ORIGINAL ARTICLE

Fracture of the lower cervical spine in patients with ankylosing spondylitis: Retrospective study of 19 cases

P. Kouyoumdjian a,∗, P. Guerin b, C. Schaeelderle b, G. Asencio a, O. Gille b

a Department of Orthopaedic Surgery and Traumatology, Carémeau Teaching Hospital center, place du Pr-Debré, 30029 Nîmes cedex 9, France
b Spine diseases Unit, René Pellegrin Hospital, Bordeaux Teaching Hospital center, place Amélie-Raba-Léon, 33076 Bordeaux cedex, France

Accepted: 28 March 2012

KEYWORDS
Spine;
Fracture;
Cervical vertebra;
Ankylosing spondylitis

Summary
Introduction: Controversy exists surrounding optimal treatment of cervical spine fractures secondary to ankylosing spondylitis (AS).
Hypothesis: The anterior approach is an effective surgical technique for these fractures and can be used to correct the AS-induced cervical-thoracic kyphosis.
Materials and methods: This continuous, retrospective series between 1990 and 2010 included 19 patients aged 33 to 84 years who presented with a lower cervical spine fracture in the context of AS. The average follow-up was 45 months. Sixteen of these patients were surgically treated using an anterior approach and anterior fixation. In five patients without any neurological deficit, their cervical-thoracic kyphosis was corrected during the same surgery. Regional kyphosis was measured before the surgery, immediately after the surgery and at the last follow-up.
Results: Five deaths occurred; these were all patients with post-traumatic complete quadriplegia. Most the incomplete neurological problems improved (66%). In no cases did the neurological condition worsen. Among the 16 patients operated with the anterior approach, two patients also required an additional procedure with a posterior approach because of a persistent neurological deficit. The fractures in the operated patients who survived (14 patients) had healed within an average 4-month delay (range 3–7 months), without worsening of the kyphosis at final follow-up. In the five cases where the kyphosis was corrected, the correction averaged 26° (range 18–36°); there were no neurological complications.

∗ Corresponding author. Tel.: +33 06 03 99 80/04 66 68 31 56.
E-mail address: kouyoumdjian.p@wanadoo.fr (P. Kouyoumdjian).


doi:10.1016/j.otsr.2012.03.011
Introduction

In one third of cases, cervical fracture in patients with ankylosing spondylitis (AS) is fatal. Even a low-velocity accident can result in a serious neurological injury [1]. The incidence of vertebral fractures after an accident increases as the disease is more established. For AS that has been on-going for 45 years, the incidence is 1.3% per year.

Most of the fractures occur at the lower cervical spine and the cervical-thoracic junction. But the diagnosis is difficult to make and can be delayed [2–7]. This delay can partly be attributed to the lack of pain associated with these fractures since the patients are undergoing corticosteroid therapy and because the fractures are difficult to visualize on conventional X-rays of the kyphotic cervical-thoracic junction in patients with AS. The fracture is not detected in 36% of cases [6] and led to worsening of the kyphosis; this is a negative situation for a patient who already has kyphosis, as the risk of neurological problems increases [2,5,8–11].

Treatment is controversial: some surgeons have reported a higher risk of complications after surgery [10,12,13], while others prefer using surgical fixation to avoid the risks related to conservative treatment [14–17].

The goal of this study was to show the benefits of surgical treatment by the anterior route only in the treatment of these fractures.

Material and methods

Patients

This is a continuous, retrospective study performed at the Bordeaux CHU between 1990 and 2010. Patients with an unconfirmed AS diagnosis were excluded, as were patients with injuries sustained earlier during the disease progression when the spine was still flexible. We excluded patients with upper cervical spine fractures.

The series consisted of 19 patients with a lower cervical spine fracture secondary to AS. The AS diagnosis had been established 28 years before, on average. The male to female ratio was 3:1. The average age was 61 years (range 33 to 84). A fall caused the benign, low-energy trauma in 50% of patients.

The injury, risk factors, complications related to the trauma and delay before treatment are given in Table 1. The types of injuries that were seen on CT scan were determined based on two classification systems: de Peretti et al. [18] and Caron et al. [17].

