ODONTOID FRACTURES : REVIEW

Güntekin GÜNER* Ü. Sefa MÜEZZİNOĞLU*

ABSTRACT:

After Corner has reported the first six patients with fractures of odontoid and atlas several articles have been published concerning this fracture. They were thought to be rare entities but the recent reports show that the incidence of the odontoid fractures constitute 9-18% of the all cervical fractures. High quality radiographs and tomograms have made the diagnosis of odontoid fractures easier and more accurate. The current major classification, diagnosis and treatment views on acute injuries of the dens among adult patients is discussed in this brief review.

Key Words: *Dens, odontoid, fractures, cervical fractures.*

After Corner has reported the first six patients with fractures of odontoid and atlas several articles have been published concerning this fracture. They were thought to be rare entities but the recent reports show that the incidence of the odontoid fractures constitute 9-18% of the all cervical fractures (4, 5, 6, 7, 10, 11, 15, 17, 18, 19, 22, 25). The number of patients in the given series has risen because of the increase in population and the greater susceptibility to injury in high speed motor vehicle accidents in recent years. Also in the last two decades high quality radiographs and tomograms have made the diagnosis of odontoid fractures easier and more accurate. But there has been little agreement as to the best method of treatment, the prognosis or the incidence of non-union. The current major classification, diagnosis and treatment views on acute injuries of the dens among adult patients is discussed in this brief review.

Cervicocranial anatomy and vascular supply.

Structurally the first and second cervical vertebrae show anatomic properties different from the remaining five cervical vertebrae. Atlas has a bony ring structure consisting of anterior and posterior arches connected with two lateral masses. Since atlas has no body, lateral masses called articular pillars are the main weight bearing structures of the C I. Axis has an odontoid process known as dens projecting cephalad from the anterior surface of the body. The osseous ligamentous and neural structures are shown in (Fig. 1). Since a unique relationship exists between these structures, this region should be considered as a functional unit in any discussion of odontoid pathology. The space between the odontoid process and the anterior arch of the atlas called the atlantal-dens interval (A.D.I.) should not exceed 3 mm. in adults in any position of the head. Secondary to greater ligamentous laxity in children under 8 years old, A.D.I. is reported as much as 4 mm. The atlanto-occipital articulation has flexion, extension, but minimal rotation, whereas, atlanto-axial joint permits rotation accounting for nearly 50% of movement in the cervical spine.

One of the most important measurements is the amount of the space available for spinal cord (S.A.C) defined as the distance from the posterior edge of the odontoid to the nearest posterior structures the foramen magnum or posterior ring of atlas. This is particularly helpful when evaluating the patient with nonunion of odontoid or os odentoideum. In both conditions, S.A.C may be considerably reduced during extension or flexion of the head whereas A.D.I is in normal range. Steel divided first the cervical vertebra into three parts; one third spinal cord, one third odontoid, one third "space" that is called the rule of thirds. The one third space is the safe zone in which displacement can occur without any neurologic disturbance and is nearly equal to transverse diameter of the odontoid (20). The transverse, the accessory, and the apical ligament originate from atlas, axis and occiput respectively. Any force applied to the cervicocranial region will be transmitted to the fracture side which would have a remarkable effect on fracture healing of the odontoid. Dens has its own blood supply by a pair of anterior and posterior arteries which arise from the vertebral arteries (3). There is an intraosseous supply after 8 years of age and finally alar and apical ligaments have some contributions (Fig. 2). Most of the investigators believe that there is a direct correlation between degree of displacement and the impairment in blood supply of the odontoid.

