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## Clinical and radiological outcomes of patients on whom posterior C1-C2 stabilization is applied in C2 odontoid fractures

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### Abstract

C2 odontoid fractures constituting 18% of total cervical fractures have a high mortality rate. These fractures may be treated with surgical methods such as external immobilization and odontoid screwing, and anterior or posterior transarticular screwing. Our study presents the clinical and radiological outcomes of patients who received C1-C2 posterior stabilization in C2 odontoid fractures. Twenty patients who underwent posterior C1-2 stabilization at İnönü University neurosurgery clinic between 01.01.2015 and 01.06.2020 were included in this study. These patients were categorized based on their age, sex, fusion ratio, failure to position the fracture line, comorbid diseases, additional trauma, type of accident, duration of hospitalization, the shape of the fracture line, complications and calcification ratios around the dens, and they were followed up for six months. There was a fusion in the fracture line of 19 (95.0%) patients. It is possible to fail to position the fracture in those with irregular fracture lines among patients, and there was a statistically significant difference regarding this issue ( $p=0.001$ ). There were 3 (15.0%) patients with calcification around the dens. There was a significant relationship between calcification around the dens and age, where the calcification ratio increased as the age increased ( $p=0.004$ ). The fusion rate is high among patients who receive C1-C2 stabilization. In patients where calcification develops around the dens, the possibility of neck pain to continue despite the stabilization removal should be kept in mind. In the treatment of C2 odontoid fractures, posterior C1-2 stabilization is an effective method.

**Keywords:** C2 dens, C1-2 stabilization, calcification around the odontoid process, fusion.

### Introduction

C2 odontoid fractures constitute 18% of total cervical fractures. [1]. Such fractures usually occur as a result of hyperflexion and hyperextension. While it is generally seen in men at early ages, there is no sex difference at advanced ages. While neurological deficits due to C2 Odontoid fractures are rarely observed, as these are high-energy fractures, 25-40% of patients are lost at the event scene [2,3]. In these patients, neck pain might be the only complaint. Direct radiography, three-dimensional computerized tomography (3D-CT), and magnetic resonance imaging (MRI) are essential in the diagnosis. 3D-CT is the gold standard. Odontoid fractures are categorized under three types; mostly including type II or type III fractures [4-6].

Surgery has been recommended for type II and some type III groups. SOMI brace and single or double odontoid screws, anterior or posterior transarticular screws are among the treatment options. In some systemic diseases like diabetes mellitus (DM) and rheumatoid diseases (RD), calcification rates around the dens and fusion decrease. Although the first treatment option is early surgical stabilization, a standard consensus has not been reached in the treatment [7]. New developments in the definition and classification of C2 odontoid fractures and cervical fixation methods cause debates on the treatment of odontoid fractures to continue still.

Considering the clinical importance of C2 odontoid fractures, our study presents the clinical and radiological outcomes of patients who received C1-C2 posterior stabilization in C2 odontoid fractures.

### Materials and Methods

After obtaining ethical approval with the decision numbered 2021/1462 of the Health Sciences Non-Interventional Clinical Studies Ethics Board of İnönü University, the study was conducted.

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Among patients who were admitted at the İnönü University neurosurgery clinic between 01.01.2015 and 01.06.2020 with trauma, cervical fractures were determined in 113 patients who were diagnosed with spinal MRI and spinal 3D-CT (images were taken by using the devices: Siemens Magneto 3 Tesla MRI and Toshiba Asteion 4 CT) and required surgery. From the 113 patients, a total of 93 patients on whom screws were applied at levels other than C2, at levels other than C2 in addition to C2, and the C2 anterior dens were excluded.

Twenty patients who received posterior C1-2 stabilization and were followed for six months were included in the study. In all patients, stabilization and reduction procedures were performed with a lateral mass screw on the ticketeral C1 vertebra, ticketeral peduncle screw on the C2 vertebra, and a ticketal rot system with inteoperative scopy. These patients were categorized based on their age, sex, fusion ratio, failure to position the fracture line, comorbid diseases (DM, HT, RD), additional trauma, type of accident, duration of hospitalization, the shape of the fracture line, complications and calcification ratios around the dens.

