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## Behaviour of the kyphotic angle in spinal tuberculosis

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**Abstract** We followed 70 adult patients with spinal tuberculosis for a minimum of 2 years. Forty patients were treated by ambulant multi-drug chemotherapy (group A), and 30 with neurological complications (group B) were treated by antero-lateral decompression and chemotherapy. We studied the angle of spinal kyphosis as calculated on lateral spinal X-ray by the modified Konstam's method. The angle at final follow-up was compared with the pre-treatment angle. The relationship between the amount of initial vertebral loss, the predicted kyphotic angle and the observed kyphotic angle was analysed. Mean initial vertebral loss, mean pre-treatment angle and mean observed kyphotic angle in group A were 0.77°, 24.3° and 31.75° respectively, with a mean increase in angle of 7.4°. In group B, the readings were 0.67, 25.9° and 26.8° respectively, with a mean increase in angle of 0.9°. Kyphotic deformity continued to progress until 2 years' follow-up. Progression was more pronounced in the non-operative group.

**Résumé** Nous avons suivi 70 malades adultes avec une tuberculose de la colonne vertébrale pendant une période minimum de deux années. Quarante malades ont été traités par chimiothérapie multi—drogue ambulatoire (groupe A) et 30 malades avec des complications neurologiques (Groupe B) ont été traités par décompression antero—latérale et chimiothérapie. Nous avons étudié l'angle de cyphose vertébrale calculé sur cliché sagittal par la méthode de Konstam modifié. L'angle à la fin de l'étude a été comparé avec l'angle avant traitement dans les deux groupes. Les rapports entre le montant de la perte vertébrale initiale, l'angle prédictif de la cyphose et l'angle observé de la cyphose ont été analysés. Dans le groupe A, la perte initiale moyenne du corps vertébral,

l'angle moyen du prétraitement et l'angle moyen observé étaient respectivement 0,77, 24,3° et 31,75° avec une augmentation moyenne de l'angle de 7,4° tandis que dans le groupe B, les valeurs étaient 0,67°, 25,9° et 26,8° avec une augmentation moyenne de l'angle de 0,9°. La déformation de la cyphose a continué à progresser jusqu'à 2 années de suivi. La progression a été plus prononcée dans le groupe non-opéré.

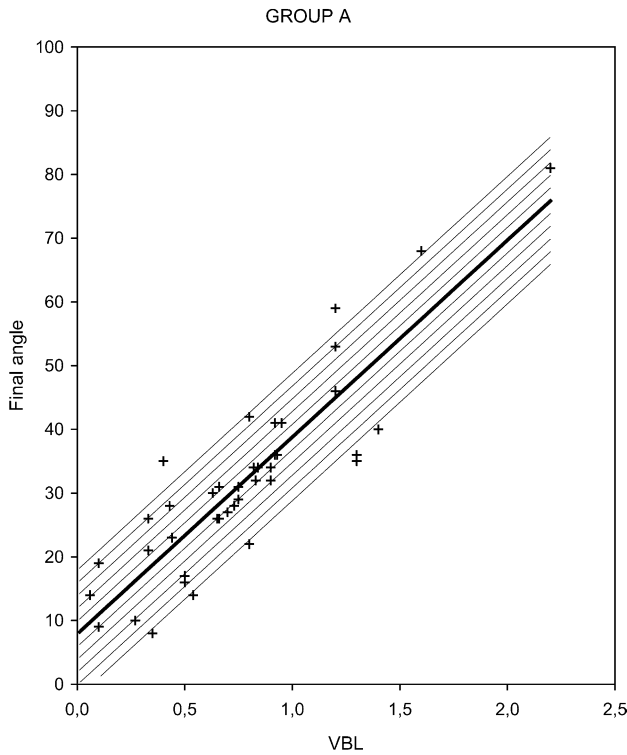
### Introduction

Spinal tuberculosis is a common cause of severe kyphotic deformity. In developing countries, 95% of patients show a clinically detectable kyphosis by the time they report for specialised treatment [8]. Treatment in the early stage of disease prevents further progression of deformity. Neglect or inadequate care may result in a progressive kyphotic deformity. In spite of adequate treatment with modern anti-tubercular drugs with or without surgery, some degree of deformity persists once the disease heals.

