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Original Article

Neurosurgery

Postoperative changes in nonspecific low back pain after atlantoaxial stabilization surgery

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ABSTRACT

Objectives: Posterior atlantoaxial stabilization can be technically challenging. Postoperative C2 nerve dysfunction occurs as a complication of this procedure or when a lateral mass is exposed and sacrificed for screw placement. Patients with cervical pathology sometimes complain of low back pain simultaneously. In this study, we aimed to investigate the results of C1-C2 posterior stabilization and C2 nerve root sacrifice on postoperative lumbar complaints.

Methods: Twenty-six patients who underwent multicentric posterior C1-C2 stabilization due to atlantoaxial dislocation were retrospectively included in the study. Those that were not sacrificed the C2 nerve root during stabilization were considered group 1 (n = 12), and those that were sacrificed the C2 nerve root were considered group 2 (n = 14). A visual Analogue Scale (VAS) was used for the neck, arm, low back, and leg pain. The EQ-5D Index was used as the overall quality of life scale.

Results: Six months postoperatively, both groups showed significant ($p < 0.01$) improvement in VAS neck, arm, and low back scores between preoperative and postoperative. In addition, there was no significant improvement in the VAS leg and EQ-5D score in either of the groups. While no significant decrease was found in occipital neuralgia in group 1, it showed significant ($p < 0.01$) improvement in occipital neuralgia in group 2.

Conclusions: Although the exact pathophysiology is unknown, cervical stabilization surgery and sacrification of the C2 nerve root in this surgery can, directly and indirectly, improve low back pain.

Keywords: Cervical vertebra, cervical instability, C2 nerve root, low back pain

C1 and C2 are unique in their anatomical and functional differences that do not conform to the typical features of vertebrae (atypical vertebrae). In addition, the C1 and C2 vertebrae cover the entire brain stem. Therefore, it is an essential bone for the survival and functionality of the human system. Although trauma is the most common cause of atlantoaxial instability, rheumatological diseases, inflammatory diseases, malignancy, and congenital malformations cause instability [1]. In atlantoaxial joint instability, most cases require C1-C2 fixation to preserve vertebral column alignment and prevent neuronal compression. Atlantoaxial stabilization is technically challenging due to the increased range of motion and anatomical relationships. Harms developed Goel's work on atlantoaxial screw fixation in 2001 and de-

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scribed the posterior C1-C2 stabilization technique using polyaxial screws. This technique was named the “Goel-Harms method” [2]. Posterior C1-C2 is an important structure in stabilization because there are vascular plexuses around the C2 nerve root and they pass under the posterior arch of C1. Preservation of the C2 nerve root in stabilization complicates the operation and impairs the quality of life by causing entrapment neuropathy. With C2 neurectomy, C1 screws are placed much more easily and perioperative blood loss is reduced. However, sensory deficits and occipital ulcers can be seen due to C2 neurectomy. Therefore, the clinical benefits of sacrificing the C2 nerve are still controversial [3, 4].

Animal studies have shown connections between neurons of the C2 spinal cord and the thalamus, hypothalamus, anterior cingulate cortex, and amygdala. Thus, the C2 spinal cord segment shows that it is directly connected to most areas of the pain matrix [5, 6].

Studies have shown that decompression of the cervical canal can improve patients' symptoms of myelopathy or radiculopathy. Studies are showing that only cervical surgery can lead to improvement in both cervical and lumbar symptoms as well as the overall quality of life [7-9].

However, there is no study between the C2 nerve root and lumbar symptoms. Accordingly, in this study, we investigated the effect of sacrificing the C2 nerve root in posterior C1-C2 stabilization on both cervical and lumbar symptoms as well as the overall quality of life.

METHODS

Patient Population

This study was approved by the İstinye University ethics committee (3/2022.G-180). 26 patients (between 18-65 years old) who underwent posterior C1-C2 stabilization due to atlantoaxial dislocation, and who were treated at our hospital between January 2015 and January 2022, were included in the retrospective study. Patients with terminal cancer, multiple traumas, chronic organ failure, patients with a history of spinal surgery, and patients with chronic rheumatic disease were excluded from the study.