The quantitative data are presented as medians (min-max) or means (standard deviations), while the qualitative data are presented by frequencies (percentages). Fisher's Exact Test and Mann-Whitney U test were used in the statistical analyses.  $P < 0.05$  was accepted as statistically significant. The IBM SPSS Statistics 26.0 program was used in the analyses.

## Results

Among the 20 patients included in the study who had C2 odontoid fractures and received posterior C1-2 stabilization (Figure 1), 18 (90.0%) were male, and 2 (10.0%) were female. The mean age of all patients was  $55.35 \pm 19.08$ , their median age was 53.50, and their minimum and maximum ages were 21.0 and 83.0.

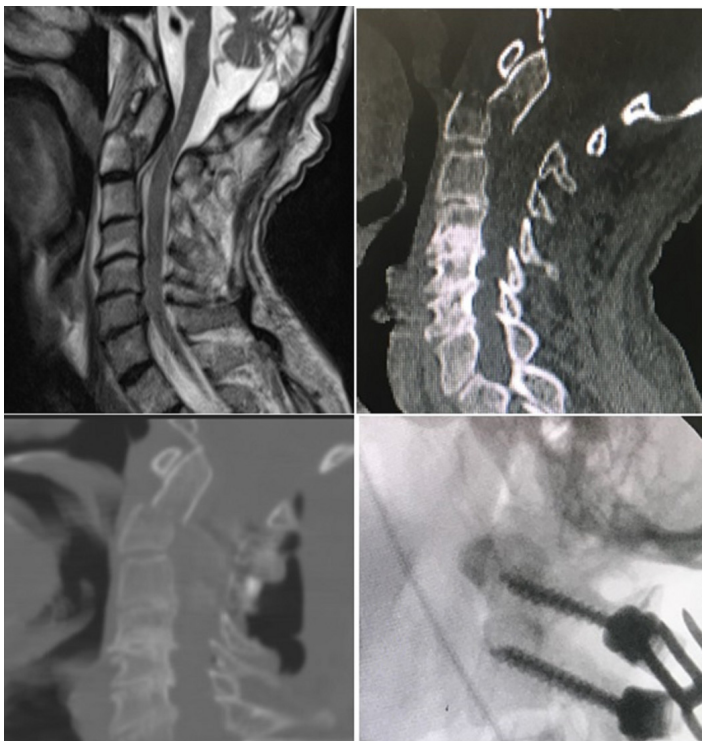


Figure 1. Pre-and postoperative radiological images

The mean age of the male patients was  $57.0 \pm 19.11$ , and that of the female patients was  $40.50 \pm 14.85$ . The patients' mean hospitalization duration was  $6.85 \pm 4.50$ , with a median value of 4.5 and minimum and maximum values of 3.0 and 15.0. As a result of six months of follow-up, there was a fusion in the fracture line in 19 (95.0%) patients. Of the six patients over the age of 70, 3 patients without additional trauma had only neck pain.

There were 17 (85.0%) patients with regular fracture lines and three patients (15.0%) with irregular fracture lines. There were 3 (15.0%) patients whose fracture line could not be positioned, while there were 17 (85.0%) whose fracture line could be positioned (Table 1). Among patients with irregular fracture lines, it is possible that the fracture line cannot be positioned, and in this study, there was a significant difference between such patients (Fisher's Exact Test;  $p = 0.001$ ) (Table 2).

