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Research Article/ Araştırma Makalesi

Experience and Results of Posterior Cervical Instrumentation Applied in Upper Cervical Injuries

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Aim: Surgical treatment options for upper cervical trauma are few and have a very high risk. We aimed to present our experiences on the cases in which we performed surgery by eliminating the flexion restriction in the postoperative period by not including the occipital region in surgery.

Materials and Method: 16 cases who underwent atlantoaxial fixation with C1 mass-C2 pedicle screwing due to atlantoaxial instability after the year 2008 were retrospectively examined.

Results: 16 patients were included in the study. While the median surgical procedure time of the patients was calculated as 107.5 (range, 60-150) minutes; Intraoperative blood loss was measured as median 350 (range, 200-550) mL. Postoperative complications were observed in 2 patients (12.5%). 1 (6.3%) of the complications was screw revision and 1 (6.3%) was superficial infection. It was observed that the VAS scores of the patients decreased significantly in the postoperative period.

Conclusion: In cases where surgery is planned due to atlantoaxial instability, internal fixation with C1 lateral mass C2 pedicular screws and rod system from the posterior is recommended as an appropriate surgical method due to early and high solid fusion and no restriction in neck flexion movements.

Keyword: Atlantoaxial instability, C1 fracture, C2 fracture, Odontoid fracture

1.INTRODUCTION AND AIM

The cervical spine is a complex structure with wide mobility that serves as protection for vital neural tissues. Anatomically and biomechanically, it is examined as the upper cervical region (C1 - C2) and the lower cervical region (C3 - C7).[1] The upper cervical region allows flexion, extension, rotation and also external movements of the head.[2] Atlantooccipital (C0-C1) joints are the region that contributes the most to head flexion-extension movement by allowing 13° flexion and 16° extension. It has been shown in joint range of motion studies in the upper cervical region by Meyer and Panjabi that 40% of head rotation is provided by the atlantoaxial (C1-C2) joints.[3]

Atlantoaxial instability usually develops due to trauma-related C1-C2-odontoid fractures, arthritis and tumors.[4-6] If not treated, the unstable atlantoaxial segment can cause excessive translational and rotational movements, causing neck pain and the risk of spinal cord compression.

Many techniques have been described for stabilization in upper cervical injuries, such as halo application, pars/pedicle/laminar screws, sublaminar C1-C2 wiring, transarticular screw fixation, and sublaminar hook.

In recent years, the screw method applied to the C1 lateral mass and C2 pedicle has gained

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popularity.[7-9] The use of C1 lateral mass screws In 2001, Harms and Melcher modified this technique by using polyaxial screws and started to use them.9 However, the techniques are not limited to the use of screws. It also carries the risk of vertebral artery injury or spinal cord injury if placed too laterally or medially.[10]

We retrospectively examined patients who were referred or referred to our center and developed atlantoaxial instability due to upper cervical vertebra fracture. The aim of the study is to evaluate and present our experience and results with fluoroscopy-assisted C1-C2 posterior fixation for atlantoaxial.

2.MATERIAL AND METHOD

Patient selection

The study was planned as a retrospective, consecutive patient series. Adult patients over 21 years of age who applied to the study center due to trauma after 2008 and underwent C1-C2 posterior fixation due to atlantoaxial instability were included. Cases operated on due to tumor, infection and arthritis were not included in the study. 16 patients with 24 months follow-up period were included in the study. All patients were operated on using the Harms technique. Ethics committee approval required for the study was received from Sakarya University Faculty of Medicine non-invasive ethics committee.

Surgical technique

Using a midline incision between the posterior inion and C3, the arch of C1 and the spinous process and bilateral laminae of C2 were dissected subperiosteally with the help of cautery. After C1 lateral masses are identified, screw holes are opened with the help of a high-speed tourner (Aesculap 50000 rpm) and polyaxial screws with a diameter of 3.5 mm and a length of 30 mm are placed after checking with fluoroscopy. Before placing C2 screws, it is checked whether the vertebral artery is located high or not from cervical computed tomography images. C2 pedicle screws are then placed as high as possible in the pedicle, parallel to the C1 screws to avoid the vertebral artery. After determining that the screw placements are appropriate under fluoroscopy control, the screws on both sides are connected to each other with separate rods and stabilized. To accelerate fusion, a synthetic graft is placed around the polyaxial screws and closed in accordance with the surgical incision layers.