The neurological injury was evaluated based on the ASIA impairment scale (Frankel classification) [19].

Treatment and surgical techniques

Anterior fixation was performed through an anterior neck incision; a tricortical iliac graft was added the fracture site and internal fixation was performed with a plate. If the patient did not have any neurological disorders, the cervical-thoracic kyphosis was subsequently corrected. The head was gradually moved into extension while verifying the motor and somatosensory evoked potentials. A wedge-shaped graft was placed at the injury site to provide lordosis to the cervical spine.

Posterior decompression without fixation was performed in addition to the anterior procedure if posterior medullar compression was noted on the preoperative MRI or neurological problems persisted and did not completely regress after anterior fusion, relative to on-going compression visible on postoperative MRI. Post-operative cervical immobilisation was carried out using a sterno-occipital mandibular immobilization (SOMI) device for two months, and then a Minerva brace for one month.

Radiological evaluation

The fusion was considered as complete when trabecular bone was visible and spanned the fracture site [20,21]. Cervical deformation and correction of the prefracture kyphosis were evaluated by comparing the regional deformation (RD) immediately before the surgery, after the surgery and/or at the last follow-up.

Results

The average follow-up was 45 months (Table 2).

Time frame of diagnosis

Most of the fractures were transdiscal (14/19); the remainder were transcorporeal (5/19). Table 1 presents information on the type and level of these fractures. The injury mechanism was low-energy in 10 cases, violent in seven cases and unknown in two cases. For five patients, the fracture diagnosis was delayed three days to three months. In one patient (Case No. 10), the fracture was not detected and was only found later as a non-union.

Ten patients presented with a neurological deficit that was medullary in nature; three patients had post-traumatic complete quadriplegia; one patient had monoplegia that progressed to quadriplegia on day 6 after the anterior fusion surgery, however no reason for this deterioration was found on CT scan. These latter four patients died between 15 days and eight months after the surgery. Three patients...
Table 1  Summary of the patient characteristics.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>D-AS</th>
<th>DD (days)</th>
<th>Mechanism</th>
<th>Injury</th>
<th>Neurological impairment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68</td>
<td>N/D</td>
<td>N</td>
<td>FH</td>
<td>C6</td>
<td>T3</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>41</td>
<td>N</td>
<td>FH</td>
<td>C6-C7</td>
<td>T1</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>33</td>
<td>N</td>
<td>MVA</td>
<td>C6-C7</td>
<td>T2</td>
</tr>
<tr>
<td>4</td>
<td>71</td>
<td>N/D</td>
<td>N</td>
<td>FH</td>
<td>C5-C6</td>
<td>T2</td>
</tr>
<tr>
<td>5</td>
<td>61</td>
<td>N/D</td>
<td>10</td>
<td>MVA</td>
<td>C5-C6</td>
<td>T1</td>
</tr>
<tr>
<td>6</td>
<td>54</td>
<td>N/D</td>
<td>N</td>
<td>FH</td>
<td>C6-C7</td>
<td>T3</td>
</tr>
<tr>
<td>7</td>
<td>33</td>
<td>N/D</td>
<td>N</td>
<td>Unknown</td>
<td>C5-C6</td>
<td>T1</td>
</tr>
<tr>
<td>8</td>
<td>47</td>
<td>N/D</td>
<td>N</td>
<td>MVA</td>
<td>C6-C7</td>
<td>T2</td>
</tr>
<tr>
<td>9</td>
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<td>MVA</td>
<td>C7</td>
<td>T3</td>
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<tr>
<td>10</td>
<td>59</td>
<td>36</td>
<td>ND</td>
<td>Unknown</td>
<td>C4-C5</td>
<td>T2</td>
</tr>
<tr>
<td>11</td>
<td>62</td>
<td>N/D</td>
<td>N</td>
<td>MVA</td>
<td>C6</td>
<td>T1</td>
</tr>
<tr>
<td>12</td>
<td>55</td>
<td>N/D</td>
<td>7</td>
<td>FH</td>
<td>C6-C7</td>
<td>T1</td>
</tr>
<tr>
<td>13</td>
<td>84</td>
<td>N/D</td>
<td>7</td>
<td>Fell in stairs</td>
<td>C6-C7</td>
<td>T2</td>
</tr>
<tr>
<td>14</td>
<td>55</td>
<td>17</td>
<td>N</td>
<td>MVA</td>
<td>C7</td>
<td>T3</td>
</tr>
<tr>
<td>15</td>
<td>53</td>
<td>11</td>
<td>15</td>
<td>FH</td>
<td>C6-C7</td>
<td>T2</td>
</tr>
<tr>
<td>16</td>
<td>70</td>
<td>42</td>
<td>120</td>
<td>FH</td>
<td>C6-C7</td>
<td>T3</td>
</tr>
<tr>
<td>17</td>
<td>62</td>
<td>N/D</td>
<td>N</td>
<td>FH</td>
<td>C7</td>
<td>T1</td>
</tr>
<tr>
<td>18</td>
<td>65</td>
<td>N/D</td>
<td>N</td>
<td>FH</td>
<td>C5-C6</td>
<td>T3</td>
</tr>
<tr>
<td>19</td>
<td>71</td>
<td>32</td>
<td>N</td>
<td>FH</td>
<td>C7-T1</td>
<td>T3</td>
</tr>
</tbody>
</table>

