Halo-vest Treatment of Odontoid Fractures

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Purpose. Treatment of odontoid fractures is controversial and there is no single therapeutic method that is universally accepted. The purpose of this paper is to retrospectively review odontoid fractures treated orthopedically with a halo-vest.

Materials and methods. Eighteen patients were retrospectively studied who presented with an odontoid fracture; fractures were treated between 1987 and 2001 by means of a halo vest.

Mean age was 38 years (range 16-75 years). Mean follow-up was 5 years (range: 1-15 years). The most usual mechanism of injury (11 cases) was a road accident. Eight of the fractures were type III and 3 were type II according to Anderson and D'Alonzo's classification.

In all cases but three, a standard and CT-scan imaging study was performed. Incorporation was documented by means of plain x-rays and tomographs (in some cases CT-scans were used). Pain, cervical mobility, return to previous activities and neurological status were assessed using the Smiley-Webster scale.

Results. Global incorporation rate was 89% (16 cases). In 9 cases (50%) results were excellent, in 4 (22%) they were good, in 3 (16.6%) they were fair and in 2 (11%) poor. Results were good in 6 cases of type II fractures (60%) and 7 cases of type III fractures (87.5%). In 7 cases it was possible to improve reduction by an average 6 mm. In two cases, initial displacement until incorporation increased by 2 mm. Poor results (11.1%) resulted from treatment failure and required a posterior cervical arthrodesis performed with Brooks and Gallie's technique. In 2 of the 5 patients over 60 (40%), treatment failed and a surgical procedure was required to stabilize the fracture. The most significant complications were 5 cases of halo loosening (27.7%), one case of a sensory nerve neuroma and one case of secondary post-traumatic syringomyelia.

Conclusions. Orthopedic treatment with a halo-vest allowed us to reduce and stabilize odontoid fractures up to incorporation in 89% of cases, with 66.5% of good results.

Key words: *cervical spine, odontoid fracture, halo-vest.*

Tratamiento de las fracturas de odontoides con halo-chaleco

Objetivo. El tratamiento de las fracturas de odontoides es controvertido, y no existe un único método terapéutico universalmente aceptado. El objetivo del presente trabajo es revisar retrospectivamente las fracturas de odontoides tratadas ortopédicamente con halo-chaleco.

Material y método. Se estudiaron retrospectivamente 18 pacientes que presentaron una fractura de odontoides y que fueron tratadas en el período 1987-2001 mediante halo-chaleco. La edad media fue de 38 años (rango 16-75 años). El seguimiento medio fue de 5 años (rango 1-15 años). El mecanismo lesional más frecuente fue, en 11 casos, el accidente de tráfico. Según la clasificación de Anderson y D'Alonzo, en 8 casos la fractura fue del tipo III y en 10 casos del tipo II. En todos los casos se realizó un estudio radiográfico estándar y mediante tomografía axial computarizada (TAC) (excepto en 3 casos). La consolidación se documentó mediante radiografía y tomografía simple (en algunos casos mediante TAC). Según la escala de Smiley-Webster, se evaluó: el dolor, la movilidad cervical, el retorno a la actividad y la situación neurológica.

Resultados. La tasa global de consolidación fue del 89% (16 casos). En 9 casos se obtuvieron resultados excelentes

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(50%); en 4, buenos (22,2%); en 3, regulares (16,6%); y en 2, malos (11,1%). Se obtuvieron buenos resultados en 6 casos de fracturas del tipo II (60%) y en 7 casos del tipo III (87,5%). En 7 casos se consiguió mejorar la reducción una media de 6 mm. En 2 casos el desplazamiento inicial hasta la consolidación aumentó 2 mm. Los malos resultados, por fracaso del tratamiento, precisaron de artrodesis cervical posterior mediante la técnica de Brooks y Gallie (11,1%). En 2 de los cinco pacientes mayores de 60 años (40%) fracasó el tratamiento y se precisó de intervención quirúrgica para estabilizar la fractura. Entre las complicaciones más importantes destacaron 5 casos de aflojamiento del halo (27,7%), un caso de neuroma sensitivo y un caso de siringomielia postraumática secundaria.

