

# Comparative Analysis Treatment of the Use Halo Vest for Odontoid Fractures

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**Abstract** The problems of providing adequate care to patients with injuries of the upper cervical vertebrae are still relevant and far from a final solution. This is indicated by the divergence of views on the choice of treatment tactics for individual specialists. The main task in their treatment is the prevention of secondary displacements, the elimination of deformities, if possible, and the provision of reliable stabilization of the vertebrae [9,11,12].

**Keywords** Traumatic injuries, Patients, Women, Craniovertebral, Neck Stabilization, Atlantoaxial complex, Cervical spine

## 1. Introduction

It is well known that the Halo vest was first described by Perry and Nickel in 1959 and has been widely used in the treatment of traumatic injuries of the upper cervical vertebrae.

According to some authors, the Halo vest provides the greatest immobilization among all external fixators. There have also been cases of complications and a high incidence of non-union of bone fragments [3-6].

Cases of nonunions can be associated with various factors, including excessive movement of the injured vertebra during daily activities. Traditionally, the effectiveness of the Neck Stabilization Halo vest has been assessed using cadaver models [15-21] and mannequins. In these studies, neck movement in the Halo vest was measured with head loading while the torso remained stationary.

Based on this, we were faced with the task of improving the methods of treatment and the fixing structure.

## 2. Purpose of the Study

To conduct a morphometric analysis in patients who used the Halo vest and the apparatus developed by us for external correction and fixation of the cervical spine (Halo vest with an arch support).

## 3. Materials and Methods

The analysis of the results of treatment of 20 patients with fractures of the odontoid process of the axis for the period from 2015 to 2021 was carried out in the Department of Emergency Neurosurgery Fergana Branch Republican Research Centre of Emergency Medicine. Of these, men - 16 (80.0%) patients, women - 4 (20.0%) patients. The age ranged from 18 to 72 years, the average age was 31 ( $\pm 14.5$ ) years. According to the mechanism of injury, road accidents prevailed - 15 (75%) cases, less often - falling from a height - 3 (15.0%) and diving in shallow water - 2 (10.0%).

The patients were divided into two groups: the 1st group - 10 patients who used the Halo-vest, and the 2nd group - 10 patients who used the apparatus developed by us for external correction and fixation of the cervical spine (Fig. 1.). The distribution of patients is presented in Table 1.

**Table 1.** The distribution of patients is presented depending on the choice of treatment

		1 group	2 group
Age		46,8 $\pm$ 6,4	44,7 $\pm$ 7,8
Type	I	0	0
	II	6	7
	III	4	3
ASIA			
	D	4	4
	E	6	6
VAS		7.0 $\pm$ 2,98	7.3 $\pm$ 2,67
NDI		43,5 $\pm$ 8,28	45,6 $\pm$ 6,34

When collecting complaints, as well as when examining patients, signs of a violation of the supporting function of the spine were identified and distinguished, manifested in the form of a pronounced limitation of mobility and forced position of the head and neck, rapid fatigue of the neck muscles, the occurrence of a sharp pain syndrome, dizziness

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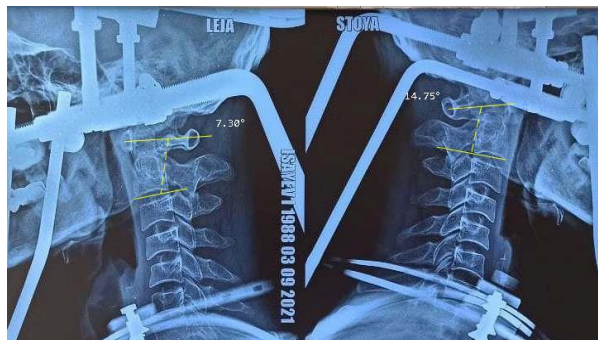
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and nausea when trying to turn the head. All patients underwent CT of the cervical spine upon admission. On radiographs, the relationship between C1 - C2 vertebrae and the base of the skull was assessed, the course of the fracture line of the odontoid process, the direction and magnitude of

the displacement of the atlantoaxial complex, and the dimensions of the Cruverier joint were determined. The segmental angle C1 - C2 and C1 - C7 was measured on lateral radiographs of the cervical spine in degrees (Fig. 2. and Fig. 3.).



