Type II odontoid fractures: Complication, mortality, and outcome after posterior C1-C2 fixation and fusion, single institute experience

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Abstract

Background The aim of the present study was to evaluate long term C1-C2 fusion rates and functional outcomes in patients with type II odontoid fractures treated with posterior fixation with polyaxial C1 lateral mass and C2 pars screws.

Methods A total of 32 patients were retrospectively evaluated. Study parameters included Japanese Orthopaedic Association (JOA) score and visual analog scale score for neck pain. All patients had computerized tomography (CT) scans preoperatively and at six months postoperatively; X-rays preoperatively and at three months and 12 months after operation

Results Among the etiological factors, first (59.4%) fall from high and second (40.6%) traffic accidents have been observed. The duration of follow-up was 28.4 ± 8.5 months. A total of 25 patients had improvement on mean VAS score. A total of 12 patients had improvement at modified JOA score. No vascular injury occurred in our series. One patient (3.1%) developed hospital pneumonia, and the patient died at postoperative 6 th week. One patient (3.1%) had nonunion, but no neurological deficit was observed, and revision surgery was not needed 30 patients (93.8%) had fracture healing and fusion after posterior C1-C2 fixation.

Conclusions In our opinion, posterior C1-C2 fixation and fusion is the treatment of choice in type II odontoid fractures with good fusion results. We achieved good results and low complication and mortality rates.

Background

Odontoid fractures constitute approximately 18% of all cervical fractures [1]. Although the incidence of neurological damage due to odontoid fractures is considered low, approximately 25–40% of the patients are lost at the site of the event [1]. The mechanism of odontoid fractures is usually responsible for hyperflexion or hyperextension injuries of the cervical spine [2]. The classification used for odontoid fractures is defined by Grauer et al. [3]. With this classification, odontoid fractures are divided into 3 basic types of fractures: Type I fractures are avulsion fractures over the transverse ligament, and at the top of the odontoid; Type II fractures are vertebral body- odontoid junction fractures; Type III fractures describe odontoid fractures involving the anterior proximal part of the vertebral body. In order to decrease the number of debates concerning the treatment modalities in Type II odontoid fractures in 2005, Gauer divided type II odontoid fractures into three subtypes as Type IIA Type IIB and Type IIC [4].

Treatment of odontoid fractures varies according to the type of fracture. Since Type I and III fractures can be treated with cervical collar applied for most 6–8 weeks or external immobilization methods such as a halo vest [5]. Type II odontoid fracture usually has lower fusion rates and is less stable compared to Type I and Type III. The treatment of these fractures is not well defined. External immobilization with cervical collar and halo results in unreliable and inconsistent results. New developments in cervical fixation methods in defining and classifying odontoid fractures cause controversies about the treatment of Type II

odontoid fractures. Although wiring methods as C1 - C2 posterior fusion techniques are commonly used surgical methods in odontoid fractures, the rotation of the neck with this technique decreases by about 50% [6]. For posterior C1 - C2 fusion techniques, wiring methods, posterior stabilization using screws applied into posterior C1 isthmus, and posterior fixation with polyaxial C1 lateral mass and C2 pars screws as described by Harms and Melcher can be used [7].

This study aims to evaluate long term C1-C2 fusion rates and functional outcomes in patients with high velocity type II odontoid fractures treated with posterior fixation with polyaxial C1 lateral mass and C2 pars screws.

Methods

Study Design:

The study has been conducted by the principles of the Helsinki Declaration and approved by the local Institutional Review Board. The need for consent was waived by the institutional IRB as the study was retrospective. A total of 32 patients with high velocity type II odontoid fractures treated by C1-C2 posterior fixation and fusion with Harm's technique between 2010 and 2017 were retrospectively evaluated.

Low velocity fractures such as elderly standing level fall odontoid fractures were excluded from the study.

Surgical Procedure:

Computerized tomography (CT) or magnetic resonance (MR) angiography was performed in all cases to predict which patients can safely undergo placement of a transarticular screw. All patients received awake fiberoptic intubation, and the surgical position was prone, taking care to avoid excessive pressure on the eyes. The incisions were at midline. Infiltration of the skin and subcutaneous tissue with a dilute 1:500000 epinephrine solution was helpful to provide hemostasis. Using electrocautery and elevators, we exposed the posterior elements subperiosteally and inserted self-retaining retractors. The inferior surface of the posterior arch of C1 was exposed towards the lateral edges. C1 articular mass screw insertion requires the direct posterior visualization of C1–C2 articular joint. Once the C1–C2 joint margins were defined by two Freers or Penfields placed on either side, a unicortical starting hole was created on the inferior border of C1 posterior arch using a high speed burr. With the aid of the two dissectors as a guide, drill was then directed anteriorly within the C1 lateral mass. Bicortical screw placement could be performed under fluoroscopic guidance with caution, although overall this was reasonably safe as there is some safety margin anteriorly prior to important structures. The screw preferred was partially threaded, to avoid irritation of the C2 root. Careful exposure of the postero-medial border of the C2 pedicle facilitated the drilling and screw placement by the direct visualization of the pedicle. The drilling could be performed safely and start from the lateral part of the articular mass of C2. The pedicle diameter should be measured preoperatively on the CT scan images and the screw diameter was 0.5 mm less than the pedicle. Postoperatively, all patients were followed with Philadelphia collar for 12 weeks.

