Original Article

Short term analysis of healed post-tubercular kyphosis in younger children based on principles of congenital kyphosis

Shantanu S Deshpande, Rujuta Mehta, MG Yagnik

Abstract

Background: The patients with healed severe progressive tubercular kyphosis may develop late-onset paraplegia. A particular subgroup of these children (Type IB progression) may benefit from the management principles of congenital kyphosis. Self-correction may be observed by selective continued growth of anterior vertebral epiphyseal end-plates over the posterior fused mass. We report a series of cases with posterior fusion of progressive post-tubercular kyphosis with an aim to prevent further progression of kyphosis and to assess if any gradual self correction is seen in followup.

Materials and Methods: Twelve children fulfilling inclusion criteria of clinicoradiological, hematological diagnosis of healed spine TB having no or <2 spine at risk signs having documented progression of kyphosis and neural deficit underwent posterior fusion *in situ* without instrumentation, using autogenous iliac crest grafts as well as allograft donor bone graft. They were followed up to maximum of 5 years.

Results: All 12 children had a progressive increase in angle preoperatively. Mean followup was 3.6 years. Post surgery, 66% showed a clinical improvement and correction, 25% had static angle, and worsening in one patient. Thus, overall 91% have a favorable result.

Conclusion: The mechanism of correction of deformity in presence of posterior fusion is continued growth of the anterior epiphyseal end plates and hence this leads to selective differential anterior column growth giving gradual correction of kyphosis. This avoids anterior, technically demanding and complex, internal gibbus surgeries. This procedure is simple, safe, and less morbid with good results, avoiding long term disability to the patients in selected group of patients.

Key words: Kyphosis, posterior fusion, tuberculosis, children

Introduction

Spinal tuberculosis achieves healed status with the effective antitubercular chemotherapy though it still leaves the stigmata in the form of spinal deformities causing disability and risk of paraplegia later in life.[1] The kyphosis is more severe with more number of vertebral bodies affected and with more loss of anterior vertebral body height. The severity varies with the different segments of spine affected.[1]

There is lack of consensus regarding indications of surgical intervention to prevent development/progression of kyphotic deformities in children. Hence these patients report with severe kyphosis and consequent complications. The treatment of these patients in active disease to correct/prevent kyphotic deformity is well accepted. Literature[1-7] abounds on surgical protocols for active spinal tuberculosis. The treatment dilemma persists in children with clinically and radiologically healed disease with progressive kyphotic deformity and without any neural deficit.

The management protocol for congenital kyphosis is well established following the works of Winter[8-12] and McMaster.[13-14] The children less than 5 years with less than 60 degrees of kyphosis would show best results with only Posterior Spinal Fusion. Winter[8] also states that in children with mild kyphosis, the posterior fusion is effective

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regardless of the age of the child. The kyphosis with more than 60 degrees in children of 12 to 15 years of age will require anterior and posterior spinal fusion.[8] We have used these principles of congenital kyphosis management to treat progressive post-tubercular healed kyphosis.

We believe that in a particular subgroup of children the progressive post-tubercular kyphosis will behave almost the same way as the congenital kyphosis in natural history. The reason being Type I of congenital kyhosis is radiologically almost similar to tuberculosis which has affected single segment and Type II of congenital kyphosis has similar radiological appearance to tuberculosis healed with spontaneous fusion. This is supported by Winter[9] to some extent.

We hereby present the short term analysis of our study of posterior spinal fusion using morcellized irradiated cancellous allografts for clinically and radiologically healed but progressive tuberculous kyphosis in children. The aim of the present study is to assess the effect of posterior fusion alone to prevent further progression and to assess if any gradual self correction happens.

