SPINAL DEFORMITY AFTER CHILDHOOD SURGERY FOR TUBERCULOSIS OF THE SPINE

A COMPARISON OF RADICAL SURGERY AND DEBRIDEMENT

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We have reviewed 80 children who were involved in the Medical Research Council (UK) trial of surgical treatment for tuberculosis of the spine in Hong Kong. Radical surgery or debridement had been performed at mean ages of 7.6 years (n = 47) and 5.1 years (n = 33) respectively. The patients were followed up to skeletal maturity (mean 17 years). Spinal deformity was measured on lateral radiographs taken preoperatively, at six months, one year, five years and at final follow-up.

Radical surgery and grafting produced a reduction in kyphosis and deformity angles at six months; this correction was maintained during the growth period. By contrast, after debridement surgery there was an increase in deformity at six months, with a tendency to some spontaneous correction during the growth period. There were statistically significant differences between angles for the radical and debridement groups only at six months postoperatively, but the changes during later follow-up were similar in the radical and debridement groups.

Our findings highlight the importance of the surgical correction of deformity, and provide no evidence to suggest that disproportionate posterior spinal growth contributes to progression of deformity after anterior spinal fusion in children.

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We have made a longitudinal study of spinal deformity due to tuberculosis in childhood, following cases to adult life after radical resection and bone grafting, or local debridement. To our knowledge, this has not previously been reported. There are many papers on the clinical aspects of the disease, but these usually concentrate on the results of conservative treatment, posterior spinal fusion and drainage of the abscess (Kidner and Muro 1927; Compere and Jerome 1935; Bennet 1936; Adams 1940; Chandler and Page 1940; Mayer 1940; Kastert 1951; Cleveland et al 1958; Karlén 1959). Few publications relate to spinal deformity after surgical treatment and none separates the results in children and adults or evaluates the deformity separately for thoracic, thoracolumbar and lumbar levels (MRC 1973a,b; 1974a,b; 1976; 1978a,b; 1982; 1985; Fountain et al 1975; Rajasekaran and Shanmugasundaram 1987).

Fountain et al (1975) reviewed 31 children with solid anterior spinal fusion after tuberculosis of the spine; they reported progressive kyphosis in three. There is no detailed study of the effect of growth on spinal deformity in such cases, although tuberculosis is still prevalent in much of the world and may be increasing in parallel with the increase in numbers of immuno-compromised patients (Rajasekaran and Shanmugasundaram 1987; Slater, Beale and Bullitt 1991).

We have reviewed 185 (94%) of the 196 patients initially entered into the MRC Hong Kong study. Of these patients, 80 were followed to skeletal maturity. We evaluated the longitudinal pattern of changes in spinal deformity, in both radical and debridement groups, and the effect of growth after anterior spinal fusion.

PATIENTS AND METHODS

The 80 children with tuberculosis of the spine were treated by either radical resection and bone grafting (the ‘Hong Kong’ operation) or by debridement alone. The patients entered the original study according to criteria set by the MRC working party (1974b). Of these, 47 (22 male and 25 female) had radical surgery at the age of 7.6 ± 5.1 years (mean ± 1 sd) and 33 (17 male and 16 female) had debridement at a mean age of 5.1 ± 4.1 years. At final follow-up after an average of 17 years, the mean ages of the groups were 22.9 and 24.8 years respectively. Most of the children (77.5%) had been under 11 years of age at the time of the operation.

Tuberculosis involved the thoracic spine in 18, the thoracolumbar spine in 36, and the lumbar spine in 26. Original treatment. Patients were randomly allocated for either debridement or radical surgery. Debridement involved...
For each unaffected vertebra the four corners of the body were selected. For affected or deformed vertebrae, the four datum points were the corners of the upper and lower vertebrae involved in the lesion (Fig. 1). The vertebral and disc heights and angles, and the angles of kyphos (K) and of deformity (D) (Fig. 1) were calculated automatically by the computer program.