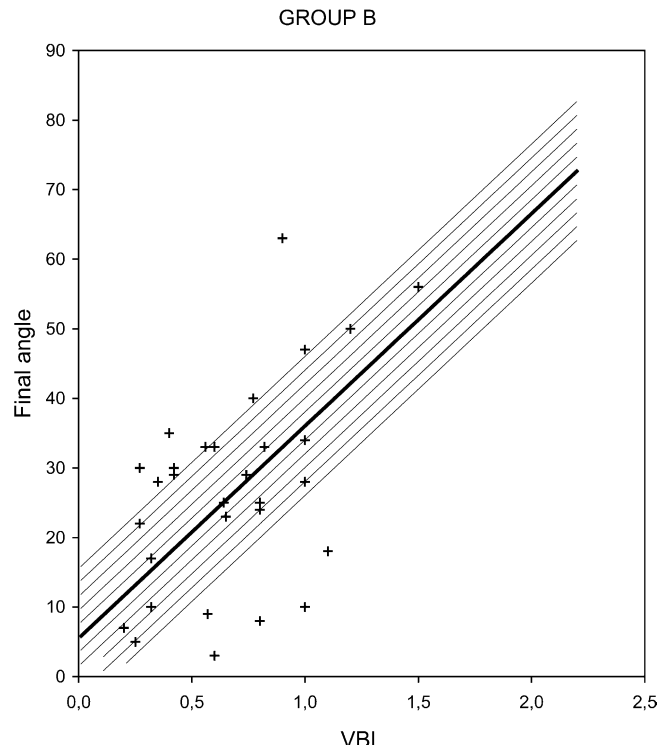
Almost 3% of patients with Pott's disease develop a severe kyphotic deformity [9]. Nearly all such patients develop cardiopulmonary dysfunction, painful costo-pelvic impingement or late-onset paraplegia at an average of 10 years after disease onset [9]. Treatment of the established disease is difficult, hazardous and has a very high complication rate. Prevention of a grotesque kyphotic deformity is possible if we can identify patients who are at risk of developing a severe deformity and predict the final kyphotic angle. In such cases, kyphosis can be corrected in the active stage of the disease [2].

The present analysis is an attempt to study the behaviour of the kyphotic angle with treatment and to define the relationship between the initial vertebral body loss (VBL), the predicted final kyphotic angle and the observed final kyphotic angle.

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**Fig. 1** Group A: Correlation between the observed final angle and the initial vertebral body loss (VBL). The predicted final angle=5.5+30.5×VBL



**Fig. 2** Group B: Correlation between the observed final angle and the initial vertebral body loss (VBL). The predicted final angle=5.5+30.5×VBL

**Material and methods**

We studied 70 patients of either gender who were older than 15 years of age with tubercular spondylitis and a single spinal lesion at level L2 or above. The patients were treated by the middle path regimen [8]. Those without neurological complications were treated by ambulant chemotherapy, while those with neural complications were treated by surgical decompression if neural deficit developed, remained stationary or deteriorated on non-operative treatment. Patients were divided into two groups: group A: 40 patients treated by ambulant un-interrupted multi-drug chemotherapy. Group B: 30 patients treated by antero-lateral decompression (ALD) and multi-drug chemotherapy.

The pre-treatment kyphotic angle and initial VBL (x) were calculated for each case on lateral spinal X-rays. The kyphotic angle was calculated on lateral spinal X-ray by modified Konstam’s method [7].

**Calculation of initial VBL**

Anterior vertebral body height of the normal vertebra above and below the lesion were measured. The average of these values was taken as presumed normal height of each affected vertebra in the lesion (d). VBL for each vertebra was calculated by subtracting the measured height of each affected vertebra from the presumed normal height. The values thus obtained for each affected vertebra were summed up to obtain the total loss of height (c). Where two or three vertebrae had lost separate identity, then total anterior height of the diseased segment was measured. This was subtracted from the presumed normal height of all affected vertebrae. Thus, the initial VBL was calculated as  $VBL=c/d$ , where c=summed-up loss of height of all affected vertebrae and d=presumed normal height of one affected vertebra.

