Evidence-based analysis of odontoid fracture management

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Object. The management of odontoid fractures remains controversial. Evidence-based methodology was used to review the published data on odontoid fracture management to determine the state of the current practices reported in the literature.

Methods. The Medline literature (1966–1999) was searched using the keywords "odontoid," "odontoid fracture," and "cervical fracture" and graded using a four-tiered system. Those articles meeting selection criteria were divided in an attempt to formulate practice guidelines and standards or options for each fracture type. Evidentiary tables were constructed by treatment type.

Ninety-five articles were reviewed. Five articles for Type I, 16 for Type II, and 14 for Type III odontoid fractures met selection criteria. All studies reviewed contained Class III data (American Medical Association data classification).

Conclusions. There is insufficient evidence to establish a standard or guideline for odontoid fracture management. Given the extent of Class III evidence and outcomes reported on Type I and Type III fractures, a well-designed case-controlled study would appear to provide sufficient evidence to establish a practice guideline, suggesting that cervical immobilization for 6 to 8 weeks is appropriate management. In cases of Type II fracture, analysis of the Class III evidence suggests that both operative and nonoperative management remain treatment options. A randomized trial or serial case-controlled studies will be required to establish either a guideline or treatment standard for this fracture type.

KEY WORDS • odontoid • odontoid fracture • cervical spine

The incidence of traumatic spinal cord injury in the United States is greater than 11,000 cases annually.[7,21] More than 60% of spinal injuries affect the cervical spine, and approximately one out of five cases of all cervical spine injuries involve the axis.[16,20] The most common axis injury is odontoid fracture, of which the majority are Type II or dens fractures.[3,5,19] They occur at the junction between the odontoid process and the body of C-2, resulting in potentially disastrous instability. The biomechanical design of the C1–2 complex allows for more motion than any other single level in the cervical spine.[4] This motion is primarily rotational, accounting for half of the axial rotation of the neck.[29] Translational motion is restricted by the strong transverse ligament containing the odontoid process in the anterior portion of the ring of C-1. All other supporting ligaments are substantially weaker than those in the subaxial spine, facilitating the motion that occurs at this joint.[29]

When the odontoid is fractured, there is no longer significant restriction of translational movements. Anterolisthesis or posterolisthesis, of the C-1 odontoid complex may occur relative to the body of C-2. If a significant degree of movement occurs, the function and integrity of the spinal cord may be jeopardized, possibly resulting in significant neurological deficit. As such, this is one of the most common sites of disruption in fatal cervical spine injuries.[1,12]

The nonoperative treatment modalities for cases in which this type of fracture occurs are either no treatment or immobilization with a cervical fixation device, which includes a cervical collar or halo vest or Minerva jacket immobilization. Patients may also undergo a posterior fusion or anterior fixation procedure in which screws are placed.

A number of practice guidelines have been developed, using a scientific model, that have resulted in not only improved patient care but also a reduction in medical cost and time.[30] The American Medical Association has suggested that a number of attributes are required for the development of scientifically sound, clinically relevant guidelines.[2] The most important of these attributes focuses on the methods by which the literature is reviewed and the evidence graded. Data may be classified into four categories: 1) Class I evidence includes data collected in prospective trials, and these trials may or may not be randomized. 2) Class II evidence consists of data that are collected prospectively or retrospectively by using reliable data; Class II studies include cohort studies, prevalence studies, and case-controlled studies. 3) Class III evidence is based on retrospectively collected data; articles that fall into this category would include clinical series, database reviews, and case reviews. 4) Class IV evidence consists of case reports, anecdotal reports, testimony, theory, and common sense.[2]

Treatment recommendations for any given disease entity may be weighted according to the available evidence.[26] Treatment recommendations are generally divided into three groups. Standards reflect a high degree of clinical certainty, and these are based on Class I data or very strong Class II data. Guidelines reflect a moderate degree of clinical certainty in terms of therapeutic efficacy, and they are usually based on Class II evidence or a preponderance of Class III evidence. Treatment options reflect mild or unclear clinical certainty, and these are usually based on Class III data.

Outcome measures used to determine the success of treatment of odontoid fractures include bone fusion, morbidity, mortality, length and degree of disability cost, and length of hospitalization. For the purpose of this review bone fusion was the only criterion chosen. As such, it is widely recognized that radiographic determination of fusion is difficult to determine and may not coincide with other long-term outcomes such as pain, disability, neurological deficit, and function.

