Spine

SPINE Volume 38, Number 26, pp 2240-2246

Effect of Type II Odontoid Fracture Nonunion on Outcome Among Elderly Patients Treated Without Surgery

Based on the AOSpine North America Geriatric Odontoid Fracture Study

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Study Design. Subgroup analysis of a prospective multicenter study.

Objective. Outcome analysis of nonoperatively treated elderly patients with type II odontoid fractures, including assessment of consequence of a fracture nonunion.

Summary of Background Data. Odontoid fractures are among the most common fractures in the elderly, and controversy exists regarding treatment.

Methods. Subgroup analysis of a prospective multicenter study of elderly patients (≥65 yr) with type II odontoid fracture. Neck Disability Index and Short-Form 36 (SF-36) version 2 were collected at baseline and 6 and 12 months. Fifty-eight (36.5%) of the 159 patients were treated nonoperatively.

Results. Of the 58 patients initially treated nonoperatively, 8 died within 90 days and were excluded. Of the remaining 50 patients, 11 (22.0%) developed nonunion, with 7 (63.6%) requiring surgery. Four of the 39 (10.3%) patients classified as having "successful union" required surgery due to late fracture displacement. Thus, 15 (30.0%) patients developed primary or secondary nonunion and 11 (22.0%) required surgery. The overall 12-month mortality was 14.0% (nonunion = 2, union = 5; $P = 0.6407$). For union and nonunion groups, Neck Disability Index and SF-36 version 2 declined significantly at 12 months compared with preinjury values ($P < 0.05$), except for SF-36 version 2 Physical Functioning ($P = 0.1370$). There were no significant differences in outcome parameters based on union status at 12 months ($P > 0.05$); however, it is important to emphasize that the 12-month outcomes for the nonunion patients reflect the status of the patient after delayed surgical treatment in the majority of these cases.

Conclusion. Nonoperative treatment for type II odontoid fracture in the elderly has high rates of nonunion and mortality. Patients with nonunion did not report worse outcomes compared with those who achieved union at 12 months; however, the majority of patients with nonunion required delayed surgical treatment. These findings may prove useful for patients who are not surgical candidates or elect for nonoperative treatment.

Key words: odontoid fracture, nonunion, geriatric, outcomes, complication.

Level of Evidence: 2

Spine 2013;38:2240–2246

A substantial shift in population demographics is underway in the United States, with the proportion of elderly expanding to unprecedented levels. The fastest growing segment of the population will be those at least 85 years of age, which is expected to double by 2025 and quintuple by 2050.[1,2] As these shifts occur, it will become increasingly important to better appreciate and effectively manage the medical and surgical conditions that commonly afflict the elderly.

Odontoid fractures are among the most common spine fractures in the elderly,[3,4] often resulting from low impact trauma, such as falls from standing. A majority of these fractures are type II based on the classification of Anderson and D'Alonzo, which are also the most challenging to treat.[5] Despite the frequency of these fractures and multiple descriptive case series in the literature, there remains controversy

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Acknowledgment date: July 11, 2013. First revision date: August 18, 2013. Acceptance date: August 24, 2013.

The manuscript submitted does not contain information about medical device(s)/drug(s).

AOSpine North America funds were received to support this work.

Relevant financial activities outside the submitted work: board membership, consultancy, expert testimony, grants/grants pending, payment for lectures, patents, royalties, stock/stock options and payment for development of educational presentations.

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DOI: 10.1097/BRS.0000000000000009

regarding whether operative or nonoperative management is the best treatment approach.[6–16] A recent study suggested a significant 30-day survival advantage and a trend toward improved longer-term survival for operatively treated compared with nonoperatively treated elderly patients with type II odontoid fracture.[15] Although the immediate stabilizing effects of instrumentation and its demonstrated high rates of resulting bony fusion[16–18] may seem to favor surgical treatment as the first-line approach, there are those among the elderly who may not be surgical candidates, whether due to chronic comorbid conditions, other associated injuries, or by personal choice.[7,9,16,19–21] Understanding the outcomes of elderly patients treated nonoperatively for type II odontoid fracture is not only important for optimizing treatment and providing counseling for these patients, but may also give insight into the broader role of nonoperative treatment for this condition in elderly patients.