Conclusiones. El tratamiento ortopédico con halo-chaleco nos ha permitido reducir y estabilizar la fractura de odontoides hasta la consolidación en el 89% de los casos, obteniendo un 66,5% de buenos resultados.

Palabras clave: *columna cervical, fractura de odontoides, halo-chaleco.*

Odontoid fractures are not unusual, their incidence ranging between 7 and 20% of all cervical fractures[1-4]. These fractures involve a high risk of spinal cord injury and are often associated to visceral lesions. Some patients do not survive the initial trauma, so real prevalence remains unknown. Odontoid fractures are the most usual cervical fractures in patients over 70; in those older than 80, they are more prevalent than any other fracture in the whole of the spine[1-3].

The classification of odontoid fractures by Anderson and D'Alonzo is afflicted with two basic limitations[5]. The first is that it does not make it possible to clearly distinguish between type II and type III fractures. The second is that, given the different type II fracture patterns, the classification provides no guidance as to the fractures' final treatment. Grauer et al[6] recently came up with a subclassification of type II fractures, which is useful for their final treatment.

Anderson y D'Alonzo's type II fractures[5] account for around 70% of all odontoid fractures. The rate of pseudoarthrosis ranges between 2.4 and 82%. Possible causes are the mechanism of injury, the type of fracture, precarious vascularization, displacement, initial diastasis, excessive traction and the patient's age. Road accidents are responsible for 62% of these fractures and 35% of them result from fortuitous falls[3-5].

Treatment is based on three basic principles: early diagnosis, fracture reduction and stabilization leading to healing. The treatment of choice for type II fractures is constantly a subject of controversy. Several treatment methods have been proposed which attempt to maintain and align the fracture until healing is achieved. These are as follows: neck braces, the Minerva cervicothoracic orthosis, the thoracic halo-vest, posterior cervical fusion and early anterior osteosynthesis[6]. Some studies recommend initial immobilization for all patients (saving surgery for cases that will not heal after 3-6 months' treatment). Nevertheless, another valid option is reduction and osteosynthesis during the acute phase. Other authors recommend fusion for elderly patients that present fractures with considerable displacement and angulation[1-4,6]. The purpose of this paper is to look into the results obtained in the treatment of 18 odontoid fractures using the halo-vest.

MATERIALS AND METHODS

In the period 1987-2001 22 patients were treated who had sustained an odontoid fracture. Mean age was 38 years (range 16-76 years). All patients were initially treated with immobilization with traction and reduction with a cranial halo. Subsequently a halo-vest was indicated. Four cases were excluded from the series: one case of complete tetraplegia that was operated on the spot, one case was lost to follow-up and in two cases the patients died from recurrent processes (chronic pulmonary conditions).

So a total of 18 patients were reviewed (9 females and 9 males). Mean follow-up was 5 years (range: 1-15 years). Four cases reviewed had a minimum follow-up of 10 years and another three had been followed up for 3 years. In 10 cases the patient was given a personal interview and subjected to an individual clinical examination. In the remaining 8 cases, the data included in the patients' clinical record were examined (Table 1). The mechanism of injury was in 11 cases a road accident, in 6 cases fortuitous accidents and in one case a fall. Seven cases presented with mild head and neck trauma. In 4 cases associated cervical injuries were identified (one fracture that involved the lateral masses of the atlas, one Jefferson fracture, one C4-C5 fracture and one comminuted fracture of the body of C2. Three cases presented with an initial neurological lesion (2 instances of a spinal cord shock that recovered in 5 minutes and one instance of monoparesis in the upper limb). According to the classification by Anderson y D'Alonzo, in 8 cases the fracture was type III and in 10 type II[5].

