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Can The Fracture Line of Type II Odontoid Fractures Come to A Neutral Position After Anterior Odontoid Screw Fixation without A Manipulation?

Turgut KUYTU, Ahmet KARAOGLU, Mesut CELIK, Fatih AYDEMIR, Rifat OZPAR, Yusuf TUZUN

[1]Istinye University School of Medicine, VM Medical Park Hospital Bursa, Department of Neurosurgery, Bursa, Turkey
[2]Sevket Yilmaz Education and Research Hospital, Department of Neurosurgery, Bursa, Turkey
[3]Bursa City Hospital, Department of Neurosurgery, Bursa, Turkey
[4]Uludag University School of Medicine, Department of Radiology, Bursa, Turkey

Corresponding author: Turgut KUYTU ✉ turgutkuytu@hotmail.com

ABSTRACT

AIM: Anterior odontoid screw fixation (AOSF) is known as a safe and effective method in type II odontoid fractures but in displaced cases, it is recommended to turn the displaced fracture line into neutral position with post-anesthesia manipulation and to return to posterior technique in cases where this is not possible. The aim of the study was to examine whether there was an improvement in the displaced fracture line in the follow-up, in which AOSF was performed without manipulation and to determine the "displacement angle range" in which AOSF was possible.

MATERIAL and METHODS: 11 patients with the diagnosis of type II odontoid fracture who underwent AOSF without manipulation were analyzed retrospectively. A control group of 30 cases was formed and odontoid related angle measurements were performed on cervical computed tomographies (CT) of the control group and the patients who were operated.

RESULTS: In 6 of 7 cases in the posterior-displaced group along with all cases in the anterior-displaced group, it was determined that the displacement angles returned to the normal range in the 1st year follow-up. In 1 case having posterior displacement with posterior longitudinal ligament (PLL) damage, it was observed that the displacement angle improved to the normal range significantly, but the displacement continued.

CONCLUSION: AOSF is a minimally invasive, safe and effective method in patients with displaced type II odontoid fracture, which is between the median odontoidobasal angle range of 100°-134°, whose PLL is preserved, and which cannot be manipulated.

KEYWORDS: Displaced odontoid fracture, Manipulation, Median odontoidobasal angle, Anterior screw fixation

INTRODUCTION

Odontoid fractures are common cervical fractures that account for 5%–20% of all cervical spine fractures (10,17). Anderson and D'Alonzo classified odontoid fractures into three groups based on the fracture location in the sagittal plane (13).

The most common Type II odontoid fractures are unstable, and treatment protocols include conservative external immobilization, anterior odontoid screw fixation, posterior cervical screw fixation, and surgical treatment with or without fusion (10,11). Although conservative treatment methods include halo vests and cervical orthoses, these approaches are poorly tolerated in the elderly and in cases of polytrauma (4,14,19,20).

Turgut KUYTU : 0000-0002-0505-3027
Ahmet KARAOGLU : 0000-0002-2992-7980
Mesut CELIK : 0000-0002-4561-1863
Fatih AYDEMIR : 0000-0002-3400-9025
Rıfat OZPAR : 0000-0001-6649-9287
Yusuf TUZUN : 0000-0003-2853-6029

Techniques such as anterior odontoid screw fixation, posterior stabilization techniques, and posterior transarticular screw fixation of C1–C2 have been described in surgical treatment of Type II odontoid fractures (2,3,7,12,18). However, in many reports for Type II odontoid fractures, anterior odontoid screw fixation has been emphasized as a safe and effective treatment method, because it preserves C1–C2 rotational motion and provides high fusion rates and rapid stabilization (1,6,9,15). In addition, it is recommended that displaced Type II odontoid fractures be brought to a neutral position by post-anesthesia manipulation; and in cases where this is not possible, a return to the posterior technique is recommended (8).

Finally, some studies have reported an increase in nonunion rates in cases with anterior or posterior displacement and with increased fracture line distance (13).

This study investigates whether patients undergoing anterior odontoid screw fixation for displaced odontoid fractures without preoperative manipulation showed an improvement in displacement angles during follow-up. In relation to displaced odontoid fractures this study also examines nonunion and the angle range in which anterior odontoid screw fixation is possible.

