

A new surgical treatment for post-tubercular thoracic kyphosis, a retrospective study.

Wenhao Hu

The First Medical Center of Chinese PLA General Hospital

Huawei Liu

Beijing TsingHua Changgung Hospital

Fangqi Hu

The First Medical Center Chinese PLA Genreal Hospital

Qi Wang

The First Medical Center Chinese PLA General Hospital

Teng Li

The First Medical Center Chinese PLA General Hospital

Yan Wang

The First Medical Center Chinese PLA Hospital

Xuesong Zhang (✉ zhangxuesong301@sina.com)

First Medical Center of Chinese PLA General Hospital

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Abstract

Background: In the late stage of Spinal tuberculosis, the bony destruction and vertebral collapse often leads to significant kyphosis, presenting clinically as a painful gibbus deformity, with increased instability, vertebral body translations. Deformity more commonly occurs and rapidly progresses in the thoracic spine. The surgical treatment of deformity in the thoracic region poses a challenge to the spine surgeon because its high neurological risk. Vertebral column decancellation—a new spinal osteotomy technique, is thought to be suitable for most patients with severe rigid kyphosis. In the current study, we report VCD technique as another surgical strategy for correction of post-tubercular thoracic kyphosis and evaluate the clinical and radiographic patient results.

Methods: Between January 2016 and January 2018, 16 patients with post-tubercular thoracic kyphosis underwent the Vertebral column decancellation. Preoperative and postoperative Konstam's angle were measured. Oswestry Disability Index(ODI), Visual analog scale(VAS) and American Spinal Injury Association(ASIA) were documented. The mean follow-up was 31.4 months

Results: The average operation time was 226 minutes (range, 200–260 minutes) with a mean intraoperative blood loss of 466 mL (range, 400–580 mL). The Konstam's angles decreased from 88.8° (range, 76°–103°) preoperatively to 19.0° (range, 9°–32°) at the final follow-up ($P < 0.01$). The mean VAS score was reduced from preoperative 7.0 (range, 6–8) to 1.7 (range, 1–3, $P < 0.01$) and the ODI improved from 67.6% (range, 59%–77%) to 20.7% (range, 15%–33%, $P < 0.01$). At final follow-up, there was radiographic evidence of solid fusion at the osteotomy site and fixed segments in all patients. Neurological function improved from ASIA scale D to E in 6 patients, C to D in 3 patients.

Conclusion: Our results suggest that VCD is a safe and effective treatment option for post-tubercular thoracic kyphosis. This technique achieves higher correction and fusion rates with adequate decompression of neurological elements.

Background

Spinal tuberculosis is the most common form of the extra-pulmonary tuberculosis. It accounts for nearly half of the musculoskeletal tuberculosis cases. Delayed diagnosis is common and patients treated with anti-TB chemotherapy alone or with simple surgical debridement without fusion may result in disease reactivation.[1] In the late stage, the bony destruction and vertebral collapse often leads to significant kyphosis, presenting clinically as a painful gibbus deformity, with increased instability, vertebral body translations and increased risk of neurologic involvement[2, 3]. Deformity more commonly occurs and rapidly progresses in the thoracic spine[4]. The surgical treatment of deformity in the thoracic region poses a challenge to the spine surgeon because its high neurological risk[5].

Anterior, posterior, or combined anterior and posterior (AP) procedures that show various degrees of success for correcting kyphosis of TB^[6–8]. The late correction of stiff and sharp angular deformities (more than 60°) is only feasible with three-column osteotomies or vertebral column resection (VCR)[9].

Pedicle subtraction osteotomy (PSO) (Fig. 1A), recommended 30–40° as a safe range [10, 11], is usually insufficient to correct severe kyphosis. Despite VCR (Fig. 1B) is considered as the most powerful tool for the correction of spinal deformity, this technique is a formidable last resort technique for severe fixed sagittal and coronal deformity due to its technical difficulty and potential for complications [12].

Vertebral column decancellation (VCD) (Fig. 1C), a combination of the eggshell technique, Smith-Petersen osteotomy (SPO), PSO and VCR, is thought to be suitable for most patients with severe rigid kyphosis [13]. In the current study, we report VCD technique as another surgical strategy for correction of post-tubercular thoracic kyphosis and evaluate the clinical and radiographic patient results.