Three different observers calculated the initial VBL, and the mean of those readings was taken as final initial VBL. The predicted final kyphotic angle was calculated at the start of treatment according to the formula  $Y=5.5+30.5 \times VBL$ , where Y is the predicted final kyphotic angle and VBL is the initial VBL [7].

The kyphotic angle was measured at 3-monthly intervals after commencement of treatment up to a minimum of 2 years. The kyphotic angle at the final follow-up was compared with the pre-treatment angle and the predicted final angle, and a correlation with initial VBL was drawn (Figs 1 and 2).

**Results**

**Group A**

The patients’ mean age was 31 (16–63) years. There were 17 males and 23 females. Thirty-two patients had no neural deficit, while three patients had stage I and five had stage II paraparesis [2]. They recovered neurologically on non-operative treatment. The average number of affected vertebral bodies was 2.23. Thirty-one patients had 2 vertebrae involvement, while nine had involvement of three. One patient had cervical spine involvement, 21 had dorsal spine involvement and 18 had dorso-lumbar junction (D10-L2) involvement. Mean follow-up was 2.3 (2–6) years.

Mean initial VBL was 0.77 (0.1–2.2), Mean pre-treatment angle was 24.3°(1–73°), mean predicted angle was 28.7°(9–73°) and mean observed final angle was 31.7° (8–81°) (Table 1).

**Table 1** The number of cases in relation to kyphosis severity as determined before treatment, at last follow-up and as predicted on the basis of the initial vertebral body loss

| Kyphos angle range | Pre-treatment angle (number of cases within each range) |         | Predicted final angle (number of cases within each range) |         | Observed final angle (number of cases within each range) |         |
|--------------------|---|---------|---|---------|--|---------|
|                    | Group A   | Group B | Group A   | Group B | Group A  | Group B |
| 0–10°              | 8   | 1       | 3   | 0       | 3  | 7       |
| 11–20°             | 11  | 11      | 9   | 10      | 5  | 2       |
| 21–30°             | 9   | 8       | 13  | 12      | 11   | 11      |
| 31–40°             | 9   | 8       | 7   | 6       | 13   | 6       |
| >40°               | 3   | 2       | 8   | 2       | 8  | 4       |
| Mean angle         | 24.3°   | 25.9°   | 28.72°  | 26.14°  | 31.75°   | 26.8°   |

In 27 patients, the kyphotic angle at 6 months was compared with the angle at the most recent follow-up. Nineteen patients showed an increase and five showed a decrease in kyphotic angle. At final follow-up, five patients showed a decrease in kyphotic angle of 0–10°, three maintained their pre-treatment angle, while 32 showed an increase (Fig. 3). Twenty patients had an increase of 0–10°, eight had an increase of 11–20° and four had an increase of more than 20° at final follow-up with a mean increase of 7.4°.

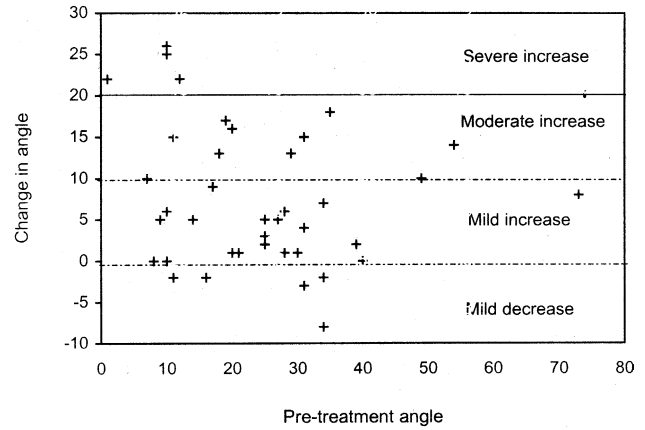
The observed final angle was  $\pm 2^\circ$  of the predicted angle in 11 patients,  $\pm 4^\circ$  in 19,  $\pm 6^\circ$  in 22,  $\pm 8^\circ$  in 28 and  $\pm 10^\circ$  in 33. Almost 17.5% of patients had a difference of more than  $\pm 10^\circ$ . The observed final angle was  $\pm 10^\circ$  of the predicted value in 82.5% of patients (Fig. 1).