Hospital electronic medical records, patients with posterior C1-C2 stabilization, and lumbar complaints were retrospectively reviewed. After identification, demographic, clinical, and radiological information about each patient was collected. Cervical and lumbar pathologies were evaluated with magnetic resonance imaging (MRI) preoperatively, both clinically and radiographically.

Study Design

The patients were divided into two groups: those who did not sacrifice the C2 nerve root in C1-C2 stabilization surgery were named group 1; those who sacrificed the C2 nerve root in C1-C2 stabilization surgery were named group 2.

The Visual Analogue Scale (VAS) was used for the neck, arm, low back, and leg pain, and the EQ-5D Index was used as the overall quality of life scale. VAS pain score was evaluated as "painless" (score = 0) and

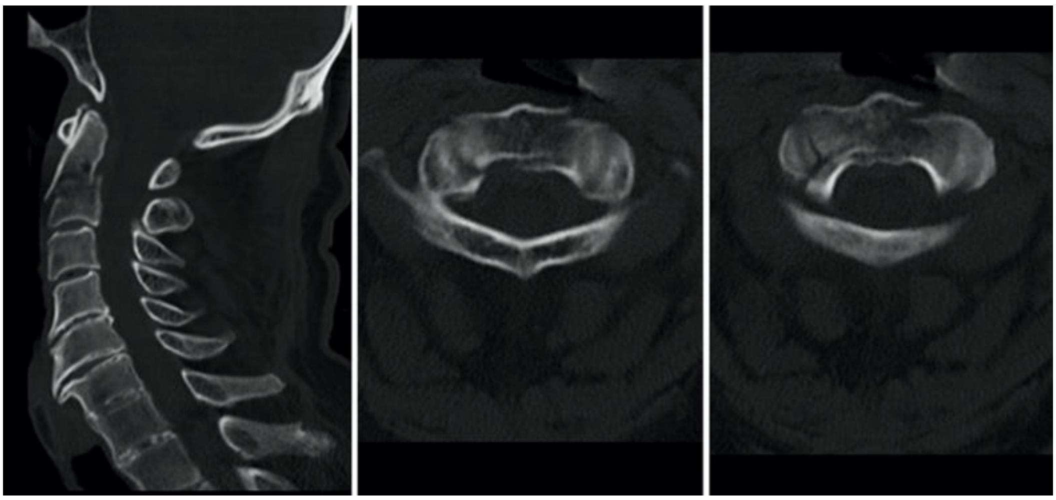

Fig. 1. Preoperative cervical CT images of a patient who has a C2 vertebral fracture.

"worst pain" (score = 10).

EQ-5D Index calculates an index score ranging from -0.59 to 1 from 5 dimensions of the scale. A value of 1 indicates perfect health, while negative values indicate conditions such as unconsciousness, and confinement to bed.

All patients were operated on in the prone position by experienced spinal surgeons using the Mayfield® nail head restraint. Posterior C1-C2 fusion was performed using the standard posterior midline approach and the Goel-Harms technique. Confirmed using fluoroscopy (Figs. 1 and 2). Operational techniques such as mobilization and preservation of the C2 nerve root by retraction (group 1) or sacrificing the C2 nerve root (Fig. 3) by deliberate cauterization with bipolar (group 2) were applied.

Both groups were mobilized with the postoperative cervical orthosis and discharged. Patients received drug therapy (eg, nonsteroidal anti-inflammatory drugs, weak opioids, muscle relaxants) and physiotherapy during follow-up. The patients were evaluated in terms of VAS, EQ-5D Index values, and occipital neuralgia at preoperative, postoperative 1st, and 6th months.

Statistical Analysis

Demographic variables among cohorts were disaggregated using Fisher's test. Continuous data between cohorts were compared with Student's t-test and post hoc paired t-tests using one-way ANOVA analyses and Tukey's test. All p values < 0.01 were considered statistically significant to adjust with multiple comparisons.

