OSTEOTOMY OF THE CERVICAL SPINE IN ANKYLOSING SPONDYLITIS

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Fifteen patients with ankylosing spondylitis who had developed a severe flexion deformity of the cervical spine which restricted their field of vision to their feet, were treated by an extension osteotomy at the C7/T1 level. The operation was performed under general anaesthesia with the patient in the prone position and wearing a halo-jacket. Three had internal fixation using a Luque rectangle and wiring. Their mean age was 48 years.

Before operation the mean cervical kyphosis was 23°; this was corrected to a mean of 31° of lordosis, a mean correction of 54°. All the patients were able to see straight ahead. One patient with normal neurology soon after operation became quadraparetic after one week; two others had unilateral palsy of the C8 root, which improved. There was subluxation at the site of osteotomy in four patients, and two of them developed a pseudarthrosis which required an anterior fusion.

Ankylosing spondylitis may produce an extreme flexion deformity at the cervicothoracic junction. The patient is unable to see straight ahead and the proximity of the chin to the chest may interfere with eating. This posture is functionally and psychologically disturbing for the patient who may confine himself to the home. The only available treatment is an extension osteotomy of the cervical spine.

In 1958, Urist described a patient with ankylosing spondylitis and a severe cervical kyphosis which was corrected by removing a posterior wedge of bone from the cervicothoracic junction and extending the head and neck. The operation was performed under local anaesthesia with the patient awake and in a sitting position, which overcame the difficult problem of intubation for general anaesthesia. It also allowed continuous intraoperative monitoring of nerve function in the limbs. Correction was achieved gradually over some days in an articulated plaster jacket incorporating the head and neck. In 1962 Law described ten patients with ankylosing spondylitis treated by a cervical osteotomy under general anaesthesia, with one death. Since then there have been few reports of this hazardous procedure in more than a few patients. The only large series is by Simmons who operated on 42 patients under local anaesthesia using a technique similar to that of Urist, except that the deformity was corrected intraoperatively by manual extension of the neck before immobilising the patient in a halo-jacket.

This paper describes the technique and results of cervical osteotomy in 15 patients with ankylosing spondylitis.

PATIENTS AND METHODS

Between 1986 and 1994, 15 patients with ankylosing spondylitis who had developed severe flexion deformities at the cervicothoracic junction were treated by an extension osteotomy of the cervical spine at the Princess Margaret Rose Orthopaedic Hospital, Edinburgh. The operations were carried out by the author with the patient in the prone position under general anaesthesia and wearing a halo-jacket. There were 13 men and 2 women whose mean age at operation was 48 years (35 to 67). The mean duration of symptoms before surgery was 16 years (9 to 35) and the indication was the inability of the patient to see straight ahead. One patient had a severe chin-on-chest deformity which interfered with eating and had caused marked weight loss. None had neurological abnormalities. In three patients the flexion deformity had deteriorated rapidly over a period of up to six months before osteotomy. All three were found to have had a fracture at the C5/6 level which had not been recognised; two had developed a pseudarthrosis and one had bony union in a deformed position.

Three patients who also had flexion deformity of the hip had been treated by soft-tissue release and total hip replacement two to three years before the cervical osteotomy. Two other patients also had severe flexion deformity at the thoracolumbar junction which had been treated by extension osteotomy of the lumbar spine at 4 and 15 months.
before the cervical osteotomy. The lumbar osteotomy had extended the spines by 35° and 40° respectively, but this had not been enough to allow the patient to see straight ahead.

Three patients had cardiac problems; two had coronary thromboses and one an aortic valve replacement.

Preoperative management. The patients were admitted to hospital several days before operation and fitted with a lightweight underarm plaster jacket. A halo was applied under local anaesthesia and connected to the jacket by means of a single upright support on either side (see Fig. 4). No attempt was made to correct the deformity at this stage, and several days were allowed for adaptation to the halo-jacket and any necessary modifications. Patients with large obese abdomens were not accepted for this operation since this would interfere with the secure fitting of the halo-jacket and stabilisation of the neck until the osteotomy had healed.

The supports for the halo were hinged at the level of the body of C7 on both sides. These hinges allowed extension of the neck during the operation, but were locked at all other times. The upright supports were designed to allow adjustment in height as the neck was extended.