D-AS: duration (years) of AS progression; N/D: not determined; DD: diagnostic delay (N: treated within 24h); mechanism: FH: fall from standing height; MVA: motor vehicle accident; type C: Caron classification [17]; type DP: de Peretti classification [18]; F: Frankel classification [19]; CBN: cervicobrachial neuralgia.

were incomplete quadriplegics (one died at 15 days after the surgery) and three others presented with signs of mono-plegia or diplegia of the upper limbs. We also found signs of moderate impairment or radicular pain in seven cases. Only two patients had no neurological deficit or radicular pain. The neurological disorder did not worsen during the preoperative immobilisation of any of the patients.

**Conservative treatment**

In four cases, conservative treatment was performed. One patient with significant history of cancer, who was initially treated with a halo-vest, was lost to follow-up (Case No. 1). In the three other patients who were monitored and treated non-surgically, the kyphosis became worse. One patient refused surgery; the fracture healed with an 18° worsening of the regional kyphosis (Case No. 8). Another patient was treated by SOMI because no displacement could be seen on the CT scan; this resulted in non-union and worsening of the kyphosis by 25°. He was subsequently operated four months after the initial injury (Case No. 16). The last patient (Case No. 9) was treated by SOMI outside the hospital centre for 75 days. Because the conservative treatment failed, he was referred for surgical treatment in our Unit.

**Surgical treatment**

Isolated posterior surgery was performed in only one patient (Case No. 12). He presented with compression that was mostly posterior; laminectomy and posterior fixation were performed.