Materials and Methods

The study was initiated in year 2000 which included the retrospective analysis of the cases operated since1998 (n=7) while cases operated after 2000 (n=5) were prospectively included in the analysis. Twelve patients between the ages of 3 and 11 years satisfied were enrolled. All these children had already completed their antitubercular chemotherapy course. The inclusion criteria used were as follows:

1. Clinically, radiologically, and hematologically documented healed spinal TB;
2. Documented progression of kyphosis at serial followup;
3. No neurological deficit.
4. The cases of spinal TB showing No or <2 spine-at-risk signs[15] This criteria was added in 2001. However, none of our cases were operated before 2001 had >2 spine at risk signs.

The clinical healing was defined as general well being without any signs and symptoms of tuberculosis with no local tenderness, inflammation, or sinus and discharge. Radiological healing was defined with remineralisation and sharpening of disc margin, reappearance of bony trabeculae and has no further destruction of vertebrae with or without sound spontaneous fusion. Hematological healing was defined as having attained normal levels of hemoglobin, erythrocyte sedimentation rate, C-reactive protein and differential WBC count.

Every patient was followed initially over a period of approximately two years to establish their radiological progression of the deformity. Later on they were classified as IB progression type.[15] These carefully selected patients had undergone posterior spinal fusion with allograft after an informed parental consent. The freeze-dried, irradiated grafts morcellized in the operation theatre prior to surgery were used in all the patients. The morcellised allografts were mixed with autogenous cancellous iliac crest bone grafts if possible. The *in situ* posterior fusion was done by excision of facet joints and decortication of posterior vertebral structures followed by the allograft–autograft mixture in the recipient bed one level above and one level below the affected segment.[14] After surgery, every child had an underarm plaster jacket which was later converted to total contact spinal brace till 1-year post surgery. There was no correction of kyphosis aimed in plaster jacket but it was used to maintain the correction.

The kyphosis angle (K) was measured in all patients by using Cobb's method from the most sagittally tilted vertebra at either end of the deformity as seen on the lateral spine radiograph as shown by Winter.[16] The radiographs were reviewed together and the measurement done after consensus between authors. These patients were followed regularly after surgery at every 6 months and kyphosis correction assessed by clinical and radiological improvement in K angle of deformity. Good result was defined as correction of kyphosis. Fair result was defined as static angle at followup without any progression or regression. However, poor result meant worsening of kyphosis angle.

Results

Age group of selected patients was between 3 and 11 years with five males and seven females. Of 12 patients, five were thoracic, five thoracolumbar, and two lumbar cases. Eight patients had no spine at risk signs and the other four patients had less than two spine-at-risk signs. All children satisfied the inclusion criteria. Initial assessment showed all 12 patients had a progressive increase in angle preoperatively.

All the 12 patients underwent posterior fusion without instrumentation and had solid posterior spinal fusion with excellent graft incorporation and consolidation. The mean followup was 3.6 years (minimum 2.5 to maximum 5 years). No perioperative complications were observed. There was no infection.

Mean angle of preoperative kyphotic deformity in all segments of spine was 48.75° (range 25° to 80°). Following posterior fusion, 66% (n=8) showed a gradual correction of kyphosis due to continued anterior growth. The kyphosis in 25% (n=3) remained static. Worsening of the kyphosis was

Table 1: Clinical details of patients

Case no.	Sex	Age (years)	Diagnosis (level of tuberculous lesion)	preoperative deformity (in degrees)	Kyphotic deformity at final followup (in degrees)	Followup (years)	Results	Remarks
1	M	3.7	D4- D5	60	40	4	Good	Solid fusion
2	M	4.4	D5- D7	20	03	5	Good	Solid fusion
3	F	4.5	D12- L1	55	40	3.8	Good	Solid fusion
4	M	4.6	D12- L1	40	25	3.2	Good	Solid fusion
5	M	5.1	D6- D7	40	30	3.6	Good	Solid fusion
6	F	5.4	D11- L1	45	35	2.5	Good	Solid fusion
7	M	6	L2- L3	40	35	3.1	Good	Solid fusion
8	F	6.2	L3- L4	45	30	3.2	Good	Solid fusion
9	F	8.1	D4- D5	80	80	4	Fair	Solid fusion
10	F	9	D6- D7	75	75	3.5	Fair	Solid fusion
11	F	9.5	D12- L1	60	60	4.2	Fair	Pseudoarthrosis at lower level
12	F	11	D12- L1	25	30	4.1	Poor	Solid fusion