Materials And Methods

23 patients with post-tubercular thoracic kyphosis were admitted to our department from January 2016 to January 2018. Diagnosis was made based on radiographic examination, laboratory tests and histopathology. This study was conducted with approval from the Ethics Committee of Our Hospital and was performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants. The indications for surgery were as follows: (1) low back pain refractory to conservative treatment; (2) being not able to lie down in dorsal position; (3) increasing neurological deficit. Patients with active infection and who cannot tolerate surgery due to poor cardiopulmonary function were excluded. Anteroposterior, lateral spine radiographs, CT 3-D reconstruction, Magnetic Resonance Imaging (MRI) were available for all patients (Fig. 2).

In all, 16 patients of whom (7 males, 9 females; mean age 38.9 years) underwent the VCD technique. The mean Konstant's angle [14] was 88.8° (ranging from 76° to 103°). Among the 16 patients, 6 patients underwent an initial debridement without fusion. Neurologic deficits were assessed according to the American Spinal Injury Association (ASIA) grading system as follows: ASIA E, 3 cases; ASIA D, 10 cases; and ASIA C, 3 case. Pain was assessed using the visual analogue score (VAS). Disability status was assessed using the Oswestry Disability Index (ODI). All patients' radiological and clinical records were recorded preoperatively, postoperatively and during the last follow-up period. Operation time, blood loss, and osteotomy levels were noted. (Table 1)

Table 1
 ☒ Demographic and Clinical Data

Patient	Age	Sex	Osteotomy level	Instrumented levels	Operative time	Blood loss	Follow-up
					(min)	(ml)	(mon)
1	32	M	T8-T9	T5-T8,T10-L1	250	420	29
2	41	M	T7-T8	T4-T7,T9-T12	260	580	33
3	50	F	T5-L8	T2-T5,T8-T11	240	450	32
4	37	M	T9-T10	T6-T9,T11-L2	220	480	31
5	35	F	T5-T7	T2-T5,T8-T11	200	430	30
6	29	F	T6-T8	T2-T5,T8-T11	210	410	32
7	32	M	T8-T9	T5-T8,T10-L1	220	400	28
8	54	F	T10-T11	T7-T10,T12-L3	240	450	35
9	32	M	T5-T7	T2-T5,T8-T11	230	480	29
10	43	F	T7-T9	T3-T6,T9-T12	250	450	32
11	36	M	T6-T7	T2-T5,T7-T10	210	530	34
12	41	F	T5-T6	T2-T5,T7-T10	200	450	31
13	40	M	T7-T8	T4-T7,T9-T12	220	520	36
14	36	F	T7-T9	T4-T7,T10-L1	240	470	27
15	46	F	T5-T7	T2-T5,T8-T11	210	430	29
16	38	F	T6-T8	T3-T6,T9-T12	230	520	34

Operative Technique

All surgeries were performed under monitoring of somatosensory-evoked potentials, transcranial motor-evoked potentials, and free-running electromyography. Under general anesthesia, the patient was placed prone on the operating table, and a standard posterior middle incision was made at the predetermined level. The spine was exposed by dissection lateral to the costotransverse joint at the thoracic level and the lumbar transverse process. The segmental vessels were coagulated using electric cauterization and hemostatic gauze. Pedicle screws (Weigao Orthopedic, Shandong, China) were then placed four levels above and below the damaged vertebral body by freehand technique. C-arm fluoroscopy was used to confirm the appropriate insertions.

Then, VCD was performed. The pedicle probe and drill were used to create and enlarge the relatively normal pedicle holes of the fused vertebrae with both sides of the pedicles. These fused vertebrae were treated as one targeted vertebra. Through the pedicle holes, the cancellous bone of the posterior half of the osteotomy column was adequately removed using rongeur and curette. A high-speed drill was used to thin the anterior cortex and lateral walls of the vertebral body and linear fractures of the anterior cortex were achieved using an osteotome. Then the spinal canal was opened laterally, and the posterior elements including the spinous process, bilateral lamina, transverse process, and the adjacent facet joints were removed. After removing the posterior cortical bone of the osteotomized vertebra, the kyphotic spine is corrected using gentle manual force stabilized by a temporary rod. The operating table and the position of the patient were adjusted for the correction.

