Pedicle subtraction osteotomy for rigid post-tuberculous kyphosis

We studied 15 patients with healed tuberculosis of the spine and a resultant kyphosis. We selected only those with no neurological deficit and performed a wedge resection of the vertebra using a transpedicular approach. The wedge was removed from the apex of the deformity. For those with a neurological deficit, we chose the conventional anterior debridement and decompression with 360° circumferential fusion. At a mean follow-up of 26.8 months (8 to 46) the outcome was good with an increase in the mean Oswestry Disability Index from 56.26 (48 to 62) pre-operatively to 11.2 (6 to 16) at the latest follow-up.

Rigid kyphotic deformities may be the result of congenital hemivertebrae, chronic infections such as tuberculosis, and vertebral trauma with significant loss of the anterior column. In tuberculosis, the risk factors for an increase in kyphosis are a young age at onset, multiple affected levels and involvement of the thoracic spine. Various techniques have been described to correct the deformity.1-14 The traditional two-stage technique allows a thorough decompression but requires two operations and has an increased morbidity. Recently, pedicle subtraction techniques have gained popularity because they achieve a reliable one-stage correction.9-11,13,15,16

We performed the 'egg-shell' procedure, first described by Heining and Boyd6 in the 1970s, in 11 patients and total vertebral resection in four. Our intentions were to correct the kyphosis, prevent further deformity and improve the cosmetic appearance of the spine. This procedure has subsequently been described by other authors.6,7,15 Suk et al13 have described the technique in detail, and included patients who have had a spinal infection in their study. However, as in the procedure described by Kawahara et al,13 the lamina was removed early in the operation. In our procedure, we carried out the laminectomy and excision of the facet joints at the end of the procedure, as we believe it helps to maintain the stability of the spine, thereby preventing inadvertent neurological damage. We have found no reports describing this modified technique for the correction of kyphosis in the tuberculosis spine.

Patients and Methods

Between 1999 and 2003, we assessed 56 patients with a severe post-tubercular kyphosis who presented at our clinic. Only those with healed tuberculosis at the dorsal (1 patient) and dorsolumbar regions (14 patients), with no neurological deficit were included in this study. A total of 14 had been treated at other centres, and ten had histopathological evidence of tuberculosis. None had undergone any previous surgical treatment. Each was treated with four-drug antituberculous therapy for nine to 12 months, and had an MRI to look for any residual abscess and changes in the end-plates. There were seven who showed bony reconstitution of the end-plates and eight had no evidence of bony fusion across the disc space, only fibrotic changes. Surgical correction of the deformity was undertaken after confirming that there were no signs of active tuberculosis. Three patients had not attained skeletal maturity and therefore had a risk of significant progression of the curve. All complained of pain, which was not relieved by analgesia, bracing or physiotherapy. All considered their deformity unacceptable. Patients without back pain or a significant cosmetic deformity were not included in the study.

The mean age of the patients was 27 years (6 to 44). All were rated for pain using a five-point Likert scale. Each patient was asked to classify their pain as one of the following: 1, severe; 2, moderate with severe exacerbations; 3, moderate but manageable; 4, mild, intermittent; 5, little or no pain. Their overall functional outcome was assessed using the Oswestry Disability Index (version 2.0).17 Table I gives details of the various cases.

Procedure. The patient was placed prone on a four-post frame. All the levels to be instru-
mented were exposed and completely decorticated to the tips of the transverse processes. The pedicles at all levels to be instrumented were identified. Generally two pedicles above and two pedicles below the osteotomy were stabilised using stainless steel Moss-Miami-type screws (Sushrut Surgicals Pvt Ltd., Pune, India). Polyaxial screws were preferred so that straighter rods could be used, allowing better compression. The pedicle screws were inserted at the start of the procedure, after complete exposure of the vertebral column. Having inserted the screws, the pedicle at the apex was localised. Its lateral wall was removed and a sharp periosteal elevator or curved osteotome used to develop the plane on the lateral side of the pedicle and vertebral body. A curved periosteal elevator was swept around the anterolateral surface of the body, retracting the soft tissues on each side.

The pedicle was probed and cleaned of cancellous bone using a sharp scoop until only the shell of the end-plates, or the residual bony cortex, remained. The medial wall and residual cortex attached to the posterior longitudinal ligament were removed last. A wedge of vertebral body at the apex of the deformity was excised with its apex at the level of the anterior longitudinal ligament. The cortical endplates were preserved and the adjacent disc spaces left intact in 11 cases. In the four patients with a deformity of 80° or more, a formal vertebral resection was performed rather than the egg-shell procedure. No more than one vertebra was removed because of the potential danger of excessive vertebral shortening. The instrumentation was used to close the wedge and provide a posterior tension band.

