Original Article

Spinal tuberculosis in children: Retrospective analysis of 124 patients

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Abstract

Background: There is a paucity of report on spinal tuberculosis in children. We report a retrospective analysis of 124 children with TB spine treated over 30 years.

Materials and Methods: We retrospectively reviewed 124 children; of cervical (n=36), cervicothoracic (n=4), thoracic (n=53), and lumbar and lumbosacral tuberculosis (n=31) with no skip or multifocal lesions treated between 1971-2004. The age ranged from 2 to 15 years of age with 28 children less than 5 years of age, 58 were between 6 and 10 years, and 38 were over 10 years, 18 had paraplegia of various degrees. Ninety-one children were treated conservatively, while 33 children were subjected to surgery for focal debridement (*n*=23), posterior interspinous wiring and cementation (*n*=4), and posterior instrumentation with rods and segmental wiring (*n*=14). Triple chemotherapy (isoniazid, streptomycin, and PAS) was given for 18 months (3HSPa, 15Hpa) between 1971 and 1975, and triple or quadruple chemotherapy (isoniazid, rifampicin, ethambutol, or pyrazinamide) after 1976 to 2004 for 12 months (12RHZ or 12 RHZE). Some of the children in the current series belonged to the British MRC conservative study patients. The average duration of followup was 5 years and 8 months (range 1.6-20 years).

Results: All children attained healed status and showed neural recovery (*n*=18). The patients attained healed status at 18 months in the first series and at 12 months in the second series after chemotherapy. Spontaneous intercorporal fusion occurred only in 10 (8.06%) of 124 children. Sagittal curve during growth showed three different patterns: Unchanged, decreased, and increased curves. The residual kyphosis was unavoidable in cases with growth plate damage. Kyphosis increased in cases with wedged monovertebra and fused wedged block vertebra, though it was different at different level.

Conclusion: The vertebral reformation and curve correction were possible only through the growth plates. The posterior instrumented stabilization alone could correct and/or prevent progress of the kyphosis. However, for active tuberculosis, posterior instrumented stabilization combined with anterior radical surgery should be reserved only for the advanced tuberculosis with instability, rapid progress of kyphosis, and/or unacceptable pre-existing kyphosis, though there is a new trend of prophylactic posterior instrumentation even for the early tuberculosis.

Key words: Tuberculosis, spine, children, kyphosis, instrumented stabilization

Introduction

There are numerous articles published on spinal TB during last 20 years.[1-8] There is a paucity of reports on spinal tuberculosis in children Since last 60 years, there were remarkable evolution in management of spinal tuberculosis by early diagnosis and under the cover of the potent antitubercular chemotherapy.

The incidences of spinal tuberculosis in children as reported by MRC (British) are variable: 58% of all spine tuberculosis patients in Korea, 1/3 of patients in Chennai, India, and 26% in Hong Kong.[8] Generally, children with spine tuberculosis were clinically presented in the relatively advanced stage by the child parents.

Children are not the miniature of the adults. Anatomically and physiologically, there are a lot of differences. Bones in children grow longitudinally and appositionally, and model during growth. The destruction of bone in children is rapid and severe by the infection than that of the adults. However, bone lesions in children heal and model much faster than those of the adults. The growth cartilage in children is relatively well preserved in the tuberculous lesions and it is

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radically excised during radical resection of the lesion.[1,2,5,8]

Tuberculous spinal deformity in children can be corrected spontaneously during growth when the end-plate and apophyseal ring cartilage are preserved,[4,9] whereas in the adults, the established deformities do not correct spontaneously. Also, children's deformed spine morphology are affected by the altered biomechanics.[6,10]

It is appropriate to analyse long term data on spinal tuberculosis and management protocols with the objective to evolve a new management protocol. Thus, the present study on 124 children with spinal tuberculosis treated during last 30 years was carried out retrospectively.

Materials and Methods

All patients were treated at eight affiliated hospitals of Catholic University of Korea, Dong-Sin General Hospital, and Sun General Hospital in Korea since 1971 to 2004.

One hundred twenty-four of 229 children, aged 2 to 15 years, with spinal tuberculosis in the various spinal segments were available for this analysis; 36 of cervical, four of cervicothoracic, 53 of thoracic, and 31 of lumbar and lumbosacral tuberculosis. Twenty eight children were under the age of 5 years, 58 were between 6 and 10 years, and 38 were over 10 years [Table 1]. None of the children had the skip and multifocal lesions. Eighteen children developed neurologic deficit of various degrees; Frankel B (n=3), Frankel C (n=12), and Frankel D (n=3) paralysis. Only two had mild spasticity of the lower extremities. Twenty six children had pulmonary tuberculosis. The followup of 34 children were not available upto healing of the disease.