D - Dorsal spine, L - Lumbar spine

documented in only one patient from 25° to 30° [Table 1]. The mean angle of Kyphosis at final followup following surgery was 40.25° (range 3° to 80°). At routine followup one patient had a break in the posterior fusion at the lower vertebral level after initial good fusion, suggestive of either tension break following effective anterior growth or probable pseudoarthrosis, but was associated with clinically and radiologically good correction of kyphosis with no fresh complaints. This patient was under observation without any other intervention. All 8 patients with good result were below 8 years (Mean 4.9 years) while fair results were between 8-11 years. Child older than 11 years had shown worsening with poor result.

Discussion

Congenital kyphosis has been classified[1] as Type I being failure of anterior vertebral body formation and Type II as failure of vertebral segmentation. In type I, a small wedged piece of vertebral body is usually present with intact adjacent end plates. In tuberculosis, due to unpredictable and uneven destruction of disc space with vertebral body, similar appearance usually results after healing with variable intact end plates. CT scan of spine performed in one of the patients showed almost same appearance as seen in Type I of Congenital kyphosis. If tuberculosis has healed with spontaneous fusion following effective antitubercular therapy, then the appearance may mimic Type II congenital kyphosis [Figure 1].

The tubercular kyphotic deformity of spine behaves differently in each child in response to various mechanical forces depending on the percentage of live, viable, growing cells left at vertebral growth plate. It depends not only on percent of variable growing cells left but also on the type of loading of one vertebrae over other. The progression of deformity occurs in two distinct phases.[15] Phase one is during the activity of disease, within first 18 months. Phase two is after the complete healing of disease. Children have an increased propensity toward developing a kyphotic deformity in both phases.[15]

Three types of progression patterns of kyphotic deformities in spinal TB in children are described.[15] Type I progression shows progressive increase in deformity seen in 39% of children. Type II progression shows spontaneous improvement, i.e., decreases in deformity seen in 44% children. Type III progression seen in 17% children has no change in deformity. Thus 61% children so affected do not require any sort of surgical intervention for kyphotic deformity.

The remainder 39% children will progress unto adulthood with the Kyphosis. A severe kyphosis is a major cosmetic, psychological and biomechanical disturbance in a growing child.[17] The spine compensates by creating reverse deformity as a result of kyphosis. The consequent degenerative process will produce back pain and/or radiculopathies.[2] On a long followup they develop evidence of severe lumbar canal stenosis. The capacity of chest cavity and in turn vital capacity is reduced.[18]

These deformities will require correction which may be complex anterior surgery or combined anterior and posterior surgery or pedicle subtraction osteotomies.[1,17] Combined anterior and posterior procedures are a major surgical undertaking irrespective of whether it is performed as single or two-staged procedure.[17] Anterior procedures are associated with difficulties in approaching the concavity of the angular kyphosis in the deformities greater than 60.[17] Increased treatment cost of an anterior and posterior procedure can also be a significant factor as many of these patients are from the poor socioeconomic status.[17]

