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Kyphus Correction in Spinal Tuberculosis

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Late-onset paraplegia is best avoided by correcting severe kyphosis in the active, healing, or healed stages of spinal tuberculosis. We report 16 patients with dorsal or dorsolumbar spinal TB—nine with paraplegia, seven without paraplegia—who underwent kyphus correction. Nine patients had active, five partially treated, and two healed disease. The patients ranged in age from 3 to 38 years and had a mean kyphosis of 58.5° (range, 35°–76°). Mean vertebral body involvement on computed tomography was 4.2 (2–9), and mean initial vertebral body loss was 1.76 (1–2.6). The sequential steps for kyphus correction were anterior corpectomy, shortening of the posterior column, posterior instrumentation and anterior gap grafting, and posterior fusion as a single-stage procedure by the extrapleural anterolateral (costotransversectomy) approach. Minimum followup was 3 months (range, 3–36 months). All but one patient with neural deficit showed complete neural recovery. Mean kyphosis correction was 27.3° (range, 9°–42°). Mean correction loss on 1-year followup was 1.4° (range, 0°–4°).

Level of Evidence: Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Neurologic deficit in patients with healed tuberculosis of the spine (late-onset paraplegia) is difficult to treat. Late-onset paraplegia is observed more often in patients with long-standing healed kyphosis of 60° or more.[16] These patients also have marked compromised cardiopulmonary function and painful costopelvic impingement.[1,16] The spinal cord undergoes intrinsic changes. Thus, overall prognosis is poor for neural recovery.[1,3,4,16]

Cosmetic correction of severe kyphosis with healed spinal TB is fraught with the risk of neural deterioration. It is desirable to prevent the development of severe kyphosis in the active stage of spinal TB.[16] However, if the patient presents for the first time with severe kyphosis in the active stage of the disease, or in a child if the kyphosis is likely to progress with growth, it should be corrected.[4]

We questioned to what extent neurologic recovery would occur and to what extent kyphus correction could be maintained. We also describe the complications.

MATERIALS AND METHODS

We retrospectively reviewed 16 patients with TB of the spine (C7–L2) who underwent surgical decompression and kyphus correction. There were four male patients and 12 female patients, with a mean age of 15.6 years (range, 3–38 years) and a mean kyphosis of 58.6° (range, 35°–76°). Two patients had kyphosis between 30° and 40°; one patient between 40° and 50°; five patients between 50° and 60°; and eight patients more than 60°. Seven patients were intact neurologically and nine had paraplegia. Seven patients had Grade IV paraplegia and two had Grade II paraplegia.[4] Eleven were children and five were adults (3–10 years, n = 4; 11–18 years, n = 7; older than 18 years, n = 5). Two patients had a healed lesion after 1 year of antitubercular therapy (ATT). Five had partially treated lesions (on ATT for 4–6 months) and, in nine cases, ATT was begun on presentation. The minimum followup was 3 months (mean, 13.2 months; range, 3–36 months); nine patients had a followup of more than 1 year.

The mean initial vertebral body loss was 1.76 (range, 1–2.6). Mean vertebral body involvement was 2.5 (range, 1–4) on plain radiograph of the spine (lateral view) and 4.6 (range, 2–9) on computed tomography scan. The apex of the lesion was in the upper dorsal region in six patients (D1–3, n = 2; D4–6, n = 4), the lower dorsal region in seven patients (D7–9, n = 3; D10–12, n = 4), and the dorsolumbar spine in three patients. Four adult patients (without neural deficit, n = 2; with paraplegia, n = 2) had severe kyphosis, while the fifth had an unstable spine because of panvertebral disease and needed stabilization. All children but two had severe kyphosis (more than 60°) on presentation. The remaining two had a healed disease with retropulsion

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and positive toppling signs as seen on lateral view of the spine indicating a progressive kyphosis.[13]