Our objective in this study was to assess the outcomes of elderly patients with type II odontoid fractures who received nonoperative treatment, with focused assessment on the potential impact of nonunion on outcome.

MATERIALS AND METHODS

Patient Population

One hundred fifty-nine elderly patients with radiographically confirmed type II odontoid fractures were enrolled in a multicenter prospective study at 10 sites in the United States and one site in Canada between January 2006 and May 2009. Sites were selected from members of AOSpine NA Research Network. Inclusion criteria for study enrollment were age 65 years or more, type II odontoid fracture within 90 days of presentation, no previous fracture treatment, and no cognitive impairment that would preclude informed consent or survey completion. Subjects were treated nonoperatively or surgically on the basis of treatment preferences reached by the treating physicians and patients. Postoperative rehabilitation was dictated by treatment protocols at each participating institution. Baseline demographics, clinical status, injury characteristics, and injury severity score,[22] were collected using standardized data collection forms. This study focuses on the 58 (36.5%) subjects who were initially treated nonoperatively.

Outcomes Assessment

Patients were followed prospectively in clinic at 6 and 12 months after initial treatment and completed the Neck Disability Index (NDI)[21] and the Short-Form 36 (SF-36) version 2.[22] The baseline NDI and SF-36 version 2 were completed on the basis of subject recall at the time of enrollment reflecting their status prior to injury. The NDI is a self-report that evaluates functional outcomes related to neck conditions and ranges from 0 (best) to 100 (worst). The SF-36 version 2 is a widely used measure of patient-reported generic health status, and it describes patient health status across 8 health domains and 2 composite scores. The SF-36 version 2 Physical Component Score (PCS) and the Mental Composite Score (MCS) were calculated using the 1998 US norms.

Nonunion was defined on the basis of radiographical evidence of failed progress of fracture healing that required clinical intervention. Clinical intervention may have included continued conservative treatment including more frequent follow-up, nonsurgical treatment modalities to encourage bony union, or surgery. Follow-up computed tomographic imaging was obtained in cases of frank instability on plain radiographs and in symptomatic patients, but was not routinely obtained for all patients. Patients without frank instability on plain radiographs and lacking symptoms of nonunion were classified into the union group.

Complications were prospectively followed using a predetermined list of 19 anticipated complications associated with the treatment of odontoid fracture. Complications that occurred but were not on the predetermined list were recorded in a free-text section of the standardized forms. All adverse events were reviewed and adjudicated by an independent physician participating in the study as either potentially treatment-related or treatment-unrelated events.

The study was externally monitored to help ensure that the data were accurate, reliable, and complete. All data were collected using a WEB-based electronic data capture system and were processed at the central Data Management Center at the University of Washington, Seattle.

Statistical Analysis

The study endpoints were the absolute changes between the preinjury and 12-month post-treatment scores in the NDI, 8 SF-36 version 2 health domains, and 2 SF-36 version 2 composite scores (PCS and MCS). Missing follow-up scores for subjects who failed to attend their follow-up visit at 12 months were imputed using the last value carry forward approach, if the 6-month score was available and was used for 11 patients (22.0%) who initially received nonoperative treatment,[23] including patients who died between the 6- and the 12-month follow-up.

The analysis of differences in preoperative characteristics between the nonunion and union patient groups were analyzed by t test for the continuous variables and χ^2 tests for categorical variables. Testing of statistical significance of changes in outcome variables among baseline and 12-month values and differences in changes between the nonunion and the union groups were performed by repeated measurements analysis of variance. The analysis included factors labeled ARM (nonunion and union), TIME (baseline and 12 mo) and TIME × ARM interaction. The actual testing was performed using the SAS PROC GLM (SAS 9.2, SAS Institute Inc., Cary, NC). The number of subjects was too small to perform adjustments for the covariates.

This study was approved by the institutional review boards at all participating sites and the institutional review board overseeing the central Data Management Center. This study is registered with clinicaltrials.gov (NCT00266929).