3.STATISTICAL EVALUATION OF DATA

In the study, the normality assumption of continuous variables was tested with the Shapiro-Wilk test. It was determined that continuous variables did not show normal distribution (Shapiro-Wilk test p-value <0.05). For this reason, while continuous variables are presented as median (range); Categorical variables were presented as frequency (n, %). In the study, VAS pain score change level was evaluated by Wilcoxon signed-rank test. Results; Significance within the 95% confidence interval was evaluated below $p<0.05$. All statistical calculations were performed with SPSS software version 26 (IBM Corp., Armonk, NY, USA). Research visual designs were made using the software GraphPad Prism 10 (GraphPad prism, Prism 10 for Windows, version 10).

4.RESULTS

Basic data

16 patients were included in the study. The median age of the patients was 39 (range, 21-79) years, and 87.5% were male. Acute trauma was the most common surgical indication (n=11, 69%). Surgery was performed two weeks or more after trauma in 5 patients (31%). A significant portion of the traumas were isolated C1 (n=5, 31%), C2 (n=4, 25%) fractures and C1-C2 (n=3, 19%) dislocations. The median preoperative VAS pain score of the patients was measured as 6 (range, 4-8) points. (Table 1).

Table 1.

Baseline data

Variable	Value
All, n	16
Age (year), median (min-max)	39(21-79)
Sex, n(%)	
Male	14(87.5)
Female	2(12.5)
Type of traumatic injury, n(%)	
Isolated C1-fracture	5(31.3)
Isolated C2-fracture	4(25)
C1-C2 dislocation	3(18.8)
C1+C2 fracture	1(6.3)
C2+L1 fracture	1(6.3)
C2 Hangman's fracture	1(6.3)
Type II odontoid fracture	1(6.3)
Cause of injury, n(%)	
In or out of vehicle traffic accident	8(50)
Fall from height	8(50)
Surgical Indication, n(%)	
Acute trauma	11(68.8)
Trauma ≥2 week	5(31.3)
Preoperative pain, median (min-max)	6(4-8)

Treatment data and results

Screw rod connection (SRC) procedure was applied to all patients. SRC was mostly performed at the C1-C2 level (n=10; 63%). While the median surgical procedure time of the patients was calculated as 107.5 (range, 60-150) minutes; Intraoperative blood loss was measured as median 350 (range, 200-550) mL. The total number of screws was 68, including 56 polyaxial screws in C1 and C2. The distribution of screw placement is presented in detail in figure 1.

Postoperatively, no neurological deficit developed in any patient and there was no vertebral artery injury. Complications in the early period were observed in 2 patients (12.5%). 1 (6.3%) of the complications was screw revision and 1 (6.3%) was superficial infection.The median postoperative VAS pain score of the patients was measured as 2 (range, 1-3) points. (Table 2).

It was determined that there was a median decrease of 4 (range, 2-5) units in the VAS pain score of the patients in the postoperative period compared to the preoperative period (Z=3.572; p<0.001). (Figure 2).

Figure 1.

Distribution of screw placement.