The patients were placed in the right lateral position. Fourteen patients were given a T-shaped incision and two were given the standard semicircular incision on the left side.[6] For the T-shaped incision, a posterior midline incision was first made over the kyphotic spinous processes. A joining incision, perpendicular to the posterior midline incision, was made on the left side at the apex of the deformity (Fig 1).[6] The skin and subcutaneous tissue were cut in the same line. The skin and muscle flaps were lifted and held with stay sutures. The posterior parts of three ribs (6–8 cm) corresponding to the apex of the lesion were removed and anterolateral exposure of the lesion was performed. The vertebral body forming the apex of the lesion was removed completely (Figs 2A–B) to decompress the spinal cord. The anterior wound was packed with a laparotomy pad and the posterior exposure was performed. At least two healthy vertebrae proximal and distal to the affected segments were exposed in a short-segment disease or a healed lesion. In a long-segment disease (five to six vertebral body destruction) with intact posterior complex only one healthy segment proximal and distal were exposed. The interspinous spaces were opened and sublaminar wires were passed (Fig 2C). A suitable length Hartshill rectangle was chosen and prebent to give about 30° to 40° of the correction of kyphosis. The posterior elements (spinous process, laminae, and facets) of the vertebrae that were lost anteriorly at the apex were excised. The spinal cord was globally released and did not have bone around it. The Hartshill rectangle was tightened gradually with sublaminar wires, first on both sides of the apex vertebrae and then further proximally and distally. A wake-up test was performed on patients without neural deficit. Once the spine was stabilized and wires were bent on both sides of the spinous process, the anterior wound was reexplored. The gap anteriorly was bridged by the rib or iliac crest graft after creating a slot in the proximal and distal vertebral body (Fig 2D). In three children, the Hartshill implant was cut at the distal end to form an inverted U (Fig 7).

The mean surgical time was 3.2 hours (range, 2.4–5.5 hours). The mean blood loss was 1100 mL (range, 700–1900 mL). On decompression, 13 patients had wet lesions with pus and three had dry lesions or healed disease. Rib graft was used in 12 patients and iliac crest graft in four patients. The mean number of segments stabilized by sublaminar wires was 6.6 (range, 6–8). In three children, the distal closed loop of the Hartshill rectangle was cut to make it an open Hartshill. This open loop was made to accommodate the remaining possible growth. The wound was closed in layers without a drain.

No patient required intensive care in the postoperative period, and there were no deaths. Postoperatively, the patients continued on the standard ATT regimen and were put to strict bed rest with in-bed exercises and turning. The mean duration of hospital stay after surgery was 12 days (range, 8–20 days). Sitting with a brace and walking were permitted around 4 to 6 weeks in neurally intact patients. Sitting or walking in paralyzed patients was dependent on the state of neural recovery.

The patients were followed by one of the authors (AJ, AVM, SJ) every 3 months for 1 year, every 6 months for the next 2 years, and then once a year. Patients were evaluated for neural recovery, wound healing, and vertebral lesion healing. The kyphosis was measured on every visit.

RESULTS

All but one patient showed the first sign of neural recovery at a mean of 12 days (range, 1–35 days) and full recovery at a mean of 42 days (range, 15–75 days). One patient with no neural recovery at last followup (8 months) had TB of the spine at D9–11 with pathologic dislocation of D9 over D10 because of a panvertebral lesion of D10. This patient had a clear postoperative myelogram suggesting adequate surgical decompression. No neurally intact patient had neural deterioration.

The mean kyphosis in the immediate postoperative period was 31.2° (range, 14°–54°) with a mean postoperative kyphus correction of 27.3° (range, 9°–42°). The mean preoperative kyphus in the nine patients who had a followup of more than 1 year was 55.8° (range, 36°–76°). The mean immediate postoperative kyphus and the mean final kyphus at 1 year in these patients was 33.3° (range, 18°–54°) and 34.7° (range, 18°–56°), respectively. The mean correction lost at 1 year was 1.4° (range, 0°–4°). All nine patients with followup of more than 1 year showed bony fusion (Fig 3).

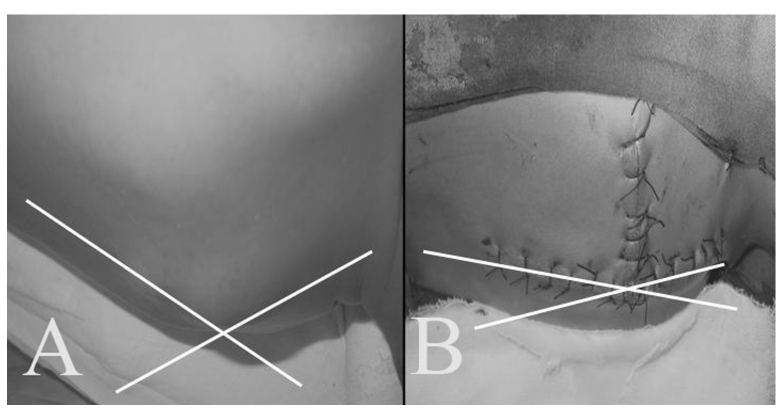

Fig 1A–B. Clinical photographs show (A) preoperative kyphosis of the upper dorsal spine in a child and (B) immediate postoperative correction of kyphosis using a T-shaped incision. (The patient is in right lateral position with the head on the right side.)