Preoperative Planning and Operative Technique

In the preoperative evaluation of our cases, neutral lateral, and anteroposterior (AP) cervical planes' X-rays and axial, sagittal, and coronal sectioned cervical CT were preferred. In the evaluation of the condition of the ligaments and spinal canal,magnetic resonance imaging (MRI) was preferred. In all cases, it was ensured that the transverse ligament was intact or not on MRI. All cases were taken to the operating table with maximum care to restrict movement in the supine position with the cervical collar attached and underwent orotracheal intubation using a fiberoptic intubation tube. Sudden and excessive cervical maneuvers were avoided during the intubation phase.

Subsequently, a pillow was placed under the shoulders and a soft roll in the neck space, and the head was slightly extended and fixed with a plaster on both sides (Figure 1). For a clear observation of the odontoid bone on anteroposterior (AP) fluoroscopy, the inside of the mouth was filled with sponges and left open. Preoperative traction application and manipulation under anesthesia were not performed in any of the cases, and a nail head was not used. After an ideal surgical positioning, neutral-lateral and AP images were taken using fluoroscopy, and the location of the broken odontoid bone and the alignment of the cervical axis were examined.

After sterile field cleaning and covering, a standard cervical discectomy opening from the right at the C4–C5 level was performed. After determining the distance with fluoroscopy, the fibrous fascia and longus colli muscles were opened with blunt dissection to reach the C2–C3 disc distance. The distance accuracy again was confirmed using fluoroscopy. The mandible was retracted cranially to provide a clearer viewing angle with a better and continuous view of the surgical area, especially in overweight and short-necked patients. Subsequently, an anterior partial discectomy was performed at C2–C3 distance and the middle superoanterior part of C3 vertebral body was drilled lightly in order to angle when rotating the screw. These preparations make manipulation comfortable to ensure an ideal rotation of the screw. Afterwards, drilling toward the fracture line was performed under fluoroscopy and care was taken to stay in the midline (Figure 2).

Again under fluoroscopy,the Kirschner wire was passed through the fracture line using a hand motor to reach the odontoid apex (Figure 3).

A different Kirschner wire was used to measure the penetration length and determine the appropriate screw size.

A thread cutter created a path for the screw to pass. We used threaded, slotted, 4 mm-self-tapping screws in our cases. During the procedures, we took care that the threaded part of the screw passed the fracture line and that the screw tip reached the odontoid apex.

Figure 1: Patient position; Supine position, the head in neutral midline, fixed with plaster, neck slightly extended, mouth open.

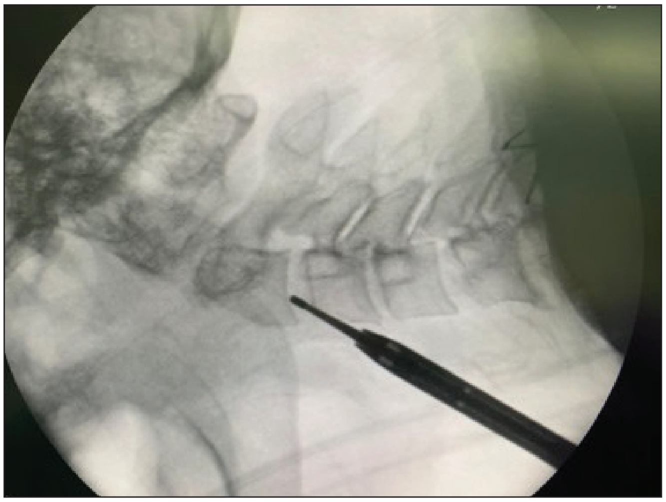

Figure 2: Drilling toward the fracture line, lateral fluoroscopy view.