* İnönü Üniversitesi, Tıp Fakültesi, Ortopedi ve Travmatoloji A.B.D. Malatya

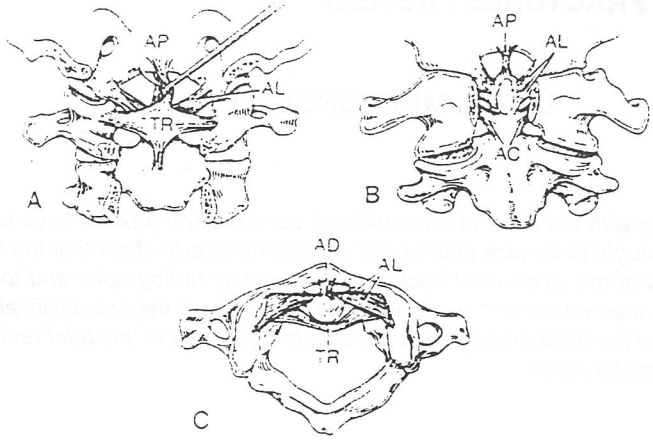

Fig. 1. Cervicocranial ligaments:
A) Posterior view B) Anterior view C) Axial view
(AP) = Apical Lig. (TR) = Transverse Lig. (AL) = Alar Lig.

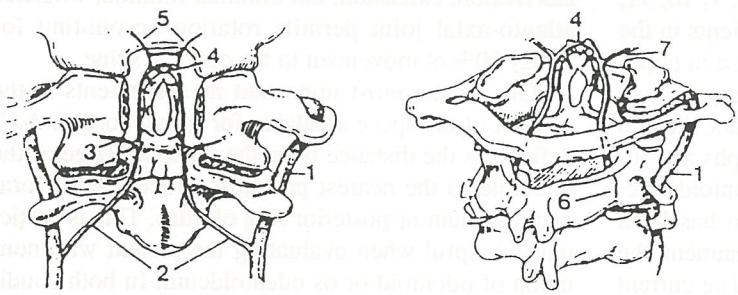

Fig. 2. Vascular supply of the odontoid:
1) Vertebral arteries 2) Anterior ascending arteries
3) Cleft perforators 4) Apical arcade
5&7) Horizontal arteries 6) Posterior ascending arteries

Etiology.

Most acute fractures of the dense are due to major forces such as occurring in motor vehicle accidents and falls particularly those associated with major trauma including the mandible, other cervical vertebrae and skull. Alcohol intoxication is commonly described in these cases. In children less violent injuries may cause dense fractures and is relatively more common than is beleived. It is also possible that many cervical spine abnormalities diagnosed as congenital anomalies such as os odetoideum are actually non-unions secondary to childhood injuries. Injury to the odontoid process of the axis results from forces arriving at the head and neck from varying directions. Most of the authors found that it was very difficult or impossible to reproduce this fracture in a cadaver specimen. It seems reasonable that flexion injury causes anteriorly displaced odontoid fracture conversely extension injury causes posterior displacement (24).

The true incidence of fractures of the dense is not known and there are some rational estimations of its relative incidence. Fractures of the odontoid process are not uncommon and account for 10-14% of all fractures of the cervical spine. Ryan M.D. and Henderson reviewed 717 fractures and fracture dislocations of the cervical spine that occurred in 657 patients and stressed that patients aged 70 years and above complaining of neck pain after trauma should be suspected of having an odontoid fracture unless otherwise proven (20).

In a retrospective analysis of 165 patients admitted to Hermann hospital with acute injuries of the axis vertebra, Burke and Harris reported the percntage of dense fractures as 41%, while Hadley found this percentage as 60% among 229 axis fracture cases (9, 18).

Diagnosis.

It is not uncommon to misdiagnose dens fractures as the patients are commonly unconcious or intoxicated, or have associated head trauma. Dunn et al. reported that they had a delay more than 24 hours in diagnosis of 16 patients after the initial injury, among 129 odontoid fractures (12). The patients with odontoid injury have immediate severe pain in the upper part of the neck or back of the head that restricts them changing their position from supine to sitting without supporting their heads. Spasm of the neck muscles and severe limitation of the motion are the common physical findings with or without neural deficit symptoms. Neural loss may occur at once from th initial injury or may be delayed some weeks or years occurring secondary to late or gradual subluxation and it may

vary from high tetraplegia to minimum motor and sensory weakness. Patients with posterior displacement are more likely to suffer any degree of neurologic loss.