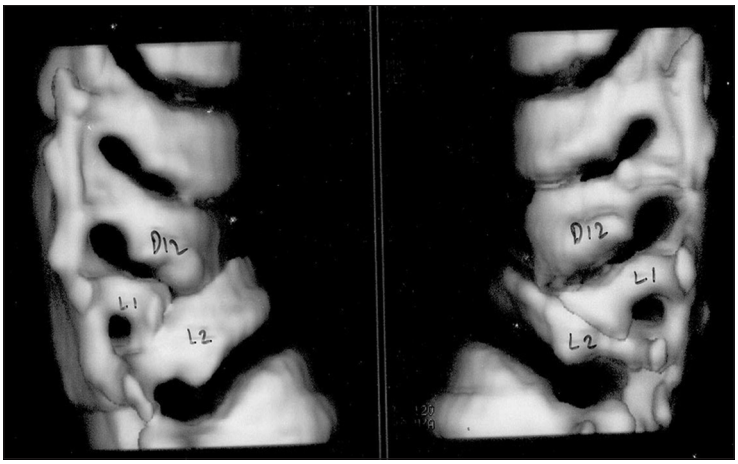

Figure 1: CT scan of dorsolumbar spine (3D) showing tuberculous lesion similar to congenital kyphosis type I (Patient: F/4.5 years, with three years after healing of tuberculosis lesion)

We decided to address these 39% children at an early age in order to give them an acceptable result with fewer complications in future. In carefully selected patients, posterior fusion has a reasonably good potential to alter the biomechanics of the natural behavior of a kyphus.

Winter and Moe[10] and McMaster and Singh[14] have recommended posterior fusion for angle less than 50 degree and age less than 5 years in treatment of congenital kyphosis. These principles were taken into account and extrapolated to guide us in treatment of healed post-tuberculosis kyphosis. Hence, we have applied them to age group up to 11 years but at the end of study, it is quite apparent that the same principles hold true as our results are better at younger age.

Review of current literature shows that a large amount of study material exists for surgical treatment of tubercular kyphosis when patients are in the active state of disease. Albee[4] and Hibbs[6] introduced posterior spinal fusion in the active stage of disease. It subsequently fell to disrepute because of progression of deformity. There is a controversy in literature with respect to progression of deformity after debridement and anterior spinal arthrodesis. Some studies[7,19-23] have reported good to excellent results, while some other studies like that of Bailey *et al*.[24] have reported an increase in deformity >10% in 42 of 100 children treated with anterior spinal arthrodesis. Fountain *et al*.[25] reported that progression of the deformity could be due to retardation of growth of anterior vertebral ring epiphyses cephalad/caudad or both to fusion mass and to overgrowth of posterior elements. Schulitz *et al*. analyzed 117 children who had either anterior radical excision and fusion, posterior fusion or combined anterior and posterior fusion and anterior debridement without fusion. The patient treated with radical resection and anterior fusion showed the worst results with respect to progression of kyphosis. They attributed contribution from posterior elements to deformity and noted the need to avoid anterior surgery in children.[8]

Correction of established deformity with anterior surgery is difficult and hazardous and with a high complication rate.[2] Therefore, no single technique can be applied to all cases as a standard mode of intervention, but successful surgery depends on selecting the right procedure and applying it at the right time.

We could find very few studies showing surgical correction of established kyphotic deformity.[1,2,17,19,26] Rajasekaran *et al*. have shown good results with single stage closing-opening wedge osteotomy to correct severe deformity in 17 patients. The average age in their study was 18.3 yrs.[17] Yau performed surgeries in three stages and still had complications.[26] The author concluded that it may be a relatively small reward for such a major undertaking. Yau and many other authors later on also believed that for patients with healed disease in whom danger of paraplegia and rapid progression of deformity are less, the hazard of deformity correction outweighs the gain hence it should not be carried out for cosmetic reasons only. For children with severe kyphosis we could not find any definite guidelines and the policy odapted was usually wait and watch.[1,26]

We performed posterior spinal fusion in all 12 patients using autogenous iliac crest grafts as well as allograft donor bone graft. 66% (eight patients) had a decrease in deformity, 25% (three patients) remained static, and only one patient showed increase in deformity. Thus, overall 91% had a favorable result. We postulate the following mechanism of correction of deformity in presence of posterior fusion. The anterior growth plates are variably destroyed and hence longitudinal growth occurs at the residual epiphyseal plates. This leads to selective differential anterior column growth,

giving gradual correction of kyphosis. Usually with single paradiscal infection destroying adjacent growth plates, the anterior far growth plate of each vertebra still remains intact with almost full growth potential as it is unaffected by tuberculosis. With correction of the deformity, the posterior fusion mass does not grow longitudinally, but the vertebral bodies in the fused region continued to increase in height and width.[27] The increase in height of the vertebral bodies in the posteriorly fused region will be initially accommodated by narrowing of the intervertebral disc spaces.[27,28]