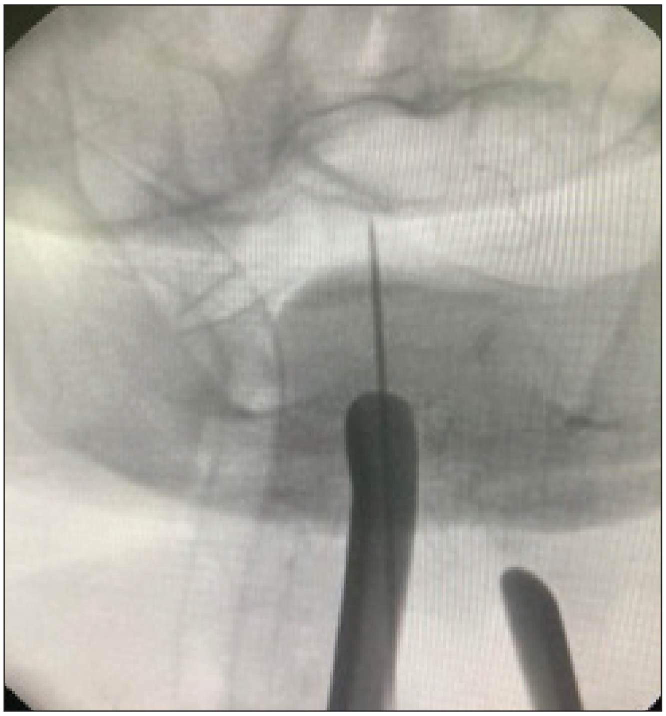

Figure 3: Advancing the Kirschner wire up to the odontoid apex using a hand motor.

MATERIAL and METHODS

The study was started with Yüksek İhtisas Education and Research Hospital ethics committee approval with protocol number 2011-KAEK-25 2021/04-29. Our study retrospectively analyzed 11 cases operated in Neurosurgery Department of Yüksek İhtisas Education and Research Hospital between the years 2017 and 2020.

All cases were Type II odontoid fractures, classified by the Anderson and D'Alonzo system. The age, gender, cause of admission to the hospital, type of trauma, results of neurological examination, duration between trauma and surgery, and follow-up periods of all cases were documented (Table I). Preoperative cervical CT, cervical MRI, and cervical direct radiographs and CTs taken on the 1st postoperative day and 1st year control were collected. Also on the 1st year control hyperflexion-hyperextension dynamic direct radiographs were obtained. Preoperative routinely determined visual analog scale (VAS), Short Form Survey (SF-36) and the Neck Disability Index (NDI) and the same parameters in the 1st year control were documented.

All CT images were evaluated by an independent neuroradiologist blinded to the study results. The preoperative, postoperative 1st day and postoperative 1st year images of 11 patients who underwent odontoid fusion surgery in the patient group were evaluated. Cervical CT images evaluated as normal from 30 patients ages 22-81 in the control group were examined. Angle and distance measurements were taken. In all cases, "median odontoidobasal angle (MOBA)", "lateral odontoid deviation angle (LODA)" and "posterior odontoid angulation angle (POAA)" were measured. In addition, "odontoid displacement distance (ODD)" was evaluated in the patient group and the direction of the dislocation was examined (Figure 4).

MOBA was measured in the patient group. Subsequently, cases were identified with displaced fractures outside the normal range and within the normal range compared to the control group. The cases were divided into three groups: anterior displaced fractures, neutral fractures, and posterior displaced fractures. Later, cervical CTs taken on postoperative 1st day and at the end of the 1st year were

Table I: Gender, Age, Complaint Before the Surgery, Trauma Type, Neurological Examination, Time Between the Trauma and Surgery, and Follow-Up Times of the 11 Cases

Case No	Gender	Age	Complaint	Trauma Type	Neurological Examination	Time between trauma and surgery (day)	Follow-up time (month)
1	M	30	Neck pain	In-vehicle traffic accident	Intact	3	18
2	F	79	Neck pain	Fall down from the same level	Intact	4	32
3	M	23	Neck pain	In-vehicle traffic accident	Intact	2	22
4	M	53	Neck pain	In-vehicle traffic accident	Intact	2	14
5	F	86	Neck pain	Fall down from the same level	Intact	2	16
6	M	59	Neck pain	In-vehicle traffic accident	Intact	2	36
7	M	24	Neck pain	In-vehicle traffic accident	Intact	3	16
8	M	52	Neck pain	In-vehicle traffic accident	Intact	93	19
9	F	70	Neck pain	Fall down from the same level	Intact	3	24
10	M	72	Neck pain	Vehicle crash	Intact	2	15
11	M	48	Neck pain	In-vehicle traffic accident	Intact	3	28