We evaluated these electronic methods of measuring kyphos and deformity angles in a reliability study of three observers on 20 spinal radiographs. Each observer traced each radiograph twice on separate occasions, and then digitised the tracings twice, again on separate occasions. Two-way analysis of variance was used to assess intra- and inter-observer variations and the residual mean square was used to calculate the pooled standard deviation to provide 95% confidence limits. We found no statistically significant differences between the measurements obtained by each observer, or between the two observers. The 95% confidence limits were ±1.6° and ±2.3° for intra- and inter-observer variations respectively.

The results of the study were analysed using SPSS PC+ statistical software package on an IBM-compatible computer, employing paired and unpaired Student’s t-tests and analysis of variance.

RESULTS
Thoracic spine. The means of kyphos and deformity angles at each evaluation are shown separately for the radical surgery and debridement groups in Figure 2. In the radical group there was a reduction in the mean kyphos (Fig. 2a) from 31° preoperatively to 24° six months postoperatively, and this improvement was largely maintained into adult life. By contrast, the debridement group showed an increase in the mean kyphos from 35° to 43° after surgery; this also remained practically unchanged, except in the period from one to five years postoperatively, when there appeared to be a spontaneous correction of about 5°. The deformity angles showed a similar pattern (Fig. 2b).

Comparison between groups. The mean changes in kyphos and deformity angles were calculated for each group and time interval (6-month minus pre-operative, 1-year minus 6-month, 5-year minus 1-year and latest follow-up minus 5-year) to determine the periods during which the main changes occurred. The mean change in kyphos angle in the first six months was statistically highly significant between radical and debridement groups: the radical group improved, while the debridement group deteriorated. We found no other significant differences for other periods of follow-up (Table 1). Deformity angles showed a similar pattern of results.

Thoracolumbar spine. The results for the thoracolumbar spine are shown in Figure 3. The radical group showed a mean reduction of 5° in kyphos six months after surgery, whereas the debridement group showed a mean increase of 11°.

In later periods, the mean angle of kyphos in the radical group changed little but the debridement group had a
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**Table I.** Results for the thoracic spine. Comparison between radical and debridement groups showing mean change ±1sd (95% confidence intervals)

<table>
<thead>
<tr>
<th>Change</th>
<th>Change in kyphos angle*</th>
<th>Change in deformity angle*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Radical (n=13)</td>
<td>Debridement (n=5)</td>
</tr>
<tr>
<td>Preop to 6 m</td>
<td>-7.0±5.8</td>
<td>8.2±5.5</td>
</tr>
<tr>
<td>6 m to 1 yr</td>
<td>1.7±6.4</td>
<td>2.7±10.6</td>
</tr>
<tr>
<td>1 yr to 5 yr</td>
<td>-2.9±7.6</td>
<td>-5.0±9.8</td>
</tr>
<tr>
<td>5 yr to final</td>
<td>1.9±8.8</td>
<td>0.2±5.3</td>
</tr>
</tbody>
</table>

* minus sign indicates improvement, no sign indicates deterioration
† by Student’s t-test

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Thoracic spine (n = 18). Mean values for kyphos angles (left) and deformity angles (right) from preop to final follow-up for the radical and debridement groups.

Thoracolumbar spine (n = 36). Means of kyphos angles and deformity angles from preop to final follow-up for radical and debridement groups.

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spontaneous mean correction of 5° from six months postoperatively to the final follow-up (Fig. 3a). The mean deformity angle was reduced by 7° in the radical group six months postoperatively, but the debridement group had a mean increase of 11°. From six months to one year, the radical group had a mean increase of 5° and then little change to final follow-up. The debridement group again showed spontaneous correction of deformity angle by a mean of 8° from six months to final follow-up.

Comparison between groups. Table II shows the kyphos and deformity angles calculated as for the thoracic spine. Again, there were statistically highly significant differences between the kyphos angles of the radical and debridement groups at six months, and no significant differences during subsequent periods.

There was a similar pattern for the deformity angles except that the mean angles at six months and one year were significantly different: the radical group deteriorated and the debridement group improved. This result was mainly due to the failure of the bone grafts in three patients during this period resulting in loss of correction.