RESULTS

Of the total 159 patients enrolled, 58 (36.5%) were treated nonoperatively. Eight patients died within 90 days of initial

TABLE 1. Demographics of Geriatric Patients Treated Nonoperatively for Type II Odontoid Fracture, Stratified on the Basis of Whether Odontoid Fracture Union Was Achieved

	Nonunion (N = 11)	Union (N = 39)	*P*
Age (yr)	78.4 ± 7.5	80.5 ± 8.0	0.4162
Female sex	18.2%	59.0%	0.0169
Tobacco smoking	9.1%	2.6%	0.3293
Race			0.1972
Caucasian	90.9%	89.7%	
African American	0%	5.1%	
Asian	0%	5.1%	
Other	9.1%	0.0%	
Marital status			0.2212
Married	54.5%	53.8%	
Divorced	9.1%	0.0%	
Widowed	36.4%	38.5%	
Unknown	0.0%	7.7%	
Associated injuries	18.2%	35.9%	0.2660
Injury severity score	4.3 ± 3.5	8.7 ± 6.0	0.0244
Residential status			0.8219
At home without support	81.8%	76.9%	
At home with caregiver support	18.2%	15.4%	
Nursing home/retirement home (independent)	0.0%	5.1%	
Nursing home/retirement home (dependent)	0.0%	0.0%	
Unknown	0.0%	2.6%	

TABLE 2. Baseline Values for Outcome Measures of 50 Geriatric Patients Treated Nonoperatively for Type II Odontoid Fracture, Stratified Based on Whether Odontoid Fracture Union Was Achieved

Baseline Outcome Measures	Nonunion (N = 11)	Union (N = 39)	*P*
NDI	21.1 (24.0)	16.8 (16.3)	0.4941
SF-36 version 2			
Physical Functioning	43.6 (14.9)	39.0 (12.9)	0.1473
Role Physical	46.6 (12.7)	40.4 (12.4)	0.0863
Bodily Pain	54.3 (8.4)	51.1 (11.4)	0.4452
General Health	47.1 (15.6)	51.0 (8.6)	0.5015
Mental Health	53.6 (14.0)	52.0 (10.7)	0.3983
Role Emotional	46.3 (14.2)	46.8 (12.3)	0.7655
Social Functioning	49.9 (14.7)	46.4 (12.3)	0.2350
Vitality	55.5 (14.9)	52.2 (10.5)	0.1650
PCS	46.8 (11.1)	42.8 (10.0)	0.1639
MCS	52.9 (14.6)	52.7 (11.1)	0.5924

NDI indicates Neck Disability Index; PCS, Physical Component Score; MCS, Mental Composite Score; SF-36, Short-Form 36.

treatment and were excluded from the analyses related to union *versus* nonunion, because assessment of union status with such short follow-up was not considered meaningful. The remaining 50 patients are the subject of this study, and their baseline demographics are summarized in Table 1. Of these 50 patients, 11 (22.0%) developed nonunion, including 2 of the 25 females (8.0%) and 9 of the 25 males (36.0%, $P = 0.0169$). The injury severity score was significantly lower in the nonunion group than union group (4.3 and 8.7 respectively, $P = 0.0244$). There were no significant differences in age, race, marital status, presence of associated injuries or residential status between the 2 groups ($P > 0.05$; Table 1). In addition, there were no significant differences between the groups for any of the outcomes measures at baseline (Table 2).

Nonoperative treatments included hard collar immobilization for 39 (78.0%), halo immobilization for 6 (12.0%), and soft collar immobilization for 5 (10.0%) patients. Hard collar immobilization was more common in the successful union than the nonunion group (84.6% and 54.5%, Fisher exact test $P = 0.0259$). Halo immobilization was more common in the nonunion than the successful union group (36.4% and 5.1%, respectively). Of the 11 nonoperatively treated patients who developed nonunion, 7 (63.6%) ultimately underwent surgical treatment, compared with 4 (10.3%) out of the 39 in the successful union group who underwent surgical treatment for delayed fracture displacement (Fisher exact $P < 0.0001$). Of these 7 patients, 6 (85.7%) had successful union after surgery, whereas one failed first surgical treatment and required a second surgery. Thus, a total of 15 (30.0%) nonoperatively treated patients developed a primary or secondary nonunion, and a total of 11 (22.0%) nonoperatively treated patients ultimately underwent surgery. A summary of all 159 patients enrolled, stratified by operative *versus* nonoperative treatment approach and union *versus* nonunion, is provided in Figure 1.