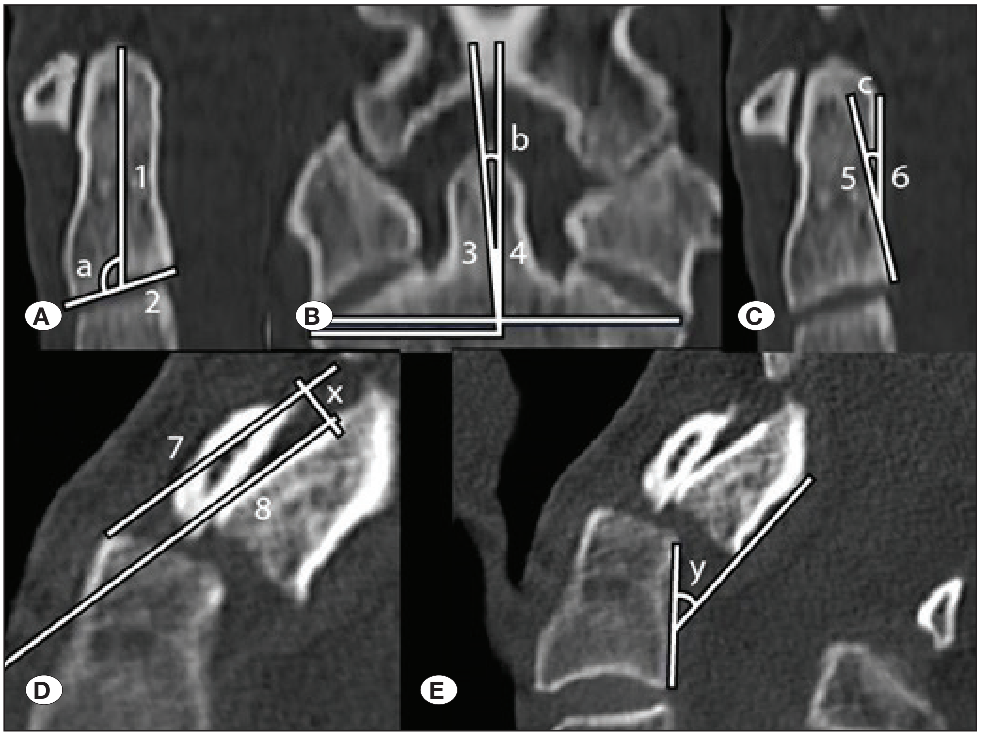

Figure 4: A) Median odontoidobasal angle (a): the obtuse angle between the line parallel to the long axis of the odontoid [1] and the line joining the lower ends of C2 [2]. **B)** Lateral odontoid deviation angle (b): the angle between the line passing to the middle of the widest horizontal diameter of C2 [3] and the line joining the odontoid tip to the middle of the horizontal diameter [4]. **C)** Posterior odontoid angulation angle (c): the acute angle between the line parallel to the posterior margin of the odontoid [5] and the line parallel to the posterior edge of the C2 corpus [6]. **D)** Odontoid displacement distance (x):the distance between the tangent to the ruptured anterior edge of the odontoid [7] and the line parallel to this and passing through the upper anterior edge of the body [8]. **E)** Posterior odontoid angulation in a displaced fractured case (y).

reviewed and the mentioned angles were measured in the sagittal and coronal planes. The displacement angles and the nonunion rate in displacement cases by the 1st year were evaluated for improvement. In cases without improvement in the displacement angles, possible causes were investigated. Finally, the effect of permanent displacement on the clinic was investigated.

RESULTS

Eight of the cases were male and 3 were female. Ages ranged from 23 to 86 (mean 54). Neck pain was the most common complaint. The most common cause of trauma was vehicular traffic accident. All patients presented no neurological deficits. The interval between the trauma and surgery ranged from 2 days to 3 months. Follow-up time ranged from 14-36 months, with a mean of 21.8 months (Table I).