**Lumbar spine.** In the lumbar spine, changes in kyphos angle were very different between the groups. In Figure 4a, a negative value indicates lordosis and a positive value, kyphosis. The mean preoperative kyphos angle in the radical group was 9° of lordosis; it did not change after surgery, and at final follow-up the mean lordosis was 14°. By contrast, the debridement group changed from a mean preoperative lordosis of 4° to a mean kyphosis of 9° at six months, and to 6° at final follow-up. In the debridement group, six of the ten children had kyphos angles of 10° or more at final follow-up (mean for these 24°, range 10° to 59°).

In the radical group the mean preoperative deformity angle was 10°, reducing to 7° at six months and 4° at final follow-up (Fig. 4b). In the debridement group, the mean preoperative deformity angle was 20°, which increased to 37° at one year and improved only to 21° at final follow-up. Examples of the results of radical surgery and of debridement are shown in Figures 5 and 6.

Comparison between groups. Again, mean differences between the groups at six months were statistically significant, with no significant differences later (Table III).
Sequence of spinal radiographs of a boy treated by radical surgery for tuberculosis of the lumbar spine involving three vertebrae. The preoperative lateral radiograph at 3.5 years of age shows a deformity angle of 21°. Six months after radical surgery the deformity was 0°. At 15 months the grafts had consolidated and the deformity angle was 2°. At 20 years' follow-up the deformity angle was 8° but the lumbar spine had a lordosis.
Sequence of spinal radiographs of a boy treated by debridement for tuberculosis of the lumbar spine involving three vertebrae. The preoperative lateral radiograph at 7.5 years of age shows a 19° deformity angle. This increased to 36° at six months. At 20 years the deformity angle was 27° with a kyphotic lumbar spine.
DISCUSSION

Müller (1906) described an anterior approach to the spine before posterior fusion was introduced by Albee (1911) and Hibbs (1912). Ito, Tsuchiya and Asami (1934) reported ten patients with lumbar spinal tuberculosis, eight treated surgically by a retroperitoneal approach with bone grafting in two. Hodgson and Stock (1956), in a preliminary communication, reported a more extensive excision of bone and diseased tissue and with reconstruction by strut bone grafts. Bailey et al (1972) reviewed 100 of these children aged one to ten years, but used different methods to evaluate kyphosis preoperatively and postoperatively. They used Kaplan’s classification into mild, moderate, and severe before operation and measured the kyphos after fusion as the angle between the top surface of the upper vertebral body in the fusion and the bottom surface of the most inferior body. This did not allow them to record the immediate correction of deformity by surgery.

In previous reports on kyphos angle, data have been pooled irrespective of the site of lesion (MRC 1973a,b; 1974a,b; 1976; 1978a,b; 1982; 1985; Rajasekaran and Shanmugasundaram 1987). We found it impossible to pool lumbar with thoracic tuberculosis because of the difference in normal anatomical curvature. We used Konstam’s method for measurement of kyphos and also evaluated a deformity angle (see Fig. 1), which excluded the influence of adjacent normal vertebrae and discs. For lumbar tuberculosis at final follow-up, the mean deformity angle was 4.4°, but the kyphos angle was lordotic because of the compensatory effect of the unaffected discs and vertebrae adjacent to the lesion.

After radical surgery producing a reduction of mean kyphos and deformity angles at six months, there was minimal variation up to maturity. The only exception was in lumbar tuberculosis where the mean lordotic angle of 10° was not reduced after surgery, but improved between one and five years postoperatively. Children who had debride-ment surgery showed a large increase in kyphos and deformity angles at six months, but after this there was a tendency towards spontaneous correction. There were slight variations in this pattern, with some showing further increase in kyphos and deformity angles between six months and one year.

From one year after operation, children who had radical surgery showed no deterioration while those who had debridement tended towards spontaneous correction. There is thus no evidence to suggest that posterior spinal growth contributes to progression of deformity after anterior spinal surgery.

Our findings show that radical surgery produces a lasting correction, and that debridement causes initial deterioration. This highlights the importance of the choice of operation: it will determine the degree of spinal deformity for many years.

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