A TECHNIQUE FOR LUMBAR SPINAL OSTEOTOMY IN ANKYLOSING SPONDYLITIS

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Fourteen patients with ankylosing spondylitis had an extension osteotomy for severe flexion deformity of the spine. The Smith-Petersen technique was modified by using a compression device which allows a slow, finely controlled closure of the osteotomy, and provides rigid internal fixation. There were no serious neurological complications. All the patients were able to see straight ahead after operation, and all had solid fusion at nine months, having maintained good correction.

Ankylosing spondylitis may sometimes cause one of the most disabling deformities seen by the orthopaedic surgeon. The characteristic spinal deformities are flattening of the normal lumbar lordosis, and an increasing smooth thoracic kyphosis with the head and neck thrust forwards. Occasionally there is increasing flexion at the cervicothoracic junction. Eventually the whole spine undergoes bony ankylosis in this deformed position, and the patient is bent forward and forced to look down at the ground. This ugly posture is not only functionally disabling but is also psychologically disturbing.

Smith-Petersen, Larsen and Aufranc (1945) recognised the plight of these unfortunate patients and devised the operation of spinal osteotomy, by which the spine is hyperextended in the lumbar region, enabling the patient to see straight ahead. Since their paper relatively few surgeons have attempted the operation (La Chapelle 1946; Adams 1952; Herbert 1959; Law 1959; McMaster 1962; Goel 1968; McMaster and Coventry 1973). Nearly all of these have reported a high incidence of major complications. The reported mortality rate has varied from 8% to 10% and neurological complications, up to and including paraplegia, have occurred in as many as 30% of the patients. Other complications have included rupture of the aorta, acute dilatation of the stomach, superior mesenteric thrombosis and psychological disturbances. Only Simmons (1977), in a study of 19 patients, reported no deaths or neurological complications following lumbar spinal osteotomy. He attributed this success to performing the operation under local anaesthesia, thus allowing continuous monitoring of the neurological state.

This paper reports the results of a prospective study of methods designed to reduce the incidence of neurological complications during and after lumbar spinal osteotomy. A modification of the usual technique was used and angular correction was obtained with a specially-designed device which allowed slow and finely controlled closure of the osteotomy, as well as providing rigid internal fixation.

CLINICAL MATERIAL

From June 1980 to August 1982, at the Princess Margaret Rose Orthopaedic Hospital, Edinburgh, 14 patients with ankylosing spondylitis each had an extension osteotomy of the lumbar spine to correct a severe flexion deformity. All the operations were performed by the author using a special method of intra-operative correction and internal fixation. There were 11 men and three women whose mean age at operation was 42 years (range 31 to 66 years). Their mean duration of symptoms was 21 years (range 6 to 44 years) and all had been treated conservatively without success.

Two patients had become much more stooped because of vertebral compression fractures of L1 and L2 respectively, which they had sustained in falls. Neither had any neurological abnormalities and the fractures healed satisfactorily. Two other patients developed increasing pain in the back and noticed that their flexion deformity was getting worse. Both had developed a spontaneous pseudarthrosis in their ankylosed spine, one between T12 and L1, and the other between L1 and L2.

In seven of the patients the hips also were affected and five of these had had bilateral total hip replacement 3 months to 10 years before spinal osteotomy. These hip replacements were needed to correct fixed flexion and to relieve pain.

Assessment of the deformity. The main indication for the operative correction of a severely flexed posture in a patient with ankylosing spondylitis is the patient's inability to see ahead for more than a few feet. It is,
however, important to assess the contribution of all levels of the spine and of the hips to the flexed posture before attempting correction. Severe flexion contracture of the hips can often be corrected by soft-tissue release and total hip replacement (Bisla, Ranawat and Inglis 1976; Williams et al. 1977) and this may be sufficient by itself to allow the patient to see straight ahead.