First, the odontoid angles of 30 cases in the normal population were measured, and the normal MOBA range was determined as 104°–111°. Then the MOBAs of the preoperative cervical CT in the sagittal plane were examined in our surgical cases. The cases were divided into 3 groups: anterior displaced fractures, neutral fractures, and posterior displaced fractures. (104–111° neutral; ≥112° posterior displaced; ≤103° anterior displaced). 2 cases were determined to be neutral (107°, 110°), 2 cases anteriorly displaced (100°, 102°), and 7 cases posteriorly displaced fractures (114°–134°) (Table II).

At the preoperative and postoperative 1st day, 1° and 2° of difference was obtained at the MOBAs of the 2 patients with neutral fracture. There was no difference in the angle measurements of the 1st case on the postoperative 1st and 1st year (Table II). The 2nd neutral fracture case was revised due to the development of disphagia on the postoperative 3rd day. The MOBA in the sagittal plane of the cervical CT taken before revision was measured as 138°. The angle measurement performed on the 1st day after the revision was observed as 128° but the 1st year angle measurement was observed in neutral range (110°), (Table II). 1st year control cervical CTs of 2 patients with anterior displaced fractures showed that the MOBAs returned to the normal range (Table II).

Angles returned to the normal range in 6 of 7 patients with posterior displacement. In 1 case the preoperative angle progressed toward the normal level (from 133° to 116°) but did not reach the normal range (Table II).

Other parameters related to this case showed that the posterior longitudinal ligament (PLL) integrity was almost completely impaired on preoperative cervical MRI (Table II). This case was a 79-year-old female patient with chronic diseases such as diabetes mellitus and hypertension. Therefore, an anterior odontoid screw fixation was performed, with the thought that she might not be able to handle a long-term and bleeding surgery. However, the necessity of posterior stabilization in cases with PLL damage has been emphasized in the literature (13). We also accept that posterior cervical screw fixation may be more appropriate in this case.

Odontoid deviation to the right was observed in 4 cases (2°-9°), while 1 case showed 3° of deviation to the left (Table II).

Fusion was observed in all patients, including the patient whose displacement did not reach the normal range (Table II).

No instability was observed in dynamic cervical radiographs in any of the cases at the 1st year (Table II).

Table II: Median odontoidobasal angle (MOBA), lateral odontoid deviation angle (LODA), posterior odontoid angulation angle (POAA), odontoid displacement distance (ODD), dislocation direction (DOD), posterior longitudinal ligament status (PLL), presence of instability in 1st year dynamic radiographs and presence of fusion in 1st year cervical CT (Figure 4)

Case No		MOBA (°)	LODA (°)	POAA (°)	ODD (mm)	DOD	PLL	Instability	Fusion
1	Preop	112	9 (R)	11	5	P	intact	-	
	Postop 1st day	112	8	10	0,9	P			
	Postop 1st year	108	8	2	0	N			+
2	Preop	133	0	30	3	P	damaged	-	
	Postop 1st day	129	0	26	1.5	P			
	Postop 1st year	116	0	12	0	P			+
3	Preop	107	3 (L)	3	0	N	intact	-	
	Postop 1st day	106	3	2	0	N			
	Postop 1st year	106	3	2	0	N			+
4	Preop	120	4 (R)	22	1.3	P	intact	-	
	Postop 1st day	118	4	20	0.8	P			
	Postop 1st year	108	4	4	0	N			+
5	Preop	115	0	12	1.9	P	intact	-	
	Postop 1st day	114	0	12	1.5	P			
	Postop 1st year	106	0	2	0	N			+
6	Preop	120	7 (R)	7	4.5	P	intact	-	
	Postop 1st day	116	7	5	2	P			
	Postop 1st year	107	7	1	0	N			+
7	Preop	110	2 (R)	4	3	N	intact	-	
	Postop 1st day	108	2	4	2	N			
	Postop 3rd day	138	2	29	5	P			
	Postop 1st day after revision	128	2	28	4	P			
	Postop 1st year after revision	110	2	5	0	N			+
8	Preop	100	2 (L)	4	3	A	intact	-	
	Postop 1st day	101	2	5	1	A			
	Postop 1st year	106	2	1	0	N			+
9	Preop	102	3 (R)	7	4.1	A	intact	-	
	Postop 1st day	102	3	7	1.2	A			
	Postop 1st year	108	3	4	0	N			+
10	Preop	114	4 (R)	25	1.7	P	intact	-	
	Postop 1st day	112	4	22	0	P			
	Postop 1st year	107	4	8	0	N			+
11	Preop	134	0	33	0.7	P	intact	-	
	Postop 1st day	129	0	28	0.4	P			
	Postop 1st year	111	0	3	0	N			+