This was proven by the MRI scan done in a single patient chosen at random which clearly demonstrated that even in children with established kyphotic deformity, the anterior growth plate was seen partially and was variably destroyed. These findings were confirmed and supported by the concerned radiologist. Thus, the remaining growth potential contributed to the overall growth of spine [Figure 2].

Figure 2: MRI Images showing the partially intact anterior growth plates (Patient: M/4.6 years, with more than one year after completion of antituberculosis therapy)

The healed kyphotic deformity may still increase even with this anterior growth potential and excessive growth of unaffected posterior elements compounded by mechanical disadvantage and altered forces. By achieving posterior fusion, the imbalance of unrestricted posterior growth over limited potential anterior growth is controlled.

This can be explained schematically as follows. Figure 3a represents the three columns of the spine with kyphosis showing anteriorly two growth plates. The dark shaded area is the fused posterior spine. The arrows represent the correction of deformity over the posterior pivot [Figure 3b].

These results are independent of site of lesion. The patients (less than 8 years of age) who had attained either their first and/or second growth spurts after the surgery fall into the 66% group of complete correction, thus substantiating our hypothesis of correction. Hefti and McMaster 1983[27] have supported this fact, documenting that even in presence of a posterior spinal fusion which stops the longitudinal growth in the posterior elements, the vertebral bodies continue to grow anteriorly and this is most apparent during the adolescent growth spurt.

To understand the cartilage growth biomechanics, we evaluated these two theories which help us to explain the correction of kyphosis. According to the Hueter-Volkmann law, the compressive forces inhibit growth and tensile forces stimulate growth.[29] The same principle is used for hemi-epiphysiodesis for genu varum or valgum. Frost plotted a single graph which he called cartilage growth force response curve. The curve shows increased growth with both mild tension and mild compression, but inhibited growth with severe compression.[30] Thus, a solid posterior fusion is likely to inhibit posterior overgrowth but

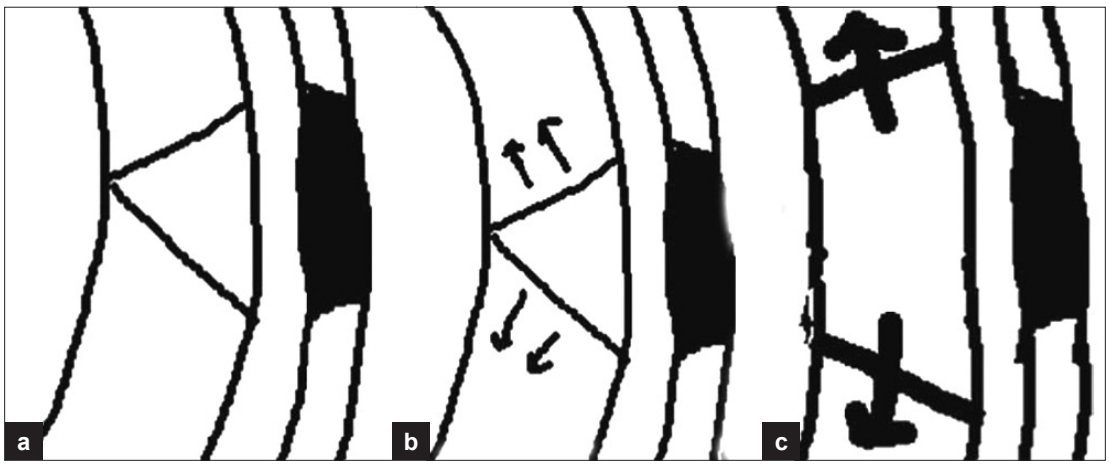

Figure 3: Schematic presentation of mechanism showing (a) triangular portion represents tubercular lesion with dark area representing posterior fusion at the concerned level. (b) double arrows represents the continued anterior growth after addition of posterior fusion. (c) big arrows represent the growth of anterior segment with correction of kyphosis