During the correcting procedure, an anterior opening wedge was created and the middle column was preserved as the hinge. The posterior interlaminar fusion was completed over the fixed segments with residual autogenous bone. After confirmation of absent soft or bony compression, a drainage tube was placed in the surgical field, and the wound was closed in layer sequence.

Statistical analysis

All statistical analysis was performed with SPSS v19.0 software (SPSS Inc., Chicago, Illinois). Student's t-test was used for all analyses, and a p-value < 0.05 was considered statistically significant.

Result

VCD osteotomy was performed in all patients. All patients completed follow-up of 31.4 months on average, from 27 to 36 months. The average operation time was 226 minutes (range, 200–260 minutes) with a mean intraoperative blood loss of 466 mL (range, 400–580 mL). The Konstantin's angles decreased from 88.8° (range, 76°–103°) preoperatively to 19.0° (range, 9°–32°) at the final follow-up ($P < 0.01$). The preoperative and last follow-up data of the 16 patients were shown in Table 2.

Table 2
The preoperative and last follow-up data

Patient	Konstam's angle(°)		ASIA		ODI(%)		VAS	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
1	85	22	D	E	65	22	7	2
2	93	32	D	E	67	18	8	2
3	100	32	D	E	75	23	7	2
4	103	28	D	E	62	19	6	2
5	78	11	D	D	69	15	8	2
6	85	18	E	E	63	20	6	1
7	97	16	C	D	59	17	7	1
8	94	13	D	E	65	22	7	2
9	88	9	E	E	67	15	8	3
10	94	22	D	D	74	22	7	1
11	81	17	D	E	66	19	6	1
12	85	15	D	D	67	25	7	2
13	89	17	C	D	75	28	7	1
14	93	21	C	D	77	33	7	2
15	81	18	D	D	62	15	7	1
16	76	13	E	E	68	18	7	2

ASIA : American Spinal Injury Association; VAS: visual analogue score; ODI: Oswestry Disability Index.

The mean VAS score was reduced from preoperative 7.0(range, 6–8) to 1.7 (range, 1–3, $P < 0.01$) and the ODI improved from 67.6% (range, 59–77%) to 20.7% (range, 15–33%, $P < 0.01$). At final follow-up, there was radiographic evidence of solid fusion at the osteotomy site and fixed segments in all patients. Neurological function improved from ASIA scale D to E in 6 patients, C to D in 3 patients.

Dural tears with transient cerebrospinal fluid leakage were encountered in one case who underwent an initial debridement, The tear was covered intraoperatively by muscle and fat grafts, lumbar drainage was placed and removed after seven days. No deep wound infection was identified. One patient suffered transient partial neurological deficit post-operatively and resolved completely within 8 weeks.

Discussion

TB spondylitis can lead to a significant osteolysis and collapse of the vertebral bodies, which results in hyperkyphosis and tethering of the spinal cord[15]. Late stages of rigid hyperkyphosis are difficult to treat[9]. The sharp angular hyperkyphosis often requires complex three-column osteotomies. Currently, the one-stage posterior approach is most often used for minimizing the risk of injury to anterior vascular and visceral structures. Pedicle subtraction osteotomy (PSO), the most popular osteotomy technique, has been applied for progressive tubercular thoracic and thoracolumbar kyphosis. Kalra et al[16] used Pedicle subtraction osteotomy to treat 15 patients with healed tuberculosis of the spine and a resultant kyphosis. They obtained a mean correction of 44.2°. The mean pre-operative kyphosis was 58.8° and the mean post-operative kyphosis was 13.7°. The mean operative time was 210 min (110–220 min) and the mean blood loss was 940 ml (550–1550 ml). Of the 15 patients, 2 complained of mild residual pain which settled with analgesics. There was a superficial wound infection in two patients and one deep infection that required debridement. The osteotomy is described as closing wedge osteotomy and correction of the deformity is achieved by the shortening of posterior column. However, the technique should be limited to 30°–40° as a safe range of single segment osteotomy; otherwise, the spinal cord is excessively shortened and distorted[17]. Some modifications of PSO are reported that could obtain a greater correction angle .Wu SS et al.[18] claimed that they obtain an average angle of correction was 38.8°(25°–60°) without postoperative complications. However, it is not suitable to correct a severe kyphotic deformity with a Konstantin's angle beyond 90°.