A summary of complications associated with nonoperative treatment is shown in Table 3. There were 22 complications reported among the 50 subjects within 1 year of presentation, for a mean of 0.44 complications per patient. In addition to 8 subjects who died during the first 90 days and were not included in the sample, 7 additional subjects had expired, including 2 in the nonunion group and 5 in the union group

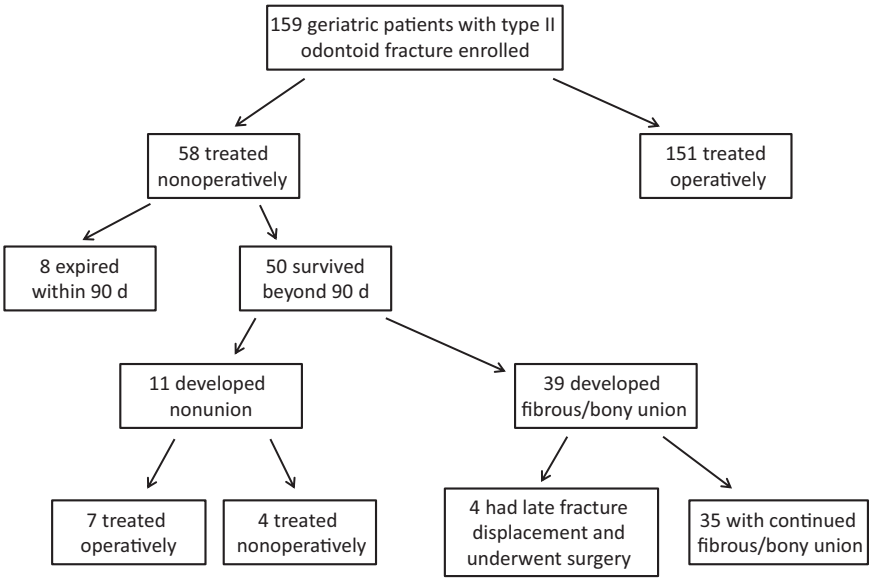

Figure 1. Summary of 159 geriatric patients with type II odontoid fracture, stratified by operative *versus* nonoperative treatment. Nonunion was defined based on radiographical evidence of failed progress of fracture healing that required clinical intervention. Patients without frank instability on plain radiographs and lacking symptoms of nonunion were classified into the union group.

($P = 0.6407$). By definition, all 11 patients in the nonunion category had a nonunion. In addition, there were 2 cases of fracture instability, 1 case of fracture displacement and 1 case of loss of reduction in the union group. There were 3 cases of dysphagia (Table 3).

NDI and SF-36 version 2 data were available for 37 of the 48 (77%) subjects who survived more than 6 months; 11 with nonunion and 26 from the union group. Changes in the outcomes measures between baseline and 12-month follow-up are summarized in Table 4. In general, after injury, NDI and SF-36 version 2 declined at 12-month follow-up compared with baseline (preinjury) values. These declines were all statistically significant, except for SF-36 version 2 Physical Functioning ($P = 0.1370$) (see TIME factor in Table 4). There were no significant differences in any of the outcome parameters between the nonunion and successful union groups as demonstrated by the TIME × ARM interactions. However, the SF-36 version 2 Domains Role Physical and Vitality TIME × ARM interactions were borderline to reach statistical significance. These 2 dimensions showed larger declines in nonunion subjects than in those subjects with successful union.

DISCUSSION

This study provides assessment of outcomes for 58 elderly patients with traumatic type II odontoid fractures who received initial nonoperative treatment, stratified on the basis of whether a fracture union was achieved. The findings demonstrate an overall high rate of mortality in this population, with 15 (25.9%) of the 58 patients having expired by 12-month follow-up. A substantial proportion (78%) of the nonoperatively treated patients seem to achieve a fibrous or bony union, whereas a minority of patients (22%) developed frank nonunion, with approximately two-thirds of these latter patients requiring surgical treatment. Notably, even patients who were initially classified as having achieved union were not immune from subsequently requiring surgical intervention, because 4 (10.3%) of these patients developed a delayed fracture displacement that required surgical treatment. Thus, a total of 15 (30.0%) nonoperatively treated patients developed a primary or secondary nonunion, and a total of 11 (22.0%) nonoperatively treated patients ultimately required surgery. Although all standardized outcomes measures demonstrated a significant decline from preinjury baseline to follow-up in both union and nonunion groups, there were no significant differences in any of the outcomes parameters between the nonunion and successful union groups. Collectively, these findings suggest that a majority of elderly patients treated nonoperatively for type II odontoid fracture can achieve a fibrous or bony union, and that those who develop frank nonunion may ultimately require surgery but do not seem to have outcomes that are negatively impacted. However, it is important to emphasize that the 12-month outcomes for the nonunion patients reflect the status of the patient after delayed surgical treatment in the majority of these cases.