In all, an anterior procedure was performed on 16 patients. In 13 of these patients, only the anterior approach was used. The average procedure time when only the anterior approach was used was 1:30 hours (range: 1:00 to 3:00 h). Intraoperative bleeding was 190 cc on average (range: 100 to 300 cm³). In one case, only two vertebral bodies (VB) were fixed by the plate. Since this injury is equivalent to a long-bone fracture, all the other plates were longer; four VBs were included in six cases, five VBs in seven cases, six VBs in three cases (fixation relative to the injury level and fixation limits summarized in Table 2). At least four screws were used to fix the plate above the injury site in 14 of the 16 cases of anterior fixation (four screws in 13 cases...
Table 2  Summary of treatments, clinical outcomes and radiological results.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Injury</th>
<th>Neurological impairment</th>
<th>Treatment</th>
<th>FU (months)</th>
<th>Neurological progression</th>
<th>Union (months)</th>
<th>Kyphosis (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>Type C [17] Type DP [18]</td>
<td>F [19] Type</td>
<td>Delay (days) AF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>C6</td>
<td>2</td>
<td>T3 E</td>
<td>C6</td>
<td>CT</td>
<td>Lost to</td>
<td>N/D</td>
</tr>
<tr>
<td>2</td>
<td>C6-C7</td>
<td>1</td>
<td>T1 C</td>
<td>Incomplete quadriplegia</td>
<td>AF 0 C5-T1 7</td>
<td>follow-up</td>
<td>3 13 11 2</td>
</tr>
<tr>
<td>3</td>
<td>C6-C7</td>
<td>3</td>
<td>T2 E</td>
<td>Paresthesia</td>
<td>AF 8 C5-T2 45</td>
<td>Neurological</td>
<td>N 3 2 9 7</td>
</tr>
<tr>
<td>4</td>
<td>C5-C6</td>
<td>3</td>
<td>T2 D/A</td>
<td>Monoplegia (upper limb), quadriplegia D6 post-op</td>
<td>AF 0 C4-C7 15 days</td>
<td>improvement</td>
<td>Death N/D −5 2 7</td>
</tr>
<tr>
<td>5</td>
<td>C5-C6</td>
<td>1</td>
<td>T1 C</td>
<td>Brachial diplegia</td>
<td>AF 10 C4-T1 155</td>
<td>Neurological</td>
<td>3 18 4 −14</td>
</tr>
<tr>
<td>6</td>
<td>C6-C7</td>
<td>4</td>
<td>T3 C</td>
<td>None</td>
<td>AF 13 C5-T1 41</td>
<td>Neurological</td>
<td>N 2 −16 2 18</td>
</tr>
<tr>
<td>7</td>
<td>C5-C6</td>
<td>1</td>
<td>T1 A</td>
<td>Complete quadriplegia</td>
<td>AF 1 C4-C7 5</td>
<td>improvement</td>
<td>Death 3 48 11 −37</td>
</tr>
<tr>
<td>8</td>
<td>C6-C7</td>
<td>1</td>
<td>T2 E</td>
<td>CBN</td>
<td>CT − − − 31</td>
<td>Neurological</td>
<td>N 4 0 −18 −18</td>
</tr>
<tr>
<td>9</td>
<td>C7</td>
<td>2</td>
<td>T3 E</td>
<td>Brachial dysesthesia</td>
<td>CT then AF + PG 9/75 aC5-D3 pC6-T1*</td>
<td>Neurological</td>
<td>N 6 −30 −3 27</td>
</tr>
<tr>
<td>10</td>
<td>C4-C5</td>
<td>3</td>
<td>T2 E</td>
<td>CBN</td>
<td>AF 0 C4-C5 30</td>
<td>Stable 6 2 5 3</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>C6</td>
<td>2</td>
<td>T1 A</td>
<td>Complete quadriplegia</td>
<td>AF 0 C4-T2 8</td>
<td>Death 3 31 13 −18</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>C6-C7</td>
<td>4</td>
<td>T1 A</td>
<td>Complete quadriplegia</td>
<td>PF 7 C4-T2 3</td>
<td>Death N/D 21 15 −5</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>C6-C7</td>
<td>3</td>
<td>T2 C</td>
<td>Incomplete quadriplegia</td>
<td>AF 0 C5-T1 + cage C5-T2 12</td>
<td>Stable 6 2 5 3</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>C7</td>
<td>2</td>
<td>T3 D</td>
<td>Monoplegia (upper limb)</td>
<td>AF 2 C5-T2 35</td>
<td>Neurological improvement</td>
<td>8 −7 11 18</td>
</tr>
<tr>
<td>15</td>
<td>C6-C7</td>
<td>1</td>
<td>T2 D</td>
<td>Monoplegia (upper limb), then balance problems at 8 months</td>
<td>AF then PA 15/240 C5-T2 50</td>
<td>Death 3 −16 +18 34</td>
<td></td>
</tr>
</tbody>
</table>
and six screws in one case). The fixation below the injury site consisted of six screws in six cases, four screws in seven cases and two screws in one case. The lower end of the plate was at T1 or lower in 75% of the cases (six times at T1, six times at T2 and once at T3).

In five patients (Cases Nos. 6, 9, 14, 15, 16), the cervical kyphosis was also corrected during the anterior fixation procedure (e.g. Case No. 15, Fig. 1). The average intraoperative correction was 26° (range 18° to 36°). The correction did not result in neurological decompensation.

In two patients (Case Nos. 9 and 15), a posterior procedure was done subsequent to the anterior procedure.