No instance of a type I fracture was documented. In 13 cases the fracture was displaced and in 5 cases no displacement was observed. In 7 cases the displacement was posterior and in 6 anterior. In 5 cases there was an associated rotational component. In 9 patients, the initial displacement was greater than 5 mm (in 4 cases greater than 8 mm) and in 4 smaller than 4 mm. In all cases an initial standard radiographic workup was performed (frontal, profile and transoral views) as well as a computerized axial tomography (CAT) (except in 3 cases).

Table 1. Cases reviewed

	Age	Gender	Follow-up	Mechanism	Cervical	HNT	INL	Type
Case 1	15 y.o.	Male	15 years	Road acc.			Yes	III
Case 2	61 y.o.	Male	8 months	Fortuitous		Yes		II
Case 3	30 y.o.	Male	9 months	Road acc.		Yes		II
Case 4	69 y.o.	Female	1 year	Fortuitous		Yes	Yes	II
Case 5	49 y.o.	Female	14 years	Road acc.				III
Case 6	65 y.o.	Male	13 years	Road acc.	Yes			II
Case 7	47 y.o.	Female	8 months	Fall	Yes	Yes		II
Case 8	19 y.o.	Female	1 year	Road acc.				II
Case 9	23 y.o.	Male	1 year 4 months	Road acc.				III
Case 10	16 y.o.	Female	10 years	Fortuitous		Yes		III
Case 11	20 y.o.	Male	5 years 6 months	Fortuitous	Yes		Yes	II
Case 12	19 y.o.	Male	2 years 2 months	Fortuitous		Yes		III
Case 13	41 y.o.	Female	4 years 6 months	Road acc.				III
Case 14	75 y.o.	Female	12 years	Fortuitous				II
Case 15	24 y.o.	Male	3 years	Road acc.		Yes		III
Case 16	70 y.o.	Female	1 year	Road acc.				II
Case 17	49 y.o.	Female	1 year	Road acc.				III
Case 18	30 y.o.	Male	1 year	Road acc.	Yes			II

INL: initial neurological lesion; HNT: head and neck trauma.

The cranial halo was placed and traction was progressively increased (up to 3 kg) until reduction was achieved. Special care was taken to avoid the diastasis of the fracture site. Halo-assisted traction before vest placement was carried out for 15 days (range: 4-25 days). Mean hospitalization was 25 days (range: 7-60 days). In all cases, an orthopedic vest was applied, except for 2 cases where a plaster vest was used. Treatment was continued either until the fracture healed or until the loosening or intolerance of the vest, which caused it to be taken off. Fracture healing was documented through a plain profile x-ray when bone trabeculae were seen to pass through the fracture site and when no displacement was observed in functional s-rays[7,8]. To define the pseudoarthrosis, the radiographic criteria proponed by Schatzker[9] were used; these include: a) the bone defect shows sclerosis of both fragments; b) the bone defect shows resorption of the site; c) the bone defect shows loss of cortical continuity; and d) the fracture site is seen to be mobile in dynamic x-rays.

In one case the vest had to be removed and re-applied since the fracture displaced further to initial placement. The mean duration of halo-vest treatment was 2 months and one week (range: 1-3.5 months). In most cases, an occipitomental orthesis was applied for one or two months after halo removal.

RESULTS

Sixteen patients were reviewed up to the healing of their fracture. Depending on the type of fracture they had, the treatment described managed to heal 100% of type III fractures with 87.5% of good results.

As regards type II fractures, 80% of them healed, 60% of them with good results. The five undisplaced cases healed *in situ*, as did the two cases that had a 2 mm displacement. In 7 the initial displacement was fully corrected. Final displacement further to healing was lower than 3 mm in 7 cases, 3-5 mm in 3 and higher than 5 mm in 1 case. In 7 cases reduction was improved by 6 mm on average (the mean final displacement was 2 mm) and in 2 cases initial displacement increased by 2 mm up to the time of healing (Figs. 1 and 2 and Table 2).

