Surgical management of severe rigid tuberculous kyphosis of dorsolumbar spine

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Abstract To assess the effectiveness of deformity correction and safety of the two major corrective spinal surgical procedures, 35 patients, aged 14–47 years, were placed into two groups according to procedures performed. Sixteen patients (group A) had four-stage procedures including initial halo-pelvic distraction after anterior release and a subsequent three procedural steps plus brace. Nineteen patients (group B) had one-set two-stage procedures: wire segmental stabilisation in eight cases and rod/hook and/or pedicle screw stabilisation in 11 cases. Average preoperative kyphosis in group A was 88° and postoperative at zero, three, six, and 18 months were 29°, 33°, 35° and 35°, respectively, while those of group B were 86° preoperative and postoperative 27°, 31°, 33°, and 33°, respectively. Neural complication developed in five cases: one in group A and four in group B. It was concluded that the one-set two-stage procedure is more

efficient, time-saving, and cost-effective, though it is highly challenging with relatively high rates of neural complication.

Introduction

Healed severe rigid tuberculous kyphosis with intact neurology was not a controversial clinical issue until early 1980, because deformity itself did not impair functional activity function. However, since mid-1980, non-paralytic young patients tend to have very high aesthetic demands [1–3]. This has led to the development of safe and effective corrective surgical procedures for unsightly kyphosis or kyphoscoliosis, but each patient must be considered individually [3–11].

Surgical deformity correction is clinically challenging because it is difficult and dangerous with many complications, particularly neurological [1, 3, 5, 11].

Our surgical goals in spinal deformity correction were to meet the patient's aesthetic demand, to maintain neural function or to perform neural decompression and stabilisation with fewer complications.

This retrospective study presents the evolution of instrumentation surgery for tuberculous kyphosis with a focus on the more complex applications of the two different major corrective surgical procedures, and assesses the efficiency of each procedure in achieving deformity correction. Also, spinal fusion, correction loss, fixation failure, and postoperative as well as improvement, including column and neurological function were recorded.

Material and methods

Thirty-five patients with unfused severe tuberculous kyphosis were included in this study. They who were treated

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between 1985 and 2005 at eight affiliated hospitals of the Catholic University of Korea, Dong-Shin General Hospital, Seoul, and Sun General Hospital, Daejeon. Patients' ages ranged from 14 to 47 years.

Patients were placed into two groups. Group A patients were cases in the early series, and group B patients were cases of the late series. Postsurgical sagittal alignment on the basis of the sagittal vertical axis and adjacent joint disease were not studied.

Group A

Sixteen patients were subjected to four-stage surgical procedures, which included: (1) application of the halo-pelvic distraction apparatus, subsequent anterior release, and axial distraction for six weeks; (2) wide wedge resection of the posterior column and body (partial) and additional axial distraction for two weeks; (3) posterior instrumentation for instrument-aided additional distraction before removal of halo-pelvic device; and (4) mixed anterior strut and massive cancellous chip grafts plus brace. The Harrington system was used in six patients and the Luque rod system with segmental wiring in ten patients.

During the second step of the surgical procedure, cord pulsation was observed after full exposure of the cord. The distraction at any stage of the procedure was immediately released if neurological symptoms developed; it was also stopped if there was severe pain in the neck and/or osteotomy site.

Group B

Nineteen patients were subjected to the one-set two-stage surgery, which included: (1) wide posterior wedge bone resection including vertebral bodies and pre-planned posterior instrument-aided correction and instrumented stabilisation, and (2) anterior interbody fusion with strut and massive cancellous chip bone grafts.

These cases were subdivided into two groups based on the stabilisation instruments. There were eight cases of posterior segmental wire stabilisation (six pure Luque's stabilisations and two Harrington-Luque's stabilisations) which were categorised as B-1, and 11 cases of hook and/or pedicle screw system as B-2. Group B-2 was further subdivided in two: four cases of hybrid fixation system (proximal hook and distal pedicle screw system) as B-2a and seven cases of pure pedicle screw system as B-2b.