A spinal osteotomy is indicated only if the hips are not significantly deformed or if, after hip operations, the patient is still unable to see ahead (Case 11, see Figs 12, 14 and 16). The thoracic spine is usually the most flexed region but osteotomy at that level does not help because the ankylosed thoracic cage prevents extension of the spine. A thoracic deformity is best overcome by the creation of a compensatory lumbar lordosis by means of a lumbar osteotomy (Figs 1 and 2). The safest level to perform the osteotomy is in the lumbar spine distal to the first lumbar vertebra because at this level there is a relatively spacious vertebral canal containing the cauda equina, which is less easily injured than the spinal cord. Ideally the lumbar spine should be extended until the patient can see straight ahead. The centre of gravity of the upper body should then lie just behind the site of the osteotomy, helping to maintain correction.

In a few patients the major flexion deformity is at the cervicothoracic junction. Correction of this deformity by a lumbar osteotomy could possibly unbalance the patient and still not enable him to see straight ahead (Figs 3 and 4). These patients require an extension osteotomy of the cervical spine (Simmons 1977).

**TECHNIQUE OF OPERATION**

Endotracheal anaesthesia is essential. Great care is necessary during intubation to avoid accidental injury to the possibly ankylosed cervical spine. Neck stiffness and deformity make intubation very difficult and the use of a fibre-optic laryngoscope is often necessary if tracheostomy is to be avoided.

The patient is turned on to the operating table with care to avoid injury to the ankylosed neck, and positioned face down, with the chest and pelvis supported on special firm foam blocks which leave the abdomen hanging free. This position reduces intra-abdominal pressure; combined with hypotensive anaesthesia and infiltration of the operation site with a 1:400,000 solution of adrenaline, it greatly reduces bleeding during operation and makes it easier to identify the neural structures (Malcolm-Smith and McMaster 1983).

The lumbar spine is exposed through a midline incision extending from T12 to L5. The paraspinal muscles are stripped subperiosteally from the bone laterally to the tips of the transverse processes at the level of the osteotomy. The anatomical details are usually obscured by ossification of the interspinous ligaments, the ligamentum flavum and the interfacial joints.

The technique of the osteotomy is basically that described by Smith-Petersen et al. (1945), and modified by Adams (1952) and Law (1959) (Figs 5 and 6). It was not found necessary to perform an anterior spinal osteotomy as a separate stage as described by Herbert (1959) and La Chapelle (1946). The preferred site for the posterior spinal osteotomy is either between the second and third lumbar vertebrae or between the third and fourth. These sites are distal to the spinal cord and are far enough from the sacrum to allow application of the internal fixation device. Identification of the level is made by noting the position of the last rib or by counting the vertebrae up from the sacrum.

The bony sites for the application of the internal fixation device must be prepared before cutting the osteotomy. With an osteotome, notches are carefully cut in the ossified ligamentum flavum on either side of the spinous processes of the vertebrae above and below the site of the osteotomy. Initially these notches are made only in the outer cortex of the bone and are completed by hammering a sharp Harrington hook (No. 1251) on an introducer until the hook lies firmly within the bone. The upper two hooks should lie over the top of the lamina of the vertebra at the level above the osteotomy site, and the lower two hooks around the bottom of the lamina at the level below the osteotomy site. Once each bony site is prepared for later use the sharp hook is removed. Hammering the hooks after the osteotomy has been cut could displace the vertebrae and cause neural damage.

The osteotomy removes a posteriorly based wedge of bone which includes the adjacent spinous processes and the ossified interspinous ligament; it exposes the interlaminar space. The ossified ligamentum flavum in the midline is nibbled away with rongeurs until a small area of dura is exposed. The dura is frequently adherent to the undersurface of the ossified structures; it can easily be torn unless it is separated carefully with a fine blunt dissector. Once separated, the dura is widely
compression rod. Blunt Harrington hooks (No. 1253) were therefore modified in the Bio-Engineering Laboratories at the Princess Margaret Rose Hospital. A slot was cut in the top of the hook so that it was able to accept a compression rod after the hook had been placed in the bone. Similar hooks are now available commercially but these are too slim and tend to cut through the relatively soft bone found in these patients. The Harrington No. 1253 hook has a broader shoe and is therefore less likely to cut through bone when compression is applied.