Table 1. Distributions of variable classes

Variable	Variable Category	n	%
Fracture Line	Irregular	3	15.0
	Regular	17	85.0
Failure to Position the Fracture Line	Absent	17	85.0
	Present	3	15.0
Fusion Rate	Absent	1	5.0
	Present	19	95.0
Comorbid Diseases	DM	2	10.0
	DM, HT	1	5.0
	HT	1	5.0
	Absent	16	80.0
Calcification around the Dens	Absent	15	75.0
	Partial	5	25.0
Type of Accident	EVTA	9	45.0
	Falling	11	55.0
Additional Trauma	Lung Contusion	8	40.0
	Craniofacial Trauma	2	10.0
	Scapular Fracture	1	5.0
	None	9	45.0

There were 3 (15.0%) patients with calcification around the dens (Figure 2). There was a significant relationship between calcification around the dens and age, and as the age increased, the presence rate of the densification around the dens increased (Mann-Whitney U Test;  $p = 0.004$ ). There was a strong correlation between the two variables ( $r = 0.641$  and  $p = 0.003$ ) (Table 2).

There were C2 odontoid fractures in 9 (45.0%) patients as a result of extravehicular traffic accidents (EVTA) and in 11 (55.0%) as a result of falling. The incidence of EVTA in the young patients and the incidence of falling in the older patients were significantly

higher as the causes of fractures (Mann-Whitney U Test;  $p=0.107$ ) (Table 2).

In terms of additional trauma, there were lung contusions in 8 (40.0%) patients, two patients had craniofacial trauma (10.0%), and one patient had a scapular fracture (5.0%) (Table 1). While there was no statistically significant difference between those with and without additional trauma in terms of the type of accident (Fisher's Exact Test;  $p=0.964$ ), the hospitalization durations of the patients who had additional trauma were significantly longer than those who did not have additional trauma (Mann-Whitney U Test;  $p<0.001$ ) (Table 2).

There were 2 patients with DM 2 (10.0%), 1 patient with HT (5.0%) and 1 patient with both DM and HT (5.0%). There was

no patient with rheumatoid diseases. In the six-month follow-up, there was a low-level increase in angulation in 3 (15.0%) patients (Table 1).

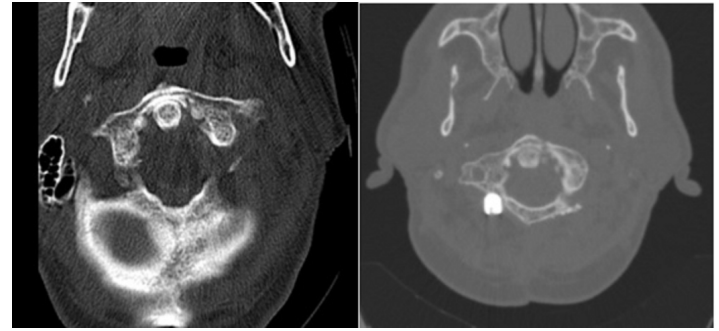


Figure 2. Soft tissue calcification around the dens on the (right)

Table 2. Statistical tests for variables

Statistical Tests				
		Fracture Line		p
		Irregular	Regular	
Failure to Position the Fracture Line	Absent	0 (0.0%)	17 (100.0%)	Fisher Exact Test $p=0.001$
	Present	3 (100.0%)	0 (0.0%)	
Calcification Around The Dens				p
Age	Absent (n=15; 75.0%)	Partial (n=5; 25.0%)		Mann-Whitney U Test $p=0.004$
	Mean±SD [Median (Min-Max)] 48.47+16.64 [48(21-80)]	Mean±SD [Median (Min-Max)] 76+7.07 [77(65-83)]		
Type of Accident				p
Age	EVTA (n=9; 45.0%)	Fall (n=11; 55.0%)		Mann-Whitney U Test $p=0.107$
	Mean±SD [Median (Min-Max)] 47.33+20.51 [39 (21-81)]	Mean±SD [Median (Min-Max)] 61.91+15.81 [65 (33-83)]		
Additional Trauma				p
Type of Accident	EVTA	4 (44.4%)	5 (45.5%)	Fisher Exact Test $p=0.964$
	Fall	5 (55.6%)	6 (54.5%)	
Additional Trauma				Statistical Test p
Hospitalization Durations	Absent (n=9; 45.0%)	Present (n=11; 55.0%)		Mann-Whitney U Test $p<0.001$
	Mean±SD [Median (Min-Max)] 3.56+0.53 [4 (3-4)]	Mean±SD [Median (Min-Max)] 9.55+3.53 [10 (4-15)]		