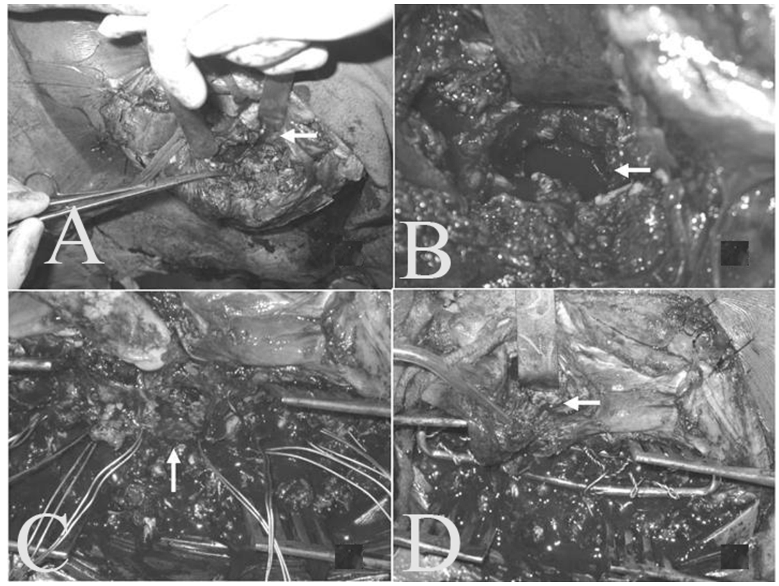

Fig 2A–D. Sequential photographs show the steps of surgery: (A) A T-shaped incision is made and the spine exposed after excision of the posterior part of three ribs (arrow). (B) The diseased vertebrae are exposed anteriorly and a spatula is placed anterior to the three vertebral bodies and resected apex vertebral body (arrow). (C) The vertebrae are exposed posteriorly. Sublaminar wires are passed and the posterior elements of the apex vertebra are excised. The spinal cord is visible between two sublaminar wires (arrow). (D) The deformity is corrected and the Hartshill rectangle is tightened posteriorly. The graft is placed anteriorly between the vertebral bodies (arrow) after creating a bed.

There were no major graft-related complications, except for partial resorption in one patient. Two patients had skin-edge necrosis and one had dehiscence at the apex of the T incision; these responded to regular dressings without further surgery.

DISCUSSION

A severe kyphosis is more than a cosmetic disfigurement. It not only disfigures the body but also affects the longevity of life. Patients with late-onset paraplegia with severe healed kyphosis have marked compromised cardiopulmonary function and painful costopelvic impingement, and when neurologic compromise occurs it is not readily resolved. Therefore, prevention of the severe kyphosis at earlier stages is crucial. We reviewed our patients to see to what extent neurologic recovery occurred with early correction, and to what extent correction was maintained.

Our study is limited by the small numbers of patients, particularly those with followup of more than 1 year. We therefore cannot make any definitive statements regarding maintenance of correction of deformity, although the