Technique of operation. General anaesthesia was induced while the patient was wearing the halo-jacket and an endotracheal tube passed, using a fibre-optic laryngoscope. The patient was then turned prone onto the operating table, which had slight head-up tilt to accommodate the flexion deformity at the cervicothoracic junction, and lifted clear of the table by large foam blocks placed beneath the chest and pelvis. The shoulders were often stiff, requiring placement of the arms by the sides.

The cervicothoracic spine was exposed from C6 to T1 through a midline longitudinal incision. The site of the osteotomy at the C7/T1 level was identified by locating the most caudal bifid spinous process, which was usually at C6, or from a lateral radiograph taken on the table.

The spinous processes of C6 and C7 were excised. The ligamentum flavum was not usually completely ossified in the midline of the interlaminar space, and it was possible to incise or nibble this layer with fine bone rongeurs to expose a small area of dura. This was often adherent to the under surface of the ossified structures, and required careful separation. Complete laminectomy was performed at C7 with removal of the inferior portion of the lamina of C6 and the superior portion of the lamina of T1. The eighth cervical nerve roots were completely exposed to beyond their intervertebral foramina by removal of the fused posterior facet joints. The pedicles of C6 and T1, lying above and below the C8 nerve roots, were then nibbled away to avoid pinching as the osteotomy closed. The adjacent lateral margins of the osteotomy slots were in the transverse plane and between 1 and 1.5 cm wide depending on the degree of correction required (Figs 1 and 2).

Spinal cord monitoring was performed throughout the procedure using somatosensory evoked potentials and an epidural electrode placed above the osteotomy. If there was any concern, a wake-up test was performed, and the patient asked to move the lower limbs.

To close the osteotomy, the hinges on the halo were unlocked. The surgeon then gripped the halo and extended the head and neck while directly viewing the exposed dura. This should become wrinkled during extension, showing that the spinal cord is being relaxed rather than stretched. The ankylosed anterior column of the cervical spine often fractured with a snap, after which it was relatively easy to place the head in a corrected position and lock the halo.

In the three most recent patients (cases 13 to 15), the osteotomy was stabilised additionally using internal fixation. A Luque rectangle with 3/16 inch rods was bent to conform to the corrected spine and secured by Drummond buttons and wires passed through the bases of the spinous processes at two levels above and below the osteotomy site. Sublaminar wires were not used because of ankylosis of the posterior bony elements and the possibility of tearing the underlying adherent dura.

The bone removed while performing the osteotomy was cut into strips and placed on either side of the spine across the osteotomy site, but not in the midline to avoid impingement on the exposed dura. Graft was also placed across the

Figures 1 and 2 - Diagrams to show the method of extension of the cervical spine at the C7/T1 level.
Table I. Details of 15 patients with ankylosing spondylitis treated by extension osteotomy of the cervical spine. The level of osteotomy was at C7/T1 in all

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Previous surgery (spine/hips)</th>
<th>Preoperative kyphosis (degrees)</th>
<th>Postoperative lordosis (degrees)</th>
<th>Total correction (degrees)</th>
<th>Loss of correction (degrees)</th>
<th>Complications</th>
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<td>50</td>
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<td>2</td>
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<td>29</td>
<td>52</td>
<td>10</td>
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<td>71</td>
<td>3</td>
<td>Deep infection</td>
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</table>

* total hip replacement

Fig. 3 Fig. 4 Fig. 5

Case 11. Figure 3 – A 35-year-old man with a severely flexed posture and a cervicothoracic kyphosis. Figure 4 – Four months after extension osteotomy of the lumbar spine, the flexed posture has been partially corrected but he is still unable to see straight ahead. A halo-jacket has been applied before a cervical osteotomy. Figure 5 – One year after a cervical osteotomy, he is fully corrected.
sites of the unhealed cervical fractures which were present in two patients.

Postoperative care. The patient was encouraged to take a few steps the day after operation. The position of the head and the ability to look straight ahead were assessed. If the head was not in the correct position and internal fixation had not been used the hinges were released and slight adjustments made under adequate analgesia. The patient usually left hospital ten days after operation and remained in the halo-jacket for three months. Radiographs taken at this time were difficult to assess and it was often necessary to use lateral tomography. When the osteotomy had healed, the halo-jacket was removed and a firm collar applied which was worn for a further three months to allow consolidation.