The diagnosis was made at the initial examination on the basis of the clinical manifestations, laboratory and roentgenographic and MRI findings (n=32). The definitive diagnosis could be made by histological and bacterial studies in the surgically treated patients, and also could be made indirectly on the basis of the nature of aspirate including color and viscosity, culture and cytology, and the drug response.

Table 1: Demographic data

Age: 2-15 years	
Under age of 5 years	28
6 ~ 10 years	58
over 10 years	38
Level of the lesions	
Cervical	36
Cervicodorsal	4
Thoracic	53
Lumbar and lumbosacral	31
Paralytics	18
Frankel B	3
Frankel C	12*
Frankel D	3

*2 had mild clonus

Laboratory tests including a complete blood count, erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP) were performed to diagnose, to monitor the disease, and to assess chemotherapeutic effects, disease arrest and healing, and reactivation regularly with certain intervals during treatment and afterwards. Assessment of the growth cartilage condition (end plate and apophyseal cartilages) was based only on the disc space observations on plain X-rays.

The disease arrest and healing was assessed with a certain interval regularly on the basis of the improvement of the clinical symptom, normalization of CBC and the inflammatory markers (ESR, CRP), absorption of the abscess and arrest of the destructive processes, and finally the reformation of the destroyed bone on roentgenograms and MRI. Reformation indicated the healing.

Antituberculous chemotherapy was given to all children; isoniazid (INH; H), streptomycin (S), and PAS (Pa) were used for 18 months (3HSPa, 15HPa) between 1971 and 1975, while since 1976 afterwards, isoniazid (H), rifampicin (R), ethambutol (E), or pyrazinamide (Z) for 12 months (12 RHZ or 12 RHZE) were used. No second line and newer drugs were used.

For the 40 children with cervical (n=36) and cervicodorsal (n=4) lesions, head halter traction in bed was applied routinely for 7 to 10 days, immediately after clinicoradiological diagnosis was made till the therapeutic regimen was finalized. When instability of the affected cervical segment was confirmed, Minerva cast was applied for 3 months in 14 children upto 1980. Afterwards, ambulatory treatment with four post cervical brace (n=7) and the halo-shoulder apparatus in 12 children was given for 4 months. Seven had ambulatory treatment without external support.

No orthotic or cast treatment was given for tuberculosis of the dorsal and lumbar spines. Surgical indications were the continuing pain, unsightly progressive kyphosis, segmental instability signs on radiograms, and worsening neurology. Twenty three children with moderately advanced lesions with large abscess at any level were subjected to simple abscess drainage and/or focal debridement. The combined interspinous wiring and cement fixation were done to stabilize and to tether the posterior spinal growth in four children in early 1970. Fourteen children had posterior segmental fixation utilizing the Rush nail or contoured Steinmann pins and wires to correct and to stabilize the

diseased deformed segments since mid 1980s. Only in five of 14 patients over 13 years of age, anterior interbody fusion was combined with posterior instrumentation.

Fourteen of 18 paraplegic children were treated conservatively, and four had focal decompressive debridement. But none of the paraplegic children had emergency decompression surgery. Average duration of followup was 5 years and 6 months (range from 18 months to 20 years). It was difficult to continue the long term followup equally in all patients due to financial reason.

Results

The mean pretreatment ESR was 41 mm/hour (range, 31-54 mm/hour) which reduced to 14 mm/hour (range, 9-17 mm/hour) at 3 months post-chemotherapy. The average CRP values before and after chemotherapy at 3, 6, 9, and 12 months were 3.9 mg/dl (range, 2.3-4.7 mg/dl), 0.51 mg/dl (range, 0.23-1.4 mg/dl), 0.08 mg/dl (range, 0.04-0.16 mg/dl), 0.06 mg/dl (range, 0.03-0.13 mg/dl), and 0.03 mg/dl (range, 0.01-0.09 mg/dl), respectively.

The discs were completely destroyed in two of 36 cervical, eight of 53 dorsal, and six of 31 lumbar spines on initial radiogram. All children responded favorably to chemotherapy without drug related complications, and finally the disease healed in all. All 18 paraplegic children recovered neurologically within 1.5 months after chemotherapy and 3 days after surgical decompression in all four children subjected to decompression surgery.