CINICAL MATERIAL AND METHODS

A Medline search of the English-language literature published from 1966 to 1999 was performed using three key words: odontoid, odontoid fracture, and cervical fracture. Ninety-five articles were identified and reviewed using the following selection criteria: human cases, a minimum follow-up period of 18 months, and the inclusion of 10 or more patients. Of the articles meeting selection criteria, five provided data on Type I, 16 on Type II, and 14 on Type III odontoid fractures.

For the purpose of this review, successful bone fusion was chosen as the only outcome criterion. Other criteria, such as complication rates, patient satisfaction, incidence of long-term disability, as well as numerous others, were less consistently documented. Although inclusion of these data would be of significant interest, for the purposes of this study we elected to use radiologically documented fusion as the sole outcome criterion because this information was more consistently available in the papers reviewed. It is generally known that radiological determination of fusion may be difficult and often imprecise. However, because medical and/or surgical management of odontoid fractures is undertaken to achieve spinal stability and thus radiologically proven fusion, this is an adequate outcome measure to examine. Radiological evidence of bone fusion such as the trabecula crossing the fracture site, as well as absence of motion on flexion–extension x-ray films, is believed to represent a successful fusion. The literature was reviewed with attention to the aforementioned criteria used to determine fusion. In using these constraints, no Class I or Class II data were identified. All Class IV data were eliminated, and therefore all of the available articles used for analysis contained Class III data. The data we obtained were used to construct evidentiary Tables 1 to 4.

RESULTS

In a single article the authors studied the course of 18 patients with Type II odontoid fractures and three patients with Type III odontoid fractures who received no treatment (data not shown).[10] This multicenter review was compiled by the Cervical Spine Research Society. In none of the patients with Type II or III odontoid fractures was fusion demonstrated; therefore, denial of treatment should not be considered as a treatment option.

In nine articles (total 269 patients) the authors treated odontoid fractures with halo/Minerva fixation for 8 to 12 weeks postinjury (Table 1).[8–10,14,15,17,22,25,27] In three of three patients with Type I fractures successful fusions were demonstrated posttreatment.[9,17,27] In 110 (65%) of 168 patients with Type II odontoid fractures treated with halo fixation fusion was demonstrated, whereas in 50 (30%) of 168 patients fusion failed to occur; the remaining cases were described as having evidence of malunion only. In 67 (84%) of 80 patients with Type III odontoid fractures fusion was eventually shown, whereas in six (8%) of 80 patients fusion did not occur and there were seven cases of malunions. Age was not clearly a predictor of successful fusion; however, halo immobilization, implicated in the negative outcome in elderly patients, often resulted in increased pulmonary infections and death. The degree of fracture displacement had a negative correlation in four studies.[10,14,15,22] In three of these the amount of displacement was specified as greater than 2 mm, 4 mm, and 6 mm, respectively.[10,14,15] Immobilization can be considered a treatment option in cases of Types I, II, and III odontoid fractures. Immobilization appears to be most successful in patients with nondisplaced odontoid fractures but should be considered with caution in the elderly patient.

In seven articles containing Class III data the authors treated patients with odontoid fractures by placing them in traction (Table 2).[3,9,10,17,18,24,25] Radiological evidence of fusion was demonstrated in three of three patients with Type I odontoid fractures. Fusion was found to have occurred in 55 (57%) of 97 patients with Type II odontoid fractures, whereas it did not occur in 42 (43%) of 97 patients. In 57 (88%) of 65 patients with Type III odontoid fractures fusion was demonstrated, whereas it failed to occur in only four (6%) of 63 patients. Thus, traction followed by cervical collar immobilization can be considered a treatment option especially in patients with Type I and Type III fractures. This modality of treatment is especially useful in cases in which the patient has sustained multiple traumatic injuries and will have an extensive stay in the intensive care unit. However, in cases of Type II odontoid fractures, it must be kept in mind that successful fusion may not occur in almost half of the patients when this treatment modality is applied.

