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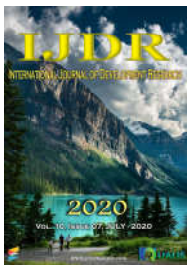

RESEARCH ARTICLE OPEN ACCESS

HALO-VEST IMMOBILIZATION FOR ODONTOID FRACTURES

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ABSTRACT

Purpose: Odontoid fractures can heal with conservative treatments such as Halo vest immobilization (HVI) without surgery. We conducted this study to investigate the clinical outcome, effectiveness, and associated complications of HVI. ***Materials and Methods:*** Between 2012 and 2019, a total of 36 patients with upper cervical spine fractures were admitted to our department and treated with HVI. Sixteen of them, comprising 16,3%, had a fracture of the odontoid process. The cause of trauma was an accident with a motor vehicle. The odontoid fracture was recognized and treated immediately in all patients but who had multiple injuries. ***Results***: The healing rate for odontoid fracture using HVI after 12 weeks was 60.9%. In most cases (93,7%), bony healing occurred within 16 weeks. Among the complications of the hardware method of treatment, inflammation of soft tissues in the area of cortical screws, difficulty swallowing, pain and numbness in the hands, perforation of the skull bones with the formation of an epidural hematoma was not observed. ***Conclusion***: The HVI, when properly used, is well tolerated by most patients and saves them from bed confinement and unnecessary surgery. In our experience, the HVI assures a high percentage of healing in this capricious fracture.

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INTRODUCTION

Odontoid fractures comprise as many as 20% of all cervical fractures. These injuries usually result from low-energy impacts such as falls in the elderly or high-energy impacts such as motor vehicle accidents in the young and middle aged. Type II fractures are the most common odontoid fracture, occurring in 65–74% of the cases. These fractures have similar biomechanical properties as transverse ligament injuries, i.e., a loss of the translational restriction of C1 on C2, creating the potential for spinal cord injury and severe late craniocervical deformities when healing is not obtained (Anderson and D'Alonzo, 1974). Therapeutic options range from conservative treatment, including soft neck collars, rigid cervical orthosis and halo-vest immobilization (HVI), to surgical treatments including anterior screw fixation, posterior C1-2 screw fixation, or transarticular screw fixation. Non-surgical treatment with cervical collar or HVI may provide adequate support in type II fracture or type III stable fractures. Posterior fixation of C1-2 achieves higher fusion rates compared to conservative treatment, but is a challenging surgical technique and results in limitations in the cervical range of motion after surgery (Choi *et al.,* 2005; Muller *et al.,* 1999). In this study, we analyzed clinical and radiographic findings of patients with odontoid fractures who were treated with Halo Vest Immobilization. The time of treatment and rate of union, as well as an analysis of factors that may be of importance for the treatment of these injuries, are reported.

MATERIALS AND METHODS

Between 2012 and 2019, a total of 36 patients with upper cervical spine fractures were admitted to our department and treated with HVI. Sixteen of them, comprising 18.7%, had a fracture of the odontoid process. The age range was 16 - 72 years (mean age: 32.6 years). Seven patients were women and 9 were men. The cause of trauma was an accident with a motor vehicle in 10 patients and a low-energy fall in 6. All patients were brought to the hospital on the day of the trauma. The odontoid fracture was recognized and treated immediately in all patients but who had multiple injuries. He was first treated for associated traumas and the odontoid fracture was not diagnosed until after 3 days. Only 1 patient had neurologic

impairment, an incomplete tetraparesis. Two patients had associated fractures in the cervical spine and 4 had other significant injuries outside the spine. The fracture was classified on the initial radiographic examination according to Andersson-d'Alonzo. Type I, fracture high in the odontoid process; Type II, fracture located at the junction of the odontoid process and the body of the axis; and Type III, fracture extending into the body of the axis. Sagittal displacement was measured perpendicularly from a line through the posterior margin of the fracture, drawn parallel with the posterior wall of the vertebral body to the dorsal aspect of the odontoid fragment. In the frontal plane the displacement was measured as the perpendicular distance from a line through the midline of the body of the axis in the fracture to a line through the midline of the odontoid fragment. The angulation of the odontoid process in the sagittal plane was measured as the angle between a line perpendicular to a line parallel with the inferior lips of the axis and a line through the midline of the odontoid fragment. The normal angulation of the odontoid process in relation to the body of the axis was measured on films of 60 normal subjects in the same way. The fracture gap was registered on the open mouth film. The same parameters were measured after reduction and stabilization in the HVI. Only dislocations or reductions of 2 mm or more were considered.