Vaccaro *et al*[24] recently provided a comparison of functional and quality-of-life outcomes of operative *versus* nonoperative treatment for traumatic geriatric odontoid fractures on the basis of the same prospective AOSpine North America geriatric odontoid fracture study data used in this study. They demonstrated a significant benefit with surgical treatment based on the NDI and the SF-36 version 2 Bodily Pain dimension, and these differences persisted after adjustment. The mortality rate was higher in the nonsurgical group than the surgical group (annual mortality rates of 26% and 14%, respectively; $P = 0.059$). Notably, the overall rate of complications was not significantly different between the patients treated operatively and those treated nonoperatively.

Because patients enrolled into the AOSpine North America Geriatric Odontoid Fracture Study were not randomized to operative or nonoperative treatment, it is possible that there could be selection bias that could contribute to the high mortality and nonunion rates among patients treated nonoperatively. However, in the primary report from Vaccaro *et al*,[24] it was reported that at baseline the operative and nonoperative

TABLE 3. Complications Among 50 Geriatric Patients Treated Nonoperatively for Type II Odontoid Fracture, Stratified on the Basis of Whether Odontoid Fracture Union Was Achieved*

Complication	Nonunion (N = 11)	Union (N = 39)	Total (N = 50)
Acute airway compromise	0	1	1
Anuria	1	0	1
Aspiration pneumonia	0	1	1
Bradycardia	0	1	1
Chest infection	0	1	1
Closed head injury and concussion	1	0	1
Delayed union	1	0	1
Dysphagia	2	1	3
Fall	1	0	1
Fracture instability†	0	2	2
GERD	1	0	1
Instrumentation/device failure‡	0	2	2
Loss of reduction†	0	1	1
Meningitis	0	1	1
Pneumonia	1	0	1
Progressive displacement†	0	1	1
Pulmonary insufficiency	1	0	1
UTI	0	1	1

In addition to the listed complications, by definition, patients in the nonunion group also had the complication of failed union.

†Patient underwent delayed surgical treatment.

‡Device failure occurred in patients classified as having achieved union who were later treated surgically after development of delayed fracture displacement.

GERD, gastroesophageal reflux disease; UTI, urinary tract infection.

patient groups did not differ significantly with regard to age, sex, race, marital status, associated injuries, injury severity score, residential status, comorbidities, or time between injury and initial treatment.

Reinhold *et al*[25] recently described a characteristic cervical spine deformity in geriatric patients with type II odontoid fractures (termed the "Geier-deformity"). The clinical findings of this deformity, which include sagittal imbalance and kyphosis of the lower cervical spine, may at least partially account for the decline in standardized outcomes measures at follow-up compared with preinjury baseline observed in this study.

The rate of mortality in this study is comparable with those previously reported in the literature for operative and nonoperative treatment of type II odontoid fractures in the elderly. On the basis of a recent systematic review from Harrop *et al*,[16] the rates of mortality for nonoperative treatment for type II odontoid fractures in the elderly ranges from 4% to 42%. However, most of the studies on which this systematic review was based were small patient series with varying lengths of follow-up. Subsequent to this review, Chapman *et al*[15] reported on a multicenter series of 322 elderly patients with type II odontoid fracture, including 157 treated nonoperatively and 165 treated operatively. The overall 30-day and long-term (mean of 2 yr/patient) mortality rates were 14% and 44%, respectively, and for the nonoperative group only were 22% and 51%, respectively. In their series, operative treatment was associated with significantly improved survival at 30 days and a nonsignificant trend toward improved survival at long-term follow-up.