### Neurological recovery

The five patients in Frankel A and B stages died. Death occurred between day 10 and month 9 after the accident (average of three months). In all the other patients, the neurological problems partially or completely resolved. Patients with no initial motor impairment had no postoperative neurological decompensation.

A haematoma had to be drained at Day 0. In two cases, the screws backed out and in one case, the Minerva brace induced pressure sores. The fractures in all the operated patients who survived had healed in an average of 4 months (range 3–7 months), without worsening of the kyphosis at the last follow-up. Most of the incomplete neurological problems improved (66%). In no cases did the neurological condition worsen.

One patient had trouble walking eight months after the anterior procedure; posterior compression at the C7 spinous process was seen on MRI; a laminectomy was performed (Case No. 15, Fig. 2). The patient became asymptomatic. The other patient who had been initially treated conservatively (Case No. 9), was operated at 3 months with a decompression and non-instrumented posterior graft, in addition to the anterior fusion. At the last follow-up, this patient no longer had neurological problems.

### Discussion

#### Injury

Patients with ankylosing spondylitis (AS) have a 3× greater risk of suffering from a cervical spine fracture than the general population [13,22]. The fracture risk is correlated with the progression and duration of the disease [10,23]. In the current series, patients had been suffering from AS for an average of 28 years at the time of injury. Rowed et al. [6] had reported a 25-year progression. The benign, even unknown, nature of the injury has been highlighted by many authors [5,6,11,14]. In both our series and the one described by Graham and Van Peteghem [24], 50% of patients had only a minor trauma. Falling is the most common injury mechanism. It causes either hyperextension with transdiscal fracture that often results in a neurological injury [10,18,25–27], or more often flexion with a transcorporeal fracture [6,17,28]. The delay in making the diagnosis can lead to a natural progression of kyphosis at the fracture site and to neurological complications, which are arguments in favour of early stabilisation [29,30].

### Table 2 (Continued)

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Injury</th>
<th>Level</th>
<th>Neurological Impairment</th>
<th>Treatment</th>
<th>FLU (months)</th>
<th>Neurological progression</th>
<th>Union (months)</th>
<th>Pre</th>
<th>Post</th>
<th>Corr</th>
<th>Kyphosis (°)</th>
<th>Progression (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>C6-C7</td>
<td>C6</td>
<td>CBN</td>
<td>AF</td>
<td>C7-T2</td>
<td>N</td>
<td>N/D</td>
<td>3</td>
<td>−2/−17,17</td>
<td>34</td>
<td></td>
<td>−2/−17,17</td>
</tr>
<tr>
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<td>C7</td>
<td>C7</td>
<td>E</td>
<td>AF</td>
<td>C6-T1</td>
<td>0</td>
<td>7 days</td>
<td>N</td>
<td>−2/−34</td>
<td>10</td>
<td>−2/−34</td>
<td>−2/−34</td>
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<tr>
<td>18</td>
<td>C5-C6</td>
<td>C5</td>
<td>AF</td>
<td>AF</td>
<td>C5-T1</td>
<td>0</td>
<td>45</td>
<td>N</td>
<td>6</td>
<td>5</td>
<td>−6/−5</td>
<td>−6/−5</td>
</tr>
<tr>
<td>19</td>
<td>C7-T1</td>
<td>C7</td>
<td>E</td>
<td>AF</td>
<td>C7-T2</td>
<td>0</td>
<td>26</td>
<td>N</td>
<td>6</td>
<td>3</td>
<td>−3/−4</td>
<td>−3/−4</td>
</tr>
<tr>
<td>20</td>
<td>C6-T1</td>
<td>C6</td>
<td>E</td>
<td>AF</td>
<td>C6-T1</td>
<td>0</td>
<td>26</td>
<td>12</td>
<td>6</td>
<td>6</td>
<td>−3/−4</td>
<td>−3/−4</td>
</tr>
</tbody>
</table>

Type: treatment type; AF: anterior fixation; PG: posterior graft; CT: conservative treatment; aC5-D3: anterior fixation; C5-D3: posterior fixation; ND: not determined; kyphosis; note (+) in lordosis angles and (−) in kyphosis angles; pre: preoperative post; secondary kyphosis.
These cervical fractures most often occur at the level of the largest moment arm, at the most distal level \([4,6,17,31]\) and are transdiscal in 50 to 70% of cases \([10,24]\). In our series, they occurred below C6 in 57% of cases. In these patients with kyphosis who are often also osteopenic, the cervical-thoracic junction is difficult to visualize on standard X-ray views \([4,10,32–34]\); CT scan with sagittal reconstruction \([35]\) and MRI \([36–38]\) could be beneficial in establishing the diagnosis early on, which would allow for earlier treatment.

