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Non-rigid immobilisation of odontoid fractures

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Abstract Despite various reports on the management of odontoid fractures, there is no consensus on the subject, and the appropriate treatment still remains controversial. While untreated fractures or fractures treated only with a cervical orthosis seem to have the highest rate of non-union, the need for rigid external stabilisation has never been substantiated. In a retrospective analysis we reviewed 26 patients with acute type II and III fractures of the odontoid, treated with a cervical orthosis only. Study inclusion was limited to fractures that had a fracture gap of less than 2 mm, an initial antero-posterior displacement of less than 5 mm and angulation of less than 11°, less than 2 mm displacement on lateral flexion/extension views, and were without neurological deficits. These fractures were defined as stable. There were 19 (73.1%) type II and 7 (26.9%) type III fractures; in 10 (38.5%) of these fractures the odontoid was displaced and/or angulated. The overall complication rate was 11.4% (*n*=3). One patient suffered from pulmonary embolism, in two patients (7.7%) with initially minimally displaced fractures, secondary internal stabilisation had to be performed because of persistent instability. In 20 (77%) of the remaining fractures healing was uneventful. In 4 nondisplaced fractures (15%) fibrous union was documented. Three of these patients were over 65 years old. The overall fusion rate was 73.7% for type II and 85.7% for type III fractures. At follow-up 39% of the patients were free of symptoms; however, the clinical outcome did not correlate with the radiological findings. According to our findings, stable type II and type III fractures of the odontoid can be successfully treated with non-rigid immobilisation, even if they are displaced. A thorough assessment of the stability of the odontoid with lateral flexion/extension views or dynamic fluoroscopy is recommended to evaluate the appropriate treatment. Non-rigid immobilisation may be an option in selected cases with stable injuries.

Keywords Cervical spine · Odontoid · Fracture · Non-rigid immobilisation

Introduction

The appropriate treatment of type II and III odontoid fractures still remains controversial. However in the recent literature there seems to be a tendency to opt for primary internal fixation with interfragmentary screws [1, 7, 8, 19, 23, 29, 36]. The reported rate of non-union varies between 2.4% and 100% for all types of fractures and treatment modalities, with the highest rates for untreated fractures and fractures treated with a cervical collar only. Important factors reported to contribute to non-union of these frac-

tures are: the magnitude of displacement of the fractured odontoid, the direction of displacement, the direction of the fracture line, the patient's age, the magnitude of angulation of the dens and the degree of neurological deficits [4, 9, 11, 12, 14, 15, 16, 25, 30, 31, 32, 35]. For non-operative treatment, application of a halo device is the method of choice, with a high success rate; however, the number of complications associated with this kind of treatment is high [12, 13, 21, 24, 33]. The need for rigid external fixation for successful treatment of type II and III odontoid fractures has never been substantiated in the literature. Polin et al. [28] compared rigid and non-rigid immobilisation for type II and III fractures and could not find a significant difference for the rate of union.

This article reports the results of a retrospective analysis of our experience with non-rigid immobilisation of stable type II and type III odontoid fractures with regard to the indication, the treatment-related complications and the outcome.

Materials and methods

Between 1984 and 1999, 26 patients (13 women and 13 men, average age 59.1 years, range 15–86 years) with acute type II and III fractures of the odontoid were treated with non-rigid immobilisation; a Philadelphia collar was applied until 1996, since when a Miami collar has been used. This treatment rationale was limited to fractures that had a fracture gap of less than 2 mm, an initial antero-posterior displacement of less than 5 mm and angulation of less than 11°, and less than 2 mm displacement on lateral flexion/extension views, and were without neurological deficits. These fractures were defined as stable. Overall, 124 patients with a fracture of the odontoid were treated at our institution during that period; 98 fractures (79%) did not meet the inclusion criteria. The majority of the injuries (n=15) were caused by a minor fall, road traffic accidents accounted for nine injuries, and in one case a fall from a significant height was the underlying cause. In the remaining patient the exact mechanism of injury could not be evaluated.