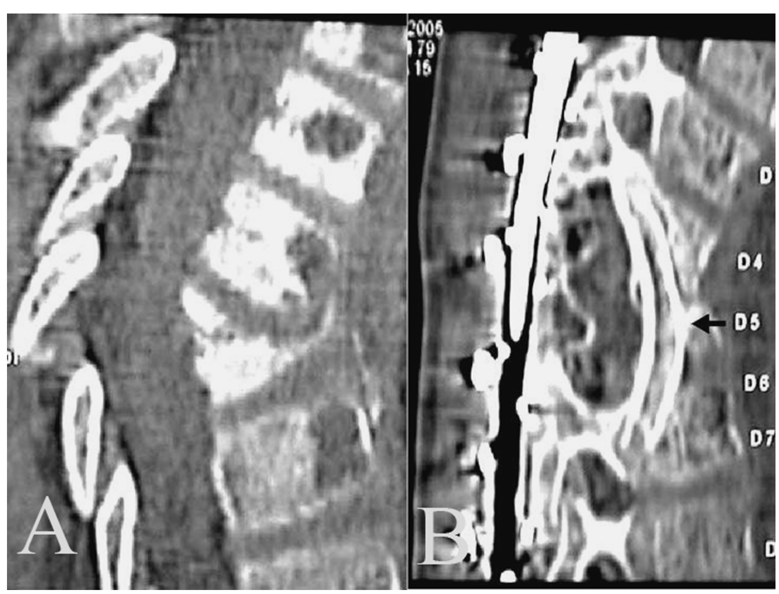

Fig 3A–B. (A) A preoperative computed tomography scan shows the involvement of six vertebral bodies and 43° kyphus in a 10-year-old child with three “spine at risk” signs. (B) The postoperative computed tomography scan shows 23° correction of kyphus and graft consolidation.

rather uniform maintenance at 1 year with the achievement of fusion suggests progression will not be a long-term problem.

Paraplegia with healed disease is produced by continuous stretching of the spinal cord over the transverse ridge of the bone or by constricting scarring around the cord or dura.[1,3,4,16] The spinal cord as a result develops inflammatory edema, cord atrophy (gliosis), or myelomalacia and syringomyelia.[7] The long-standing gradual insult to the cord leads to exhaustion of physiologic reserve, hence, the late-onset paraplegia becomes a difficult proposition for decompression surgery and neural recovery.[1,3,4,16] The excision of a hard internal salient has a risk of neural deterioration due to inadvertent handling of the cord.

Cosmetic correction of severe healed kyphus is fraught with complications and poor results.[11] The kyphosis can continue to grow despite successful posterior spinal fusion particularly if anterior fusion is not achieved.[2,11] Multistage anterior osteotomy, halopelvic distraction, and posterior instrumentation and fusion have been reported with high complication rates (immediate and late), with a mean deformity correction of only 28°; hence, it is not considered a good option.[10,17] Moon[11] suggested correction of severe kyphosis should not be performed for cosmesis alone.

The best treatment of sequelae of severe healed kyphus is to prevent the development of severe kyphosis. We have to identify patients with spinal TB in the active stage, which on healing will have 60° or more kyphosis in adults or children. The kyphus correction should be performed in the active stage of disease.[4] Any patient with initial vertebral body loss of more than 1.5 to 2 in the dorsal and dorsolumbar spine will end up with kyphus of 60° or more.[5,14] In children with TB of the spine, 3.5% of deformities are more than 60° when treated nonoperatively. The deformity progresses not only in active disease but on healing as well. Progression of deformity depends on the severity of the angle of kyphosis before treatment, the level and severity of lesion, and the age of the patient. Over a long followup, 44% of deformities in children improved; 17% had no change; and 39% increased.[13] The patients whose kyphosis will progress more than 60° at completion of growth should undergo surgical correction of the kyphosis.

Four radiographic signs have been suggested as “spine at risk” signs: (1) subluxation or dislocation of the facet joint at the apex of the kyphus; (2) presence of retropulsion; (3) translation of vertebra in the coronal plane; and (4) the posterior toppling sign (ie, if a drawn line along the anterior border of the distal healthy vertebra in an upward direction meets the upper half of the proximal healthy vertebra, the spine is considered unstable).[13] If two of the four signs are present, the kyphosis is considered progressive.[13] All of these signs are indirect indicators of severe vertebral loss and panvertebral (grossly unstable) involvement and hence considered signs of progressive kyphosis. In summary, if a child has three or more vertebrae destroyed in the dorsal or dorsolumbar spine or if a child is younger than 10 years with two or more “spine at risk” signs, he or she has a progressive kyphosis, which should be corrected in the active stage of disease (Fig 3).

Posterior spinal fusion has been suggested to stop the progression of kyphosis in children.[16] Growth changes of solidly fused kyphotic block (n = 117) after surgery for TB were evaluated.[15] The progression of kyphosis was most severe in the patients receiving anterior radical resection and fusion. When anterior resection of lesion was combined with posterior fusion, the progression of kyphosis was less. The anterior débridement group had the least progression of kyphosis because some growth potential anteriorly was preserved.[15] This suggests, even in an anterior tubercular lesion of the spine, part of the anterior growth potential was left, which was preserved with anterior débridement but completely destroyed after anterior radical resection of lesion. Posterior elements contribute to the growth; therefore, posterior fusion along with anterior resection resulted in less progression of kyphosis. However, posterior spinal fusion alone does not always stop the progression of kyphus in children. Thus, it is best to correct the kyphus in the active stage of the disease.