RESULTS

Study Population

Analysis was performed with 26 patients with at least 6 months of follow-up. Twelve patients in group 1 and 14 patients in group 2 were included in the study. The mean age of the patients was 49.7 (age range: 18-65

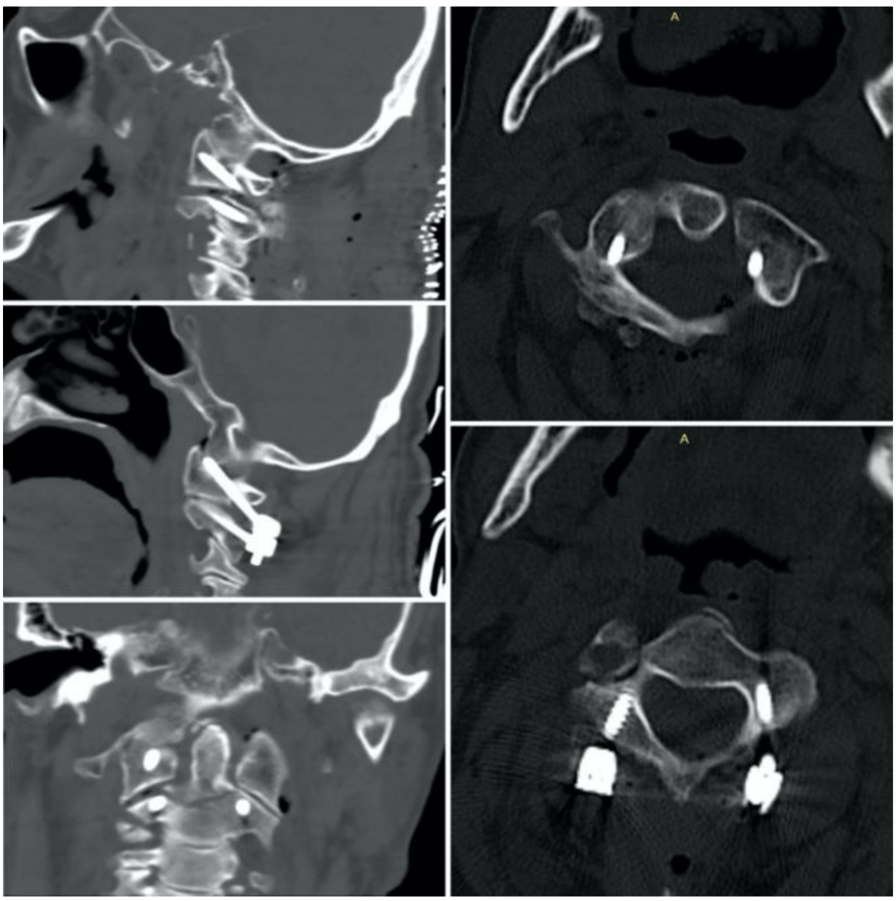

Fig. 2. Postoperative cervical CT images of a patient who has a C2 vertebral fracture.