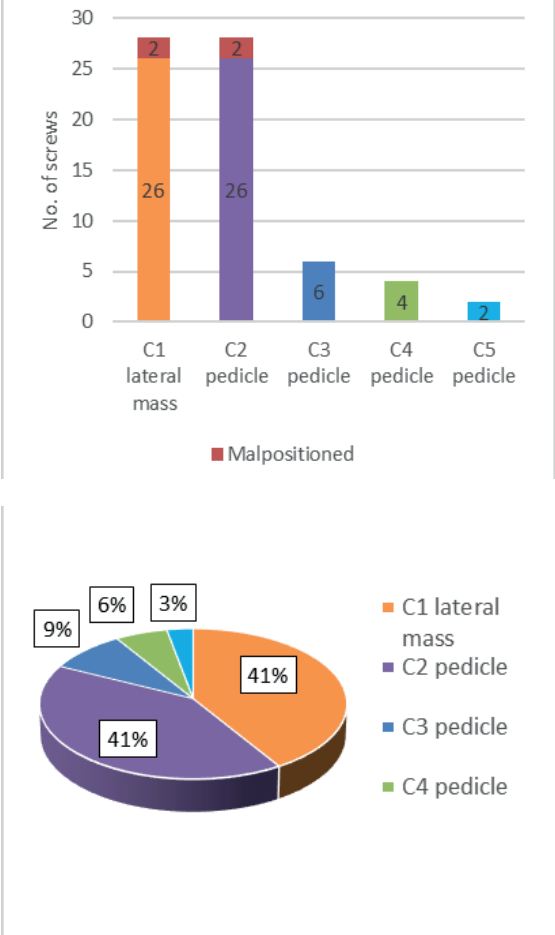


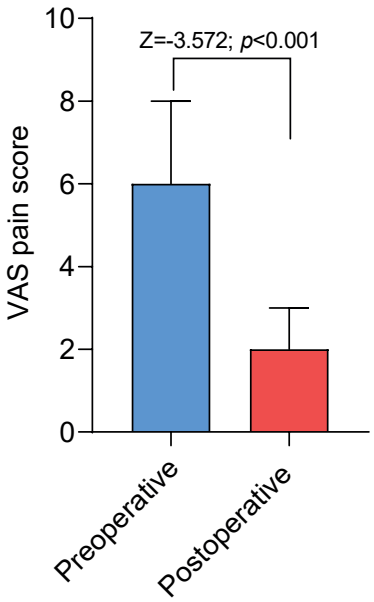
Table 2.

Treatment data and outcomes (SRC: Screw- rod-construct)

Variable	Value
Surgical method, n(%)	
SRC C1	1(6.3)
SRC C2	2(12.5)
SRC C1–C2	10(62.5)
SRC C1–C3	1(6.3)
SRC C1–C4	1(6.3)
SRC C1–C5	1(6.3)
Fusion, n(%)	16(100)
Operative time, median (min-max)	107.5(60-150) min
SRC C1	60(N/A) min
SRC C2	65(60-70) min
SRC C1–C2	107.5(80-120) min
SRC C1–C3	135(N/A) min
SRC C1–C4	150(N/A) min
SRC C1–C5	120(N/A) min
Intraoperative blood loss, median (min-max)	350(200-550) mL
SRC C1	250(N/A) mL
SRC C2	200(200-200) mL
SRC C1–C2	375(300-550) mL
SRC C1–C3	250(N/A) mL
SRC C1–C4	500(N/A) mL
SRC C1–C5	500(N/A) mL
Total number of polyaxial screws in C1 and C2	56
Total number of screws	68
Complications, n(%)	2(12.5)
Screw revision	1(6.3)
Superficial infection	1(6.3)
Postoperative pain, median (min-max)	2(1-3)

Figure 2.

VAS pain score



5.DISCUSSION

Halo vest, rigid cervical collar, cervicothrocic orthosis are used for external fixation in the treatment of upper cervical traumas. Techniques such as sub-laminar wring and trans-articular screw (TAS) have been widely used for internal fixation for a long time.

Halo vest is widely used for external immobilization, but it may have various complications such as swallowing, breathing difficulties, aspiration, pneumonia, skin site infections and cerebral infections [11].

The sublaminar wring method has two main problems: cutting the posterior axis of the atlas and absorption of the bone graft. This causes redislocation after surgery [12]. Additionally, a 5-7% rate of spinal cord damage is observed in this method.[13] Yuan et al., in their series of 49 cases (25 patients with sublaminar wring, 24 patients with screw-rod-construct), had a fusion rate of 80% and screw-rod-construction in their patients

who applied sublaminar wring. They showed that (SRC) was 100% in the patients they applied.[13]

Transarticular screw fixation is a method used together with posterior ring techniques defined by Magerl and Seeman[14]. In the C2 vertebra, the foramen vertebralis is located high in 18% of cases. Patients must have preoperative CT angiography. 68For this reason, a 4% rate of vertebral artery injury has been reported when performing transarticular screws[15]. In their study, Lee et al compared the fusion rates of patients to whom the SRC method was applied and the TAS method. They found it to be 96% in the SRC method and 82% in the TAS method [16]. Additionally, this method cannot be used in cases with C1 subluxation and high vertebral artery access to the C2 vertebra.

Recently, the C1-C2 SRC method has become more valid in internal fixation, which allows intervention in almost all types of upper cervical pathologies, has higher fusion rates than other methods, and has less risk of spinal cord damage and vascular injury.

This study evaluated 16 consecutive cases treated with posterior C1-C2 fixation due to atlantoaxial instability due to trauma. The bone fusion we targeted was achieved in all cases. In addition, with this method, although there is a screw rod system that provides 360° stabilization, unlike other systems, restrictions on neck flexion movement were eliminated.