Four of these modified hooks are inserted into the prepared fixation sites above and below the osteotomy. A Harrington compression rod is pressed down into the hooks on each side of the spine. These rods are held in place by special bushes which are advanced along the rods and into the base of each hook where they are enclosed by the hook but cannot pass through it. The osteotomy is closed by slowly tightening the nuts on the threaded rods, thus applying compression by the four hooks.

The advantage of this technique is that it allows a slow and finely controlled closure of the osteotomy; there is no sudden snap or rapid closing of the wedge space. As the osteotomy closes, the dura, which is well exposed in the midline, is seen to wrinkle, confirming that the neural elements are being relaxed. If the dura does not wrinkle, the osteotomy should be inspected to make sure there is no premature impingement of bone posterior to the neural structures. The interlocking 'V' shape of the osteotomy makes it very stable and prevents any rotation. The compression rods prevent distraction and maintain correction.

Once the osteotomy is closed a wake-up test is performed and the neurology of the lower limbs is checked. If there is a neurological deficit the fixation can be released. If all is well, bone chips removed during the osteotomy are placed posteriorly and also on both sides between the transverse processes of the vertebrae above and below the osteotomy. These transverse processes are nearer to each other once the osteotomy has been closed (Fig. 5).

Postoperative care. Gastric dilatation is a serious complication which may occur in the few days after lumbar spinal osteotomy. Extension of the spine may cause the third part of the duodenum to be pinched between the superior mesenteric vessels which pass over it and the spine which lies behind it. The obstruction usually resolves after a few days but if it is not recognised the stomach may become distended and the patient may vomit large quantities of fluid, with the danger of aspiration into the lungs. Because of the ankylosed thoracic cage, these patients cannot cough properly and easily develop aspiration pneumonia, which can be fatal. To prevent this complication, a nasogastric tube is passed before the patient wakes up from the anaesthetic and is in place for 48 hours or until it is apparent that there is no obstruction.
After the operation, the patient is nursed on a firm bed with a small pillow under the osteotomy site. Because of the rigid internal fixation, external support is unnecessary, and the patient can be log-rolled safely from side to back to side. Physiotherapy is needed to encourage coughing and the removal of pulmonary secretions. The use of an absorbable subcuticular stitch allows the application of a well-moulded underarm plaster jacket five days after the operation. This jacket is applied with the patient lying face down on a plaster frame and no further correction is attempted. The patient is then allowed to walk and is usually fit to leave hospital two weeks after operation. After a few weeks, light sedentary work is allowed but heavy lifting is forbidden until the spine is solidly fused. The plaster jacket is removed after nine months provided that radiographs show a solid fusion. A Jewett brace is worn for a further three months and after this there are no restrictions.

Complications. There were no deaths or neurological complications in any of the 14 patients treated by this technique.

The only complication during operation was a small tear in the dura in three patients. This occurred in each case while the ossified ligamentum flavum was being nibbled away from the midline before the osteotomy was extended. Dura was adherent to the ligamentum flavum and could not be separated until an initial small opening had been made in the ossified ligament. The small tears were repaired and gave no further problems.

Soon after operation two patients had excessive volumes of bile-stained fluid aspirated through their nasogastric tubes. In both patients, bowel sounds were normal and there was no other evidence of paralytic ileus. Obstruction of the third part of the duodenum was suspected, but gastric distension was not allowed to develop, and the gastric aspirations settled within a few days in both patients, allowing removal of the nasogastric tubes without further complications.