**Figure 1.** Position of the patient using the Halo vest with an arch support and lateral radiography of the cervical spine



**Figure 2.** Measurement of the segmental angle C1 - C2 on lateral radiographs of the cervical spine



**Figure 3.** Measurement of the segmental angle C1 - C7 on lateral radiographs of the cervical spine

The halo vest was applied according to the standard technique, after which a dosed distraction was performed in order to eliminate the displacement of bone fragments.

Patients were transferred to a vertical position on the first day after the application of the apparatus. Control radiographs of the cervical spine were performed once every 4 weeks. Fixation in the Halo-apparatus lasted up to 3 - 4 months. After its removal, external fixation was carried out with a removable head holder for 2–3 months.

The effectiveness of treatment (bone fusion) was assessed according to lateral radiography and CT of the cervical spine

3 months after the patient was discharged. The quality of life of the victims before and after the operation was assessed using the VAS and NDI (Neck Disability Index) scales.

When determining NDI, patients were asked to evaluate certain criteria that can significantly affect the quality of life: the intensity of pain, the ability to independently maintain personal hygiene, the ability to lift objects, read, the severity of the headache, the ability to concentrate, they were also asked questions about changes in the ability to work, sleep, fully relax, drive a car, etc. NDI was calculated as a percentage (0% - absolute usefulness, 100% - profound disability).

## 4. Results

Cervicalgia syndrome in both groups of patients before treatment was the same within an average of 7.20 - 7.60 points on the VAS scale. The table presents a comparative analysis of pain intensity among groups before and after treatment. In all groups, the VAS pain score decreased after treatment. In group 1 and group 2, the intensity of the pain syndrome is the lowest - 1.50 and 1.05, respectively. The highest intensity of pain syndrome after treatment remained in the control group, which used a hard trench collar. After the injury and before the operation, the intensity of pain on a 10-point VAS scale ranged from 2 to 10 points, on average 6.2 points, immediately after surgery - from 1 to 8 points, on average 6 points, after 1 month - from 0 to 6 points, an average of 2.2 points, after 6 months - from 0 to 3 points, an average of 0.33 points (Table 2).

**Table 2.** Study of VAS before and after surgery

Group	VAS, points			
	Before	after 1 day	after 1 month	after 3 month
1 group	7.0±2,98	5.5±2,32	3,10±2,42	1,40±0,70
2 group	7.3±2,67	3,20±2,15	0,40±0,70	0,20±0,60

When analyzing the radiographic results, it was noted that external immobilization with a conventional Halo device does not keep an unstable fragment of the axis tooth from secondary displacement. Out of ten patients, 5 patients had a recurrence of shear deformity and 3 of angular deformity. The magnitude of these deformations approximately corresponded to the initial one and ranged from 4 to 12 mm. Four patients with anterior displacement of the odontoid process had kyphotization at the level of the C1-C2 segment. The segmental angle ranged from 4° to 17°. Only in 4 (40%) patients the final X-ray result was “good”, i.e. there are no offsets. The other had only 2 (20%) patients with a shear deformity and radiological outcome of the treatment was “satisfactory”, the remaining 8 (80%) patients had “good” results (Table 3).

**Table 3.** Radiological results of treatment

Results	1 group	2 group	all
Good	4 (40%)	8 (80%)	12 (60%)
Satisfactory	5 (50%)	2 (20%)	7 (35%)
Nosatisfactory	1 (10%)		1 (5%)

Our results demonstrated an S-curve due to the halo vest, consisting of extension at the upper cervical spine and flexion at the lower spine. In the prone position, significantly more C1/C2 extension and C1/C7 flexion were observed in patients using the Halo apparatus compared to the Halo apparatus with an arch support. Axial separation of the head and vT1 was observed due to the Halo Vest, which is consistent with the tensile loading that has been observed clinically in patients with the Halo Vest [1,2,7,8,13,14]. The difference in segmental angles C1-C2 and C1-C7 in the sitting and lying position among groups of patients is presented in Table 4.

**Table 4.** The difference in segmental angles when sitting and lying down

	1 group	2 group	P
Segmental angles C <sub>1</sub> -C <sub>2</sub>	10,41±3,0	4,45±1,2	0,005
Segmental angles C <sub>1</sub> -C <sub>7</sub>	9,43±1,69	4,78±0,76	0,005

Before surgery, NDI ranged from 15 to 96% (average 46%), on the first day after surgery - from 8 to 51% (average 28%), after 1 month. - from 0 to 47% (average 19%), after 6 months. - from 0 to 42% (average 15%), then practically did not change (Table 5).