Chronological sagittal curve changes observed after conservative treatment are categorised as below:

a. Cervical and cervicodorsal lesions (n=40): In eight (20%) children, the curve (average 10° kyphosis) did not change, whereas in 26 (65%), the curve on average increased from 8° to 14° and in six (15%), the curve decreased from 8° to 3°, spontaneously during growth [Figures 1 and 2].
b. Dorsal and dorsolumbar lesions (n=53): The curve {mean 13° kyphosis in 13 (six instrumented)} did not change, whereas the curve decreased from 15° to 11° in seven and increased from 14° to 23° in 33 [Figures 3 and 4].
c. Lumbar and lumbosacral lesions (n=31): The curve (mean curve 5°) did not change in five children, decreased from 12° to 4° in four children and increased from 14° to 28° in 22 children [Figures 5-10].

The increase of kyphosis was seen more in the advanced cases in which the growth plates were damaged regardless of the level of the lesion. In 13 of the 14 posteriorly instrumented children, the sagittal curves were well maintained, whereas it deteriorated in one with loose instrumentation. The combined posterior instrumentation and anterior surgery in five adolescent patients could correct the kyphosis and/or maintain the restored sagittal curve. The lesion gradually arrested at 3 months, was almost arrested at 6 months, and was assessed to be healed at 18 months in the first series (n=77) and 12 months after chemotherapy in the second series (n=47).

Spontaneous fusion occurred only in 10 (8.06%) of the 101 conservatively treated children in whom discs and end-plate cartilages were completely destroyed. Adjacent segment disease was not complicated even in the patients with moderate residual kyphosis.

Discussion

Tuberculous spondylitis is the most dangerous form of skeletal tuberculosis.[1-8] The number of the reported tuberculosis cases have increased because of the spread of HIV/AIDs. In HIV-positive patients, about 60% of the cases involve the bone and joints.[6] The recent emergence of drug resistant variant of *M. tuberculosis* in particular poses further threat, and has raised great concerns worldwide.[9, 11-14] The persisting issues related with spinal tuberculosis in children have been the delayed diagnosis and management because of delayed presentation for the treatment. However, the recent improved nationwide health system and individual awareness of the disease following the national economical growth in each country made a significant change in the management. Even as late as 1970s, the primary goal of the management was to save the patients' life by healing the disease rather than prevention and/or correction of the deformity and paraplegia. The antituberculous drugs helped in achieving the healed status and neural recovery from paraplegia.

The appropriate duration of chemotherapy has been a controversial issue; Triple chemotherapy (PAS, INH, streptomycin) for 18 months (3HSPa, 15HPa) was the standard regimen by 1975, and afterwards, triple or quadruple chemotherapy (INH, rifampin, ethambutol, and pyrazinamide) for 12 months were adopted, though 6 to 9 months of chemotherapy was accepted for lung tuberculosis. Both regimens were proven equally effective in the current series. The disease healing pattern coincided with that of the previous other reports.[4,8]

The current authors observed whether nonoperative and operative treatments would result in similar drug response, spontaneous intercorporal fusion, residual kyphosis, and neurological recovery at the end of treatment, and also observed further whether progressive kyphosis after the disease healing would result during the growing period.

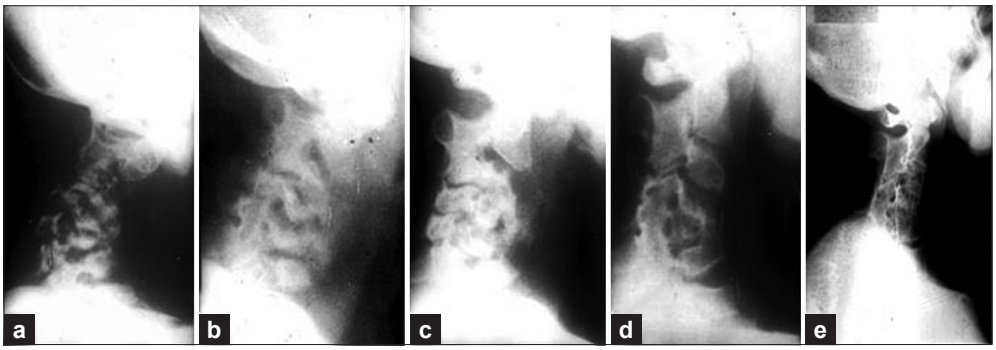

Figure 1: Tuberculosis of C_{3-6} in a 5-year-old boy: (a) Initial lateral radiograph showing narrowed disc spaces of C_{3-4}, C_{4-5}, and C_{5-6} with round cervical kyphosis and huge prevertebral soft tissue shadow. Initially, cervical traction was applied in bed for 3 weeks under the cover of the triple chemotherapy which was followed by Minerva cast for 5 weeks. Radiograms taken at postchemotherapy, (b) 18 months, and (c) 36 months are shown in which gradual spontaneous correction of kyphosis and visible undestroyed affected discs and reformation of the diseased vertebral bodies. Radiograms, taken at 4 and 20 years (d, e) after initial chemotherapy, showing the fused C_2-C_6 block vertebra circumferentially with good spontaneous correction of kyphosis