Issues related to surgery for kyphosis include: (1) Spinal TB lesions have a retropulsion of disc, granulation tissue, and bony sequestrum. Correction of kyphosis without opening the diseased area would produce more prominent spinal cord indentation by retropulsed fragments (internal salient) (Figs 4A–C). Hence, the internal salient should be removed by anterior corpectomy; (2) It takes 3 to 6 months to develop severe loss of height and eventual kyphosis in spinal TB. Hence, the vertebral column is shortened anteriorly and the spinal cord has adjusted to the shortened length. If this spine is straightened out abruptly, it will lengthen the anterior vertebral column and lead to stretching of the spinal cord and consequent neural deterioration. Hence, the vertebral column must be shortened posteriorly. (3) The spine needs stabilization because both anterior and posterior segments of the vertebrae have been resected.

Kyphus correction surgery involves anterior corpectomy to achieve decompression, shortening of the posterior column, posterior instrumentation, and anterior and posterior bone grafting, hence the vertebrae needs to be exposed both anteriorly and posteriorly. Ideally, both of these steps should be undertaken in one stage. Guven et al[2] performed transpedicular decompression and posterior instrumentation in a single stage by the posterior midline approach. Instrumentation was performed to prevent pro-

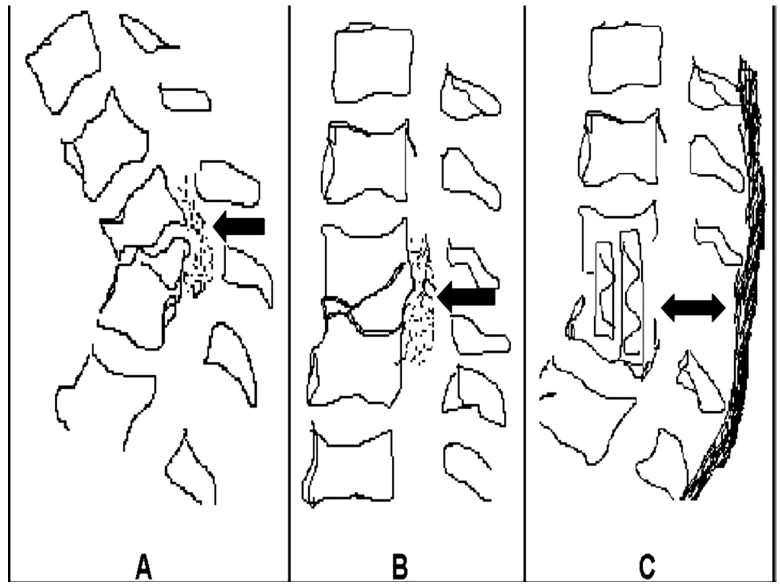

Fig 4A–C. Line diagrams illustrate (A) canal compromise (note the resulting retropulsion in the canal), (B) kyphus correction without removing the internal salient, producing more prominent spinal cord indentation, and (C) kyphus correction with anterior corpectomy, posterior column shortening, stabilization, and anterior bone grafting.

gression of the kyphus while on treatment and not to correct kyphus and most of the cases had only one or two vertebrae involved. Moon et al[12] performed two-stage surgery in which the spine was instrumented posteriorly without opening the diseased area first, and 2 to 4 weeks later transthoracic decompression and bone grafting were performed. Later, both procedures were performed in one stage. The kyphoses in these cases were not severe; the mean angle of kyphosis was 37° (range, 12°–45°) in adults and final kyphus achieved was 18°. Surgery was primarily undertaken to stop progression of the kyphus after anterior decompression.[12] This approach cannot be adopted for the correction of severe kyphus.