**Table 5.** NDI study before and after surgery

Group	NDI, points			
	Before	after 1 day	after 1 month	after 3 month
1 group	43,5±8,28	28,20±4,34	20,30±4,90	13,10±4,65
2 group	45,6±6,34	19,30±3,53	11,5±4,25	7,6±3,44

Consequently, after the operation, the quality of life of the victims improved significantly after 1 month.

Thus, all patients felt much better already 1 month after

the operation, and after 6 months, almost all Halo apparatus with an arch support experienced pain.

It should be noted that 3 months after the operation, head turns were practically not limited. The condition of the patients made it possible to engage in hard physical work, sports, independently maintain personal hygiene, drive a car, etc. All examined patients experienced pain in the occipital region in extreme positions when turning the head (according to VAS, an average of 1.7 points).

Among the complications of the hardware method of treatment, inflammation of the soft tissues in the area of the cortical screws, the development of bedsores in the places of corset pressure, difficulty in swallowing, pain and numbness in the hands, perforation of the skull bones with the formation of an epidural hematoma were not observed.

## 5. Discussion

Clinical studies by several authors have documented changes in cervical lordosis and excessive intervertebral rotation in patients with the Halo vest in prone and supine positions [1,10,13,14].

Curvature of the cervical spine, defined as counter-rotation throughout the cervical spine, is thought to be due to the movement of the torso during the transition from vertical to horizontal and back [1,13].

In the present study, neck movements in the sitting and lying position were determined and compared between wearing the Halo Vest with arch support and the conventional Halo Apparatus. Our results demonstrated an S-shaped curvature due to the Halo Vest, consisting of extension at the upper cervical spine and flexion at the lower spine. In the prone position, there was significantly greater head/C1 extension and C1/2 and C1-7 flexion in patients using the Halo apparatus compared to the Halo apparatus with an arch support. An axial separation of the head and vC7 was observed due to the Halo, which is consistent with the tensile loading that has been observed clinically in Halo patients [1,10,13]. Our model has limitations that should be taken into account. The patient was transferred from a prone position to a vertical position, to a supine position, and neck movements were determined using a halo vest. This protocol was chosen in order to be able to calculate the range of motion of the neck during these simulated activities in daily life. In the future, this work will help investigate the effectiveness of the halo vest in stabilizing the neck during body movements [3].

A halo vest is often used as an alternative to internal fixation to treat patients with type II odontoid fracture or stable Jefferson, facet, or compression fractures. Previous clinical studies have documented up to 10° of total C1/2 range of motion in patients treated with the Halo Machine while performing daily activities [5,10,13]. Patients with a VC2 fracture were treated with the Halo vest and suggested that more than 5° of fracture site displacement may indicate an increased risk of nonunion. Our results showed that the

Halo Vest effectively immobilized mean peak C1/2 rotation to less than 4.45° in both the sitting and supine positions. In contrast, the conventional Halo apparatus produced an average peak C1/2 stretch of 10.47° in the supine position. The halo apparatus produced a significant increase in rotation beyond the physiological range in the prone position, in head/C1 extension, and in C4/5 and C7-T1 flexion. These results indicate that an improperly fitted or loose vest can reduce its immobilization capacity, resulting in delayed healing or non-union.

The existing patterns of movement of the cervical spine due to the halo vest help us understand its immobilization capabilities and may be helpful to clinicians in choosing the optimal treatment based on the classification, anatomical location, and severity of the neck injury. Our results highlight the importance of monitoring and tightening the vest straps as needed, especially in those who lose weight or chest circumference during halo vest treatment. The results may also be useful to biomechanical engineers to improve the design of the Halo vest to reduce neck tortuous movement in the prone and prone positions.

## 6. Conclusions

The modified apparatus for external correction and fixation of the cervical spine proved to be effective in eliminating displacements of bone fragments, restoring anatomical relationships in the craniovertebral region with simultaneous fixation of the cervical vertebrae, which allows early activation and rehabilitation of the victims. In addition, the apparatus proposed by us is more comfortable for patients compared to the classical Halo vest, as it allows them to take horizontal postures.

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