The rate of nonunion in this study (22.0%) is lower than previous reports of elderly patients, likely reflecting differences in the classification of union *versus* nonunion. In this study, patients without frank instability seen on plain radiographs and without symptoms were classified into the union group, which likely included cases with fibrous union only. The 4 patients initially classified as having achieved union who developed delayed fracture displacement and underwent surgical treatment may have been patients in whom only a fibrous union was achieved and are reflective of difficulties in determining fracture union stability with nonoperative treatment in clinical practice.

A recent systematic review of the literature clearly demonstrates an association between increasing age and decreased osseous healing of type II odontoid fractures.[16,26–28] For example, a retrospective review from Polin *et al*[26] reported an 82% (9/11) osseous fusion rate with halo or hard cervical collar treatment in patients younger than 40 years, but in patients older than 60 years, this rate decreased to 38% (5/13). In a report of 16 patients treated with halo immobilization, Ekong *et al*[27] demonstrated a 100% fusion rate for patients younger than 55 years, but only a 14% (1/7) fusion rate for those older than 55 years. Of the 9 patients treated with halo immobilization, Fuji *et al*[28] reported that the only patients who developed pseudarthrosis were older than 60 years of age.

Although this study suggests that a majority of the elderly patients treated nonoperatively in this series for type II odontoid fracture seemed to develop a fibrous or bony union, our data are not sufficient to recommend this approach as a routine first-line treatment. Although the outcome data in this study do suggest that even those patients who develop nonunion seem to have similar outcomes as those who do not (albeit with delayed surgical treatment in the majority of these cases), other reports provide a mixed assessment. In a retrospective review from Hart *et al*,[19] 5 patients with a mean age of 81 years who had chronic nonunion of a type II odontoid fracture were assessed during a mean period of 55.2 months. Each of these patients had an intercanal distance of at least 14 mm, and none developed myelopathic symptoms during the follow-up interval, leading them to conclude that serial observation may be an acceptable approach. Similarly, Ryan and Taylor[29] did not note development of myelopathy among

TABLE 4. Outcome Measures for Patients Treated Nonoperatively for Type II Odontoid Fracture, Stratified on the Basis of Whether Odontoid Fracture Union Was Achieved

	Nonunion (N = 11)		Union (N = 26)		*P*		
Baseline Outcome Measures	**Baseline (Preinjury)**	**12 mo**	**Baseline (Preinjury)**	**12 mo**	**TIME**	**ARM**	**TIME × ARM**
NDI	21.1 (24.0)	37.7 (27.6)	17.1 (17.5)	31.0 (22.5)	0.0001	0.4565	0.6819
SF-36 version 2							
Physical Functioning	43.6 (14.9)	36.4 (15.9)	37.6 (14.1)	37.2 (16.0)	0.1370	0.5922	0.1845
Role Physical	46.6 (12.7)	34.8 (12.9)	39.4 (13.7)	38.4 (13.3)	0.0242	0.6463	0.0573
Bodily Pain	54.3 (8.4)	43.7 (12.8)	50.4 (11.0)	45.0 (11.0)	0.0041	0.6689	0.3347
General Health	50.3 (9.1)	47.4 (8.0)	47.1 (15.6)	42.4 (13.2)	0.0230	0.2515	0.5876
Mental Health	53.6 (14.0)	48.0 (15.7)	51.5 (11.7)	48.6 (9.9)	0.0267	0.8574	0.4691
Role Emotional	46.3 (14.2)	36.1 (18.9)	47.1 (12.8)	40.6 (16.1)	0.0196	0.5424	0.5790
Social Functioning	49.9 (14.7)	41.0 (13.2)	45.9 (13.2)	43.2 (13.3)	0.0345	0.8315	0.2498
Vitality	55.5 (14.9)	44.1 (16.6)	51.3 (11.1)	46.6 (11.0)	0.0001	0.8274	0.0767
PCS	46.8 (11.1)	39.3 (12.8)	41.5 (10.1)	40.2 (11.3)	0.0390	0.5240	0.1434
MCS	52.9 (14.6)	42.7 (13.3)	52.8 (11.6)	47.5 (12.6)	0.0021	0.5546	0.2962

NDI indicates Neck Disability Index; PCS, Physical Component Score; MCS, Mental Composite Score; SF-36, Short-form 36.