**Group B**

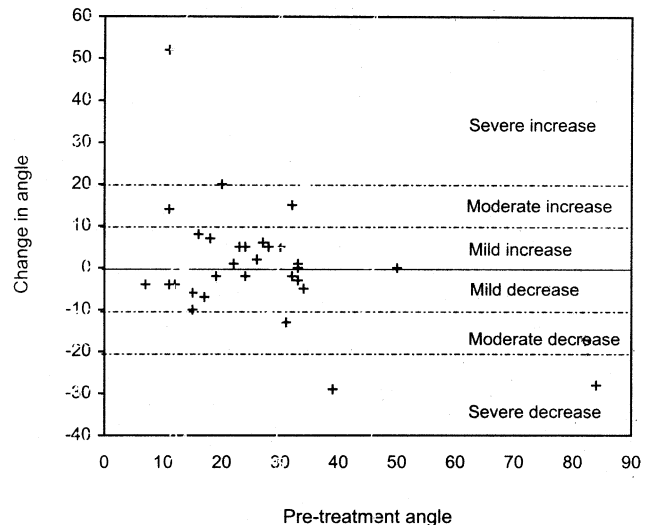
Anterolateral decompression was performed in 30 patients who presented with stage IV paraplegia [2]. Mean patient age was 31.6 (16–70) years. There were 17 males and 13 females. Twenty-one patients had involvement of two vertebrae and nine had involvement of three. The average number of affected vertebral bodies was 2.3. Twenty-nine patients had dorsal spine involvement, while one had dorso-lumbar involvement. Twenty-seven patients had complete neural recovery, whereas one showed no neural recovery. Patients were followed up for a mean of 2.5 (2–6) years.

Mean initial VBL was 0.67 (0.2–1.5), mean pre-treatment angle was 25.9° (7–84°), mean predicted angle was 26.1° (12–51°) and mean observed final angle was 26.8° (3–63°). In 20 patients, the angle at 6 months' follow-up was compared with the angle at most recent follow-up; 11 patients showed an increase, while nine (45%) showed a decrease.

At the final follow-up, 15 patients showed a decrease in kyphotic angle (Fig. 4), of which 12 had a decrease of less than 10°, one a decrease of 11–20° and two a decrease of more than 20°. Thirteen patients showed an increase, nine showed an increase of 0–10° and one an increase of more than 20°. The mean increase was 0.9° (0–52°). In four patients, the observed final angle was  $\pm 2^\circ$  of the predicted,  $\pm 4^\circ$  in six,  $\pm 6^\circ$  in 12,  $\pm 8^\circ$  in 16 and  $\pm 10^\circ$



**Fig. 3** Group A: Correlation between the pre-treatment angle and the change in angle at last follow up (n=40)



**Fig. 4** Group B: Correlation between the pre-treatment angle and the change in angle at last follow up (n=30)

in 18. Almost 40% of patients had a difference of more than  $\pm 10^\circ$  between the observed and the predicted angle.

Initial VBL and observed final kyphotic angle showed a correlation coefficient of 0.88 in group A and 0.51 in group B (Figs. 1 and 2).

## Discussion

In spite of effective treatment for spinal tuberculosis, it is common to find residual kyphosis at the end of treatment [7]. Patients with severe deformity after lesion healing may develop late-onset paraplegia after 5–20 years of the initial disease. Most of the deformity in adults is the outcome of, and directly proportional to, the diminution in disc-space height and vertebral body destruction [9]. Late-onset paraplegia is best avoided by preventing the development of severe kyphosis. Patients with spinal tuberculosis who are likely to develop severe kyphosis ( $>60^\circ$ ) on completion of treatment should be identified and have surgery in the active stage of disease to improve kyphosis [2].

The average number of affected vertebrae in both groups in our study was 2.3. Hodgson and Stock [1] reported average vertebral involvement of 3.4, while Tuli et al [10] reported average involvement of 2.5 for adults. Initial VBL was found to be less than one in 59 patients (84%), whereas Rajasekaran [6] found the initial VBL of less than one in only 60% of his patients. In our study, initial VBL was less than one in 32 patients (80%) in group A and 27 patients (90%) in group B (mean 0.77 and 0.67 respectively). Thus, both groups were equally matched for VBL for comparative analysis.