In eight articles containing Class III data the investigators treated odontoid fractures with posterior cervical fixation (Table 3).[9–11,14,17,23,25,28] In one of one case with Type I odontoid fracture postoperative fusion was eventually demonstrated. In patients with Type II odontoid fractures, radiological fusion was revealed in 109 (74%) of 147 patients. In patients with Type III odontoid fracture, fusion was documented in 28 (97%) of 29 patients. The rate of surgery-related mortality was between 2% and 4%, with a major morbidity rate of approximately 2%. Complications

TABLE 1

*Treatment and outcome of odontoid fractures by nonoperative means in cases reported in the literature**

Authors & Year	Therapy	Description of Study	Class of Data	Outcome
Anderson & D'Alzono, 1974	traction/ collar	37 pts: 2 Type I, 22 Type II, 13 Type III (kept in traction for 6 wks and then in cervical brace; radiographic criteria for fusion not provided)	III	Type I: 2 fusions (100%); Type II: 14 fusions (64%), 8 nonunions (36%); Type III: 12 fusions (92%); 1 nonunion (8%)
Marar & Tay, 1976	traction	26 pts: 0 Type I, 24 Type II, 2 Type III (radiographic criteria for fusion: fibrous union at fx site)	III	Type II: 9 fusions (37.5%), 15 nonunions (62.5%); Type III: 2 fusions (100%)
Ekong, et al., 1981	halo	22 pts w/ C-2 fx involving OP: 0 Type I, 16 Type II, 6 Type III, immobilized for 3 mos in the halo; FU was 6 mos–5yrs w/ average FU of 30 mos (radiographic criteria: fusion on lat flex/ext radiographs)	III	Type II: 6 fusions (50%), 6 nonunions (50%); Type III: 4 fusions (80%), 1 nonunions (20%; 1 pt lost to FU): 4 deaths (3 Type II, 1 Type III)
Ryan & Taylor, 1982	halo/ Minerva/ SOMI	retrospective review of 23 pts over a 10-yr period: 1 Type I, 16 Type II, 6 Type III, (radiographic criteria for fusion: no movement on lat flex/ext radiographs)	III	Type I: 1 fusion (100%, 6 wk average); Type II: 9 fusions (60%), 6 nonunions (40%) (1 pt lost to FU; average FU 8 wks); Type III: 6 fusions (100%, average FU 7 wks)
Clark & White, 1985	halo	54 pts: 0 Type I, 38 Type II, 16 Type III (radiographic criteria for fusion: evidence of trabeculation across fx site & absence of movement on lat flex/ext radiograph)	III	Type II: 25 fusions (66%), Type III: 16 fusions (100%)
Pepin, et al., 1985	halo/ traction	retrospective review of 41 pts: 26 treated conservatively w/ tongs, four-poster brace, collars & halo vests for an average of 12 wks: 0 Type I, 13 Type II, 13 Type III (radiographic criteria for fusion: union on plain radiograph & tomogram as well as lat flex/ext views; nonunion defined as movement of the dens fragment on lat flex/ext radiographs)	III	Type II: 6 fusions (46%), 7 nonunions (54%); Type III: 11 fusions (85%), 2 nonunions (15%)
Dunn & Seljeskog, 1986	halo	80 pts treated w/ either fixation for 2–4 mos & then collar immobilization for 4–6 wks, or immobilization w/ traction for 2–6 wks & then rigid bracing [SOMI brace] for 3–6 mos followed by additional collar support for 6 wks; minimum 6 mos, w/ 80% having FU > 8 mos (radiographic criteria: fusion on lat flex/ext radiographs at 3–4 mos)	III	Type II: 40 fusions (68%), 19 nonunions (32%), (4 lost to FU); Type III: 15 fusions (100%) (2 lost to FU)
Fuji, et al., 1987	halo/ traction	retrospective review of 52 pts: 24 treated conservatively: 1 Type I, 9 Type II, 14 Type III. (radiographic criteria: fusion demonstrated on AP & lat CT scans)	III	Type I: 1 fusion (100%); Type II: 3 fusions (43%), 4 nonunions (57%) (2 pts lost to FU); Type III: 10 fusions (71%), 3 malunions (21%), 1 nonunion (7%)
Lind, et al., 1987	halo	14 pts: 0 Type I, 9 Type II, 5 Type III w/ a 2-yr FU period, placed in halo & evaluated at 12 wks w/ flex/ext radiography; if no movement of the OP in relation to body of the axis, the fx was deemed stable; otherwise treatment continued for another mo (radiographic criteria: fusion on lateral flex/ext radiographs)	III	10 fusions (91%) combined Type II & Type III fx, 1 nonunion (9%; 3 deaths)
Govender & Grootboom, 1988	traction/ collar	41 pts: 0 Type I, 26 Type II, 15 Type III (treated for 1 mo in traction [2–4 Kg], then w/ rigid collar for 6–8 wks, & then assessed at 3 mos; radiographic criteria for fusion: bone continuity across fx site and no movement on flex/ext)	III	Type II: 19 fusions (73%), 2 fibrous unions (8%), 5 nonunions (19%); Type III: 15 fusions (100%) (no deaths, 7 halo pin–site infections, 3 skin excoriation over chin secondary to halter traction)
Bucholz & Chung, 1989	halo	26 pts: 0 Type I, 17 Type II, 9 Type III (immobilized in halo for a minimum of 3 mos & if no movement on flex/ext radiographs, pts were placed in a Philadelphia collor for an additional 4 wks; radiographic criteria for fusion: no movement or subluxation at fx site on flex/ext)	III	Type II: 15 fusions (88%), 2 nonunions (12%); Type III: 9 fusions (100%)
Chiba, et al., 1996	traction/ collar	104 pts: 2 Type I, 62 Type II, 32 Type III (2 groups: 72 pts w/ fx identified w/in 3 wks of trauma; 32 pts w/ an extended period before treatment: 1 Type I, 21 Type II, & 8 Type III)	III	Type I: 100% fusion; Type II: 1 fusion (10%), 2 malunions (20%), 6 nonunions (60%); Type III: 1 nonunion (5.9%), 5 malunions (29.4%), 11 unions (64.7%) (of patients reported)