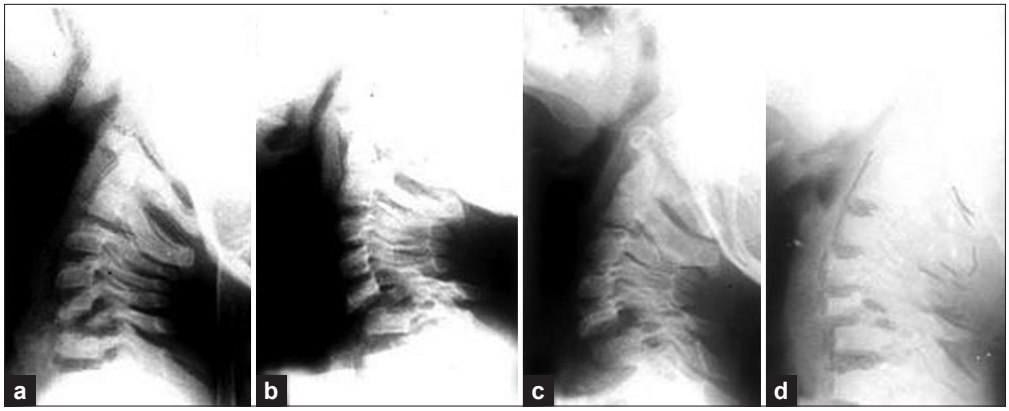

Figure 2: Tuberculosis of cervical spine at C_5-C_7 in a 2-year-old paraplegic boy, treated by triple antituberculous chemotherapy (INH, rifampin, ethambutol) for 12 months. Serial lateral radiograms, taken at initial (a), 12 (b), 24 (c), and 36 (d) months are shown. (a) The initial radiogram shows the almost completely destroyed C6 body with minimum kyphosis. After chemotherapy there were no further vertebral body destruction, while slippage of C_5 over C_7 occurred due to facet joint gapping at 12 months (b). However anterior C_5 slippage was well reduced and stabilized spontaneously at 24 and 36 months (c, d)

The individualized treatment for each patient according to different therapeutic indication was essential to heal and to minimize complications. A treatment model was suggested which might help to improve treatment outcomes and reduce complications and sequelae. The fate of the healed unfused and fused tuberculous kyphosis in the growing period has been our main concern, because the sagittally wedged vertebral body with or without growth plate damage took the 3 different clinical courses which was not observed in adults.[9,14]

The vertebral collapse patterns during the active stage and after healing of tuberculosis were different at each spinal level because of its anatomical features; anatomy (shape, size, and location of the transverse processes, and facet arrangement) of the affected spinal level, growth plate condition, and the patients' age in addition to severity of body destruction gave influence on the collapse pattern which led to the kyphosis.[10,15]

Cervical spine has coronally and obliquely (rather flat) oriented facet joints, and wide rather anteriorly and horizontally positioned transverse process projected directly from the body. The characteristic anatomy prevents the early vertical collapse, while it allows anterior slip which is followed by kyphotic collapse by facet joint gaping in the later stage, particularly in children.

Thoracic spine has coronally and vertically arranged facet joints and anteroposteriorly narrow and flat transverse process away from the body posteriorly and projected from the upper part of the pedicle. Its flexion axis locates ventrally. These anatomic features allow kyphotic collapse at an early stage of the disease by the facet gapping.

Lumbar spine has rather sagittally and vertically oriented facet joints and anteroposteriorly thin and vertically wide flat transverse processes. Its flexion axis is rather posteriorly located because of lordotic curve. This characteristic