Rajasekaran et al. [7] calculated initial VBL by dividing each vertebra arbitrarily into ten equal parts on lateral radiograph. The summed-up loss of all vertebrae was taken as the initial VBL. The affected vertebrae in spinal tuberculosis usually are so damaged that it is not possible to define the borders of all vertebrae in the destroyed segment. To arbitrarily divide each vertebra into ten equal parts is not always possible. We faced this problem in almost 50% of patients. Therefore, we calculated the initial VBL by our alternative method successfully in all cases.

Tuli et al. [10] treated 100 patients by ambulant chemotherapy. He reported either no change in angle or an increase of less than  $10^\circ$  in 78% of patients as against 57% in our series. He reported an increase of  $10^\circ$  or more in 20% as against 30% in our series, and a decrease in 2% as against 13% in our study. The Medical Research Council (MRC) [3] in its third report found a mean increase of  $6^\circ$  in the group with ambulant chemotherapy as against  $7.4^\circ$  in our series.

In group B (operative group), 15 patients (50%) showed a decrease in angle at the final follow-up. Decrease or increase was less than  $10^\circ$  in 26 cases (85%). Only four cases (15%) showed an increase of more than  $10^\circ$ , of which only one had an increase of more than  $20^\circ$ . Antero-lateral decompression and debridement surgery of the lesion was performed in our group B.

The MRC [4], in its sixth report found a mean angle decrease of  $1^\circ$  in the radical surgery group and a mean increase of  $4^\circ$  in the debridement surgery group. Upadhyay et al. [11] found that 53% showed an increase in kyphotic angle after debridement surgery as against 46% in our series. The MRC [5], in its 13th report, found a

mean increase of  $11^\circ$  in the debridement series at 15 years' follow-up as against a mean increase of  $0.9^\circ$  in our study at a mean follow-up of 2.5 years. Thus, we could prevent deterioration of kyphosis after debridement surgery.

The kyphotic angle achieved at 6 months was not maintained at the most recent follow-up in our series. In the operative group, 11 patients (55%), and in the conservative group, 19 patients (70%), showed an increase from 6 months to final follow-up at 2 years. This is in contrast to the observation of Upadhyay et al. [11] that the kyphotic angle at the 6-month post-operative evaluation was maintained at final follow-up and that there was no statistically significant difference between the angle at 6 months and final follow-up.

Rajasekaran [7] suggested the formula to predict the final angle in patients treated non-operatively, and he predicted the final angle with 90% accuracy. However, the statistical method to calculate 90% accuracy is not spelled out. In our ambulant chemotherapy group (40 patients), the observed angle was  $\pm 4^\circ$  of the predicted angle in 47.5% patients and  $\pm 10^\circ$  in 82.5% patients. In the operative group, the observed angle was  $\pm 4^\circ$  of the predicted angle in 20% and  $\pm 10^\circ$  in 60% of patients only. Analysis of the amount of initial VBL and final angle showed a correlation coefficient of 0.88 (77.64% accuracy) in the conservative group and 0.51 (26.01% accuracy) in the operative group in our series. Thus, we feel that kyphotic angle prediction is not feasible in the surgical decompression group, while in the ambulant chemotherapy group, the final angle could be predicted with 77.64% accuracy.

Although in the conservative group the initial VBL and the observed final angle had better correlation than in the operative group, the mean pre-treatment angle in this group varied from the mean observed final angle by  $7.45^\circ$  as compared to only  $0.9^\circ$  in group B. The variation between the mean predicted final angle and the mean observed final angle was  $3.03^\circ$  and  $0.64^\circ$  in groups A and B respectively. This is attributed to the fact that in group B, only 33% of patients had an increase in the final angle compared to their pre-treatment angle, while another 50% showed a decrease in the final observed angle; hence the mean value did not alter significantly. On the contrary, in group A, the majority of the patients (80%) had an increase in the final angle, hence an increase in mean value, in spite of a better correlation between the initial VBL and the observed final angle. In summary, all cases of spinal tuberculosis having an initial VBL of 2 would have a predicted kyphosis angle of  $66.5^\circ$ . It is these cases that require operative correction of the kyphosis in the active stage of the disease.

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