***** AP = anteroposterior; CT = computerized tomography; flex/ext = flexion/extension; FU = follow up; fx = fracture(s); OP = odontoid process; SOMI = suboccipital mandibular immobilizer.

TABLE 2

*Treatment and outcome of odontoid by nonoperative or traction therapy in cases reported in the literature**

Authors & Year	Therapy	Description of Study	Class of Data	Outcome
Anderson & D'Alzono, 1974	traction/ collar	see Table 1	III	see Table 1
Marar & Tay, 1973	traction	see Table 1	III	see Table 1
Clark & White, 1985	traction	11 pts: 0 Type I, 3 Type II, 8 Type III; see Table I	III	Type II: 2 fusions (66%), 1 nonunion (33%); Type III: 7 fusions (88%), 1 malunion (13%)
Pepin, et al., 1985	halo/ traction	see Table 1	III	see Table 1
Fuji, et al., 1987	halo/ traction	acute fx w/ displacement were treated w/ skull traction to obtain reduction, then immobilized by means of halo vest or plaster cast & finally neck brace; see Table 1	III	see Table 1
Govender & Grootboom, 1988	traction/ collar	see Table 1	III	See Table 1
Chiba, et al., 1996	traction/ collar	2 Type II; See Table 1	III	Type II: 0 fusions (0%), 2 nonunions (100%)

* See Table 1 for description of additional study data.

associated with this procedure include loss of reduction of the fracture and development of new neurological deficits.

In four articles, anterior fixation was performed to treat cases of odontoid fractures (Table 4).[6,9,13,17] No case of Type I odontoid fractures was reported in these four articles. In patients with Type II odontoid fractures who underwent anterior fixation, fusion was achieved in 66 (90%) of 73 patients. Of 20 patients with Type III odontoid fractures, radiographic fusion was demonstrated in all. Thus, anterior cervical fixation can be considered a treatment option for cases of both Type II and Type III odontoid fractures. Currently anterior odontoid fixation in which lag screws are placed is the preferred approach.[6,13,17]

TABLE 3

Treatment and outcome of odontoid fractures treated by posterior cervical fixation

Author & Year	Description	Class of Data	Outcome
Maiman & Larson, 1982	34 of 49 Type II pts were treated w/ early posterior wire/graft stabilization & postop immobilization w/ Minerva for an average of 5 wks; 2 Type III pts & 0 Type I (radiographic criteria for nonunion: CT evidence of avascular necrosis, gross instability w/ a demonstrable gap at the fx line, & no evidence of healing, results evaluated 6 mos postop	III	17 fusions (35%); mortality rate 4%
Waddell & Reardon, 1983	24 pts: 20 Type II, 4 Type III fx: 16 of the 20 Type II fx were treated w/ C1–2 arthrodesis (Gallie procedure); all Type III fx treated nonoperatively	III	Type II: 15 fusions (94%), 1 pt lost to FU; Type III: 3 fusions (75%), 1 nonunion
Clark & White, 1985	32 pts treated w/ posterior fusion: 26 Type II, 4 Type III	III	Type II: 24 fusions (92%) (2 complications: 1 fx displacement & 1 worsening myelopathy thought to be secondary to wire placement); Type III: 4 fusions (100%)
Pepin, et al., 1985	12 of 41 pts treated surgically: 1 Type I, 4 Type II, 7 Type III; see Table 1	III	Type I: 1 fusion (100%); Type II: 4 fusions (100%); Type III: 7 fusions (100%)
Dunn & Seljeskog, 1986	42 pts treated w/ posterior cervical fusion: 37 Type II & 5 Type III w/ chronic injuries, nonunion after skeletal fixation & acute injuries	III	40 of 41 fusions (98%) of combined Type II & Type II fx, 1 nonunion (2%) (1 death)
Fuji, et al., 1987	7 of 52 pts treated w/ posterior fusion: 7 Type II	III	7 fusions (100%)
Coyne, et al., 1995	15 pts treated w/ posterior wire fusion & immobilized postop in either Philadelphia collor or halo; minimun FU 2 yrs, mean 4.7 yrs (radiographic criteria for fusion: absence of C1–2 movement on lat flex/ext radiographs & evidence of continuity of trabecular bone formation between C1 & C2 across the graft	III	Type II: 13 fusions (87%), 2 nonunions
Chiba, et al., 1996	10 pts treated w/ posterior cervical fusion: 7 Type II nonunion fx, 2 Type II fx identified w/in 3 wks, & 1 irreducible Type III fx identified w/in 3 wks	III	Type II: 9 fusions (100%); Type III: 1 fusion (100%)