All operations were carried out in the prone position under normotensive general anaesthesia. During surgery blood loss was continuously replaced to maintain the normal blood pressure. Cold saline wound irrigation during posterior surgery was avoided so as not to reduce cord

circulation. Cord pulsation was monitored during surgery and a wake-up test was repeated during surgery.

Temporary malleable rods were used routinely to prevent sagittal translation during correction and to reduce the risk of neurological injury in group B.

At the time of final instrumented stabilisation of the osteotomised kyphotic spine, utmost attention was paid to balance the anterior spinal column and cord length.

Assessment

Pre- and postoperative tuberculous kyphosis was measured by Cobb's method. Establishment of anterior fusion was defined as the time when loss of correction stopped.

Results

The overall average kyphosis in 35 patients preoperative and postoperative at zero, three, six and 18 months were 87° (range 62–123°), 28° (23–61°), 32° (25–67°), 34° (31–67°) and 34° (31–67°), and the correction rates at postoperative zero, three, and 18 months were 67.9%, 63.2%, and 60.9%, respectively (Table 1).

Group A

There were 16 patients in group A, which was the four-stage corrective procedure group. Average preoperative kyphosis in group A was 88° (range 62–123°) and postoperative at zero, three, six, and 18 months were 29° (26–43°), 33° (32–46°), 35° (33–48°) and 35° (33–49°), respectively. The average correction rates postoperatively at zero, three, six, and 18 months were 67.0%, 62.6%, 60.2% and 60.2%, respectively (Table 1, Figs. 1 and 2).

Group B

Group B cases were for posterior instrument-aided deformity correction and stabilisation after posterior partial vertebrectomy, and subsequent second stage anterior interbody fusion ($n=19$ patients). Average kyphosis preoperatively was 86° (range 69–120°), and postoperative at zero, three, six, and 18 months were 27° (23–61°), 31° (25–67°), 33° (32–67°) and 33° (32–67°), respectively. The average correction rates at postoperative zero, three, six, and 18 months were 68.6%, 63.9%, 61.6% and 61.6%, respectively (Table 1).

Group B-1

This subgroup considered posterior segmental stabilisation (Luque's) in eight patients. Average kyphosis at pre- and

Table 1 Results of corrective spine operations ($n=35$ cases)

Surgical procedures (cases)	Kyphosis (range) and correction rates					Final	Remarks
	Preoperative	Postoperative			18 months		
		0 months	3 months	6 months			
Four-stage procedures (<i>n</i> = 16) Anterior release and halo-pelvic traction, posterior resection, anterior fusion, posterior instrumentation and PL fusion	88° (62–123°)	29° (26–43°)67.0%	33° (32–46°)62.6%	35° (33–48°)60.2%	35° (33–49°)60.2%	One C paralysis recovered one grade up	
Posterior instrument-aided (<i>n</i> = 19) deformity correction after posterior column resection + AIF	86° (69–120°)	27° (23–61°)68.6%	31° (25–67°)63.9%	33° (32–67°)61.6%	33° (32–67°)61.6%		
Posterior segmental stabilization (<i>n</i> = 8) Luque system (<i>n</i> = 6) H-L system (<i>n</i> = 2)	88° (69–120°)	29° (24–61°)67.1%	34° (31–61°)61.1%	36° (31–61°)59.1%	36° (31–61°)59.1%	One C paralysis recovered one grade up	
Hooks and/or pedicle screw system (<i>n</i> = 11)	84° (77–119°)	28° (23–41°)66.7%	30° (29–45°)64.2%	34° (32–45°)59.5%	34° (32–45°)59.5%	One C paralysis recovered one grade up	
Hybrid fixation (proximal hooks and distal pedicle screws) (<i>n</i> = 4)	77° (71–112°)	25° (24–37°)67.5%	30° (29–40°)62.3%	35° (32–46°)54.5%	35° (32–47°)54.5%		
Pedicle screws only (<i>n</i> = 7)	91° (73–118°)	30° (23–37°)67.0%	31° (29–41°)65.9%	33° (32–41°)63.7%	33° (32–45°)63.7%	Two B paralysis did not recover	
Average kyphosis at each observation time	87° (62–123°)	28° (23–61°)67.9%	32° (25–67°)63.2%	34° (31–67°)60.9%	34° (31–67°)60.9%		