Since moving the head and neck is potentially dangerous, initially antero-posterior open mouth and lateral radiographs are made under gentle traction. If displacement and/or angulation is present, most of the odontoid fractures are demonstrated in this way. In case of great suspicion of odontoid fracture and negative findings in plain X-Ray, a conventional antero posterior and lateral tomogram must be carried out. Ehara at al. reviewed 50 dens fractures and reported that 3 patient's plain X-Rays were negative and fractures were seen only on conventional tomogram (13).

Classification.

Several classifications of these fractures have been proposed. Schatzker et al. divided dens fractures into high and low at the accessory ligament and did not include the fracture entering into the centrum of axis (27). This classification did not seem to be related to the outcome. The most accepted classification is that reported by Anderson and d'Alanzo (Fig. 3) (5). In their classification type I is thought to be an avulsion fracture caused by pulling force of an alar ligament on a piece of the dense. It is very rare and has little clinical significance. Type II fractures are the most common fractures in all series. They occur through the base of the odontoid and do not extend into the body of the axis. Type III fracture goes deep into the body or centrum of the axis. Table 1 shows the distribution of the fracture type in different series.

Table 1. Distribution of the fracture type in different series.

	Type I	Type II	Type III
Clark C.R. and et al.	0	106	50
Fujii E. and et al.	2	31	19
Dunn M.E. and et al.	0	106	22
Ryan M.D. and et al.	3	85	24
Hadley M.N. and et al.	0	87	49
TOTAL	5	415	164

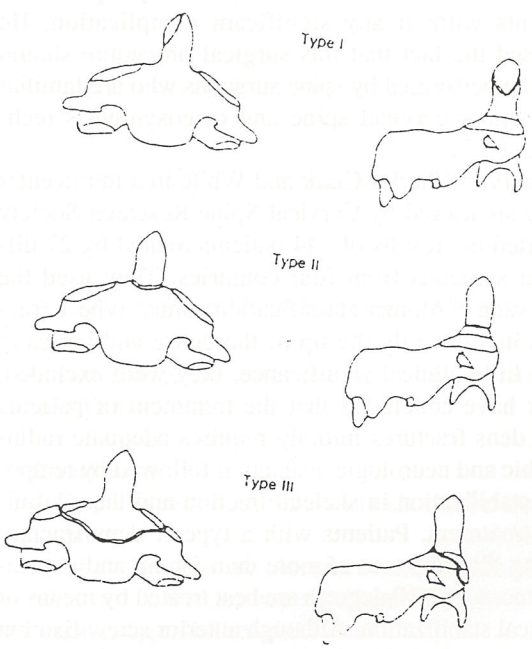

Fig. 3. The Anderson and D'Alanzo classification of the odontoid fractures.

Treatment.

Odontoid fractures can be treated by conservative and surgical methods. Conservative methods include cervical braces, skeleton traction, halo cast and halo device. Although the halo vest usage has some complications such as difficulty in taking X-rays, scars, pin tract infection, stiffness and degenerative changes in facet joints, decubitus ulcers in elderly patients, limitation of social life, malunion, non-union, restriction in maintaining personal hygiene (15, 18). It is the most popular and effective form of non-operative immobilization method in the dens fracture. Whenever an external immobilization is applied, frequent monitoring is required to make sure adequate alignment and bone union without any pin tract complication (15, 17, 18).

Many authors have recommended surgical stabilization for dens fractures especially in patients having a high non-union risk because of the well-known problems with the use of the halo west (8, 12, 14, 15, 17, 18, 23, 28).

Surgical options are divided into two main groups, arthrodesis and repair.

Arthrodesis.

a. Posterior fusion with wiring (Galie, Brooks, etc.)

b. Posterior transarticular screw technique

c. Anterior C1-2 fusion
d. Halifax clamps.