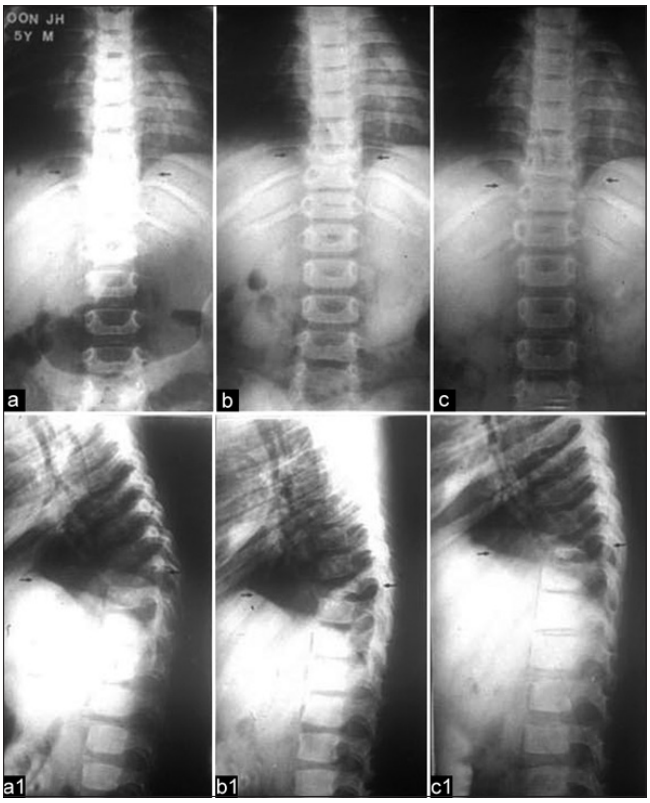

Figure 3: Tuberculosis of thoracic spine at D_9-D_{11} in a 5-year-old boy, arrows indicate the lesion. Initial radiograms (a) show the flattened D_{10} vertebral body with mild kyphosis (Cobb angle 18°), and the disease arrest and gradual correction of kyphosis (Cobb's angle 10°) are seen at 12 (b) and 18 (c) months after triple chemotherapy. Intercorporal fusion did not occur

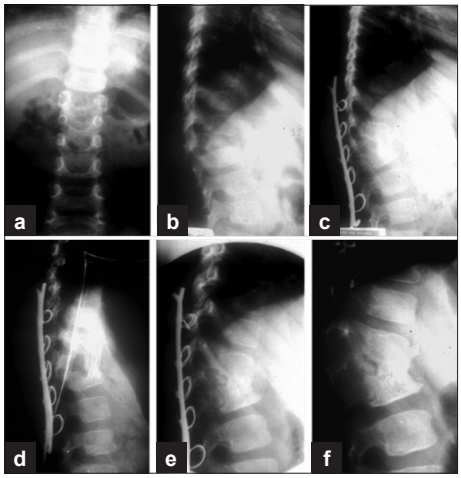

Figure 4: Preoperative radiographs (a: anteroposterior view; b: lateral view) of a 6-year-old boy showing L1 tuberculosis with kyphosis involving neighboring discs. (c) Lateral radiogram immediately after posterior segmental sublaminar wiring showing a fair amount of correction of kyphosis. (d) Radiograph of immediate postoperative anterior interbody fusion showing three rib grafts, one of which is out of the graft bed. (e) Six-month postoperative radiographs showing good maintenance of corrected kyphosis, although there is some loss of correction. (f) Radiographs 1 year 3 months after surgery showing complete consolidation of the fused segment, with some natural correction of the kyphosis

anatomy allows the vertical (telescoping) collapse at an early stage of the disease which shifts gradually into kyphosis in the late advanced stage.

Clinically, there are two types of kyphosis: Stable (fixed non progressive) and unstable (progressive) ones. The stable kyphosis is the disease related, single, slightly wedged vertebra and the fused wedged block vertebrae without segmental instability by Schulitz *et al*.,[3] while the unstable one is a progressive kyphosis with unfused severely wedged, vertebrae with retropulsion and positive toppling sign.[16,17]

In estimating the final residual kyphosis in the conservatively treated group, the treating physician should not depend on the Rajasekaran and Shanmugasundaram's predicting formula in children.[16] Children's spine behave differently from the adult spine because of the growth potentiality, remarkable remodeling capacity, and also the difficulty of the accurate assessment of the percentile destruction of the bony vertebral body.[15] The pediatric spine grows at an accelerated pace during growth spurts.[9,11,13,17,18]

In the current series, three sagittal spinal curve change patterns were seen after healing of the disease: Fixed (stationary) curve pattern, kyphus decreasing pattern, and kyphus increasing patterns. In summary, kyphosis increased pattern was seen only in the cases with the damaged growth plate cartilage, and the other two patterns were seen in the cases with the undamaged or minimally damaged growth cartilages.

In assessing and predicting the final kyphosis, the growth plate condition and vertebral peak height growth velocity should be contemplated. Therefore, even after the healing, regular followup examinations are essential to assess the stability and the curve change of the kyphotic segment until growth maturity [Figures 1 and 3]. Both single kyphotic wedged vertebra and fused kyphotic block vertebrae can give influence on the sagittal curve during growth.

As regards the management, when the facet joint gapping, forward vertebral slippage [Figure 2] and the progression of kyphosis were observed at anytime, posterior instrument-aided stabilization and fusion were strongly recommended by the senior author to stabilize the diseased segment and to prevent the instability-associated complications.