As regards the patients' neurological status, two patients presented with an initial 5-minute spinal cord shock from which they fully recovered. There was one case with an initial posterior displacement of 15 mm, which subsequently shrank to 2 mm and was initially accompanied by a monoparesis that later evolved into a secondary post-traumatic syringomyelia diagnosed by MRi. Another case of monoparesis improved neurologically with no sequelae.

Results were analyzed according to a pain score (grades 0 to 5)[10] (Table 3). A functional evaluation was made according to the Smiley-Webster Functional Outcome Scale, which assesses pain, joint balance, neurological status and return to the activities of daily living[10] (Table 4). Nine of the 16 cases that healed with the halo-vest obtained an excellent result (44.5%), 4 had a good result (22.2%) and 3 a fair result (16.6%).

If we consider fractures by type, all type III fractures healed and 87,5% obtained good results; whereas the healing rate of type II fractures was 80% and only 60% of patients obtained a satisfactory result.

As far as age is concerned, of the 5 patients over 60, two required surgical stabilization through a posterior ap-

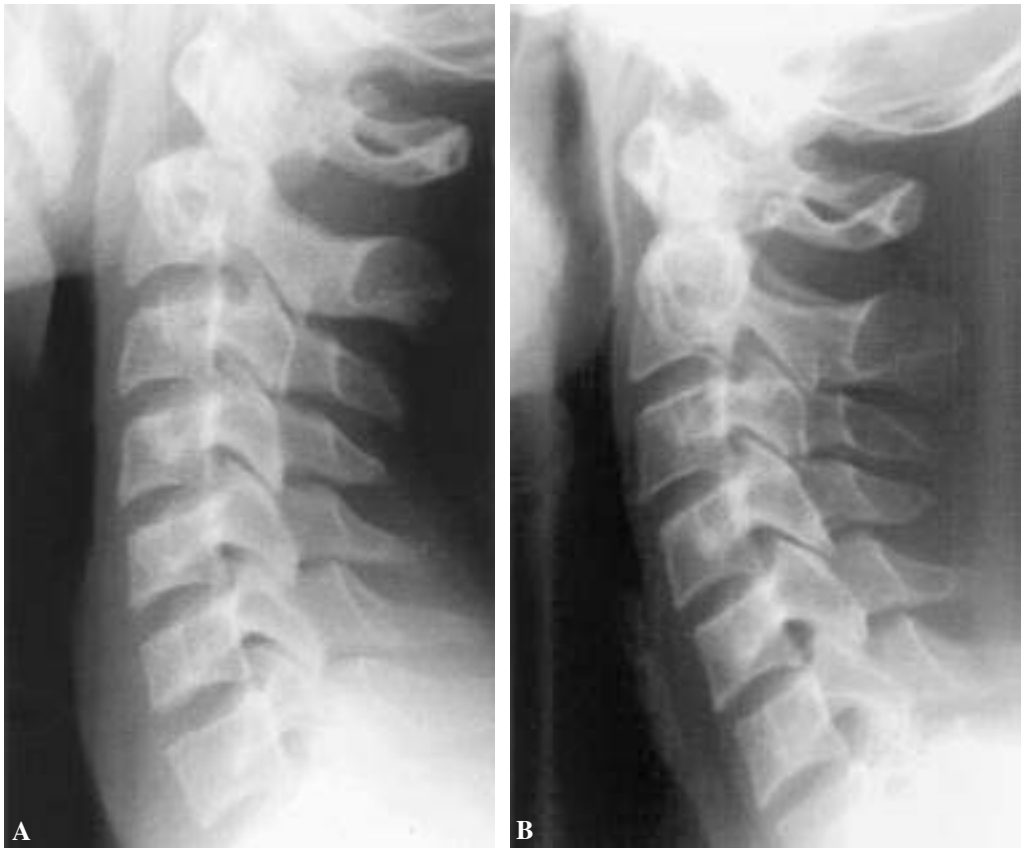

Figure 1. *15-year old male with a type III odontoid fracture. (A) Initial profile x-ray showing a 9 mm posterior displacement. (B) Profile radiograph at 15 years.*