TABLE 4

Treatment and outcome of odontoid fractures treated by anterior cervical/transoral fixation

Authors & Year	Description of Study	Class of Data	Outcome
Bohler, 1982	15 pts w/ acute and chronic OP fx treated w/ anterior screw fixation followed by fixation in a plastic collar for 4–16 wks: 8 Type II, 7 Type III (radiographic criteria for fusion not given)	III	Type II: 8 fusions (100%); Type III 7 fusions
Fuji, et al., 1987	10 pts treated w/ anterior screw fixation: 0 Type I, 8 Type II, 2 Type III	III	Type II: 6 fusions (75%), 2 nonunions (25%); Type III: 2 fusions (100%)
Dickman, et al., 1995	14 pts w/ acute or subacute Type II fx (radiographic criteria for fusion: postop radiographs and CT scans)	III	14 fusions (100%)
Chiba, et al., 1996	45 pts underwent anterior screw fixation: 35 Type II, 10 Type III (transoral pts: 8 Type II & 1 Type III; radiographic criteria for fusion not given)	III	Type II: 8 fusions (100%); Type III 7 fusions (100%)

Complications include retropharyngeal wall injury, misplaced screw, screw fracture, infection, and injury to surrounding vascular and neural structures.[6,13,17] Attempts at odontoid fixation by performing a transoral approach have been shown to yield significant complications.[9]

DISCUSSION

This review indicates that there are currently no treatment standards available to guide the care of all three types of odontoid fracture. Additionally, no treatment guidelines can be determined based on the review of the available literature. The four treatment options that do exist are halo or Minerva vest therapy, traction followed by immobilization in a cervical collar, posterior cervical fusion, and anterior fixation.

For Type I and Type III fractures, immobilization tends to yield satisfactory results in 100% and 84% of cases, respectively, although the number of cases is limited. Anterior fixation for treatment of Type III fractures appears to improve the fusion rate (100%).

For Type II fractures, halo vest immobilization and posterior fixation were shown to yield relatively similar fusion rates (65% and 74%, respectively). Anterior fixation appears to increase the fusion rate (90%), whereas traction alone is less successful (57%).

These observations are based entirely on the review of Class III data that are inadequate to establish either a treatment standard or guideline. Therefore, all management modalities described remain treatment options.

CONCLUSIONS

More data are necessary to determine treatment standards and/or guidelines for the management of the three types of odontoid fracture. For Type I and Type III fractures the available Class III evidence suggests that a well-designed case-controlled study could provide evidence to establish a practice guideline for cervical immobilization for 6 to 8 weeks as appropriate management in the initial treatment. This is based on the fact that in the reported cases, immobilization appeared to be an adequate treatment. Unfortunately, there were limited numbers of reported cases, and all the data that we obtained were classifed as Class III. A well-designed, prospective study or a case-controlled retrospective study would potentially allow the creation of a clinical guideline. For Type II fractures, analysis of results reported in the literature suggests that both operative and nonoperative management remain treatment options. In this case, there is no clear trend found even in the available Class III data. Although larger numbers of cases are reported and are available for analysis, there is no clear consensus among the investigators, leaving only treatment options. Because this remains a more controversial issue, a randomized or series of well-designed prospective studies will be required to establish a practice guideline or treatment standard for this fracture type.

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