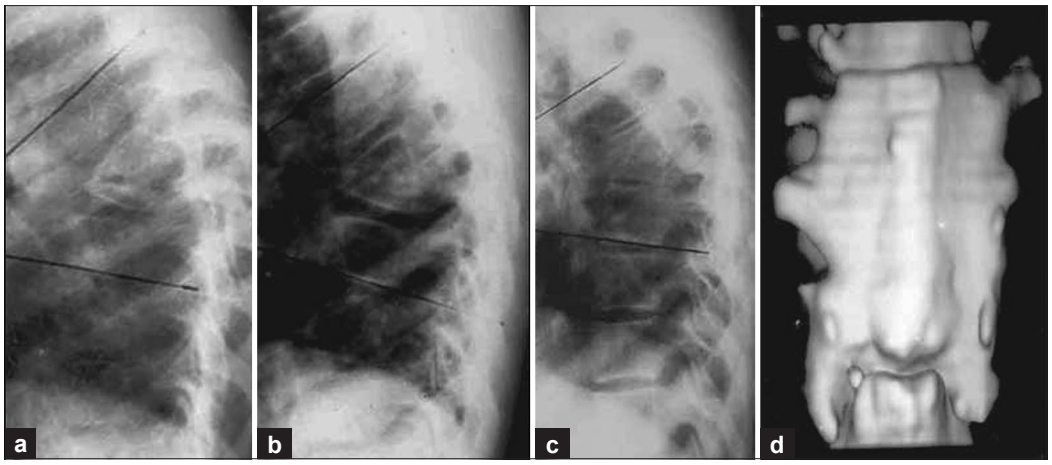

Figure 4: (a) Preoperative X-ray of dorsal spine (lateral view) with tubercular lesion and kyphosis: Angle of 40° (case No. 5 (5 years old male) with progressive kyphosis over two years followup prior to surgery). (b) followup X-ray: 1.6 years after posterior fusion. (c) followup X-ray: 3.6 years after posterior fusion: angle of 30°. (d) CT scan showing excellent fusion mass at contiguous three levels

simultaneously putting mild tension on growing anterior cartilage cells causing increased growth.[31]

Those patients who remained static probably had a zero residual growth potential due to complete destruction of the growth plates. When complimented with the addition of posterior fusion in-effect ultimately, a global fusion is achieved, thus eliminating inappropriate growth of posterior elements which might have been causing progression of kyphosis, as evident with preoperative assessment [Figure 4].

The lone patient who showed worsening of kyphosis was a female of 11 years of age. This led us to believe that the beneficial effect of residual growth was lacking due to completion of the second growth spurt already. Though we had only 12 patients, it is quite apparent that children less than 8 years had done well. Children aged 8 to 10 years have done fairly. This method is simple, safe, easily reproducible, universally acceptable, and less morbid; and can give good results that may perhaps change long term disability of patients. Although the early trends are encouraging, we understand that our study was done on a small sample size; therefore, the routinely used statistical tests of analysis are not applicable. With longer followup and larger sample size, we may be able to answer few questions like what is the earliest and the latest age at which this simple procedure will have desirable effect? Will the growth forces bend the fusion mass? Will this result in progressive lordosis? Will an early fusion stunt the growth of torso? Winter and Moe[10] and Hefti and McMaster[27] answered most of these questions negatively in respect to congenital kyphosis but it needs to be explored whether it will prove true for tubercular kyphosis. Young patient with age less than 8 yrs with well healed spinal tuberculosis but with progressive kyphosis are best suited for posterior fusion surgery to get the desirable result with growth.

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