***N:** Neutral, **A:** Anterior, **P:** Posterior.*

Complications

In 1 patient with neutral fracture, dysphagia developed on the postoperative 3rd day. Cervical CT revealed that the screw was displaced posteriorly, so the patient was re-operated for revision. The displaced screw was placed again using an anterior approach and subsequently the dysphagia complaint improved. Fusion was observed in the 1st year control cervical CT and the MOBA was observed in the neutral range (Figure 5). It was thought that 1st operation failed because the screw could not hold the fractured odontoid tightly enough and the screw angle could not be fixed properly because the screw was not completely inside the cortex (Figure 5).

No other complications were observed.

Preoperative and postoperative 1st year VAS, SF-36 and NDI scores of the cases showed that pain was relieved in all cases, quality of life was high, and there was no restriction in neck rotation (Table III). In the patient whose displacement did not improve exactly, there was no decrease in the quality of life compared to the patients who were clinically neutral or whose displacement improved (Table III). A statistical improvement was observed within the preoperative and postoperative clinical parameters (Table IV).

Other than this, no complications were observed.

DISCUSSION

Due to the development of surgical instruments and the less traumatic nature of the technique, anterior cervical odontoid screw fixation has become increasingly common.It has many advantages over posterior cervical interventions: normal C1–C2 anatomy and rotation can be preserved, no bone graftis required, patients can tolerate postoperative pain more easily with the preservation of the posterior paravertebral muscle structure, perioperative bleeding is less, and postoperative immobilization is not required (13).

This method is contraindicated in the presence of C1–C2 instability, transverse ligament damage, fragmented fractures

