenital scoliosis due to hemivertebrae and hemivertebrae with bars. J Bone Joint Surg Am 57(4):456–466
4. Ozturk C, Alanay A, Ganiyusufoglu K, Karadereler S, Ulusoy L, Hamzaoglu A (2012) Short-term X-ray results of posterior vertebral column resection in severe congenital kyphosis, scoliosis, and kyphoscoliosis. Spine 37(12):1054–1057
5. Suk S-I, Kim J-H, Kim W-J, Lee S-M, Chung E-R, Nah K-H (2002) Posterior vertebral column resection for severe spinal deformities. Spine 27(21):2374–2382
6. Lenke LG, O'Leary PT, Bridwell KH, Sides BA, Koester LA, Blanke KM (2009) Posterior vertebral column resection for severe pediatric deformity: minimum two-year follow-up of thirty-five consecutive patients. Spine 34(20):2213–2221

7. Hui H, Zhang Z-X, Yang T-M, He B-R, Hao D-J (2014) Vertebral column resection for complex congenital kyphoscoliosis and type I split spinal cord malformation. Eur Spine J 23(6):1158–1163
8. Tsou PM, Yau A, Hodgson A (1980) Embryogenesis and prenatal development of congenital vertebral anomalies and their classification. Clin Orthop Relat Res 152:211–231
9. Wang S, Aikenmu K, Zhang J, Qiu G, Guo J, Zhang Y et al (2017) The aim of this retrospective study is to evaluate the efficacy and safety of posterior-only vertebral column resection (PVCR) for the treatment of angular and isolated congenital kyphosis. Eur Spine J 26(7):1817–1825
10. Winter R, Moe J, Wang J (1973) Congenital kyphosis: its natural history and treatment as observed in a study of one hundred and thirty patients. J Bone Joint Surg Am 55(2):223–274
11. Leatherman K, Dickson R (1979) Two-stage corrective surgery for congenital deformities of the spine. Bone Joint J 61(3):324–328
12. Bradford DS, Tribus CB (1997) Vertebral column resection for the treatment of rigid coronal decompensation. Spine 22(14):1590–1599
13. Demirkiran G, Dede O, Karadeniz E, Olgun D, Ayvaz M, Yazici M (2017) Anterior and posterior vertebral column resection versus posterior-only technique. Clin Spine Surg 30(7):285–290
14. Suk S-I, Chung E-R, Kim J-H, Kim S-S, Lee J-S, Choi W-K (2005) Posterior vertebral column resection for severe rigid scoliosis. Spine 30(14):1682–1687
15. Papadopoulos EC, Boachie-Adjei O, Hess WF, Perez-Grueso FJS, Pellisé F, Gupta M et al (2015) Early outcomes and complications of posterior vertebral column resection. Spine J 15(5):983–991
16. Wang Y, Zhang Y, Zhang X, Huang P, Xiao S, Wang Z et al (2008) A single posterior approach for multilevel modified vertebral column resection in adults with severe rigid congenital kyphoscoliosis: a retrospective study of 13 cases. Eur Spine J 17(3):361–372
17. Cho SK, Shin JI, Kim YJ (2014) Proximal junctional kyphosis following adult spinal deformity surgery. Eur Spine J 23(12):2726–2736
18. Sun X, Zhu ZZ, Chen X, Liu Z, Wang B, Qiu Y (2016) Posterior double vertebral column resections combined with satellite rod technique to correct severe congenital angular kyphosis. Orthop Surg 8(3):411–414
19. Hallager DW, Gehrchen M, Dahl B, Harris JA, Gudipally M, Jenkins S, Wu AM, Bucklen BS (2016) Use of supplemental short pre-contoured accessory rods and cobalt chrome alloy posterior rods reduces primary rod strain and range of motion across the pedicle subtraction osteotomy level: an in vitro biomechanical study. Spine 41(7):E388–E395
20. Palumbo MA, Shah KN, Eberson CP, Hart RA, Daniels AH (2015) Outrigger rod technique for supplemental support of posterior spinal arthrodesis. Spine J 15(6):1409–1414
21. Shen FH, Qureshi R, Tyger R, Lehman R, Singla A, Shimer A, Hassanzadeh H (2018) Use of the "dual construct" for the management of complex spinal reconstructions. Spine J 18(3):482–490

Affiliations

Belal Elnady[1] · Ahmed Shawky Abdelgawaad[1,2] · Mohamed El-Meshtawy[1]

✉ Belal Elnady
belalelnady83@gmail.com

[1] Department of Orthopedic and Trauma Surgery, Assiut University Medical School, 71111 Assiut, Egypt

[2] Spine Center, Helios Klinikum Erfurt, 99089 Erfurt, Germany