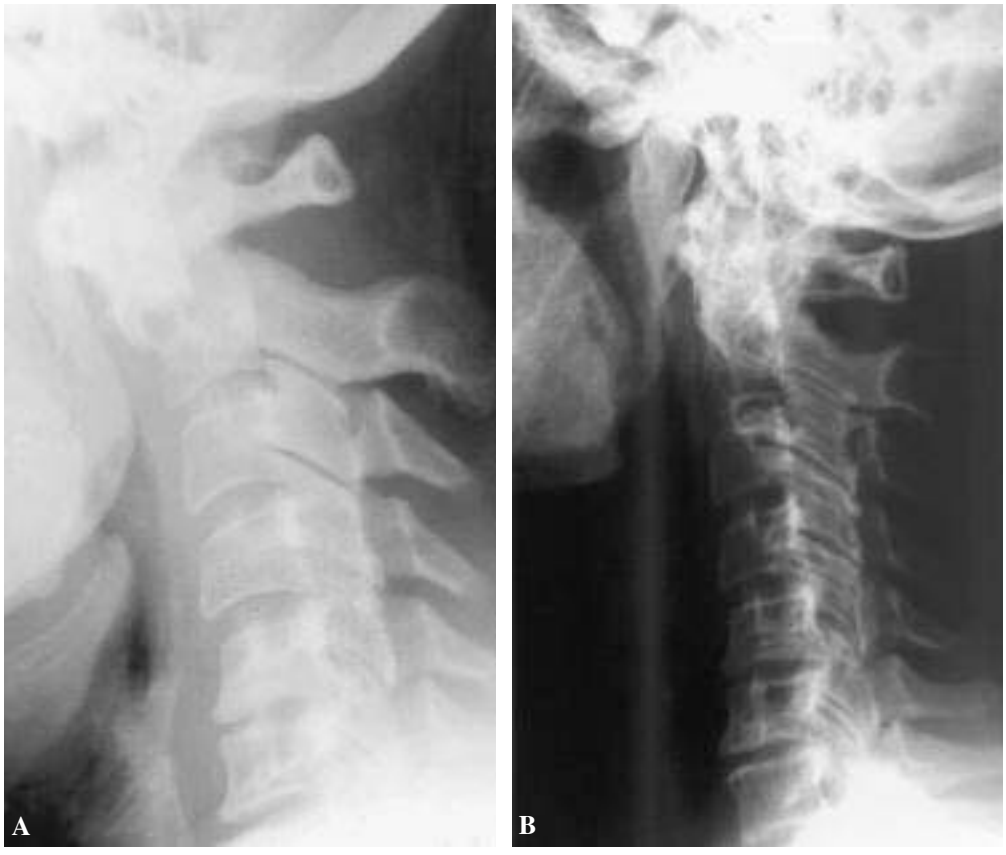

Figure 2. *48-year old female with a type III odontoid fracture. (A) Initial profile x-ray with a 9 mm anterior displacement. (B) Profile radiograph at 14 years.*