Laheri et al[8] performed single-stage decompression, anterior interbody fusion, and posterior instrumentation for tuberculous kyphosis of the dorsal and dorsolumbar spine by the posterolateral retropleural approach in the prone position. Kyphus correction was achieved in one stage by gradual elongation of the anterior column of vertebrae, which we believe is a dangerous proposition in a partially treated or healed kyphosis. Louw[9] reported on a series of 19 patients with TB of the dorsal and dorsolumbar spine with neural deficit.[9] He performed transthoracic transpleural anterior débridement decompression and vascularized rib grafting followed during the same procedure (n = 13) or 2 weeks later (n = 6) by multilevel posterior osteotomies, instrumentation, and fusion. The mean preoperative kyphus of 56° could be corrected to a final kyphus of 30°. The anterior column length was not altered as the anterior graft was used as a pivot to correct the kyphus by posterior column shortening. When the procedure was performed in a single stage, the anterior graft was placed after using posterior instrumentation. He believed one stage allowed maximum correction of the kyphosis by elongation of the anterior column and shortening of the posterior column in such a way that the spinal cord was neither compressed nor distracted. We shortened the posterior column in a wedge manner with its apex at the posterior border of the apex vertebrae. When the kyphosis is corrected, the closure of the gap at the facets occurs first and acts as a pivot point to allow elongation of the anterior column and closure of laminar gap so that spinal cord is neither distracted nor kinked. We performed the kyphus correction as a single-stage procedure. The patient in lateral position is stable and obviates the risk of neural deterioration during surgery when anterior corpectomy and posterior shortening and stabilization are being performed. An extrapleural anterolateral approach allows us to expose the vertebral bodies and posterior complex simultaneously to correct the kyphosis predictably. Our mean surgical time of 3.2 hours had considerably less morbidity than two-stage surgery.

Because the mean vertebral involvement in our patients was 4.2, the Hartshill rectangle was the implant of choice for stabilization. The aim was to stabilize at least two healthy segments above and below the corpectomy. In a long-segment disease, one healthy segment proximal and distal to the lesion was enough to hold the spine stably through the healthy posterior complex of the diseased vertebral bodies. This was the situation in one of our cases, in which nine vertebrae were involved anteriorly and posterior instrumentation spanned only eight healthy posterior segments after resecting the destroyed apex vertebra (Figs 5 and 6). Most authors have used posterior instrumentation to stabilize the spine in TB to prevent postoperative pro-

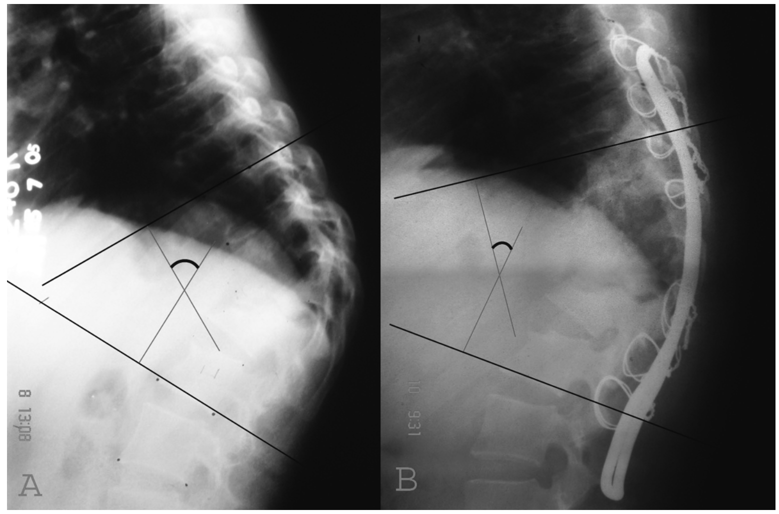

Fig 5A–B. (A) Preoperative and (B) postoperative radiographs of an adult patient show a kyphus angle (K) of 66° at the dorsolumbar spine, which has been corrected to 32°.

gression of the kyphosis or to correct the kyphosis.[2,8,12,15] Anterior instrumentation is reported in active disease but is not favored by us for long-standing kyphus deformity and long-segment vertebral column involvement.[18] The Hartshill implant provides effective three-point fixation of the spine and segmental stabilization of the corrected kyphus. However, when kyphus correction is attempted in healed disease, posterior pedicle screws and a rod construct can be used.