The patients were mobilised in a Taylor brace (T. N. Medical College and Nair Hospital, Mumbai, India) on the third day after their drains had been removed. They were encouraged to sit with support in the immediate post-operative period and to stand and walk with support by the end of the first week. The brace was discontinued at six weeks.

**Statistical analysis.** We analysed our results using the paired t-test. A p value < 0.05 was considered to be significant.

### Results

The mean pre-operative kyphosis was 58.8° (34° to 100°). The mean immediate post-operative kyphosis was 13.7° (0° to 40°) and was a significant improvement (p < 0.001) (Fig. 1). A mean correction of 44.2° (18° to 70°) was obtained. At a mean follow-up of 26.8 months (8 to 46) the mean loss of correction was 4.2° (0 to 13) (p < 0.05). There were no major intra-operative complications. The mean operative time was 210 minutes (110 to 220). The mean blood loss was 940 ml (550 to 1550). The mean Oswestry Disability Index improved from 56.26 (48 to 62) pre-operatively to 11.2 (6 to 16) at the latest follow-up. There was a superficial wound infection in two patients (cases 4 and 5) and one deep infection (case 6). The superficial infections resolved with a prolonged course of antibiotics. The deep wound infection required surgical debridement on day ten and had resolved completely by day 21.
Of the 15 patients, 13 were completely satisfied with their outcome, but two still complained of mild residual pain which settled with analgesics.

**Discussion**

Traditional approaches to spinal corrective surgery, such as fusion in situ, convex growth arrest or a two-stage correction, can produce only a limited improvement. Bridwell et al. described posterior resection of the vertebral body in multplanar deformities with a satisfactory outcome, although pseudarthrosis was a significant complication. We saw this in none of our cases. In our series, patient satisfaction was higher, mainly because we only included uniplanar deformities and our fusion rates were better.

The kyphotic spine should not be fused in situ. Setting with loss of height in the anterior column and subsequent kyphosis in a long fusion can occur if the structural integrity is not restored to the anterior column by grafting. Long constructs which extend well beyond the involved levels are needed to neutralise the bending moments of these rigid deformities. The length and location of the stabilising construct are critical. The length of the implant must be sufficient to apply the necessary bending moment to the spine, but not so long as to create excessive stiffness. To achieve this, a two-stage procedure, with both anterior and posterior stabilisation, may be required to maintain the correction until fusion occurs. The posterior segmental spinal instrumentation can pull out and displace the anterior structural graft if the graft-body junction is not stable.

Shimode et al. described the technique of pedicle subtruction osteotomy in seven cases of severe rigid kyphosis. They carried out a posterior wedge resection osteotomy at the apex and instrumented three levels above and below. Our arthrodesis and instrumentation extended two levels above and below the principal vertebral body since good bony apposition of the end-plates obviated the need for longer fusion. Radiological evidence of fusion was seen in all our patients. Wu et al. obtained similar results even though they only instrumented the adjacent level.

A dorsal osteotomy provides bone-to-bone apposition with inherent stability and aims to shift the sagittal vertebral axis dorsally, bringing the spine into balance. It is most safely performed in the lumbar spine.

Kawahara et al. treated kyphosis of a non-infectious aetiology with a closing-opening wedge osteotomy in which they inserted a graft in the anterior half of the spinal column after closing the wedge osteotomy. They reported no neurological complications. However, their technique was demanding and required precise control over the mobile segments of the spine to prevent injury to the spinal cord. Ventral grafting was undertaken in all cases. We did not feel the need for ventral grafting, as we were able to achieve bone-to-bone contact after removing all cancellous bone. However, in one case, where we were unable to achieve this, anterior grafting was used.

When needed, the ventral weight-bearing strut should be placed well ventral to the neutral axis and in line with the load-bearing axis. Suk et al. reported anterior as well as posterior column fusion using the same posterior approach. The condition of the para-discal bone, which is commonly involved in tuberculosis, is difficult to gauge preoperatively on MRI. We had seven patients in whom the bone had reformed and eight who healed by fibrosis. We could not correlate the presence of bony or fibrotic endplate changes with the need for ventral bone grafting. A conventional Smith-Petersen osteotomy hinges on the middle column, lengths the anterior column and may require structural grafting of the anterior column. If there is significant residual deformity or rotation, it may shorten the concavity, lengthen the convexity, and displace the patient towards the concavity.

Transpedicular three-column (pedicle/vertebral body subtraction) osteotomy uses a posterior approach and generally leaves no gap anteriorly. The anterior column is not opened as in a Smith-Petersen osteotomy. Blood loss is variable, but is usually more than with a Smith-Petersen osteotomy. The osteotomy should be carried out at the apex if possible, even if a rotational deformity is present. It shortens the posterior and middle columns and hinges on the anterior column, and offers the advantages of a one-stage correction.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

**References**