Diagnosis was made by radiography, including standard anteroposterior, lateral, and open-mouth radiographs. In addition, three-dimensional computed tomography (3D-CT) was performed to assess the fracture type and precisely define the combined cervical fracture. Magnetic resonance imaging was performed in all patients to assess the integrity of intervertebral discs and ligamentous injury or evaluate spinal cord contusion or compression, if clinically warranted. The Halo-vest apparatus consists of a metal halo ring and a plastic jacket. The Halo-vest devises were applied in a standardized manner based on the usual clinical method. The patient was placed in a supine position with the heads supported by a wooden board. The skin is thoroughly scrubbed, and the skin and underlying periosteum at the four pin sites were infiltrated with a 1% lidocaine solution. The four cranial pins were inserted until they contacted bone. The surgeon and the assistant simultaneously tightened each diametrically opposite pin using the torque screwdriver to a maximum torque of 8 in/lb. Neurological assessment was performed before and after fitting the HVI. All patients underwent immediate radiographic imaging consisting of an open-mouth view and lateral cervical spine radiograph, to check alignment with the HVI in place. Within 24 hours, the pins were retightened to the same torque level. One week later, all patients received a routine follow-up evaluation and scheduled the next follow up visit (approximately 2, 4, 6, 8, 12 and 16 weeks). The patients were discharged or assigned to a rehabilitation facility as soon as they accomplished enough ambulation independently. The decision to remove the HVI was based on a plain radiograph with evidence of union and absence of pain or minimal pain in the neck. All patients underwent a CT scan before HVI removal, and flexion extension radiographs were obtained immediately afterwards to confirm the stability. Each patient was then examined neurological outcome by the American Spinal Injury Association (Table 1) assessment and radiologically at 12 and 16 weeks after the injury. The union was classified into three grades: Grade 1, no movement was detected between the odontoid process and the axis on extension-flexion films; Grade 2, callus formation was seen and no movement on extension - flexion films; and Grade 3, the fracture was bridged with bone trabeculae.

Table 1. American Spinal Injury Association (ASIA) Impairment Scale

ASIA grade	Clinical state (below level of injury)
A	Complete: No preservation of function below level of injury, and no sacral sparing (S4-S5).
B	Incomplete: Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5.
C	Incomplete: Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3.
D	Incomplete: Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more.
E	Normal: motor and sensory function are normal.

The clinical outcome was ascertained by reviewing hospital charts. During the study period, patients were contacted and the quality of life measures was assessed by an independent examiner, using the neck pain visual analog scale (VAS). The neck VAS score was determined from the preoperative and postoperative visits as documented in medical records.

RESULTS

Type of fracture: No patient had a Type I fracture. Eleven patients had a Type II fracture. Five of these had a fracture line in the anterior wall of the axis but the facet joints were not involved. Five patients had a Type III fracture.

Grade of initial displacement: Five fractures (Three Type II and two Type III) were undisplaced. Three fractures (two Type II and one Type III) were displaced posteriorly, and all three were displaced more than 4 mm. Eight fractures (six Type II and two Type III) were displaced anteriorly and five of these were displaced 4 mm or more. In the frontal plane there were two fractures (Type II) that were displaced by 3 mm and 5 mm. No patient had an initial fracture gap. In our normal material, angulation of the odontoid process was 21.1° in the posterior direction, (standard deviation (SD): ±4.85°). Of the patients with odontoid fractures, seven had an anterior tilting from the normal of more than 9.8° (2SD). No patient had a posterior tilting of more than 9.8°.

Grade of reduction: After HVI fixation, the reduction was checked with radiographs in lateral and frontal projections. Initially, there were eight fractures displaced 4 mm or more in the sagittal plane. In six of these, the dislocation decreased to less than 4 mm, but in two patients, one failed to reduce the fracture before fixation in the HVI. Reduction of the fracture in the two patients with dislocations in the frontal plane was successful. In one patient, the odontoid process separated from the body of the axis with gaps 3 mm when the cervical spine was stabilized in the HVI. The angulation deformity of the odontoid process was reduced to within 2 SD of normal angulation in five of the seven patients with this displacement.

Duration of HVI treatment: The patients were discharged from the hospital after a mean time of 8.3 days if they were neurologically intact and without other major injuries. In one patient the HVI was removed after only 10 weeks. At this time, callus formation was demonstrated, and the fracture was

stable when tested in extension - flexion, ie, there was a Grade 2 healing. The remaining 15 patients were treated for 12 weeks after which the HVI was removed.

Grade of union: At 12 weeks, in nine fractures, five Type II, four Type III, there was a Grade 3 union (Table 2). Four patients had a Grade 2 union and three patients had a Grade 1 stabilization. At 16 weeks, fifteen of the sixteen examined fractures had healed with a Grade 3 union and one fracture still had a Grade 2 union.