Table 2. X-ray assessment (initial and final displacement) and results

	Displacement	Initial	Final	Result	Complications
Case 1	Posterior	9 mm	3 mm	Excellent	Loosening
Case 2	Posterior	7 mm	ST	Poor	
Case 3	Posterior-rotation	7 mm	4 mm	Excellent	
Case 4	Posterior	15 mm	2 mm	Regular	Syringomyelia
Case 5	Anterior	9 mm	2 mm	Excellent	Cheloid scar
Case 6	Anterior-rotation	2 mm	4 mm	Good	
Case 7	Posterior-rotation	7 mm	2 mm	Good	Loosening
Case 8	–	–	–	Excellent	
Case 9	Anterior-rotation	6 mm	4 mm	Good	
Case 10	Anterior-rotation	5 mm	7 mm	Excellent	
Case 11	–	–	–	Excellent	
Case 12	Anterior	8 mm	2 mm	Excellent	
Case 13	Anterior	2 mm	2 mm	Good	Loosening
Case 14	Posterior	2 mm	ST	Poor	
Case 15	–	–	–	Excellent	Loosening
Case 16	–	–	–	Regular	Neuroma
Case 17	Posterior	2 mm	2 mm	Regular	Loosening
Case 18	–	–	–	Excellent	

ST: surgical treatment.

Table 3. Pain score (0-5)[10]

0	No pain
1	Occasional slight pain; does not require medication
2	Occasional moderate pain, occasional medication, does not prevent daily activity
3	Moderate main with slight modifications of occupational and everyday activities
4	Moderate or severe pain, chronic medication, significant activity changes
5	Continuous, severe and disabling pain

proach, once case obtained a good result and in 2 the result was only fair. Two of the patients excluded from this series died within the first year. Of the 4 cases with associated cervical fractures, 2 obtained excellent results and 2 obtained good results.

The global healing rate was 89% (16 out of 18 cases). Orthopedic treatment failed in two cases where the fracture was seen to be unstable after vest placement. This prompted a posterior cervical C1-C2 arthrodesis carried out according to the technique described by Brooks and Gallie (Fig. 3). Complications were: 5 cases of screw loosening, one instance of a frontal neuroma, one cheloid scar and one case of post-traumatic syringomyelia (with no neurological effect).

DISCUSSION

There are multiple variables that influence the healing of odontoid fractures, although the most significant is the location of the fracture site. Type II fractures are avulsion injuries. Type II ones are the most usual and the most problematic since a high rate of pseudoarthrosis is observed. Type III fractures have a high healing potential since they tend to affect cancellous bone. Other variables that influence fracture prognosis are: the direction and magnitude of the displacement, the type of initial treatment, the patient's age and the delay in making a diagnosis[5,9,11,12].

The age distribution of odontoid fractures in this series was in line with what has been published in the literature. Two incidence peaks have been observed: one in patients younger than 30 (9 cases) and another in those over 60 (7 cases). Müller et al[1], Pepin et al[13] and Ryan et al[14] report an incidence peak for odontoid fractures between the third and the ninth decade of life.

Table 4. Smiley-Webster Functional Outcome Scale (1-4)[10]

	Pain	Mobility	Return to activity	Neurologic
1. Excellent	No pain	Normal	No limitations	Intact
2. Good	Occasional	Decreased	Decreased	Intact
3. Fair	Moderate	Severely affected	Severely affected	Slight
4. Poor	Significant	Severely affected	Disability	Catastrophic