Repair.

a. Anterior screw fixation

The first option and golden standard for the surgical stabilization of dens fractures is posterior fusion with different wiring techniques which have been widely used for many years. The most important disadvantages of these techniques are restriction in neck motion and requirement for rigid external support after surgery. In case of posteriorly displaced dens fracture, the Brooks method should be preferred to the Galie technique since it has less posteriorly directed vector (Fig. 4). (29). Magerl advises primary posterior fusion whenever anterior screw fixation is not possible or preservation of the motion at the atlanto axial joint does not seem to be important as in the conditions below. Otherwise he prefers the direct anterior screw fixation technique (21).

a. Odontoid fractures associated with atlanto axial joints
b. Dens fracture with unstable Jefferson fracture
c. Unstable type III fracture in elderly or polytraumatized patients
d. Atypical type II fracture
e. Irreducible fracture dislocation
f. Unstable type II and type III fracture in elderly patients with narrow spinal canal
g. Pathologic dens fracture

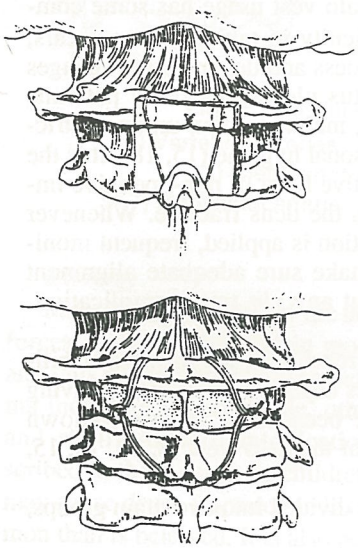

Fig. 4. A) Gallie type of posterior wiring and grafting B) Brooks type of posterior wiring and grafting.

Their preference for posterior stabilization is intraarticular screw fixation and the fusion may or may not be enhanced by additional posterior wiring techniques. The intra articular screw fixation does not make Galie or Brooks techniques useless but reduces the postoperative translational movements in the atlanto axial joint and also allows the patients ambulate in few days after the operation with a cervical collar. If posterior wiring is not possible transarticular screw should be inserted after a bone graft is placed into the joints C 1-2 (Fig. 5).

Primary anterior screw fixation of odontoid fracture first described by Bohler and Nakanishi has an advantage of preserving atlanto axial motion (8). In 1993 Doherty at al. measured the stability of the odontoid process after fracture and subsequent screw fixation. He reported that single or two screw fixation of an odontoid fracture would provide stability approximately equal to one half that of the unfractured bone (13, 26). In a study Heller analyzed 120 axis vertebrae by quantitative computed tomography in which they measured the external and internal dens dimensions. He has noticed that some axis vertebrae might not be broad enough for an internal fixation so they have proposed preoperative planning should include quantitative CT analysis of the dens. Although it is technically demanding and has severe complications, anterior screw fixation has been widely used especially in European countries (Fig. 6). Such serious complications were reported by Aebi in his first series of 17 patients in 1991. However he has recently reported 15 patients without any significant complication. He stressed the fact that this surgical procedure should only be performed by spine surgeons who are familiar with upper cervical spine and osteosynthesis techniques (1, 2).

In 1985 Charles Clark and White in a multicenter study sponsored by Cervical Spine Research Society reported the results of 144 patients treated by 27 different surgeons from four countries. They used the Anderson d'Alonza classification. Since type I fractures involve only the tip of the dense and typically have little clinical significance, they were excluded. They have concluded that the treatment of patients with dens fractures initially requires adequate radiographic and neurologic evaluation followed by temporary stabilization in skeletal traction and then definitive treatment. Patients with a type II dens fracture having displacement of more than 5 mm. and angulation more than 10 degrees are best treated by means of surgical stabilization. Although anterior screw fixation of the dens offers the theoretical advantage of preserving atlanto-axial motion, posterior fusion has less complications and limited motion of the neck due to the posterior fusion, rarely has clinical significance.