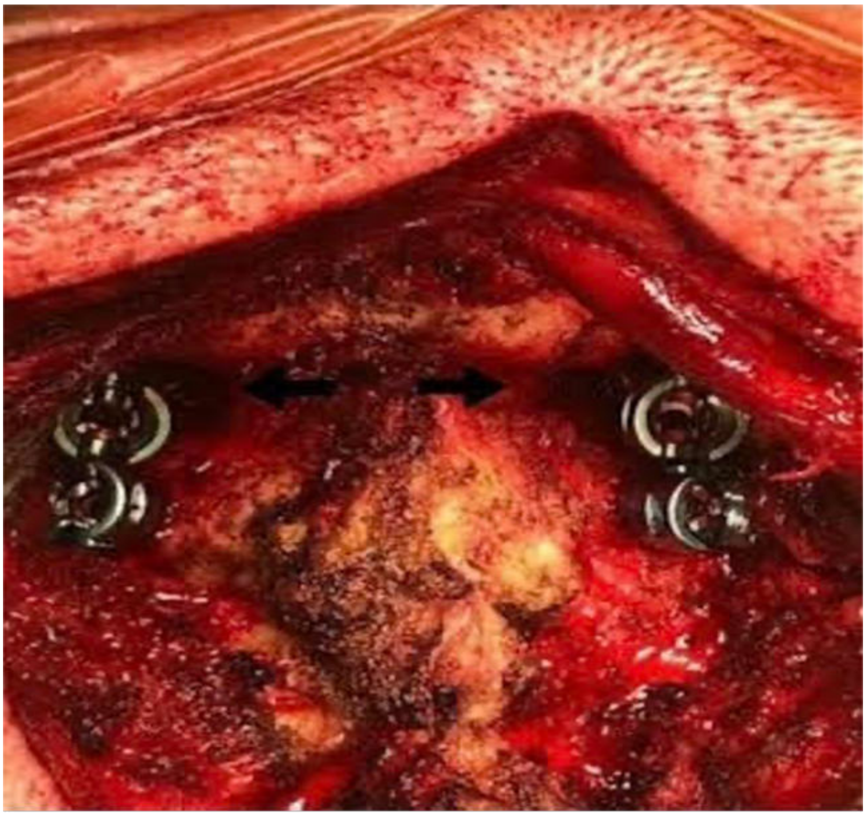

Fig. 3. Sacrified C2 nerve root is indicated by arrows.

years). Nine (34.6%) of the patients were female and 17 (65.4%) were male. The demographic and clinical data of both groups are summarized in Table 1. While there was no statistically significant difference in age ($p = 0.17$), the difference was statistically significant in terms of gender ($p < 0.01$). The mean hospital stay was 6.2 days (4-12) in group 1 and 5.9 days (3-18) in group 2. The difference was not statistically significant ($p = 0.34$).

The most common etiology for the operation of C1-C2 fusion was trauma (84.6%), the most common indication for instrumentation was type 2 dens fracture (68%), and the most common symptom was axial (mechanical) neck pain (87.3%). The most common pathology in the lumbar was degenerative disc disease (69.2%). The most common symptom was low back pain (94.2%).

Posterior C1-C2 fusion was applied to all patients using the Goel-Harms technique. Screws were placed properly in instrumentation in all patients on postoperative imaging. In three patients, the C2 pars screw breached the vertebral artery foramen without complications. No patient had evidence of instrumentation failure or nonunion based on postoperative routine standard standing radiograms and computed tomography scans. No special treatment (medication or physiotherapy) was applied to any patient due to lumbar pathology.

Patient Characteristics

There was a significant decrease in VAS Arm (3.6, 3.3), VAS Neck (3.7, 3.1), and VAS Low Back (3.1, 2.6) in the early postoperative period. Despite this, there was no significant decrease in VAS Leg (3.1, 2.5), even a slight increase in group 1 (Table 2). However, these decreases in VAS scores for both groups were statistically significant ($p < 0.01$). The changes in the preoperative and postoperative 6th-month scores of the patients were as follows. VAS Arm (-2.4, -3.1), VAS Neck (-3.7, -4.3), VAS Low Back (-0.3, -0.9), VAS Leg (0.1, -0.2) and EQ-5D (0, 0.01). At the end of 6 months, VAS was found to be statistically significant in both surgical cohorts ($p < 0.01$). However, there was no statistically or clinically significant im-

Table 1. Patient Characteristics

	Group 1 (n = 12)	Group 2 (n =14)	*p* value*
Age (years)	47.3 ± 10.6	51.7 ± 6.7	0.17
Female sex, n (%)	4 (33.3)	5 (35.7)	0.01
Smoker, n (%)	5 (41.6)	6 (42.8)	0.73
Diabetic, n (%)	4 (33.3)	5 (35.7)	0.64
BMI	25.7 ± 6.3	26.1 ± 1.4	0.68
Cervical disease type, n (%)			
Trauma	10 (83.3)	12 (85.7)	–
Degenerative	2 (16.7)	2 (14.3%)	
Lumbar disease type, n (%)			
DDD	8 (66.7)	10 (71.4)	–
LSS	4 (33.3)	4 (28.6)	

Data are shown as mean ± standard deviation or n (%).
BMI = Body Mass Index, LSS = lumbar spinal stenosis, DDD = degenerative disc disease

provement in EQ-5D ($p = 0.42$).