The postoperative correction of the spine was measured on lateral radiographs using the Cobb method from the vertebra above to the vertebra below the site of osteotomy.

RESULTS

The osteotomy was performed at the C7/T1 level in all patients (Table I). Twelve had no internal fixation (Figs 3 to 7) and three had a Luque rectangle secured to the posterior spine by Drummond wires (Figs 8 and 9).

Figure 6 – Preoperative lateral radiograph. Figure 7 – Radiograph one year after cervical osteotomy. The osteotomy is soundly healed and the neck has been extended 50°.

Case 15. Figure 8 – Lateral radiograph of a 51-year-old man with a cervicothoracic kyphosis of 35°. Figure 9 – One year and four months after cervical extension osteotomy at the C7/T1 level with internal fixation using a Luque rectangle with spinous process wiring. The neck has been extended through 68° and the osteotomy is soundly healed.
Before surgery, there was a mean kyphosis of 23° (10° to 45°) at the cervicothoracic junction. Lateral radiographs of the spine after the operation showed that closure of the posterior wedge had fractured the ossified anterior longitudinal ligament and opened the anterior disc space at the C7/T1 level, producing a mean cervical lordosis of 31° (5° to 50°). The mean total correction was 54° (30° to 71°); all of the patients were able to see straight ahead. Follow-up was for a mean of 18 months (9 months to 3 years) and the mean loss of correction at the osteotomy site during this period was 6° (0° to 20°). Five patients had no loss of correction. The greatest loss was 20° during the first six months in two patients (cases 1 and 7) treated without internal fixation. After six months the fusion at the osteotomy became fully consolidated and there was no further loss of correction after two years and 18 months, respectively.

The unhealed fractures which were found in two patients (cases 1 and 12) before operation united during immobilisation in a halo-jacket.

One patient (case 13), whose cervical correction was well maintained at 51°, developed an increasing thoracolumbar kyphosis and may require an extension osteotomy of the lumbar spine at a later stage.

None of the patients had been able to work before operation but afterwards four were able to obtain employment six to nine months after osteotomy.

Complications

Neurological. After operation all the patients became independently mobile in their halo-jackets but one man (case 8) whose cervical kyphosis had been corrected by 68°, became quadraparetic one week later. There was no apparent reason: he had been walking normally and check radiographs showed no obvious displacement at the osteotomy site. The head and neck were allowed to flex to their preoperative position but there was no recovery.

Two patients developed unilateral compression of one C8 nerve root at the site of the osteotomy, causing some weakness and hypoesthesia in the hand. This was noted one to two days after operation and was treated by distracting the halo on the jacket. One patient (case 6) recovered to normal over a period of two months; the other (case 13) recovered full motor function but was left with mild hypoesthesia affecting the little and ring fingers.

Four patients had intermittent pain in one arm in the C8 dermatome but no neurological deficit. No treatment was given and the pain resolved completely at from a few days to two weeks.

Subluxation. There was subluxation with forward displacement of the seventh cervical vertebra on the first thoracic at the site of the osteotomy in four patients. This was not seen to happen at operation and was first noted on the immediate postoperative radiographs (case 12; Figs 10 and 11). The halo was distracted on the jacket but with very little improvement. One patient (case 3) with 10% forward displacement at the osteotomy healed satisfactorily with 8° loss of correction. A second patient (case 6), with 40% forward displacement at the osteotomy, had unilateral signs of compression of the C8 nerve root which fully recovered spontaneously within two months; the osteotomy healed without loss of correction. The other two patients (cases 12
and 14) had 50% forward displacement, and unilateral arm pain in the C8 distribution but no neurological deficit. Both developed nonunion which required anterior cervical fusion using an inlay autogenous iliac bone graft at four and six months after the osteotomy. One of these patients gained solid fusion (Fig. 12); the other did not heal and was found to have a deep infection.

**Dysphagia.** Three patients had difficulty in swallowing because of retropharyngeal swelling at the site of the osteotomy, which resolved completely over ten days. Three patients with a severe chin-on-chest deformity found that after correction their mouths tended to hang open, but this resolved in a few weeks.

**Haematemesis.** One week after operation one patient (case 1) had a haematemesis which settled with conservative treatment.

**DISCUSSION**

The indication for extension osteotomy of the cervical spine in patients with ankylosing spondylitis is severe flexion deformity at the cervicothoracic junction which prevents the patient from seeing straight ahead and limits the field of vision to the area around the feet.