The diagnosis was established radiographically, including standard antero-posterior, lateral and open-mouth radiographs, and lateral flexion/extension views. Radiological investigation was performed immediately after admission of the patients; flexion/extension views – guided by a physician – were performed within 24 h after admission. Conventional tomography was used to confirm the diagnosis when necessary.

The stability and the status of healing of the fracture were determined radiographically. Specific criteria for osseous union included evidence of trabeculation across the fracture and absence of movement of the odontoid on lateral flexion-extension views. When necessary, conventional tomography was used to confirm union of the fracture.

The fractures were classified according to the scheme of Anderson and d'Alonzo [3] into three groups. They were further distinguished according to the amount and direction of angulation and displacement. The majority of the fractures (n=19; 73.1%) were classified as type II injuries; in 38.5% (n=10) of the cases, the fractured odontoid was displaced and/or angulated on initial radiographs (see Table 1).

Apart from an associated fracture of the posterior ring of the atlas in two patients, there were no other associated fractures in the remaining spine. One patient, who had been involved in a road traffic accident, had sustained multiple injuries (ISS=25). Associated injuries of the skeleton were documented in 12 patients (see Table 2).

Table 1 Fracture classification modified according to Anderson/d'Alonzo [3]

Type I	∅	–	–	–
Type II	19	12 undisplaced	7 displaced	3 anteriorly 4 posteriorly
Type III	7	4 undisplaced	3 displaced	2 anteriorly 1 posteriorly

Table 2 Associated injuries in 12 of the 26 patients

Head injury	3
Fracture of the C1-ring	2
Chest trauma	1
Fracture of the pelvis	1
Extremity fracture	7

At follow-up, the restriction of range of motion of the cervical spine was assessed clinically. The pain level was assessed with three different categories: no pain, inconsistent neck pain, permanent neck pain.

Because of the small numbers, no statistical analysis was performed.

Results

All patients had clinical and radiological follow-ups at regular intervals after 6, 12 and 16 weeks. The final follow-up took place after 25.4 months on average (range 12–75 months) for all patients. The overall complication rate was 11.4% (n=3). One patient (3.8%) with multiple injuries suffered from pulmonary embolism. In two patients (7.7%), aged 15 and 76 years, with initially minimally displaced type II fractures, secondary internal fixation had to be performed after 11 and 13 weeks, respectively, because of delayed union and instability of the odontoid process, with more than 2 mm of motion of the odontoid on lateral flexion/extension views. This represents 10.5% of the type II injuries. The postoperative course was uncomplicated in these two patients.

In 20 (77%) of the remaining 24 fractures, healing was uneventful, and the cervical orthosis was removed after 3 months in 16 patients, and in 4 patients after 4 months. In ten (39%) of these, the odontoid united in an anatomic position. In four non-displaced fractures (15.4%) trabecular bridging was not evident radiographically. However, because of the absence of signs of instability on lateral flexion-extension views, all four were classified as a stable pseudarthrosis; three of the four were in patients older than 65 years (see Table 3), three were type II injuries and one a type III injury. At follow up, ten patients (39%) were completely free of symptoms, eight of these had sustained a type II and two a type III fracture. In six of these the fractured odontoid was united in an anatomic position, in two the fracture was consolidated with more than 2 mm

Table 3 Fracture healing after non-rigid immobilisation

Radiographic fusion	20/26 (76.9%)
Type II fractures	14/19 (73.7%)
Type III fractures	6/7 (85.7%)
Fusion in an anatomic position	10 (38.5%)
Fusion with malalignment	10 (38.5%)
Persistent instability	2 (7.7%)
Stable pseudarthrosis	4 (15.4%)

anterior displacement and less than 11° angulation. In the remaining two a stable pseudarthrosis was diagnosed. Of the remaining 14 patients, 11 complained about persistent neck pain and three about inconsistent neck pain. Associated significant degenerative changes in the subaxial spine were seen in 60% (6/10) of the pain-free patients and in 64% (9/14) of the patients with significant pain. A significant restriction of range of motion (ROM) (<120° rotation) was documented in nine patients. Six of these patients had sustained a type II and three a type III fracture. Two of the fractures were united in an anatomic position; in seven the odontoid fracture was consolidated with more than 2 mm antero-posterior displacement and angulation of less than 11°.