Another argument in favour of surgical treatment is the extremely unstable nature of these fractures, which often involve the three columns \([39,40]\). These are serious injuries \([30]\) that are potentially lethal \([41]\). Murray and Persellin reported a 35% mortality rate \([10]\). More than 90% of our patients had a neurological involvement, but it was moderate in 60% of cases (Frankel stage D or E). This is consistent with the published literature \([6,10–12,26]\). In 75% of cases, these are severe injuries, such as complete quadriplegia, Brown-Sequard syndrome and syringomyelia \([24]\).

All the patients in our series with severe neurological impairment that led to death presented with transdiscal fractures (type C3) \([17]\) due to hyperextension (type P1 or P3) \([18]\) and distraction. This fracture mechanism is very often associated with severe neurological complications. Vertebral manipulations \([13]\), CPR \([12]\), endotracheal intubation \([15]\), patient transportation \([42]\), imaging performed without taking appropriate precautions \([43]\), and inappropriate use of traction to reduce non-reducible cervical kyphosis \([14]\) can all cause hyperextension and subsequent neurological decompensation. In this context, patient packaging is challenging. Prefabricated cervical collars used in ambulances and emergency ward admission rooms can cause dangerous hyperextension at the fracture site. Detwiler et al. \([14]\) advocate use of anterior and superior cervical traction to maintain spine flexion while waiting for the surgical procedure.

### Fracture treatment

Treatment for this type of fracture is controversial. Conservative treatment has long been the gold standard \([9,10,12,13,24,39]\). This typically involves bed rest, traction with Gardner-Wells tongs and then immobilisation with halo-vest. But bed rest is not appropriate for these patients, as they are susceptible to pulmonary and...
decubitus complications. Axial traction can be at the origin of extremely serious medullary distractions [6]; use of a halo is a secondary source of aggravation [13,15]. Any immobilisation must take the pre-existing kyphosis deformation into consideration [9,42]. Broom and Raycroft [11] propose that patients be immobilized in the initial kyphosis position to avoid any hyperextension and subsequent neurological deterioration [13]. However the poor results of conservative treatment cannot be ignored: worsening of the regional kyphosis with loss of reduction, risk of non-union because of the shearing forces on the fracture site [44–46] and risk of neurological aggravation [14,22,30,47,48]. Our series includes only one case where an external brace was used and bone union occurred, however the kyphosis worsened by 18°.

Although certain published reports seem to have a high number of deaths in patients treated surgically, typically only isolated posterior decompression was used, which is a very controversial surgical technique [10,12,13]. Surgical treatment is now being used more often [14–17]. Either a posterior [17,49,50] or combined [16,51,52] approach is used. Some surgeons have performed fixation with screws and plates alone or added a posterior bone graft if the kyphosis was significant [8,34]. A circumferential graft was used when the anterior column is also deficient. Other authors recommend an anterior approach. But the stability of anterior fixation only has been questioned. Olerud et al. [16] described the results of the surgical treatment of 15 lower cervical fractures. Four patients had anterior fixation only. Six patients had decompression plus anterior and posterior fixation. Four patients had posterior fixation only. Loss of fixation occurred when only one type of fixation was used, thus dual fixation approaches were recommended for this type of fracture.

There are no reports of a homogeneous series where only anterior fixation is used in this type of patient. To our knowledge, the current series is the largest anterior fixation series reported in the literature. Despite many patients having significant kyphosis in the operated spine, an anterior neck incision was performed in all the patients, without sternotomy or sternoplasty. The fixation was sometimes extended to T2 with this anterior surgical approach. Anterior plate fixation seems to provide sufficient stability if the hardware is long enough to avoid significant moment arms. These fractures must be treated like long bone fractures. There were two cases of screw back-out. Screws often back-out and this does not always result in the loss of reduction. For two patients, the quality of the fixation was deemed fragile during the intraoperative period. The hold is often relative due to the associated osteoporosis. In our experience, the screws must cross both cortices to be effective [53].