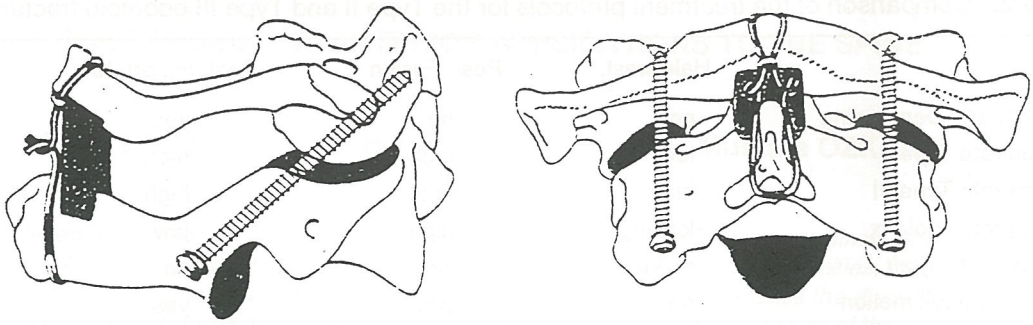

Fig. 5. Transarticular screw fixation with posterior fusion

They have also recommended a halo device for type

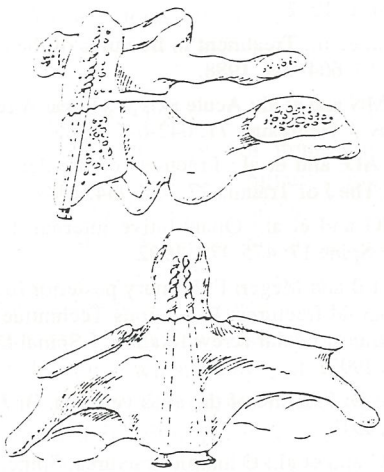

Fig. 6. Anterior transodontoid screw fixation

III fractures since the non union rate has been found to be only 13%.

Conclusion:

- Type I fractures of the dens should be treated with a brace
- The amount of displacement and degree of angulation of the fracture are significant factors affecting union in type II fractures.
- Halo vest treatment is an effective mode of management for undisplaced type II fractures of the dens.
- The patients with type II dens fractures who have significant displacement or angulation should be treated by surgical methods.
- The halo vest is the most effective method for external immobilization but it should not be applied to aged or in case of unstable and non union.
- The halo vest is the best treatment methods for acute type III dens fractures.
- Surgical stabilization is essential for all non union cases with or without neurologic deficit.
- As it maximizes posttreatment cervical motion anterior screw fixation of type II dens fracture appears to be an optimal method of treatment but since it is technically demanding its use should be limited only experienced spine surgeons with the appropriate surgical facilities.
- Compared to the other posterior fusion techniques transarticular screw fixation has the advantages of increased stability and allows immediate ambulation with minimal head support. This technique can be performed even when the posterior arch of the atlas is fractured or absent.

Since there are various limitations and problems in different treatment models, no single method has been accepted universally. Table II compares the treatment protocols for the Type II and Type III odontoid fractures. It may help in decision making for the treatment of the patients with odontoid fractures.

As a result it can be said that every treatment option has its own advantages and problems. Treatment must be specified for each patient according to the patient features such as age, or neurologic loss, fracture characteristics such as degree, direction, amount of displacement, delay in diagnosis after initial injury and the optimal method should be selected with respect to the surgeon's experience.

Table 2. Comparison of the treatment protocols for the Type II and Type III odontoid fractures.