PL posterolateral, *H-L* Harrington-Luque, *AIF* anterior interbody fusion

Fig. 1 Pre- (a) and postoperative (b) lateral radiograms show Harrington-distraction rod instrumentation in a 26-year-old woman with T₁₂-L₃ tuberculous kyphosis (98°). Final kyphosis was 33°

postoperative zero, three, six, and 18 months were 88° (range 69–120°), 29° (24–61°), 34° (31–61°), 36° (31–61°), and 36° (31–61°), respectively. The average correction rates at postoperative zero, three, six, and 18 months were 67.1%, 61.1%, 59.1% and 59.1%, respectively.

Group B-2

This subgroup considered rod/hook and/or pedicle screw system fixation in 11 patients. The average kyphosis at pre- and postoperative zero, three, six, and 18 months were 84° (71–119°), 28° (23–41°), 30° (29–45°), 34° (32–45°) and 34° (32–45°), respectively. The average correction rates at postoperative zero, three, six, and 18 months were 66.7%, 64.2%, 59.5% and 59.5%, respectively (Table 1, Fig. 3).

Group B-2a

This subgroup considered hybrid fixation (rods/proximal hook and distal pedicle screw fixation) in four patients. The average kyphosis at pre- and postoperative zero, three, six, and 18 months were 77° (71–112°), 25° (24–37°), 30° (29–40°), 35° (32–46°) and 35° (32–47°), respectively. The average correction rates at postoperative zero, three, six, and 18 months were 67.5%, 62.3%, 54.5% and 54.5%, respectively (Table 1, Fig. 4).

Group B-2b

This subgroup considered rods/pure pedicle screw fixation in seven patients. The average kyphosis at pre- and postoperative zero, three, six, and 18 months were 91° (73–118°), 30° (23–37°), 31° (29–41°), 33° (32–41°) and 33°

Fig. 2 Severe tuberculous kyphoscoliosis (80°) at T₁₀-T₁₂ in a 14-year-old boy with Frankel C paralysis (a). Residual kyphosis (45°) after bilateral costotransversectomy and posterior segmental instrumentation with Rush nail and segmental wiring (b). Three rib grafts between T₁₀-L₁ were inserted to fill the anterior column defect which developed after instrument-aided correction and stabilisation (c). Corrected deformity (49°) was well maintained up to seven months without graft failure (d)

(32 – 45°), respectively. The average correction rates at postoperative zero, three, six, and 18 months were 67.0%, 65.9%, 63.7%, and 63.7%, respectively (Table 1, Fig. 4).

In the one-set two-stage instrument-aided correction and stabilisation group, the loss of correction was greater in the hybrid fixation (B-2a, 10° and Luque B-1, 7°) groups than that of pure pedicle screw fixation (group B-2b, minimum 3°). However, there were no statistically significant differences in correction rates between groups A and B.

Overall anterior graft consolidation started from 3.5 months postoperative (range, three to four months) and completed at six months postoperatively (range, five to nine) on average, which was proven by the stabilised sagittal curve.

There were four types of complications: neurological complication in five cases (14.3%), thrombophlebitis in three cases (8.6%), bed sore in three cases (8.6%), and superficial wound and halo pin tract infection in four cases (11.4%). Wound infection was well controlled in all. None of the patients complained of pain around the osteotomy site.

