

Clinical Study

# Atlantoaxial instability in acute odontoid fractures is associated with nonunion and mortality

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Received 31 October 2013; revised 3 February 2014; accepted 16 March 2014

## Abstract

**BACKGROUND CONTEXT:** Odontoid fractures are the most common geriatric cervical spine fractures. Nonunion rates have been reported to be up to 40% and mortality up to 35%, and poor functional outcomes are common. Atlantoaxial instability (AAI) is a plausible prognostic factor, but its role has not been previously examined.

**PURPOSE:** To determine the effect of severe AAI on the outcomes of nonunion and mortality in patients with acute odontoid fractures.

**STUDY DESIGN:** Retrospective cohort/single institution.

**PATIENT SAMPLE:** One hundred twenty-four consecutive patients with acute odontoid fractures.

**OUTCOME MEASURES:** Rates of nonunion and mortality.

**METHODS:** Two independent blinded reviewers measured AAI using postinjury computed tomography scans. Patients were classified as having “severe” or “minimal” AAI on the basis of greater versus less than or equal to 50% mean subluxation across each C1–C2 facet joint. Rates of nonunion and mortality were compared using independent samples *t* tests and adjusted for age, displacement, and subtype using binary logistic regression.

**RESULTS:** One hundred seven patients had minimal AAI and 17 had severe AAI. Mean follow-up was 4.4 months (standard deviation=4.6). Patients with severe AAI were more likely to experience nonunion (29% vs. 10%, respectively;  $p=.03$ ) and mortality (35% vs. 14%, respectively;  $p=.03$ ) regardless of treatment modality. Fracture displacement correlated with AAI ( $r^2=0.65$ ). When adjusted for patient age, the odds ratio of nonunion with severe AAI approached significance at 3.3 (95% confidence interval [CI]: 0.9–11.7). Mortality prediction with AAI approached a twofold increased risk (odds ratio=2.1; 95% CI: 0.6–6.8). In patients with Type-II fractures, the odds of mortality with severe AAI approached a threefold higher risk (odds ratio=3.3; 95% CI: 0.9–12.3).

**CONCLUSIONS:** Patients with acute odontoid fractures and severe AAI may be more likely to experience nonunion and mortality, suggesting the possibility that aggressive management could be warranted. Further investigation with a large prospective study including patient-important functional outcomes is justified. © 2015 Elsevier Inc. All rights reserved.

## Keywords:

Trauma; Odontoid; Cervical; Mortality; Nonunion; Spine

FDA device/drug status: Not applicable.

Author disclosures: **NE:** Nothing to disclose. **BY:** Nothing to disclose.

**KM:** Nothing to disclose. **MG:** Nothing to disclose. **BD:** Nothing to disclose. **MB:** Consulting: Stryker (F); Smith & Nephew (F), Amgen (F), Zimmer (F), Moximed (F), Bioventus (F); Grants: Stryker (F, paid directly to institution), Smith & Nephew (E, Paid directly to institution). **DK:** Nothing to disclose.

The disclosure key can be found on the Table of Contents and at [www.TheSpineJournalOnline.com](http://www.TheSpineJournalOnline.com).

This study received funding from the Hamilton Health Sciences Spine Program and MB is funded in part by a Canada Research Chair. The authors do not declare any conflict of interests.

Investigation performed at McMaster University, Ontario, Canada.

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## Introduction

Odontoid fractures are the most common geriatric cervical spine fractures and account for up to 15% of all adult cervical spine fractures [1,2]. Their clinical management has proven particularly challenging and is part of an emerging geriatric spine fracture health care crisis [3]. Nonunion rates have been reported to be up to 40% and mortality rates up to 35%, and poor functional outcomes are common [4–6]. There remains substantial uncertainty about the optimal treatment of patients with acute odontoid fractures [5,7–9].

The identification of prognostic factors is critical to optimize the clinical management and guide potential randomized trials. Acute atlantoaxial instability (AAI) may be a marker of increased injury severity, but its role as a plausible prognostic factor in the evaluation of patients with acute odontoid fractures has not been defined. Biomechanical studies confirm that acute AAI requires substantial ligamentous disruption [10–12], and case reports describe an association between AAI and catastrophic neurologic deterioration [13–16].

The objective of this investigation was to determine the effect of severe AAI on the outcomes of nonunion and mortality in patients with acute odontoid fractures. This is a retrospective cohort study that included all eligible patients treated at a single institution over a 10-year period.

## Material and methods

This study received approval from the study hospital's Research Ethics Board (Study # 13-493-C).

### Patient selection

All consecutive patients of any age from 2003 to 2013, who were diagnosed with acute odontoid fractures and had postinjury computed tomography (CT) scans were retrospectively identified from a hospital medical records database at a single academic tertiary care institution. Patients were excluded if they [1] had rheumatoid arthritis because they would be at higher baseline risk for AAI [17]; [2] had pathologic fractures because they would be at higher baseline risk for nonunion and mortality [18]; or [3] did not have a post-injury CT scan available for retrospective review because CT scans were required to diagnose and measure AAI.

### Clinical data collection

A single reviewer extracted demographic and clinical outcome data from electronic medical records into an electronic spreadsheet database. Data points included age, gender, modality of initial treatment (cervical orthosis, halo immobilizer, anterior odontoid screw(s), anterior C1–C2 fusion, or posterior C1–C2 fusion), duration of follow-up, and occurrence of nonunion, deep infection, neurologic deterioration, or mortality. Comorbid medical conditions, associated nonspinal injuries, and smoking status were not

## EVIDENCE & METHODS

### Context

Odontoid fractures are among the most common fracture patterns identified in the elderly. Non-union and mortality in the setting of this injury are known to be high. The contribution of atlantoaxial instability (AAI) to these outcomes has not been sufficiently examined previously.

### Contribution

The authors performed a retrospective review of 124 patients with odontoid fractures, 17 of whom were found to have radiographic evidence of severe AAI. Patients with severe AAI developed non-union and died at greater rates than individuals with minimal AAI.

### Implications

The authors correctly point out that this study is confounded by selection, measurement and classification bias. Limitations in the study sample as a whole, as well as the number of patients identified as having severe AAI, impaired the authors' capacity to identify statistically significant associations and evaluate the role of surgery in mediating outcomes. While the authors report patients with severe AAI as being at increased odds of mortality, these findings were not statistically significant.

—The Editors

collected because initial screening revealed inconsistent documentation and frequent missing data. All of the nonunions were diagnosed by treating surgeons on their basis of flexion-extension radiographs or CT scans combined with their clinical judgment.

### Radiologic data collection

Two experienced reviewers independently reviewed all of the presenting CT scans (sagittal, coronal, and axial sequences) and classified the fractures using the system of Anderson and D'Alonzo [19]. Differences were resolved by consensus or discussion with a senior colleague. One reviewer performed measurement of linear fracture displacement and AAI using standard radiologic software and the second reviewer verified or corrected all of the measurements. Linear fracture displacement was measured using midline sagittal images [5]. Atlantoaxial instability was defined as mean subluxation across both C1–C2 facet joints in each patient, and subluxation at each facet joint was calculated as the percentage of uncovering of the C2 superior articular facet (Fig. 1). The sagittal CT image that best displayed the facet joint and maximal subluxation was selected for each measurement. Patients were classified as having “severe” or “minimal” AAI on the basis of greater versus less than or equal to 50% mean subluxation across

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