Table 2. Healing Time

	12 weeks	16 weeks
Grade 1	3	-
Grade 2	4	1
Grade 3	9	15
Total number	16	16

Clinical outcomes: The overall neck VAS scores decreased from a HVI mean value of 6.92 ± 0.76 to 2.08 ± 0.64. The initial ASIA spinal cord injury grades denoted no neurological deficits (all 24 patients in ASIA grade "E") with only severe neck pain and dysesthesia in the posterior neck area. After HVI all patients maintained ASIA E neurological status.

Complications: Among the complications of the hardware method of treatment, inflammation of soft tissues in the area of cortical screws, the development of bedsores in the places of pressure of the corset, difficulty swallowing, pain and numbness in the hands, perforation of the skull bones with the formation of an epidural hematoma was not observed. In all cases, there were no secondary dislocations.

DISCUSSION

Fracture union in this series was evaluated by repeated radiologic examinations (X ray and CT) including maximal extension - flexion of the cervical spine. With appropriate radiologic examination technique and evaluation, it was possible to classify the healing of the fracture into three grades. We did not consider the healing to be complete until bridging bone was seen. For healing of the odontoid fracture have been different prognostic factors reported in the literature. Authors reported a poor outcome in fractures dislocated 4 mm or more (Apuzzo, 1978). Posterior dislocations of the odontoid process (Althoff, 1979; Vieweg and Schultheiss, 2001) and fracture gaps (Ryan, 1982; Schweigel, 1979) have also been reported to promote nonunion of the fracture. Many authors found patients, older than 40-60 years of age, (Johnson 1981; Majercik S 2005) and patients with Type II fractures (Rockswold, 1990; Fabris Monterumici et all 2007) to be most prone to have nonunion. Five of the patients were more than 50 years of age, three patients had posterior dislocations and nine of the fractures were initially displaced more than 4 mm. In the HVI, five patients still had a dislocation of more than 4 mm and three patients still had an angulation deformity. Thus, we were not very successful in reducing the fracture by skull traction. Nevertheless, only one fracture did not heal. This occurred in a 62 year old patient with a Type II fracture. The fracture was dislocated less than 4 mm initially and after stabilization in the HVI. However, in the HVI the fracture was stabilized with a gap of 4 mm between the fragments. This may have influenced the outcome. On the other hand, exact reduction of the fracture during treatment in the HVI does not seem to be a prerequisite for fracture healing. Even with healing of the odontoid fracture, several patients in other series are reported to have symptoms (Althoff and Bardholm, 1979; Maiman, Larson, 1982). Eight patients was totally free from pain and/or stiffness in motion of the neck. Furthermore, most patients demonstrated a decreased ability of axial rotation in the neck at the follow-up. This may indicate a disturbance of the motion in the C1 - C2 segment where normally a large part of axial rotation in the cervical spine takes place (Kim et all, 2008). This can be explained by damage to the cartilage and/or soft tissue at the fracture site. However, no correlation was found between the degree of symptoms and the degree of reduction. Hence, the stiffness may be an effect of the long immobilization time in the HVI. It is interesting to note that those two patients with the least mobility of the cervical spine at the follow-up also experienced the most pain. Otherwise, complications in this series were few and mild. Avascular necrosis of the odontoid process that has been reported by authors was not found (Tredwell et al, 1975). The halo - vest was well tolerated by all patients and even by the elderly in contrast to what has been reported by author (Pepin et all, 1985).

Our union rate corresponds with that of other series of Halo vest treated odontoid fractures (Donovan, 1979, Pepin et all, 1985, Vieweg, 2001, Wang et all 1984). Ekong (1981) reported a high incidence (41%) of nonunion in a Halo vest treated series. His conclusion was to recommend primary fusion of all Type II fractures in patients older than 60 years of age. Otherwise, the results of odontoid fracture treatment with HVI contrast to the results of treatment by other conservative means (Althoff B, Bardholm P 1979; Apuzzo MLJ, Heiden JS, Weiss MH, et al 1979, Maiman DJ 1982). The HVI provides a high degree of stabilization of the upper cervical spine (Kim et all, 2008; Vieweg, 2001) and rigid immobilization seems to be of great importance for the healing of these fractures. This is further supported by Schatzker et all (1975) in an experimental study of odontoid fracture healing. He found that a firm posterior fusion between occiput and C2 could unite an established nonunion of an odontoid fracture. In our opinion, the HVI is the treatment of choice for all odontoid process fractures, including the Type II fractures. The HVI, when properly used, is well tolerated by most patients and saves them from bed confinement and unnecessary surgery. In our experience, the HVI assures a high percentage of healing in this capricious fracture.

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