RESULTS
The 14 patients have been followed-up from one year to three years, with a mean of one year eight months (Table I). Osteotomy was between the second and third lumbar vertebrae in nine patients and between the third and fourth lumbar vertebrae in three. The two patients who had a spontaneous pseudarthrosis before operation had their osteotomy performed at the site of the

Table I. Details of 14 patients with ankylosing spondylitis who underwent extension osteotomy of the lumbar spine

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Before spinal surgery</th>
<th>Correction of curve</th>
<th>Back pain</th>
<th>Increase in deformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43</td>
<td>F</td>
<td>Bilateral THR at 36 years</td>
<td>L3-L4</td>
<td>Severe</td>
<td>Slight flexion at cervicothoracic junction</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>M</td>
<td>L2-L3</td>
<td>40</td>
<td>Mild</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>66</td>
<td>F</td>
<td>L3-L4</td>
<td>30</td>
<td>Severe</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>31</td>
<td>M</td>
<td>L2-L3</td>
<td>33</td>
<td>Severe</td>
<td>Hip flexion contractures</td>
</tr>
<tr>
<td>5</td>
<td>58</td>
<td>M</td>
<td>L2-L3</td>
<td>44</td>
<td>None</td>
<td>Required bilateral THR at age of 33</td>
</tr>
<tr>
<td>6</td>
<td>47</td>
<td>M</td>
<td>L2-L3</td>
<td>40</td>
<td>Mild</td>
<td>Slight flexion at cervicothoracic junction</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>M</td>
<td>T12 L1 (pseudarthrosis)</td>
<td>30</td>
<td>Severe</td>
<td>None</td>
</tr>
<tr>
<td>8</td>
<td>35</td>
<td>F</td>
<td>L3-L4</td>
<td>37</td>
<td>Mild</td>
<td>None</td>
</tr>
<tr>
<td>9</td>
<td>35</td>
<td>M</td>
<td>L2-L3</td>
<td>35</td>
<td>Severe</td>
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</tr>
<tr>
<td>10</td>
<td>47</td>
<td>M</td>
<td>L2-L3</td>
<td>37</td>
<td>Severe</td>
<td>None</td>
</tr>
<tr>
<td>11</td>
<td>31</td>
<td>M</td>
<td>L2-L3</td>
<td>48</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>12</td>
<td>46</td>
<td>M</td>
<td>L2-L3</td>
<td>45</td>
<td>Mild</td>
<td>None</td>
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<tr>
<td>13</td>
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<td>M</td>
<td>L2-L3</td>
<td>26</td>
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<tr>
<td>14</td>
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<td>M</td>
<td>L2-L3</td>
<td>38</td>
<td>Moderate</td>
<td>None</td>
</tr>
</tbody>
</table>

THR, total hip replacement

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pseudarthrosis. This was between T12 and L1 in one patient and between L1 and L2 in the other.

Radiographs of the spine after operation showed that, as the posterior wedge closed, correction occurred in the anterior part of the vertebral column in one of three different ways. In 10 patients there was a fracture of the ossified anterior longitudinal ligament with opening of the anterior disc space (Case 2, Figs 7 to 11; Case 11, Figs 12 to 17). In two patients the anterior longitudinal ligament avulsed a bone fragment from the lower of the two vertebrae. In the other two patients, the anterior longitudinal ligament remained intact and there was a wedge compression fracture of the posterior part of one of the vertebral bodies at the level of the osteotomy (Case 4, Figs 18 and 19). The immediate postoperative correction measured on the radiographs of the spine ranged from 26 to 48 with a mean of 38.

All patients had solid posterior fusion on radiographs taken when the plaster jacket was removed after nine months. One patient had a broken Harrington rod but the rod on the other side was intact and there was minimal loss of correction. After fusion of the osteotomy, there was very little loss of correction in any patient. At final follow-up, the mean correction at the osteotomy site was 33 (range 20 to 45) showing a mean loss since operation of 5 (range 0 to 12).

The osteotomy had corrected all the patients sufficiently for them to see straight ahead (Case 2, Figs 7 and 9; Case 11, Figs 12 and 16). Both their height and their posture was significantly improved and all were pleased with the result. During the period of follow-up, satisfactory correction was maintained at the osteotomy site, but three patients noticed a deterioration in their posture caused by increasing flexion deformity at other sites. Two of these patients had increasing flexion at the cervicothoracic junction, not yet severe enough to require treatment, though they may need cervical osteotomy in the future. The third patient had increasing
pain and flexion contractures at the hips. His posture was restored by bilateral total hip replacements 18 months after his spinal osteotomy. At final follow-up all the patients could still see straight ahead.