Although VCR or Posterior-only VCR could provide the greatest amount of surgical correction when compared to all other spinal osteotomy types[19], it is restricted owing to its high inherent neurological risk related to the instability induced during correction of the malformation[20]. The complication rate has been estimated as high as 59% for posterior VCR[21]. Zheng et al.[22] described Posterior-only multilevel modified vertebral column resection for extremely severe Pott's kyphotic deformity, and the spinal sagittal Konstantin's angle was corrected from a preoperative kyphosis 100.3° to a postoperative angle of 15.9°. The mean duration of surgery was 285 min (246–400 min), the average intraoperative blood loss was 2933 ml (2000–6000 ml). a neurological deficit occurred in 1 patient in their study. This procedure, however, was recommend to be performed at or below lower thoracic spine. In our study, The Konstantin's angles decreased from pre-operative 88.8°(76°– 103°) to 19.0°(9°– 32°)at the final follow-up. The mean operation time was 226 min (200–260 min) with a mean intraoperative blood loss of 466 mL (400–580 mL). No permanent neurological deficit or other major complications occurred. VCD technique is a simpler and safer osteotomy procedure than VCR, and at the same time it allows a greater correction angle than PSO.

For those with upper post-tubercular thoracic kyphosis, we prefer the VCD technique. First, post-tubercular fused vertebrae were treated as one targeted vertebra so that one-level osteotomy could obtain satisfactory outcomes. Second, Osteoclasts of anterior cortex of the osteotomy vertebra facilitates the correction of a rigid kyphosis[13].Third, Compared to PSO, a kind of closing wedge osteotomy (CWO), VCD technique could open the anterior column of the targeted vertebrae when posterior column closing that allows greater correction angles. In our study, the average correction angle was 69.9°, and the maximum correction angle was 81°; In addition, VCD preserves the middle column as the hinge providing

greater stability and better fusion than VCR. All of the 16 patients with post-tubercular thoracic kyphosis who underwent VCD technique achieved satisfactory rehabilitation and no permanent neurological complications occurred.

Conclusion

Our results suggest that VCD is a safe and effective treatment option for post-tubercular thoracic kyphosis. This technique achieves higher correction and fusion rates with adequate decompression of neurological elements.

Abbreviations

AP: Anterior and Posterior; VCR: Vertebral Column Resection ; PSO: Pedicle subtraction osteotomy; VCD: Vertebral column decancellation; MRI: Magnetic Resonance Imaging; ASIA : American Spinal Injury Association; VAS: Visual Analogue Score; ODI: Oswestry Disability Index.

Declarations

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Availability of data and materials

The spinal internal fixation devices including pedicle screws, rod, and cage in surgical procedure are available and produced by Weigao Orthopedic, Shandong,China. The patients' data were collected in Chinese PLA General Hospital, the First Medical Center.

Authors' contributions

All authors have read and approved the final manuscript. WH. H was involved in the study design, data collection, drafting and revising of the manuscript. HW.L was involved in the study design, analysis and interpretation of the data, drafting and revising of the manuscript

FQ.H was involved in the data collection. Q.W was involved in the analysis and interpretation of data. XS. Z and T.L were involved in the study design, data collection, analysis and interpretation of the data .Y.W. was involved in the study design, drafting and revising of the manuscript and has given final approval.

Ethics approval and consent to participate

This study was conducted with approval from the Ethics Committee of Chinese PLA General Hospital and was performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures



Figure 1

Spinal osteotomy for Pott's deformity a) Pedicle subtraction osteotomy(PSO) b: Vertebral column resection(VCR) c: Vertebral column decancellation(VCD)



Figure 2

Pre- and post-operative radiological outcomes. An 50-year-old woman with Kyphotic deformity secondary to spinal Tuberculosis. Muscle strength decreased (grade 4/5) in the hip flexor, quadriceps and sphincter disturbance. Pre-operative radiographs (a,b), CT (c) and MRI (d) show that the apex of kyphosis is located at T5-T8, The Konstantin's angle was 100°. The kyphosis was corrected to only 32° immediately after the surgery. (e,f,g). Neurological function improved from ASIA scale D to E. Solid fusion of resection site was achieved 2.5 years postoperatively (h).