One Frankel C paralytic (6.2%) out of 16 group A patients recovered to D. There were four Frankel B paralytics (21.1%) out of 19 group B patients, two (10.5%) did not recover while two (10.5%) recovered to D. Mesenteric arterial occlusion was not encountered. None of the patients complained of pain around the osteotomy sites. All patients except the two Frankel B paralytics were satisfied with the surgical results including residual kyphosis. There was no pseudarthrosis, graft failure, fixation and/or instrument failure.

Discussion

Severe spinal deformities are caused by various diseases; some are congenital and the others are acquired in origin [12–16]. Young non-paralytic patients with severe rigid tuberculous kyphosis tend to have very high aesthetic demands [3, 5]. This had led to the development of safe and effective corrective surgical procedures for the unsightly kyphosis [1–3].

Even in patients with the same degree of spinal deformity, the spinal canal shape and cord conditions are individually different. This is because in severe tuberculous kyphosis around the apex level of gibbus, the bony anatomy is severely deformed, and cord in the area is also deformed, less mobile and ischemic. It is often trapped in the deformed narrow hypoplastic canal, and is adherent to the dura [1, 3, 5].

There are also variations in blood supply to cord by the radicular artery (Adamkiewicz) in the lower dorsal spine. In spondylectomy, some authors particularly stress the importance of saving the segmental vessel intact for the cord blood supply [17, 18], while others disagree [17, 18]. However, this radicular arterial issue in deformity correction surgery of the tuberculous kyphosis has never been discussed. Thus, each patient must be considered individually in correction surgery [4, 5].

Until now there have been few reports on the results of corrective surgery of severe tuberculous kyphosis [1, 3, 5, 7–9]. Among those studies none separated the patients into several groups, e.g. healed and unhealed tuberculosis and less severe and very severe group, or fused kyphotic block

Fig. 3 Preoperative simple radiographs (a) of a 47-year-old paraparetic woman with tuberculous kyphosis of T₁₂-L₂ illustrate 70° of the initial kyphosis. Kyphosis at postoperative zero (b), six (c), and 18 months (d) were 30°, 36°, and 36°, respectively. Total loss of correction was 6°

spine and unfused (non-block) kyphotic spine. Also, none dealt essentially with the aesthetically acceptable and safe degree of correction with maintenance of normal spinal function. Some authors, including the senior author of this series, doubted the unsubstantiated concept and/or rationale that complete deformity correction is essential [5–9].

Surgery should be considered on the basis of the overall preoperative structural deformities at the gibbus area and the spine above and below the gibbus. Surgically correctable degrees of kyphosis depend on rigidity of the lesion due to morphological deformities of the vertebral bodies, discs and rib cage.

In early 1970, Yau et al. recommended a thorough anterior release which was an important pre-requisite to good correction by halo-pelvic distraction, because the deformity in healed tuberculosis was more rigid than that of active disease and that in the young [1]. In their series average correction angle in the 30 patients was 32.4°, which was 28.3% of the preoperative curve. They reported that structural changes of the vertebral bodies and discs

prevented the full correction of kyphosis [1], and they later concluded that the complication hazards of deformity correction outweighed the gain. They concluded that it should not be carried out for cosmetic gains. We modified the procedure of Yau et al. and shortened the application period of the halo-pelvic apparatus to nullify or minimise traction-related complications.

Recently, decancellation or posterior closed wedge resection and subsequent instrument-aided correction and stabilisation has become popular [18–28]. However, those two procedures are not applicable to the unfused severe deformities.

Sapardan et al. reported on 16 out of 21 patients who received non-distraction treatment (NDT) and five patients who received distraction treatment (DT). The average pre- and postoperative kyphosis in the NDT group were 100.3° and 53.5°, respectively, while those of the DT group were 101° and 27.4°, respectively. Thus, correction rates in the NDT and DT groups were 46.8% and 73.6%, respectively. In their series, three (18.8%) out of 16 NDT patients

Fig. 4 Initial rigid tuberculous kyphosis of 95° at T₁₀-T₁₂(a) in a 37-year-old man became 57° (b) after staged surgical procedures. Posterior column resection and instrument-aided correction and stabilisation as a second step after a first step anterior release procedure, and anterior two ribs and cancellous bone grafts as the last procedure which was followed up over three years

developed neurological complications, while none of the DT group developed neurological complications. They obtained better results than Yau et al. [10]. However, their results were similar to ours.