It is important to assess the contribution of all levels of the spine and hips to the overall flexed posture. A thoraco-lumbar kyphosis is the most common deformity and is best treated by an extension osteotomy in the lumbar region to create a compensatory lordosis. Severe flexion deformities at the hips can often be overcome by soft-tissue release and total hip replacement. Less frequently, the major deformity is at the cervicothoracic junction and this requires an extension osteotomy of the cervical spine. When other regions are affected, it is best to start with surgery on the hip, then perform lumbar osteotomy and finally a cervical osteotomy if this is still required. An attempt to compensate fully for a severe flexion deformity of the cervical spine by means of a lumbar osteotomy alone may unbalance the patient and even then fail to allow vision straight ahead. Three of the patients now reported had prior total hip replacements and two had osteotomies of the lumbar spine (Figs 3 to 7).

The preferred site for the osteotomy is between the C7 and T1 vertebrae. At this level, the vertebral arteries pass in front of the transverse processes of C7 before passing into and through the foramen transversum of C6 and are less liable to kink when the neck is extended (see Fig. 2). The spinal canal is also larger in this region.

Closure of the posterior wedge excision is performed manually and a halo-jacket is required to immobilise the neck in the corrected position until the osteotomy becomes stable. A preliminary anterior osteotomy is unnecessary because the ankylosed anterior column fractures easily. It can be difficult or impossible to approach this area anteriorly with the patient uncorrected and the chin flexed onto the chest. Correction at the site of the osteotomy occurs by rupture of the ossified anterior longitudinal ligament and the opening of the C7/T1 disc space anteriorly. Care is needed to avoid overcorrection.

A cervical osteotomy is much more hazardous than lumbar osteotomy in patients with ankylosing spondylitis. Three of the 15 patients reported developed neurological deficits and one became quadraparetic. There were no neurological complications in a personal series of 50 extension osteotomies of the lumbar spine in patients with ankylosing spondylitis. Neurological complications after cervical osteotomy have several possible causes.

First, the neural structures may be stretched if the osteotomy has been cut incorrectly and the axis of angulation in the sagittal plane is at or posterior to the spinal cord. This would result in immediate injury to the cord when the neck is extended. None of the patients in this series had this complication: the osteotomy was cut far laterally (Fig. 1) to prevent impingement of the posterolateral bony masses as the neck is extended. Wrinkling of the dura during extension indicates that the neural structures are being relaxed rather than stretched.

Secondly, the C8 nerve roots may be compressed in their intervertebral foramen if sufficient bone has not been removed from the pedicles above and below the osteotomy. Two patients were affected by this, but both spontaneously recovered full motor function; one had mild residual hypoesthesia. Four patients complained of transient unilateral C8 root pain, but without neurological deficit, which settled quickly.

Thirdly, neurological complications may be due to instability and subluxation at the osteotomy. Subluxation with forward displacement of C7 on T1 occurred in four patients. This was the main technical problem which occurred when the neck was being extended manually and was due to disruption of the posterior longitudinal ligament, the hinge about which angulation takes place (Fig. 11). Subluxation was not apparent during the operation, possibly being disguised by the wide bony decompression and angulation at the osteotomy site. This complication was first described by Herbert and was the cause of death in one of his three patients undergoing cervical osteotomy. To prevent cord compression due to subluxation it is important to perform an extensive midline bony decompression above the osteotomy level so that the lamina of C6 does not impinge on the spinal cord if the vertebral body becomes displaced forwards. A halo-jacket does not provide complete postoperative stability and ‘snaking’ of the cervical spine can occur in the sagittal plane if there is no internal fixation, resulting in transient displacement. This may have caused the quadraparesis in the patient (case 8) who had no internal fixation and was mobilising in his halo-jacket one week after operation. The addition of internal fixation may prevent loss of correction and displacement postoperatively but cannot prevent subluxation during manual extension of the neck (Fig. 11).
If subluxation occurs, there is a high incidence of non-union at the osteotomy site, especially with displacement. Both patients with 50% subluxation developed nonunion which required anterior spine fusion.

Cervical osteotomy in ankylosing spondylitis is a difficult and potentially hazardous procedure but a successful operation allows the patient to see straight ahead and provides major functional and psychological benefits.

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REFERENCES