Six children with moderately advanced lumbar tuberculosis developed kyphosis by the disease-related wedged monovertebra and fused kyphotic block vertebrae. They were subjected to close observation for assessment of

Figure 5: X-ray anteroposterior (a) and lateral (a1) view of dorsolumbar spine showing TB L1-L3 Cobb's angle 20 degree in a 3 years old child treated by triple chemotherapy (INH, R, ETB) for 12 months. It shows approximately 50% L2 vertebral body collapse and almost destroyed L1- L2 disc. The kyphosis at 6 months followup (b, b1) was 23 degree. Semi-intercorporal fusion of L1-2 was taken place at final followup. kyphosis increased (c, c1) slightly at the lesion level Cobb's angle 25 degree, though the disease was well arrested

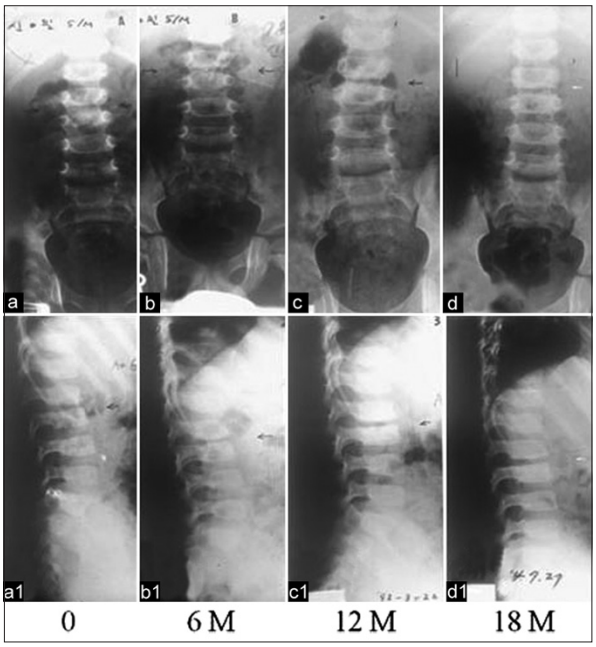

Figure 6: Tuberculosis of L_{2-3} in a 6-year-old boy, treated conservatively with triple chemotherapy (INH, rifampin, ethambutol) for 12 months (a). The disease was well healed with good preservation of L_{2-3} disc and the affected L_2 and L_3 bodies (b, c, d)

the effect of the kyphotic vertebra on the progress of kyphosis and adjacent segments. However, spontaneous deformity correction could not be expected in the above-listed cases.

Clinically, every effort should be made to minimize residual kyphosis less than 10° not only for the cosmesis, but also prevention of the progress of kyphosis and late adjacent segment disease. Because the adjacent segments cannot accommodate properly, the excessive load and motion transfer from the fused kyphotic block vertebrae and mono-kyphotic vertebra, and consequently the adjacent segments can fail and vertebral body deform in the adulthood.[5]

In summary, the therapeutic goal in children is to heal the tuberculosis with minimum residual deformity and without neurologic sequelae.[1-3] Therefore, the treatment should be aimed not only at the healing, but also at the maintenance of stability, normal spinal growth, and sagittal alignment of spine by preventing the additional progressive bone destruction and/or by hastening the neurological recovery during the treatment period and afterwards. Hence the children should remain under surveillance till completion of growth phase.

Anterior decompressive debridement was performed when there was a substantial abscess collection and rapidly deteriorating neurological symptoms. It was stressed that during curettage, utmost care should be taken not to damage the growth plate and cord. Radical curettage and excision of the ring apophysis and the end-plate cartilage in the lesion, and anterior fusion contributed to the development of the progressive kyphosis during growth.[3]

Interspinous tether-wiring with cement augmentation to stabilize the affected segment and to arrest the posterior spinal growth failed to obtain the favorable stabilization.[5] However, posterior segmental fixations with segmental wires and Rush-nail or Steinmann pins were successful in correcting the spinal kyphosis and preventing the progress of kyphosis. When some residual deformity of the instrumented spine at the time of disease healing was found, instruments were left until growth maturity to arrest the posterior growth, and to allow anterior column growth.[5,8,11]

In the current study, a substantial increase of kyphosis during treatment developed in children with advanced disease initially. Therefore, posterior instrumented correction and stabilization was recommended for the kyphotic monovertebra with the destroyed growth cartilage, and the anteriorly fused kyphotic block vertebra. The reason was that Schulitz *et al*. reported the non-continued growth of the solidly fused kyphotic vertebrae resulting in increase of