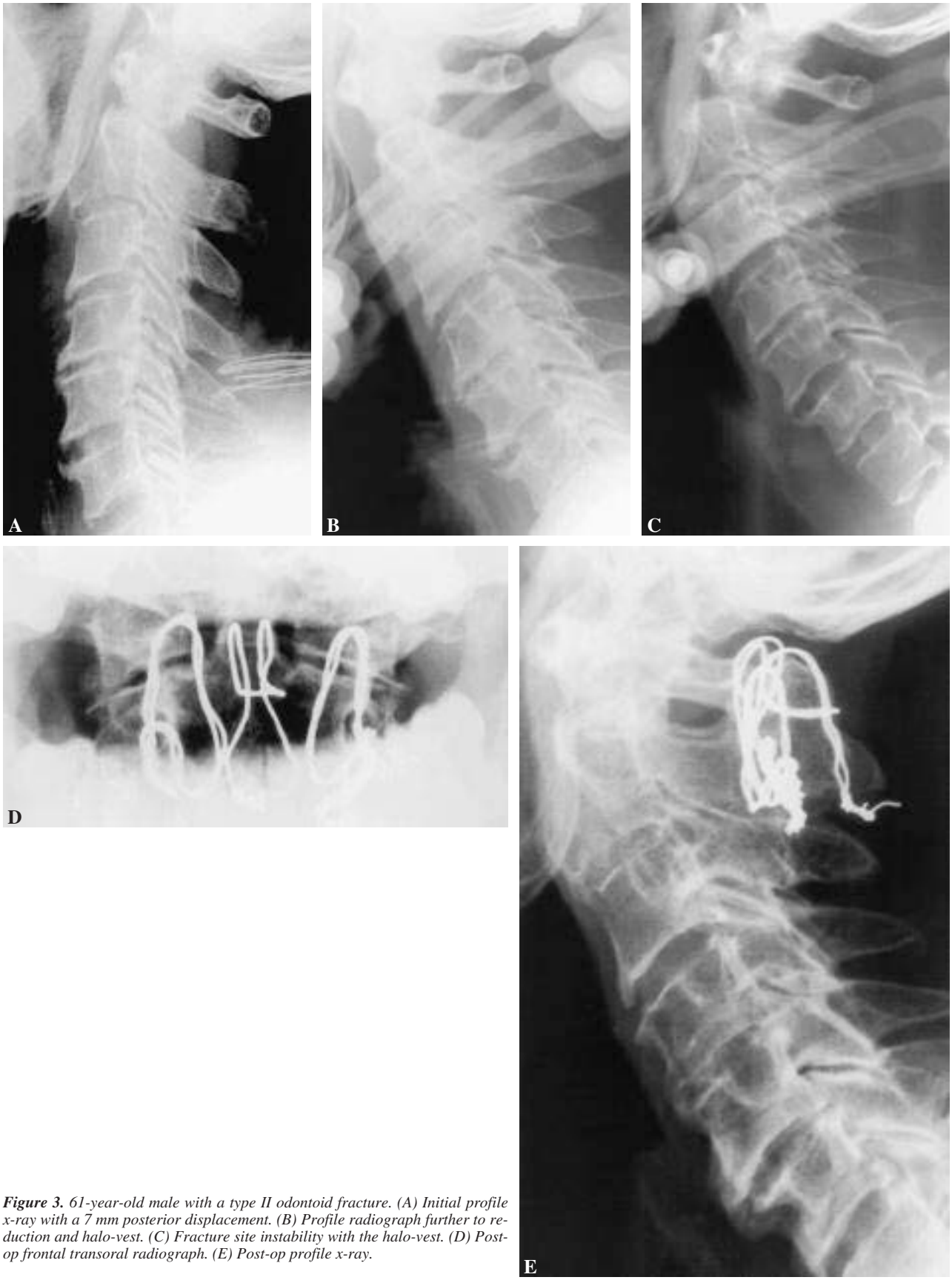

Figure 3. *61-year-old male with a type II odontoid fracture. (A) Initial profile x-ray with a 7 mm posterior displacement. (B) Profile radiograph further to reduction and halo-vest. (C) Fracture site instability with the halo-vest. (D) Post-op frontal transoral radiograph. (E) Post-op profile x-ray.*

In this paper, all odontoid fractures in young patients occurred as a result of a road accident. These results are in line with those of the reviewed series[1-3,7]. These report that whereas young people tend to sustain fractures caused by high-energy trauma, often accompanied by associated lesions, in he elderly the usual mechanism of injury is low-energy and with few associated injuries[13,15-17]. In our series, we found 2 cases of atlas fractures associated to odontoid fractures. Pina et al[8] report 5 cases, while Anderson y D'Alonzo[5] has one single case out of a total of 60 odontoid fractures.