Before their osteotomies, all but two of the patients had had back pain. Seven of these 12 patients, including the two with spontaneous pseudarthrosis, described their pain as being very severe, while five had mild to moderate pain. At final follow-up only two patients complained of mild backache.

Before spinal osteotomy, deformity had prevented all but two of the 11 men from working. After the operation, seven of these men were able to return to work after recovery periods varying from three months to one year. Of the women, two were housewives and one had retired; all three felt that their operation enabled them to work more easily in the home.

A further major advantage of the operation, which was expressed by all the patients, was an improvement in self-esteem. Before the osteotomy many of these patients, especially the women, were reluctant to be seen outside their homes. The new appearance provided a marked psychological improvement.

**DISCUSSION**

This study has shown that modification of the operative technique and the method of correction make lumbar spinal osteotomy for severe deformity in ankylosing spondylitis possible, without the high incidence of major complications which has been reported in other series.
All these series used the technique described by Smith-Petersen et al. (1945), in which the spine is osteotomised through the posterior elements and corrected by direct pressure on the osteotomy site while the upper body and legs are extended.

![Fig. 18](image1)
![Fig. 19](image2)

Case 4. The spine has been corrected 31° by extension osteotomy. There is a posterior wedge compression fracture of L2.

The ossified anterior vertebral column is fractured by this pressure. This often occurs with a sudden snap, making it difficult to prevent displacement and over-correction, which could result in serious neurological complications (McMaster and Coventry 1973). The neural structures can also be stretched by this extension if the osteotomy has been incorrectly cut and the axis of angulation lies either in the same plane as the cauda equina or posterior to it. A third source of problems may be the nipping of nerve roots in their intervertebral canals at the level of the osteotomy when too little bone has been removed. After the closure of the wedge osteotomy using the old technique, the spine becomes very unstable and needs to be controlled by the application of plaster shells, before the patient is removed from the operating table.

By contrast, the technique described in this paper allows a slow and finely controlled closure of the osteotomy without any sudden displacement of the vertebrae. During the correction, the dura can be seen to wrinkle, indicating that neural structures are being relaxed and that the osteotomy has been cut correctly. If this does not occur, compression can be released and more bone removed. Up to 45° of correction can be obtained safely.

The combination of the ‘V’ shape of the osteotomy and the compression apparatus provides immediate rigid and stable fixation, which allows the patient to be nursed safely in an ordinary bed without external support. It also facilitates the respiratory care of these patients, who have difficulty in coughing because of their rigid chests.

We had no serious complications using this technique, and all 14 patients were corrected sufficiently to see straight ahead. All had a solid fusion in nine months with maintenance of good correction at the osteotomy, though it should be noted that the overall posture in three of our patients deteriorated during follow-up because of increasing flexion at either the cervicothoracic junction or the hips. McMaster and Coventry (1973), reporting on 17 patients followed for a mean of 10 years after lumbar osteotomy, found that once the osteotomy had fused correction in the lumbar region was maintained; but active disease in the thoracic and cervical spine or the hips could allow increased local deformity and detract from the initial overall correction. The correction was more lasting if osteotomy was done after the disease had “burnt out”. Unfortunately, if the spinal deformity is already crippling, it is not possible to wait for the disease to become quiescent. However, correction lost at sites other than that of the lumbar osteotomy can often be improved by either hip replacement or cervical osteotomy.

In conclusion, lumbar spinal osteotomy is a potentially dangerous operation but, with carefully controlled correction at operation and rigid internal fixation, many of the complications can be overcome. The operation provides not only major functional advantages but also psychological benefits.

I am grateful to Dr Mark Coventry who first introduced me to the Smith-Petersen technique of lumbar spinal osteotomy while I was working at the Mayo Clinic, Rochester, Minnesota, USA.

REFERENCES