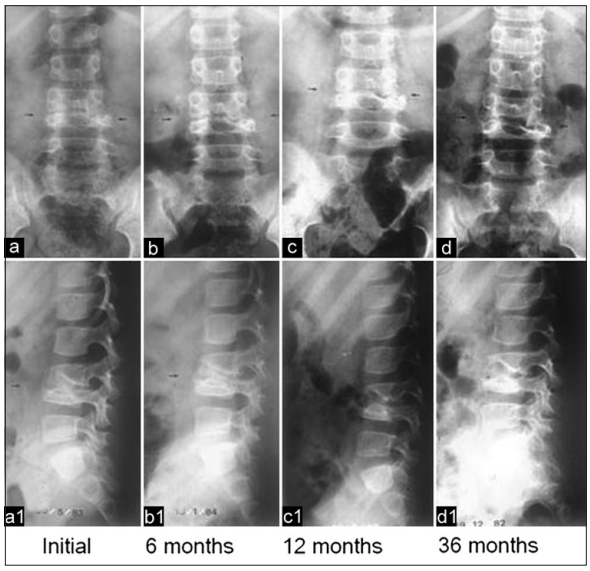

Figure 7: Tuberculosis of L_3-L_4 in a 7-year-old boy, treated conservatively with triple chemotherapy for 12 months. On initial radiograms incompletely fused L_3-L_4 bodies with cystic lesion in anteroinferior part of L_3 body (a) which was maintained until last followup (b, c, d). The flattened lumbar curve is seen

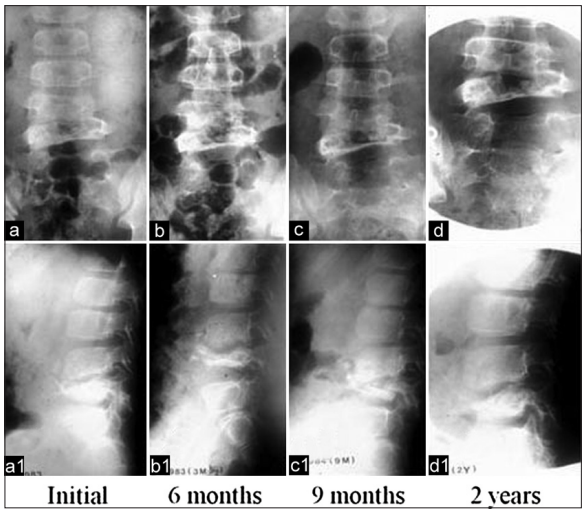

Figure 8: Tuberculosis of L_4-S_1 in a 12-year-old boy which was treated conservatively with triple chemotherapy (INH, rifampin, ethambutol) for 12 months. Initial radiograms (a, a1) demonstrate the narrowed L_{4-5} and L_5-S_1 discs and wedged and flattened L5 body. The vertebral body continued to loose height at 6 months (b, b1) at 9 months (c, c1) after chemotherapy (c). However, disc spaces of L_{4-5} and L_5-S_1 and vertebral body of L_5 reformatted with spontaneous correction of deformity (d)

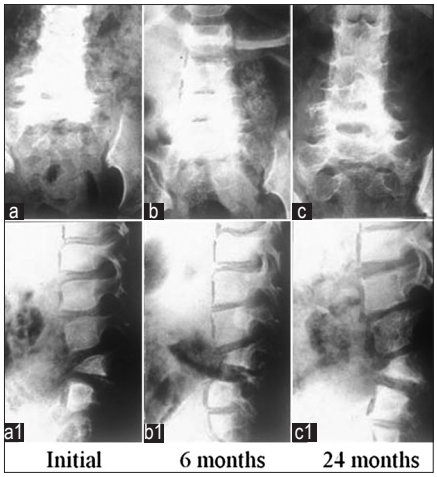

Figure 9: Tuberculosis of L_3-L_5 (initial Cobb angle, 25°) in a 7-year-old girl, treated with triple chemotherapy for 12 months (a, a1). Retrolisthesis of wedged L_4 with increased kyphosis (final Cobb angle, 35°) is seen, though the disease healed (b, b1, c, c1)

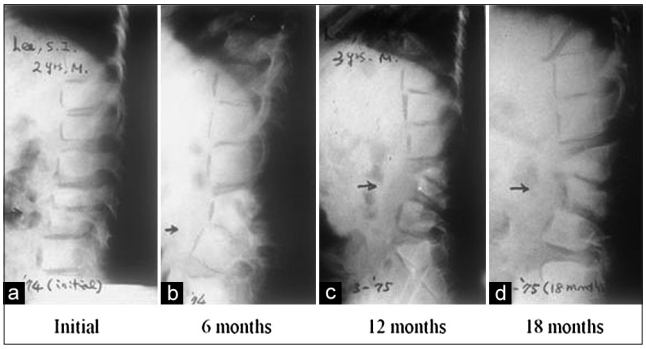

Figure 10: An example of failed chemotherapy secondary to unsupervised inadequate triple chemotherapy for tuberculosis of L_2-L_4 (initial Cobb angle, 0°) by 6 months (a) in a 2-year-old boy. Then direct observed chemotherapy was performed. However, further destruction progressed by another 6 months (b). Thereafter the disease arrested with retrolisthesis of wedge L_3 and L_4 bodies and increased kyphosis (final Cobb angle, 30° at 18 months) (c, d)