9 patients with nonunion who were serially followed for 21 months. In contrast to the reports of Hart *et al*[19] and Ryan and Taylor,[29] Crockard *et al*[30] presented 16 patients who developed myelopathy after odontoid fracture nonunion. Notably, myelopathy did not develop until more than 1 year after fracture in 69% of these patients, and in 38% of the 16 patients, myelopathy developed more than 5 years after fracture. They concluded that there is significant risk of delayed myelopathy without surgical reduction and stabilization.

It is important to recognize the limitations of this study. Although the data were collected as part of a multicenter prospective study, the primary limitation of this study is the retrospective design. There were no standardized criteria for assessment of union across the study centers, which may have introduced variation in its determination. Routine follow-up computed tomographic image was not obtained to distinguish fibrous *versus* osseous union specifically, because of institutional-review-board concerns that this did not necessarily represent the standard of care, likely resulting in an overestimation of the union rate. Because the database on which this study was based is derived from a consortium of surgeons, there is possible perception of bias toward surgical treatment; however, it should be recognized that more than one-third of the patients were treated nonoperatively in the original study and the operative and nonoperative patients had similar demographics, associated injuries, and comorbidities. Notably, there was a wide divergence of approaches and philosophies toward the treatment of geriatric odontoid fracture among the surgeons enrolling in the AOSpine North America study. In addition, the original study was externally monitored to help ensure that the data were accurate, reliable, and complete. Another potential limitation is the use of imputations, which were used in 11 out of 50 subjects (carry forward available 6 mo value if 12 mo was missing—last value carry forward). Although it would be ideal to have actual values, the imputation by using last value carry forward is a common approach used to populate missing observations. In this population of elderly people, it is expected that a portion of subjects will miss the follow-up. Imputation is a better method than ignoring these subjects in the analysis. Furthermore, with longer follow-up, additional patients classified into the union category may experience decline and warrant surgical treatment, as suggested by the study of Crockard *et al*.[30]

CONCLUSION

Odontoid fractures are the most common isolated spine fracture in the elderly, and the number of elderly is rapidly increasing in the United States. A subset of patients may not be surgical candidates, whether due to chronic comorbid conditions, other associated injuries, or by personal choice. Of the 50 elderly patients with type II odontoid fracture treated nonoperatively, 11 (22.0%) developed nonunion, with 7 subsequently requiring surgical treatment. Another 4 nonoperatively treated patients initially placed in the union category developed late fracture displacement and subsequently had surgical treatments. Thus, a total of 15 (30.0%) nonoperatively treated patients developed a primary or secondary nonunion, and a total of 11 (22.0%) nonoperatively treated patients ultimately required surgery. Outcome data demonstrated a significant increase in disability and decline in health-related quality of life at 12 months after injury, but did not demonstrate apparent differences in these measures between patients who did

and did not achieve union. However, it is important to emphasize that the 12-month outcomes for the nonunion patients reflect the status of the patient after delayed surgical treatment in the majority of these cases. These data do not necessarily support nonoperative treatment as a first-line approach for all type II odontoid fractures in the elderly, and suggest that if it is pursued, it should be done so with the recognition that the nonoperative approach is associated with high rates of mortality, nonunion, and need for delayed surgical treatment.

➢ Key Points

- ❑ Odontoid fractures are among the most common fractures in the elderly, and controversy exists regarding management.
- ❑ Nonoperative treatment for type II odontoid fractures in the elderly has high rates of nonunion and mortality. Fifteen (30.0%) nonoperatively treated patients who survived beyond 90 days from presentation developed a primary or secondary nonunion, and 15 (25.9%) of the total 58 patients expired by 12-month follow-up.
- ❑ Four (10.3%) patients initially classified as having achieved fracture union developed a delayed fracture displacement and underwent surgical treatment. This highlights the difficulties of determining fracture union stability with nonoperative treatment in clinical practice.
- ❑ Elderly patients with type II odontoid fracture who developed nonunion after nonoperative treatment did not report worse 12-month outcomes compared with those who achieved union; however, the majority of patients with nonunion required delayed surgical treatment.
- ❑ These data do not necessarily support nonoperative treatment as a first-line approach for all type II odontoid fractures in the elderly, and suggest that if it is pursued, it should be done so with the recognition that the nonoperative approach is associated with high rates of mortality, nonunion, and need for delayed surgical treatment.

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