## Discussion

In C2 fractures, while the male sex is more prevalent at early ages, women and men are equal in terms of prevalence at older ages. In our study, the male sex was dominant in all age groups. Low-energy traumas may occur in patients over the age of 70, and the only complaint may be neck pain. [8] In our study, all patients over the age of 70 had fallen, and all three patients without additional trauma had only neck pain, which was in parallel with the literature. In young adults, odontoid fractures usually occur as a result of high-energy traumas following an EVTA, additional organ injury rates increase, and in addition to this, hospitalization durations are extended. [9, 10] Our results were in line with this information.

While C1-C2 posterior fusion techniques are frequently used surgical methods in odontoid fractures, the rotation range of the neck is reduced by approximately 50%. [11] Fusion rates of 74% in halo usage and 53% in only cervical collar usage were reported. [1, 12-14] For posterior C1-C2 fusion, wiring methods, posterior stabilization with screws applied on the posterior C1 isthmus and C2 lateral mass and the C1 lateral mass and C2 partial polyaxial screw placement techniques defined by Harms and Melcher may be applied. [15] It was proven that patients who had posterior C1-C2 arthrodesis surgery had significantly higher rates of fusion than those treated with anterior odontoid screw fixation. [7, 16-18] Studies have reported fusion rates close to 100% in the long-term follow-ups of patients treated with these techniques. [2, 19] In our

study, fusion was detected in 95% of the patients who received C1-2 stabilization, which was lower than those reported in the literature. The reason for this may be the failure to position the fracture line, the low number of patients in the series, and the short follow-up time. Additionally, complications like failure to position the fracture line and vertebral artery injuries were reported at rates of 2-4%. [20, 21] The rate of failure to position the fracture line in our study was 15%, which was higher than those in the literature, whereas there was no vertebral artery injury. We think the reason for this was that the fracture line was not regular. Calcification around the dens in patients who receive C1-C2 fixation has not been encountered in the literature. However, in some studies, crowned dens syndrome was confirmed with clinical and radiographic results by soft tissue calcification around the atlantoaxial joint. Nevertheless, these patients had a fever, high CRP levels, and RD. [22] Masakazu Sano et al. reported positive calcification around the odontoid process in 88 of 554 patients (15.9%). Age, female sex, and stroke were reported as causes that increased calcification rate around the odontoid process. [23] In our study, there were 3 (15.0%) patients who did not have calcification around the dens before the surgery but had calcification in their six-month follow-up. Findings of RD or infection were not encountered in these patients, while a correlation was determined between age and calcification. Calcification around the dens may cause ongoing neck pain in patients whose stabilization needs to be removed. However, studies with larger numbers of patients are needed.

## Conclusion

Surgical treatment forms and their superiorities in the treatment of C2 odontoid fractures are still under debate. Our study concluded that there was a relationship between the shape of the fracture line and the failure to position the fracture line, calcification around the dens increased by increasing age, and the fusion rates were sufficient. In patients where calcification develops around the dens, the possibility of neck pain to continue despite the stabilization removal should be kept in mind. In the treatment of C2 odontoid fractures, posterior C1-2 stabilization is an effective method.

## Conflict of interests

*The authors declare that they have no competing interests.*

## Financial Disclosure

*All authors declare no financial support.*

## Ethical approval

*After obtaining ethical approval with the decision numbered 2021/1462 of the Health Sciences Non-Interventional Clinical Studies Ethics Board of İnönü University, the study was conducted.*