kyphosis in spite of obtained segmental stability.[3] Based on this information and current authors' personal experiences, non-instrumented anterior radical surgery alone was not done in anyone of the current series.

Hong Kong surgeons strongly suggested that healing of spinal tuberculosis must be done by fusion. However, in the current series, the spontaneous fusion rate was quite low in children compared with that of adults in other reports.[14]

The senior author's hypothesis (MSM) for the low rates of spontaneous intercorporal fusion in children was due to the following factors: Poor bony apposition of the two diseased vertebral bodies by interposition of the thick disc and end plate and ring apophyseal cartilages, and high local production of anti-BMP factor against the increased production of BMP by the infection-related inflammatory cells around the lesions.[9,13]

It is strongly recommended that the unfused diseased segment should be carefully observed whether the segment becomes unstable and/or more kyphotic. It is the authors' view that spontaneous fusion in non anatomical alignment should not be allowed in children. In later years, it cannot only complicate the unsightly deformity but also neurological disorders. The surgically fused solid single block vertebra became stable. However, the

kyphosis progressed during the growth due to the growth discrepancy between the anterior and posterior spinal columns.[3] The diseased single vertebra which healed in wedge shape also contributed the progression of kyphosis during growth.

Some surgeons discussed the stability of the unfused diseased segment on progression of the kyphosis at the time of healing and growth discrepancy between anterior and posterior columns after healing.[10,14] This has been a controversial issue. Therefore, even after the disease healing in children, regular followup examinations are essential.[9,11-13]

As regards Pott's paraplegia, good neural recovery was obtained in all paralytic children who were treated either nonoperatively or operatively. The main cause of paralysis was the pure abscess or early granulation tissues compressing the cord, and the early paralysis. Therefore, it is believed that decompressive surgery should be reserved only for those in whom chemotherapy of 3 to 4 weeks fails to recover the paralysis. However, for the children presenting the worsening respiratory distress by huge abscess compressing the trachea and/or cervical cord above C_4, emergency decompression was mandatorily indicated.[13]

Spinal tuberculosis in the current series was effectively treated by chemotherapy despite of a slight increase of kyphosis. Reformation of the diseased bony vertebra could be observed when the growth plate cartilage was preserved.

It was found that posterior instrumentation for active tuberculous kyphosis could effectively correct the kyphosis and maintain the restored sagittal alignment. As regards the extent of instrumentation, the current authors recommend the short segment pedicle screw-rod stabilization instead of long segment fixation, because short segment instrumentation can provide sufficient stability until disease arrest.

The effect of the posterior instrumentation of the different devices for the children's spine of different age group (age of 5-6 years, 7-10 years, and 11-14 years of age) was not assessed. However, Winter *et al*. reported that posterior instrumentation of young children before their growth spurts developed crankshaft phenomenon in the anterior column.[18]

Also, effect of anterior radical surgery on spinal growth at the different levels of each age group, listed above, has not been reported and discussed. Only Upadhyay *et al*. reported that anterior surgery did not affect much the anterior column growth, while Schulitz *et al*. reported that the fused block vertebra gave ill effect on the spinal sagittal curvature.[14] However, in general, infantile spine was found to adapt well even to the kyphosis without complicating the adjacent segment disease which often complicated in the adults.

There is a new trend of prophylactic posterior instrumented stabilization even for the early tuberculosis by a small group of surgeons. It is expected that these issues will be clarified in the not distant future by the surgeons who live in the countries where the spinal tuberculosis is still prevalent.

In summary, spinal tuberculosis is curable medical condition and did not require surgery if accurately diagnosed and properly treated at an early stage. The nonoperative treatment produced favorable results comparable with those of the surgical treatment, if patients receiving nonoperative treatment were carefully selected.

Continuous vigilant observation should be practiced to detect the progress of kyphosis until maturity when the tuberculosis of the spine heals with residual kyphosis of any severity. Posterior instrument aided correction and/or stabilization surgery is recommended when there are unacceptable pre existing kyphosis and/or any evidence indicating progress of kyphosis due to the disease related wedged vertebrae and instability of the unfused healed segment(s).

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