Outcome Parameters:

All fractures were classified according to Grauer classification system [3].

Study parameters included pre- and postoperative neurologic status evaluated by Japanese Orthopaedic Association (JOA) score and visual analog scale score for neck pain [8].

All patients had CT scans preoperatively and at six months postoperatively; X-rays preoperatively and at three months and 12 months after operation (Fig. 1, 2).

Results

Thirty-two patients met the eligibility criteria for the study. Of the 32 patients (14 males, 18 females) whose charts were reviewed, the mean age was 50.14 ± 13.12 (range, 28 to 78) years. The duration of follow-up was 28.4 ± 8.5 months. Among the etiological factors, first (59.4%) fall from high and second (40.6%) traffic accidents have been observed (Table 1).

Table 1
General characteristics of patients.

	Sex	Injury Type	Preop JOA	Postop JOA	Preop VAS	Postop VAS	6th mo fusion	12th mo fusion	FU
1	M	Accident	9	14	4	3	+	+	36
2	F	Fall	15	15	5	2	-	+	14
3	M	Fall	18	18	7	2	+	+	42
4	F	Accident	9	13	6	3	+	+	28
5	F	Fall	17	18	3	5	-	+	21
6	F	Fall	18	18	4	0	+	+	31
7	M	Accident	16	12	5	1	+	+	35
8	M	Fall	17	13	8	5	-	+	39
9	F	Fall	16	16	5	2	+	+	41
10	M	Fall	18	18	4	1	+	+	42
11	F	Accident	18	18	5	8	-	+	27
12	M	Fall	18	18	4	2	+	+	25
13	M	Fall	16	16	4	1	+	+	31
14	F	Fall	12	15	8	3	+	+	23
15	M	Accident	18	18	3	3	+	+	26
16	F	Fall	18	13	5	2	+	+	24
17	F	Fall	18	12	4	8	-	-	2
18	F	Fall	16	16	3	1	+	+	29
19	M	Fall	14	16	3	1	+	+	25
20	F	Accident	18	18	4	1	+	+	22
21	F	Accident	18	18	5	2	+	+	24
22	M	Accident	18	18	4	3	+	+	27
23	M	Fall	18	18	4	2	-	+	27
24	F	Accident	14	17	5	2	+	+	33

FU: Follow up; F: Female; M: Male; JOA: Japanese Orthopedic Association; VAS: visual analog scale.

	Sex	Injury Type	Preop JOA	Postop JOA	Preop VAS	Postop VAS	6th mo fusion	12th mo fusion	FU
25	F	Fall	18	18	6	2	+	+	36
26	M	Fall	18	18	7	1	+	+	32
27	F	Fall	18	18	8	3	+	+	34
28	M	Accident	8	8	7	2	+	+	33
29	F	Accident	9	13	6	2	-	+	38
30	F	Fall	9	9	6	3	-	-	18
31	M	Accident	5	11	5	2	+	+	22
32	F	Accident	15	13	6	1	+	+	23
FU: Follow up; F: Female; M: Male; JOA: Japanese Orthopedic Association; VAS: visual analog scale.									

VAS score for neck pain was 5.09 ± 1.48 preoperatively, and 2.75 ± 1.77 postoperatively. A total of 25 patients had improvement on mean VAS score, and three patients had the same VAS score, and three patients had worsened VAS score in the postoperative period.

Modified JOA score was 15.2 ± 3.8 (range, 5 to 18) preoperatively, and 15.5 ± 2.90 at 12 months postoperatively. A total of 12 patients had improvement at modified JOA score, and four patients had worsened modified JOA score in the postoperative period. The mean JOA score was 13.4 ± 4.77 in patients with a traffic accident in etiology, and this value was 16.4 ± 2.45 in patients with a fall from a height ($p > 0.05$).

No vascular injury occurred in our series. One patient (3.1%) had surgical wound infection, one patient (3.1%) had surgical wound site hematoma, 1 patient (3.1%) had pulmonary embolism, and 1 patient (3.1%) had a cerebrovascular event, all patients were treated. One patient (3.1%) developed hospital pneumonia, and the patient died at postoperative 6th week. One patient (3.1%) had nonunion, but no neurological deficit was observed, and revision surgery was not needed. 30 patients (93.8%) had fracture healing and fusion after posterior C1-C2 fixation.

Discussion

Odontoid fractures constitute 15–20% of all cervical spine fractures and are formed by a combination of flexion, axial loading or extension, and rotational forces. Type II fractures constitute 60% of odontoid fractures [9]. Odontoid fractures seen in young age are frequently observed in males, but there is no gender difference in the prevalence of odontoid fractures seen in old age [9]. The most common cause of odontoid fracture is trauma [10]. All of our cases presented with a history of a traffic accident or fall from height.