The results are consistent with previously published studies suggesting that posterior C1-C2 fixation is an effective treatment for cervical instability and pain.[5,6,17-25]

Hitti et al. reported a significantly longer mean surgery time using navigation of 198 minutes compared with 157 minutes for surgery without navigation. They stated that they estimate that as the experience and use of navigated operating room time becomes widespread, the values reported for surgery without navigation will approach.[26]

In this study, which we conducted without navigation, we managed to reduce the average surgical time to 102.5 minutes. We think that the most important factor in this is the experienced surgical team and operating room team.

Elliot et al. found the average surgical bleeding amount as 350 ml and they reported this result in their literature review study for cases in which atlantoaxial fixation was performed[27]. In our surgical series, our average bleeding amount was 362.6 ml, which was generally similar to other surgical series.

Sei Woong Jeon and colleagues examined 17 patients, 16 of whom had trauma and 1 had bacillary intussusception. They used average screw lengths as 27.5 mm in C1 and 28.8 mm in C2. As complications, occipital neuralgia was observed in 1 patient, CSF fistula was observed in 1 patient, screw malposition was observed in 1 patient, and no vascular or spinal injury was observed in any patient. They reported that they observed radiological solid fusion in 16 of the patients who were followed for an average of 26 months.18 In our study, 30mm screw lengths were used in C1 and C2 in all patients. Screw placement was observed to be bicortical in 7 patients in the C1 vertebra. We think that this situation is positive in terms of fusion. As complications, screw malposition occurred in 1 patient and superficial infection developed in 1 patient. Revision surgery was performed for screw malposition. Superficial infection was treated with ampicillin-sulbactam.

In 2002, Harms and Melcher published a study in which they applied posterior atlantoaxial

stabilization with the C1 lateral mass C2 pedicular screwing rod system. Technically, they connected the C1 lateral mass and C2 pedicle screws independently with a rod system. According to the case results, the fusion of C1 and C2 was observed to be 100% successful. Biomechanically, the C1 lateral mass and C2 pedicular screwing method and the transarticular screwing method are similar to each other, but they stated that the C1 lateral mass and C2 pedicular screwing method allows more flexion.[19]

In their study as they published, Yang Xie et al. applied internal fixation to 25 cases with atlantoaxial instability from the posterior using C1 lateral mass C2 pedicular screws and rod system. 13 of the cases were traumatic fractures, 3 were rheumatoid arthritis, 2 were rotatory subluxation, 2 were congenital malformations, and 5 were unsuccessful surgeries. The cases were followed for an average of 16 months, and all cases were evaluated with direct radiography and dynamic films and were observed to have solid fusion. They concluded that the C1 lateral mass C2 pedicular screwing rod system is the appropriate method in cases with atlantoaxial instability.[28] In our study with the Harms technique, C1 and C2 fusion was achieved in all cases in which we performed surgery with the diagnosis of atlantoaxial instability, like both Harms and Melcher and Yang Xie et al. Since we did not include the occipital region in rotation, the patients' flexion movements continued in the postoperative period.

The well-known and potentially most dangerous complication of screw misplacement associated with the screw and rod technique is vertebral artery injuries.[6,21] Buchmann et al. In his study, he showed vertebral artery canal violations in 5.1% of the applied screws and vertebral artery occlusion in 4 patients .[20] In our C1-C2 posterior fixation cases, vertebral artery canal violation was observed in 1 patient and was revised in the early period. No vertebral artery occlusion was observed in the control MR angiography.

C1-C2 posterior stabilization performed with the help of fluoroscopy is a method with a long learning curve and high risks. However, we think that it is a good surgical treatment method for atlantoaxial instability as it reduces complications and provides a high rate of fusion with an experienced team.

6.CONCLUSION

C1-C2 pedicle posterior stabilization is a safe and effective surgical treatment option for atlantoaxial instability. It provides pain relief for patients and a high rate of bone fusion. In this study, which we performed under fluoroscopy, screw placement was performed with a low revision and complication rate. And our study showed that posterior stabilization surgeries for upper cervical injuries are an extremely reliable treatment method that requires experience. We think that this surgical technique will be used routinely as the navigation system, which is still available in very few centers in the world, becomes widespread in the future.

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Conflict of Interest

There is no conflict of interest between the authors.

Ethics Committee

Sakarya University Rectorate Dean's Office of the Faculty of Medicine Non-Interventional Ethics Committee application file, Number: E-71522473-050.04-340192-45

Author Contributions

Working concept/design: MK, HTS

Data collecting: MK

Data analysis/interpretation: MK

Manuscript draft: MK, HTS

Technical/material support: MK

Critical review of content: MK, HTS

Literature review: MK

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