Overall, the rate of instability/stable pseudarthrosis was 26.3% (5/19) for type II and 14.3% (1/7) for type III injuries.

Discussion

Currently there are no treatment standards available to guide the care of type II and type III odontoid fractures. In the available literature four treatment options exist including traction followed by immobilisation with a cervical collar, rigid immobilisation with a halo device or a Minerva-PoP, anterior screw fixation of the odontoid or posterior fusion of the C1/2 segment. Many reports have enumerated the risk factors for non-union of odontoid fractures, including initial displacement of the odontoid and non-rigid immobilisation [2, 4, 9, 11, 12, 14, 22]. Whereas rigid immobilisation with a halo device was thought to have a high success rate and was recommended as the method of choice for non-operative treatment [12, 21, 33, 34, 35], Polin et al. [28] demonstrated that there is no statistical significance regarding differences in fracture healing and late instability between non-rigid and rigid immobilisation. This finding correlates with our experience, demonstrating that a high fusion rate can be achieved with non-rigid immobilisation in stable fractures. The rate of union in this series is 77% – a figure comparable to previous reports on non-operative treatment with rigid external fixation. In comparison to internal stabilisation, the success rate is lower; however, if the four patients with a stable fibrous union are included, the success rate is 92%. Our results also demonstrate that a non-union of the odontoid can be stable without clinical symptoms and without any need for internal stabilisation. This finding is consistent with previous reports [6, 34].

Greene and co-workers [15] found a displacement of the odontoid of 6 mm or greater to be the most significant factor regarding the rate of union. However, the authors did not comment on the stability of the fractures. This correlates well with our results, and demonstrates that even displaced fractures can be successfully treated with non-rigid immobilisation. However, we feel the inherent stability of the displaced odontoid to be an important factor. This experience is certainly biased by our treatment rationale, where unstable fractures with a displacement of more than 2 mm on lateral flexion/extension views are selected for primary internal stabilisation.

In two cases, primary evaluation of fracture stability failed and secondary operative stabilisation had to be performed. Both fractures were only minimally displaced on initial radiographs (<2 mm) and did not show significant displacement on lateral flexion/extension views. The reason for this might be the initial pain-induced contraction of the paravertebral muscles, which results in a reduced range of motion and additional stabilisation of the cervical spine segments [37]. If the contraction of the paravertebral muscles is reduced due to a decrease of pain, the ROM is increased and potentially unstable fractures may displace. Therefore, we recommend repeating the stability evaluation after several days, as has also been proposed by Roy-Camille et al. [30]. Alternatively, dynamic fluoroscopy may be used to overcome this problem [10, 17, 37].

Both fractures with secondary instability were type II injuries, a fact that confirms the reported higher rate of non-union for type II fractures in the literature [4, 9, 21, 22, 28, 32, 33].

Three of the four patients with a stable pseudarthrosis of the odontoid were older than 65 years – a finding that is consistent with previous reports stating that age is a risk factor for non-union of odontoid fractures [5, 14, 26, 31, 35].

We could not find any correlation between radiological findings and clinical outcome. Obviously, malalignment of the odontoid and non-union alone are not primary determinants of poor clinical outcome.

Conclusions

This retrospective analysis demonstrates that stable type II and type III fractures of the odontoid can be successfully treated with non-rigid immobilisation, even if they are displaced. To evaluate the stability of the injuries, lateral flexion/extension views or dynamic fluoroscopy are mandatory, and should be repeated after several days. While elderly patients seem to have a higher rate of pseudarthrosis, in a stable situation there is no need for internal fixa-

tion. However, it has yet to be proved whether a stable pseudarthrosis can be left untreated in younger patients. According to our results, there is no clear correlation between the clinical outcome and function and the radiological healing status of the odontoid. Based on our experience, we recommend a thorough assessment of the stability of fractures of the odontoid to evaluate the appropriate treatment. Non-rigid immobilisation may be an option in selected cases.

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