Doherty et al[16] show that type II occur as a result of extension and lateral inclination forces, whereas type III ones are caused by pure extension. The mechanism of injury in the elderly tends to be an anterior trauma with cervical hyperextension.

In all elderly patients (except for one undisplaced case) fractures showed posterior displacement, which in one case was 15 mm. In young patients, however, anterior displacement was the most common (6 out of 14 cases) and in cases there was no displacement at all. These results are comparable to those of Bednar et al[15] and Pepin et al[13]. In this work we found no differences as to the associated neurological lesions, which range between 3 y el 25% according to the different series[1,3,18,19].

In this series, patients over 60 obtained the clinical and functional worst results. Two cases required a surgical procedure (as a result of treatment failure) to stabilize the fracture; two cases obtain a fair result and one case was considered satisfactory. These patients showed an increased morbidity with the use of the halo-vest and the result obtained, especially type II fractures, has been worse. These results are comparable to those published in other series[2,3,7,10,13]. As far as the ideal treatment is concerned, in a retrospective study of 19 patients older than 60, Pepin et al[13] advise conservative treatment for sedentary patients. However, Bednar et al[15], in a prospective study, conclude that initial aggressive treatment could significantly reduce intrahospital mortality.

A review of the literature indicates that type I and type III fractures can be treated conservatively[5,13]. The controversy lies in the treatment of type II fractures. The healing rate of these fractures ranges between 0 and 89% in the different series (D'Alonzo et al[5],74%; Althoff et al[20], 69%; Apuzzo et al[11], 33%; Belmonte et al[7], 82%; Clark and White[12], 32%; Traynelis et al[18], 70%)[4,7,10,13,14,16]. Schatzker et al[9] define the prognostic factors to be used to reject halo-vest treatment: fragment resorption, instability as shown in dynamic x-rays and lack of cortical continuity.

Several papers recommend surgical treatment for type II fractures in patients over 40 with displacement higher than 6 mm and an angle of over 10°, and in unstable fractures, which tend to heal poorly[11,16,17,20]. Abanco et al[21] consider that a direct anterior screw fixation of odontoid fractures, following Böhler's technique, should be the treatment of choice for type II fractures, in case of both transverse and oblique fracture lines. However, as regards type III fractures, authors seem to agree that orthopedic halo-vest treatment should be applied in most cases[22-27].

In this series, the rate of complications inherent in halo-vest treatment was 37% (7 cases), in line with the findings of Pepin et al[13]. The halo-vest has had complications such as screw loosening, infection, bedsores, dysphagia and painful neuromas[28]. However, in the series by Belmonte et al[7] the halo-vest was well tolerated, even by elderly patients. The morbidity rate of this treatment ranges between 0 and 3.7% in the different series[19,29]. In 5 patients complications were caused by an early loosening of the device, which was resolved by applying an occipito-mental orthosis until healing was achieved. Two patients older than 60 with type II fractures showed instability of the fracture further to the placement of the vest, so a posterior cervical C1-C2 arthrodesis was performed.

Gracia and Calatayud[30] report an instance of an atypical complication further to a type III odontoid fracture that went undetected and caused a subacute compression of the anterior subarachnoid space that manifested itself clinically 2 months after the injury in the form of obstructive hydrocephalia and myelopathy.

After analyzing the results, we can conclude that treatment of odontoid fractures with a halo-vest provides a high degree of stability and immobilization that is rigid enough to promote the healing of the fracture in a large number of cases[7]. Nonetheless, an effective halo-vest treatment requires that the patient should restrict his ordinary activities and stay away from his job for at least three months; the treatment also has been shown to have higher morbidity in elderly patients. So, in short, halo-vest treatment decreases the patients' quality of life.

For this reason, it is important to consider the different treatment options available (including osteosynthesis) depending on fracture type and the patient's age and clinical status. However, we consider that initial stabilization and reduction with a halo in type III fractures (especially in young patients) has afforded us a high healing rate and good functional results.

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