## References

- Vaccaro AR, Madigan L, Ehrler DM. Contemporary management of adult cervical odontoid fractures. *Orthopedics*. 2000;23:1109-13.
- Maak TG, Grauer JN. The contemporary treatment of odontoid injuries. *Spine*. 2006;31:S53-S60.
- Ivancic PC. Odontoid fracture biomechanics. *Spine*. 2014;39:E1403-E10.
- Bohlman HH. Acute fractures and dislocations of the cervical spine. An analysis of three hundred hospitalized patients and review of the literature. *JBJS*. 1979;61:1119-42.
- Clark CR, White A. Dens Fractures: a Multi-center Study. *Cervical Spine I: Springer*; 1987. p. 236-8.
- Jenkins S, Bordes S, Aly I, et al. Internal morphology of the odontoid process: Anatomic and imaging study with application to C2 fractures. *World neurosurgery*. 2019;127:e1120-e6.
- Grauer JN, Shafi B, Hilibrand AS, et al. Proposal of a modified, treatment-oriented classification of odontoid fractures. *The Spine J*. 2005;5:123-9.
- Alas H, Segreto FA, Chan HY, et al. Association between frailty status and odontoid fractures after traumatic falls: investigation of varying injury mechanisms among 70 elderly odontoid fracture patients. *J Ortho Trauma*. 2019;33:e484-e8.
- Tenny S, Dulebohn S. Fracture, Odontoid. *Treasure Island: StatPearls*. 2017.
- AlEissa SI, Alhandi AA, Bugis AA, et al. The incidence of odontoid fractures following trauma in a major trauma center, a retrospective study. *J Craniovertebr Junction Spine*. 2020;11:71.
- Lapsiwala SB, Anderson PA, Oza A, et al. Biomechanical comparison of four C1 to C2 rigid fixative techniques: anterior transarticular, posterior transarticular, C1 to C2 pedicle, and C1 to C2 intralaminar screws. *Neurosurgery*. 2006;58:516-21.
- Platzer P, Thalhammer G, Sarahrudi K, et al. Nonoperative management of odontoid fractures using a halothoracic vest. *Neurosurgery*. 2007;61:522-30.
- Kim SK, Shin JJ, Kim TH, et al. Clinical outcomes of halo-vest immobilization and surgical fusion of odontoid fractures. *J Korean Neurosurg Soc*. 2011;50:17.
- Frangen TM, Zilkens C, Muhr G, et al. Odontoid fractures in the elderly: dorsal C1/C2 fusion is superior to halo-vest immobilization. *J Trauma*. 2007;63:83-9.
- Bransford RJ, Lee MJ, Reis A. Posterior fixation of the upper cervical spine: contemporary techniques. *JAAOS-J Am Acad of Orthop Surg*. 2011;19:63-71.
- Joaquim AF, Patel AA. Surgical treatment of type II odontoid fractures: anterior odontoid screw fixation or posterior cervical instrumented fusion? *Neurosurg Focus*. 2015;38:E11.
- Magerl F, Seemann P-S. Stable posterior fusion of the atlas and axis by transarticular screw fixation. *Cervical spine I: Springer*; 1987. p. 322-7.
- Cho D-C, Sung J-K. Analysis of risk factors associated with fusion failure after anterior odontoid screw fixation. *Spine*. 2012;37:30-4.
- Posterior fixation of the upper cervical spine: contemporary techniques Baogui L, Juwen C. Fusion rates for odontoid fractures after treatment by anterior odontoid screw versus posterior C1-C2 arthrodesis: a meta-analysis. *Arch Orthop Trauma Surg*. 2019;139:1329-37.
- Grob D, Crisco 3rd J, Panjabi MM, et al. Biomechanical evaluation of four different posterior atlantoaxial fixation techniques. *Spine*. 1992;17:480-90.
- Elgafy H, Pompo F, Vela R, et al. Ipsilateral arcuate foramen and high-riding vertebral artery: implication on C1-C2 instrumentation. *The Spine J*. 2014;14:1351-5.
- Cox TH, Gentle SV, Rees DH. Crowned dens syndrome; a diagnostic thorn. *Rheumatology*. 2020;59:694-.
- Sano M, Yamashita S, Aiba T. The prevalence of calcification around odontoid process and the incidence of crowned dens syndrome in the neurosurgical ward: a single institution's analysis. *Mod rheumatol*. 2018;28:182-7.