We believe the ideal procedure for kyphus correction in spinal tuberculosis is anterior corpectomy followed by posterior column shortening, instrumented stabilization, and reconstruction of the anterior gap by graft in one stage. This is best achieved by an extrapleural anterolateral approach, in which corpectomy is performed after removal of three ribs. The posterior exposure with the same incision allows adequate exposure, desired shortening of the posterior column of the apex vertebrae, and sublaminar

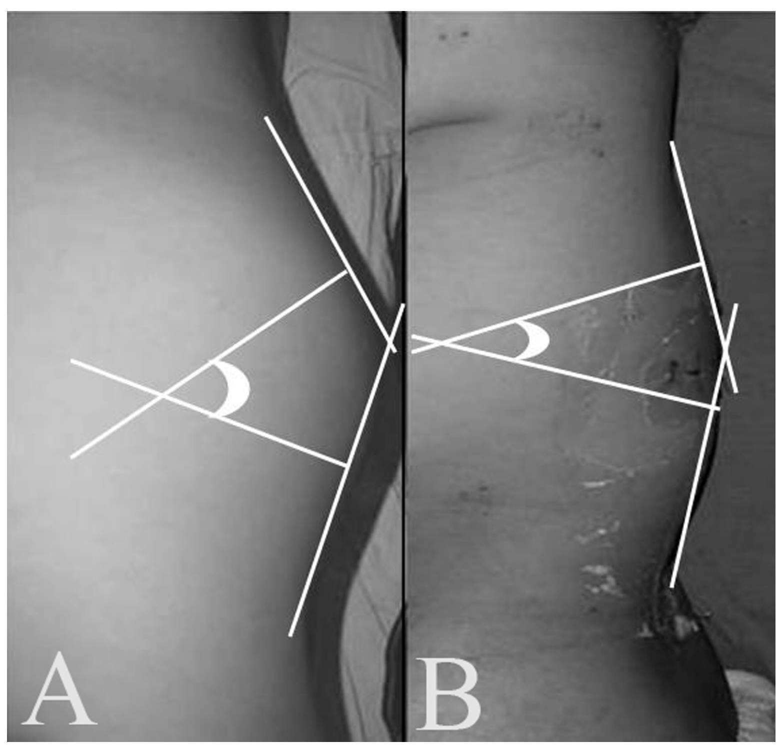

Fig 6A–B. (A) Preoperative and (B) postoperative clinical photographs of the same patient in Figure 5 show a kyphus angle (K) of 66° at the dorsolumbar spine, which has been corrected to 32°.

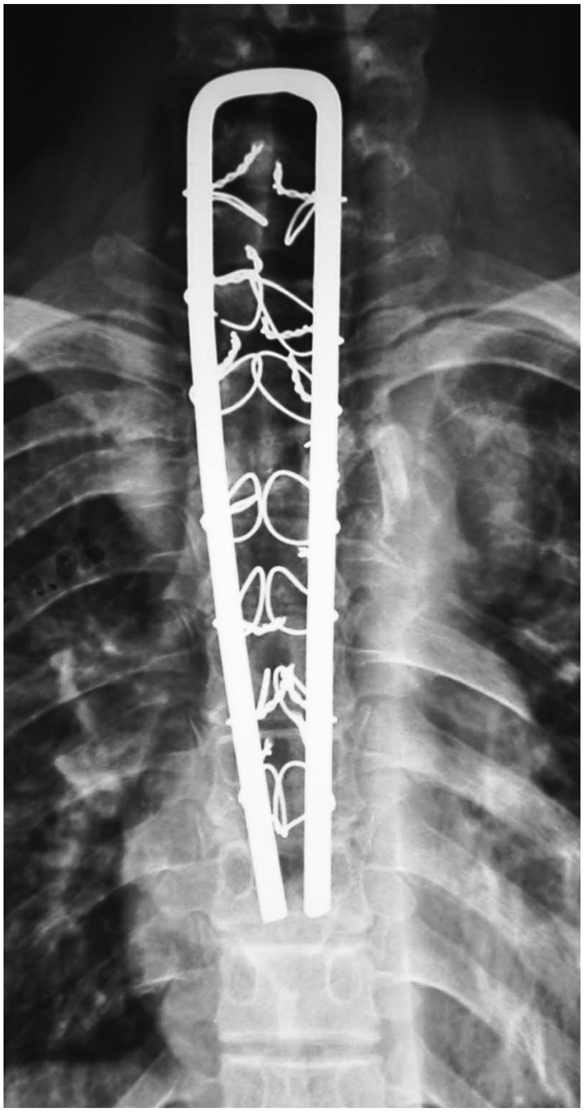

Fig 7. Postoperative radiograph shows the use of an open Hartshill implant (inverted U) in a child.

wiring of the desired segments along with Hartshill fixation to correct and hold the kyphus. This approach has the following advantages: (1) morbidity of thoracotomy is avoided; (2) it gives adequate exposure of the internal salient; and (3) the anterior and posterior parts of the vertebrae and spinal cord are visible throughout the procedure.

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