Post-traumatic neck pain in odontoid fractures can often be the only complaint. Non-displaced fractures can be overlooked in direct radiography, axial CT and magnetic resonance images. the best imaging modality is CT reconstructions [10]. In the present study, all patients had preoperative CT with 3-dimensional reconstruction.

It is reported that there are many factors affecting the percentage of fusion. Dunn and Seljeskog stated that posterior dislocation, being 64 years and over, and having severe neurological deficits were negative factors in the achievement of the union [11]. In a series of 45 patients, Apuzzo et al. found the rate of nonunion as 33% in patients over 40 years of age and in patients having dislocation over 4 mm. [12]. The degree of dislocation of dens is the most frequently affecting factor in the percentage of the union in external immobilization. In their series of 107 cases, Hadley et al. reported nonunion rates as 67, and 9% in dislocations of more and less than 6 mm, respectively [13]. In the present study, ten patients had odontoid displacement more than 5 mm (mean 6.2 mm), and 12 patients had posterior dens displacement.

In the present study, 96% fusion rates were achieved by posterior C1-C2 fixation. In literature, nearly 90–100% fusion rates were achieved with lower complication and mortality rates [14, 15]. Complication rates were similar to literature. During the application of C1 and C2 screwing techniques, many complications involving the vascular and neural anatomical structures contained in this region should be avoided. Therefore, many researchers strive to develop different techniques [16]. Abumi et al. reported that the C2 pars screwing technique was very safe and screw malposition decreased to 7% in proportion to developing technology and experience [17]. In our study, nonunion was observed in only one (3.1%) patient, but revision surgery was not needed due to the absence of any neurological deficit. In the initial evaluation and follow-up of patients with cervical trauma, various authors evaluated the clinical and neurological recovery with different parameters such as ASIA, Frankel, JOA score or subjective satisfaction [18, 19]. Song et al. reported a 78.3% improvement in the JAO score with the surgical treatment in patients with unstable cervical injury [20]. We used the JOA scores in our study.

In their study, Jing et al. detected their complication rate as 6.67% (2 patients). In one patient, while inserting a screw into the C1 lateral mass, intraoperative vertebral artery damage occurred in one patient, and screw loosening happened in the follow-up of another patient [21]. In their study, Zheng et al. reported venous plexus injury in 6 patients (7%), C2 root injury in 4 patients (4.7%), urinary tract infection in 1 patient and wound infection in 1 patient [22]. Kizmazoglu et al. reported peroperative dura mater damage in 2 (18.2%), postoperative wound discharge in 4 patients (36.4%), while one patient died due to postoperative cardiac arrest [23]. In our study, surgical wound infection, hematoma, pulmonary embolism, and cerebrovascular events developed in individual patients and treatment was provided for all patients. One patient developed nosocomial pneumonia, and the patient died at postoperative sixth week.

Although the VAS is an incomplete representation of the pain experience and cannot fully reflect the multidimensional aspects of pain, it remains the most widely used metrics of pain after surgery. However,

VAS would not always reflect the sense of pain. That may be the reason of which three patients had worse VAS scores at final follow up compared the pre-surgery VAS score.

The main limitations of the present study were the retrospective design and the relatively small size of our series. Also, some details of history and factors that may influence the outcome may not be completely documented. Finally, surgeries were performed by different surgeons. Due to these restrictions, associations should be interpreted with caution.

Conclusions

In our opinion, posterior C1-C2 fixation and fusion is the treatment of choice in type II odontoid fractures with good fusion results. We achieved good results and low complication and mortality rates.

Abbreviations

CT

Computerized tomography

MR

Magnetic resonance

JOA

Japanese Orthopaedic Association

Declarations

Ethics approval and consent to participate: The approval of the Gaziantep University Institutional Review Board was obtained prior to the study. Necessary permission was obtained in using the hospital records of the patients. The need for consent was waived by the institutional IRB as the study was retrospective.

Consent for publication: Not applicable.

Availability of data and material: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: All authors have read and approved the manuscript. I.G. analyzed and interpreted the data, was a major contributor in writing the manuscript, read and approved the final manuscript. M.G. analyzed and interpreted the data, was a major contributor in writing the manuscript, read and approved the final manuscript. C.S. analyzed and interpreted the data, was a major contributor in writing the manuscript, read and approved the final manuscript. A.S. analyzed and interpreted the data, was a major contributor in writing the manuscript, read and approved the final manuscript. A.M.G. analyzed and

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Figures

Figure 1

Type II odontoid fractures managed by C1-C2 posterior fixation. Computed tomography scan showing A. Fractures with posterior displacement, B. C1 lateral mass screw postoperatively, C. C2 pedicle screw.

Figure 2

Computed tomography scan showing A. Anterior displacement of Type II odontoid fracture, B. C2 pedicle screw, C. C1 lateral mass and C2 pedicle screws.