	Halo west.	Post. Fusion	Post. Int. art. fus.	ant. fus.
Technically Demanding	no	no	yes	yes
Union rate Type II	low	high	high	high
Union rate Type III	high	high	high	high
Union rate in old fx	low high	high	low	
Needs bone graft	no yes	yes	no	
Restricts neck motion	no	yes	yes	no
Requires intact post. arch	no	yes	no	no
Long term immobilization	yes	yes	no	no
Severe complications	no	no	yes	yes

REFERENCES:

1. Aeibi M. and et al.: Fractures of the odontoid process. Spine 14: 1065-1070, 1988.
2. Aeibi M. and et al.: Ventral direct screw fixation in dens fractures. Orthopade 1991: 147-153, 1991.
3. Althoff B. and Goldie IF: The aretial supply of the odontoid process of the axis. Acta Orthop Scan 48: 622-629, 1977.
4. Amyes EW and Anderson FM: Fractures of the odontoid process. Arch Surg. 72: 377-393, 1956.
5. Anderson LD and D'Alanzo RT: Fractures of the odontoid process of the axis. J. Bone Joint Surg 56A: 1663-1674, 1974.
6. Appuzzo Michael LJ and et al.: Acute fractures of the odontoid process. J. Neurosurg 48: 85-91, 1978.
7. Blokcney NJ. and Purser DW: Fractures of the odontoid process of the axis. J Bone Joint Surg 33B: 794-816, 1956.
8. Bohler J: anterior stabization for acute fractures and non unions of the dens. J Bone Joint Surg 64: 18-28, 1982.
9. Burke JT and Harris JH: Acute injuries of the axis vertebra. Skeletal Radiol 18: 335-346, 1989.
10. Clark CR and White AA: Fractures of the dens: A multicenter study. J Bone Joint Surg 67: 1340-1348, 1985.
11. Corner EM: Rotatory dislocation of the dens. Ann Surg 45: 9, 1907.
12. Dieter Grob and et al.: Atlanto-axial fusion with transarticular screw fixation. J. Bone Joint Surg. (Br.) 73-B: 972-976, 1991.
13. Doherty BJ. and et al.: A Biomechanical study of odontoid fractures and fracture fixation. Spine 18: 178-184, 1993.
14. Donavan MM: efficiency of rigid fixation of fratures of the odontoid process and retrospective analysis of 54 cases. Orthop Trans 3: 309, 1979.
15. Dunn ME and Seljeskog EL: Experiences in the management of odontoid process injuries: An analysis of 128 cases. Neurosurg 18: 305-310, 1986.
16. Ehara S and et al.: Radiologic evaluation of dens fracture; Role of plain radiography and tomography. Spine 17: 475-479, 1992.
17. Fiji E and et al.: Treatment in fractures of the odontoid process. 13: 604-609, 1988.
18. Hadley MN and et al.: Acute axis fractures: A review of 229 cases. J. Neurosurg 71: 642-647, 1989.
19. Hansen AD. and et al.: Fractures of the dens in adult patients. The J of Trauma 27: 928-934, 1987.
20. Heller JG and et al.: Quantitative internal dens morphology. Spine 17: 475-479, 1992.
21. Jeanneret B and Megerl F: Primary posterior fusion C1/2 in odontoid fractures: Indications Technique and results of transarticular screw fixation. J Spinal Disord 5: 464-475, 1992.
22. Jefferson G: Fracture of the atlas vertebra. Br J Surg 7: 407-422, 1919.
23. Heller JG and et al.: Odontoid fractures. Spine State of the Art Rewiews 5: 217-234, 1991.
24. Mouradion WH. and et al.: Fractures of the odontoid. A Laboratory and clinical study of the mechanism. Orthop clin North Am 9: 985-1001, 1978.
25. Ryan MD. and et al.: The epidemiology of fractures and fracture dislocations of the cervical spine. Injury 23: 38-40, 1992.
26. Sasso R. and et al.: Biomechanics of odontoid fracture fixation. Spine 18: 1950-1953.
27. Schatzker J. and et al.: Fractures of the dens (odontoid process). An analysis of thiry seven cases. J. Bone Joint Surg. (Br) 53B: 392-405, 1971.
28. Southwick WO and et al.: Management of fracture of the dens (Odontoid process). J. Bone Joint Surg. (Am.) 62-A: 482-486, 1980.
29. Shannon ES: Wiring techniques of the cervical spine for the treatment of trauma. Orthopaedics 11: 1543-1548, 1988.