Kawahara et al. reported that they could correct the average 67° of non-tuberculous kyphosis to 18° safely without neural complication, and that four paraparetic patients recovered to normal after surgery [17].

In six patients of Kalra et al., average kyphosis at the pre- and postoperative zero and final follow-up were 79.3°, 21.0°, and 28.5°, respectively. However, they did not mention in detail the preoperative rigidity of the fused and unfused kyphotic segments [7].

It was known that patients who had gradual gentle distraction treatment by halo-pelvic apparatus had less neurological complications than in a two-stage procedure without distraction, and that the four-stage procedure was a time-consuming tedious procedure with high traction-related complications [1, 10].

It is our view that before deformity correction, sufficient room for the cord should be provided by excising the scar and diseased tissues around the cord during vertebral osteotomy. Subsequently, the demonstrable segmental spinal movement at the osteotomy or spondylectomy site before deformity correction should be examined. In the early era of deformity correction surgery, to produce complete fracture of the osteotomised and decancellated vertebrae, repeated gentle force under the cover of a stabilisation instrument or device was applied. During this

maneuver, rods should be allowed to slide axially. Utmost care should be paid not to close the posterior gap suddenly.

In groups A and B of our series, average overall correction rates at 18-month follow-up were similar (60.2% and 61.6%). Anterior graft consolidation or fusion on radiographs in both groups took an average six months postoperatively. Therefore, the two stage procedure is thought to be the more efficient, time-saving, and cost-effective procedure.

Previously reported complications were neurological injury, pulmonary embolism and pneumonia, thrombophlebitis, infection, pseudarthrosis, bed sores, superior mesenteric artery syndrome, wound dehiscence, subcutaneous metal prominence and painful adventitious bursa over metal, and hardware and/or fixation failure [1, 7, 8, 10, 13, 23, 26].

Yau et al. listed the two types of management-related complications [1] as traction- and surgery-related. Most of the traction-related complications were localised to the cervical spine and were grave. However, luckily, they did not experience surgery-related neural complication.

In our series, the complication rates were similar to those of previous authors. However, the neural complication rates were relatively higher (21.1%) in the two-stage procedure group than the multi-stage procedure group with halo-pelvic distraction (6.2%) [10, 13].

In the multi-stage procedure series of Yau et al., most of the complications were traction-related [1], while complications in our current one-set two-stage procedure group were surgery-related.

Overall reported incidence of neurological deficit after pedicle subtraction and closed wedge osteotomies ranged from 0% to 15.2% [5, 10, 13, 23].

Cho et al. recommended not to hyper-extend the anterior column at the time of kyphosis correction to avoid the superior mesenteric artery syndrome [8].

In addition to these factors, we additionally stress that the column and cord length be equalised to create balance to avoid neural stretch or kinking [5, 26].

Limitations of our study are the small number of patients in each group, short observation time, and lack of sagittal balance studies of the whole spine and adjacent segment disease.

An accepted regimen in correction surgery should be developed which does not jeopardize the cord and nerve root function.

Future study will essentially be to clarify whether bone morphogenic protein will hasten and guarantee early solid fusion, minimise of loss of correction and avoid of instrument fixation failure [5].

Any decision to operate must weigh the high complication and reoperation rates against anticipated improvement. Therefore, risks and complications must be fully understood, and the patient must ultimately choose between those risks and his/her quality of life.

It is concluded that the two-stage surgical procedure using the pedicle screw fixation system is more efficient, time-saving, and cost effective, though it is highly challenging with relatively high surgical risks. Also, the one-set two-stage or one-stage procedure is a more well-accepted and competitive procedure which will replace the multi-stage procedures [5, 17] if neural complications can be minimised or avoided.

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