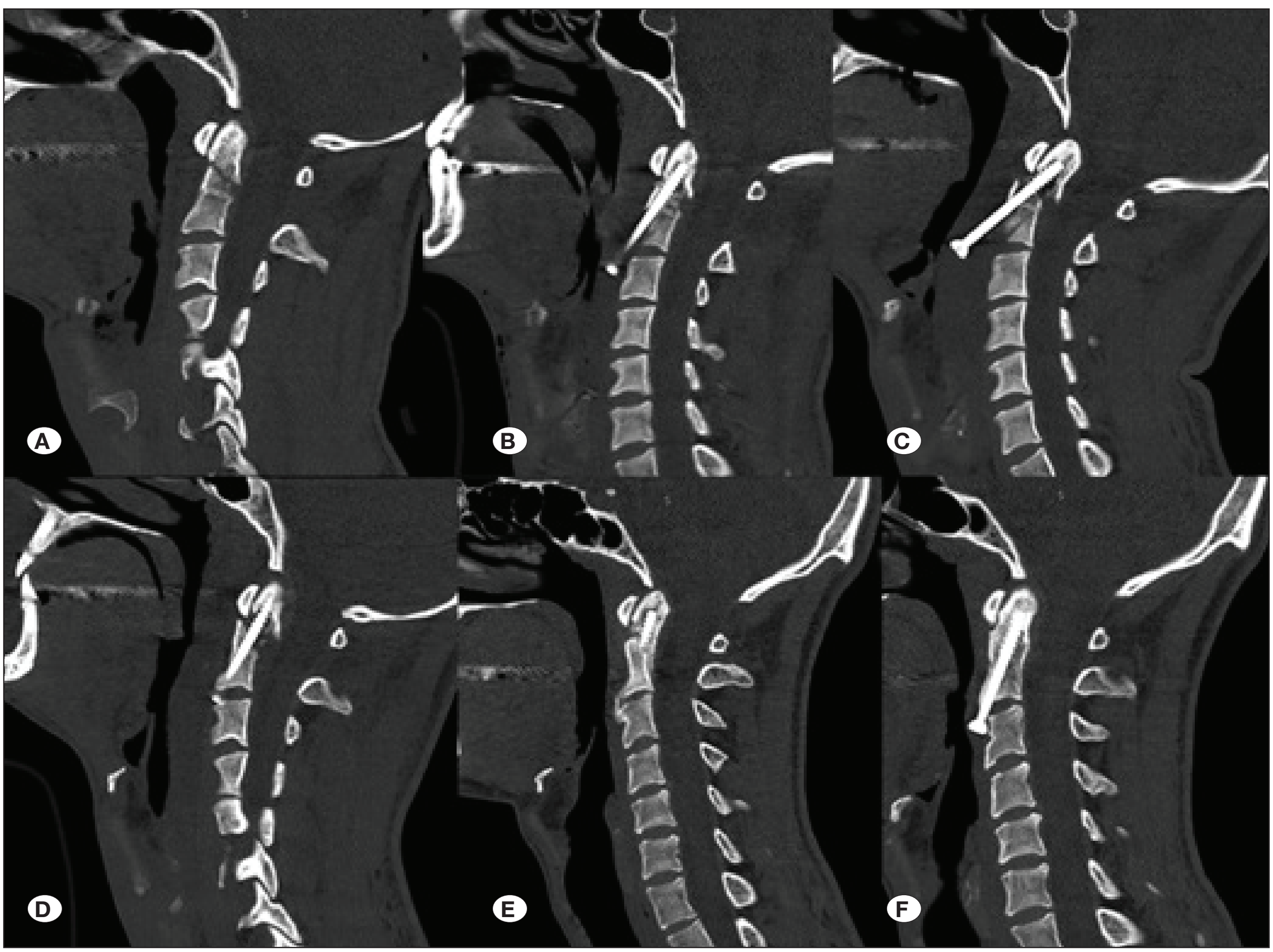

Figure 5: Sagittal plane cervical CT images of the patient who underwent revision surgery: **A)** Preoperative, **B)** postoperative 1st day after the 1st operation, **C)** postoperative 3rd day after the 1st operation (after the development of dysphagia), **D)** postoperative 1st day after revision surgery, **E)** postoperative 3rd month after revision surgery, **F)** postoperative 1st year after revision surgery.

Table III: Clinical Outcomes (Preoperative/Postoperative 1st year)

Case No	VAS (Preop/Postop)	NDI (Preop/Postop)	SF-36 (Preop/Postop)	Limitation in NeckRotation
1	8/2	38/3	20/85	-
2	10/3	41/5	15/80	-
3	6/1	32/3	25/85	-
4	9/3	37/7	20/80	-
5	8/3	36/5	20/80	-
6	9/2	40/4	15/85	-
7	7/1	38/3	25/95	-
8	8/3	35/6	20/75	-
9	7/2	34/6	25/80	-
10	7/2	32/5	25/85	-
11	8/3	27/5	20/80	-

Table IV: Statistical Analysis of Clinical Outcomes; Mean Values for Pre-Postoperative Values of VAS, NDI and SF-36 Parameters were Obtained. Paired Samples t Test was Used to Calculate the Difference and p-values

Parameter	Preoperative	Postoperative	Difference	p
VAS (neck pain)	7.91	2.27	23.11	<0.001
NDI	35.45	4.73	23.02	<0.001
SF-36	20.91	82.73	-39.93	<0.001

of C2 corpus and pathological fractures. Osteoporosis is among the relative contraindications. Although short, kyphotic neck structure and barrel chest do not constitute contraindications, they make the surgery more difficult (13).

The group in which the technique was applied most easily and with high success was the neutral group, followed by posterior displacement group (2). However, screw rotation is relatively difficult in anterior displaced cases (2).