The fracture can be an opportunity to correct the kyphosis deformation of the cervico-thoracic spine, as it results in the type of osteotomy advocated in this context [54]. In patients who presented with a disabling pre-injury cervical-thoracic kyphosis, did not have a horizontal gaze, but had no neurological problems, we took this opportunity to correct the kyphosis (Fig. 1). This surgical procedure did not increase the surgery time. All five patients were satisfied with the result since their field of vision had improved. However, reduction can be difficult in this context. In case No. 15, 30° of kyphosis correction was achieved. Because of persistent neurological problems eight months after the initial procedure, an additional procedure was performed to release the posterior aspect. When the patient is installed on the surgical table, verifying the reduction with an image intensifier and checking the evoked potentials are basic requirements. Since angular correction was performed on only five patients, these results must be interpreted with caution. In two cases, another procedure (posterior approach) was required. Neurological decompensation did not occur in these cases. In cases of initial neurological impairment, recovery occurred over time. Although this study only included a small number of patients, we are cautious but encouraged with the surgical outcomes and suggest using this treatment approach for all patients.

For postoperative immobilisation, most surgeons agree that a halo brace should not be used [15,31]. We and others prefer using a moulded cervical collar, as fusion occurs in three months [8]. None of our patients developed neurological complications during this immobilisation phase.

There were no significant immediate or secondary postoperative complications after the anterior surgical procedure, with kyphosis correction or not. The observed deaths were in quadriplegic patients (Frankel stage A or B) before the surgery who had significant medulla injuries visible on MRI. Olerud et al. [16] listed three factors as being predictive of death: Frankel stage, age and surgical time. In the current series, the surgical time was short (1:30 h) for anterior fixation, with or without kyphosis correction. As with age, this was not a predictive factor in our series. Only the neurological status, which is itself related to the injury type (hyperextension fracture), was predictive. As with other published reports [4,12,14], the overall mortality rate in this series was high (33%) and related to the initial medullary involvement [27]. Note that the two patients that were lost to follow-up are not taken into consideration. The patients with the most serious conditions in our series (Frankel stage A and B) all died. In comparison, mortality in patients with a healthy spine under the same circumstances is 18% [4,41]. Neurological injuries are often serious. Any neurological improvement is typically sensory and not often motor in nature [14]. The re-establishment of patient independence in daily life is rarely addressed in the published literature. The existing series have a small number of patients and are heterogeneous in terms of neurological involvement. Ohry and Frankel showed how difficult it was to rehabilitate patients with medullary involvement in the context of ankylosing spondylitis [55]. These patients do not recover as well as those with a healthy spine [56]. Among the 12 patients who were still alive and available for follow-up in our series, seven had returned to work, four could walk and one could not walk (Case No. 13).

Bone union was achieved in 3 to 4 months in our series. There were no cases of non-union. These data support the notion that a circumferential fusion is not required.

**Conclusion**

Fractures in patients suffering from ankylosing spondylitis are often missed, so better education for emergency service providers seems necessary.
These fractures have a high risk of serious and sometimes fatal neurological complications. All of the quadriplegic patients in our series died. Appropriate conservative treatment is difficult to achieve in kyphotic patients. There is a significant risk of secondary loss of reduction and fracture-related kyphosis. Surgery using an anterior approach provided good results in our series. Anterior plate fixation provides satisfactory stability if long enough plates are used. If there are no neurological problems, the fracture is an opportune time to correct the cervical-thoracic kyphosis.

However, surgical management does not change the perioperative mortality that is inherent to the severity of the initial neurological presentation, which itself is related to the injury type and fracture mechanism (typically in hyperextension). With a mortality rate over 30% in all the published series, better prevention should be advocated. Patient and physician education can help to prevent some of these severe injuries and their complications.

**Disclosure of interest**

The authors declare that they have no conflicts of interest concerning this article.

**References**


Cervical spine fracture secondary to spondylarthropathy