While 3 patients (25%) had occipital neuralgia preoperatively in group 1, occipital neuralgia was seen in 3 patients (21.4%) in group 2. In the office visits made 1 month and 6 months after the operation, 4 (33.3%) of 12 patients in group 1 complained of occipital neuralgia, while 1 (7.1%) of 14 patients in group 2 complained of occipital neuralgia.

The difference between the two groups in terms of occipital neuralgia was statistically significant ($p < 0.01$). While only 2 (12.5%) of 12 patients in postoperative group 1 had occipital numbness, 4 (33.3%) of 14 patients in group 2 had occipital numbness. While 1 (8.3%) of these patients in group 1 had C2 paresthesia, 3 (21.4%) in group 2 had C2 paresthesia. During the follow-up, none of the patients had earache, speech, or swallowing difficulties. After 6 months, 1 patient (8.3%) in group 1 and 4 patients (28.6%) in group 2 complained of symptomatic drowsiness.

No patients in either group had postoperative neurological deterioration, CSF leakage, or vascular injury. A deep wound infection developed in one patient, intravenous antibiotic therapy was given, and the instrumentation was removed. Another patient developed a superficial subcutaneous infection that resolved with intravenous antibiotics. No patient developed neuropathic ulcers in the occipital region.

DISCUSSION

Sacrificing the C2 nerve root in C1-C2 stabilization has advantages such as increasing the adequate visualization of the C1 facets [10], reducing blood loss, and reducing the operation time secondary to avoiding C2 dissection [11, 12]; It also has disadvantages such as developing dysesthesia in the C2 dermatome area or causing postoperative numbness in the occiput and retro auricular areas. Few researchers have examined the effects of the C2 nerve in C1-C2 instrumentation, and although some studies have been reported on this topic, it is still unclear whether it affects patients' quality of life [11-16].

The primary aim of this study was to demonstrate the effect of the sacrification of the C2 nerve root in atlantoaxial instrumentation on quality of life and postoperative changes in low back pain. Although VAS Low Back decreased in both groups, it decreased significantly in group 2.

Studies suggest that the prevalence of both cervical and lumbar lesions (Degenerative disc disease, spinal stenosis) is high. Its prevalence was found to be 1-5.5 percent in studies with cadavers [17]. Its prevalence was found to be 11% in a study with random MRI in the patient population [18]. In some studies, the prevalence of its association was found to be 9-

Table 2. **Quality of Life Outcomes at 6 months follow-up**

	Group 1	Group 2	*p* value
VAS Arm			
Pre-op	5.7 ± 1.5	5.9 ± 2.2	
Post-op/1m	3.6 ± 2.9	3.3 ± 2.6	< 0.01
Post-op/6m	3.3 ± 3.0	2.8 ± 2.5	
VAS Neck			
Pre-op	6.8 ± 2.7	6.7 ± 2.2	
Post-op/1m	3.7 ± 1.9	3.1 ± 2.5	< 0.01
Post-op/6m	3.1 ± 3.1	2.4 ± 1.8	
VAS Low Back			
Pre-op	3.2 ± 3.1	3.4 ± 2.6	
Post-op/1m	3.1 ± 2.5	2.6 ± 2.2	< 0.01
Post-op/6m	2.9 ± 3.1	2.5 ± 2.8	
VAS Leg			
Pre-op	2.9 ± 2.5	2.7 ± 2.5	
Post-op/1m	2.8 ± 2.9	2.5 ± 2.3	< 0.01
Post-op/6m	3.0 ± 3.0	2.5 ± 2.1	
EQ-5D Index			
Pre-op	0.52 ± 0.21	0.54 ± 0.2	
Post-op/1m	0.53 ± 0.18	0.55 ± 0.17	0.42
Post-op/6m	0.52 ± 0.19	0.55 ± 1.8	
Occ Neur, n (%)			
Pre-op	3 (25)	3 (21.4)	
Post-op/1m	4 (33.3)	1 (7.1)	< 0.01
Post-op/6m	4 (33.3)	1 (7.1)	

Data are shown as mean ± standard deviation or n (%). VAS = visual analogue scale, EQ-5D = Euro QOL-5 Dimensions, Occ Neur = occipital neuralgia

60% [19, 20]. Therefore, the coexistence of cervical and lumbar lesions should be considered.