In displaced cases, manipulation with fluoroscopy is recommended before the surgical procedure under general anesthesia (8). In addition, some studies suggest switching to the posterior approach in displaced cases that cannot be brought to the neutral position despite manipulation (5,8,13,16). In the follow-up of 129 patients with anterior displaced odontoid fractures, Apfelbaum et al. reported significantly higher nonunion rates compared to other forms (2). Similarly, Dantas et al. reported 94% fusion in posteriorly displaced and neutral fractures, stating that the fusion rate was much lower in anterior displaced cases recommending against anterior cervical odontoid screw fixation in these cases (5). Another report published on the treatment algorithm showed that the inability to reduce the displaced fracture preoperatively requires a return to posterior stabilization (8).

In contrast to these studies, there was no nonunion complication in our study. Fusion was observed in the first-year controls of all our cases.

Unlike other reports in the literature, we did not perform post-anesthesia manipulation in any of our cases due to the risk of cord injury.

In the follow-up of the cases in which we performed anterior cervical odontoid screw fixation with a displaced angle without manipulation and neutralization of the fracture angle in anterior or posterior displaced cases, we observed that the odontoid angles reached the normal range within the 1st year in all but one case. In the one case that did not improve, we found that the fracture odontoid angle progressed toward the neutral range but did not reach the normal range (Table II). In this single case, there was no significant difference in extent of pain and quality of life compared to the clinically neutral or displacement-corrected group (Table III).

Two of our cases had anterior displacement and seven had posterior displacement. The other two cases were in the neutral group (Table II).

In preoperative and postoperative 1st day cervical CT scans, there was nosignificant difference between the MOBA and POAAs. However, in six of the seven patients with posterior displacement, we observed that the displacement angles increased and reached the neutral normal range in the 1styear control cervical CTs. In one case, we saw that although there was a significant improvement in the displacement angle, it did not reach the normal range (Table II).

In both cases with anterior displacement there was no significant difference between the MOBA and POAAs in the cervical CTs of the preoperative and postoperative 1st days. We found that the displacement angles increased and reached the normal range in the 1st year control cervical CTs (Table II).

In both cases in the neutral group, no evident difference was observed between the MOBA and POAAs in the preoperative and postoperative 1st days cervical CTs and between the odontoid angles in the 1st year control cervical CTs (Table II).

In the case that was displaced posteriorly and did not reach the normal range despite significant improvement in the displacement angle at the 1st year follow-up, we observed that the integrity of the PLL was disrupted in cervical MRI. In other cases, however, PLL was intact (Table II).

Surgical treatment, regardless of age, seems to be the standard in the surgical treatment of Type II odontoid fractures, which are considered unstable. Among the surgical techniques, anterior odontoid screw fixation seems superior due to C1–C2 rotational movement, high fusion rates, fast stabilization, no requirement of bone graft, enhanced pain tolerance in the postoperative period due to the preservation of posterior paravertebral muscle structure, diminished bleeding in the preoperative period and no requirement for immobilization after the intervention. For cases that cannot be reduced among displaced cases, abandoning the anterior approach results in the loss of all advantages of the anterior approach. Our study shows that in cases with displacement angles in the range of 100°–134° (MOBA) and intact PLL, even if reduction cannot be achieved by manipulation, it would be more advantageous to apply the anterior intervention regardless of age.

CONCLUSION

Anterior cervical odontoid screw fixation is a minimally invasive, safe, and effective method in isolated type II displaced odontoid fractures that cannot be reduced by preoperative manipulation, and in cases with anterior and posterior displacement between 100°–134° (MOBA) and preserved PLL integrity. In the follow-up of these cases, the displaced fracture line returns to the neutral position.

Limitation of the Study

In our series of 11 cases, we determined a suitable angle range for anterior intervention in displaced cases. In the future, this angle range will perhaps expand with new multicenter studies involving more cases.

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AUTHORSHIP CONTRIBUTION

Study conception and design: TK, AK

Data collection: AK, MC

Analysis and interpretation of results: TK, AK, RO

Draft manuscript preparation: FA

Critical revision of the article: TK, YT

All authors (TK, AK, MC, FA, RO, YT) reviewed the results and approved the final version of the manuscript.

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