Although the cause of non-specific low back pain in patients with cervical spinal cord compression is not known, several hypotheses have been proposed regarding its pathophysiology. First, cervical cord compression may affect the spinothalamic tract, limiting activity by causing central sensitization, and indirectly causing low back pain [21-23]. Second, due to cervical cord compression, inhibitory systems and central nociceptive sensation may alter the integrity of endogenous descending pain, causing central tenderness in the lumbar region, resulting in a low back pain response [22, 23]. Third, cervical cord compression may cause low back pain by disrupting the spinal sagittal axis [21, 22]. Fourth, findings such as pain, sensory impairment, and spasticity caused by cervical pathology may cause decreased physical activity and thus indirectly cause low back pain [24]. For these reasons, it is thought that it may affect low back pain directly or indirectly.

Kawakita *et al*. [25] showed that 43% of patients' low back pain complaints improved after cervical surgery in 28 patients with cervical cord compression.

Our study included patients mostly with lumbar degenerative changes, similar to this study. However, in our study, we found that the complaints of VAS-Leg improved slightly in the postoperative period in both groups, and even worsened after improvement in group 2, ie vice versa. This may be due to the small number of patients included in both studies.

Studies by Kim *et al*. [24] and Epstein *et al*. [26] thought that physical activity might help improve low back pain by causing patients with cervical decompression surgery to be more active. In our study, we found that although the VAS Low Back was statistically significantly decreased in both groups (VAS Low Back (-0.3, -0.9)), it was statistically significantly decreased in group 2 ($p < 0.01$).

Alvin *et al*. [9] showed significant improvement in EQ-5D in their 1-year study on 84 patients and Dagi *et al*. [27] in a 22-month retrospective study with 19 patients. In our study, no significant difference was found in VAS Leg and EQ-5D. It may be related to the severity of cervical pathology or lumbar pathology. It may also be a coincidental finding due to the small number of patients in the study.

In C1-C2 instrumentation, visualizing the C1 lateral mass requires mobilization of the C2 nerve root. In the preservation of the C2 nerve root, the pressure of the screw on the C2 nerve root is a possible cause of this neuralgia. Dewan *et al*. [13] showed that it may be associated with occipital neuralgia in approximately 35% of patients in instrumentation with the preserved C2 nerve root. This may explain the increase in postoperative occipital neuralgia in group 1 and the decrease in neuralgia in Group 2 in our study. A larger and longer follow-up study is required to clarify the pathophysiology of low back pain after cervical instrumentation surgery.

Limitations

Due to the small number of patients included in this study, it did not have a sufficiently large comparison group in which the C2 nerve root was preserved, and it has several limitations, including being retrospective. Because its pathophysiology is unclear, this study may identify an incidental finding. We speculate that the reduction of low back pain symptoms is due to increased mobilization. However, the activity was not implemented and evaluated systematically.

CONCLUSION

Improvement of lumbar symptoms following atlantoaxial instrumentation surgery was determined by clinical findings rather than imaging findings. Although the exact pathophysiology cannot be demonstrated, it can, directly and indirectly, ameliorate low back pain. There was no improvement in the quality of life of the patients in our study. Future prospective studies are needed to confirm these findings and examine the effect of sacrificing the C2 nerve root on patients with low back pain.

Authors' Contribution

Study Conception: CS, RA; Study Design: CS, RA; Supervision: CS, RA; Funding: CS, RA; Materials: CS, RA; Data Collection and/or Processing: CS, RA; Statistical Analysis and/or Data Interpretation: CS, RA; Literature Review: CS, RA; Manuscript Preparation: CS, RA and Critical Review: CS, RA.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

Financing

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