

# Comparison of surgical and conservative treatments for odontoid fractures in the elderly: results from three tertiary referral centers in the netherlands

## Abstract

**Objective:** Odontoid fractures are the most common cervical spine fractures in elderly patients. The optimal treatment in this age group remains controversial. The goal of this study was to compare outcomes of surgical and conservative treatments.

**Methods:** A retrospective cohort study was conducted in three tertiary referral centers in the Netherlands. Patient records were reviewed for patients who met the selection criteria (i.e. age  $\geq 55$  years, type II/III odontoid fractures). Fracture healing (union/stability) and clinical outcome (Likert scale) were assessed. The influence of age, applied treatment, and treatment strategy ('fracture based approach' or 'primarily conservative') was studied.

**Results:** A total of 105 patients was included (18 treated surgically, 87 treated conservatively; 52 treated with 'fracture based approach', 53 treated 'primarily conservative'). No difference was found in fracture union (68% overall) and fracture stability (88% overall). Data on clinical outcome were scarce, but did not differ between treatment groups. Patients  $\geq 80$  years had worse outcomes in both applied treatment- and treatment strategy arms.

**Conclusion:** No radiological differences in outcome between surgical or conservative treatment (strategies) were observed. The majority of patients achieved fracture healing. The exact correlation between the quality of fracture healing (union or stability) and clinical outcome remains unclear. Advanced age ( $>80$  years) negatively influenced outcome.

**Keywords:** Odontoid fractures, Elderly, Surgical treatment, Conservative treatment, Cohort study

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**Abbreviations:** LUMC, Leiden University Medical Center, Leiden, The Netherlands; MCH, Medical Center Haaglanden, The Hague, The Netherlands; UMCU, University Medical Center Utrecht, Utrecht, The Netherlands; OR, Odds ratio; CI, Confidence interval;  $\kappa$  = Kappa; P, P-value

## Introduction

Accounting for 9-18% of cervical spine fractures in the elderly, odontoid fractures are the most common fractures of the geriatric cervical spine. As the population ages, the incidence is expected to increase.<sup>1-7</sup>

Treatment for odontoid fractures is either surgically or conservatively in nature. Surgical treatment involves anterior odontoid screw fixation or posterior (extended) atlanto-axial arthrodesis. Conservative treatment involves devices by which the patient's neck is immobilized, e.g. by halo-vest or hard cervical collar.

Particularly in the elderly, the choice for a particular treatment remains controversial. Elderly patients suffer from increased risks of surgical complications, as well as from increased risks of non-union, deterioration of the cervical spine alignment and prolonged treatment duration when treated conservatively. Finding the right balance between fracture healing and treatment complications is often challenging.<sup>8-10</sup>

Recent literature reviews on this topic were inconclusive, due to limited quantity and quality of the available data.<sup>5,11,12</sup> Recent clinical studies focused on survival and complications, but not on union, stability or clinical outcome.<sup>13,14</sup> One study showed better outcomes for surgically treated type II fractures.<sup>15</sup> Debate remains as to what

the goal of treatment should be, as there is little evidence that fracture union and -stability clearly correlate to favorable clinical outcomes.<sup>12,16</sup>

The primary goal of this retrospective study was to compare outcomes of surgical and conservative treatment for odontoid fractures in the elderly. Radiological (union/stability) and clinical outcome were assessed. Particular focus was laid on the influence of age on treatment outcome ( $\geq 55$ -80 versus  $\geq 80$  years), and the correlation between radiological and clinical outcome. Potential prognostic factors were studied (i.e. fracture dislocation, baseline functioning).

## Materials and methods

### Participating centers

There are two regions in the Netherlands with similar populations but different treatment strategies for odontoid fractures. The Leiden University Medical Center (LUMC) and Medical Center Haaglanden (MCH) are two hospitals following a fracture based approach. Surgical treatment is applied for dislocated fractures and relatively healthy patients. Conservative treatment is applied for non-dislocated fractures and patients in weak medical condition. The University Medical Center Utrecht (UMCU), on the other hand, follows a strategy of primarily conservative care always, irrespective of fracture characteristics and the patient's condition. These regions used these different strategies consistently during the last decades.

### Patient selection

The data manager working for the LUMC and MCH conducted a sensitive search of the electronic patient records between 2000-2012. If necessary, hard-copy records were also consulted. The UMCU has

two prospectively acquired databases available of patients treated for spinal injuries between 2001-2012. Using these databases, patients with odontoid fractures could easily be identified. All patients who met the selection criteria and were admitted in these years were included (Table 1).

**Table 1** Selection criteria

Radiologically proven type II/III odontoid fracture according to the Anderson and d'Alonzo classification <sup>19</sup>
≥ 55 years
< 2 weeks after trauma
No previous treatment for odontoid fracture
No rheumatoid arthritis
No ankylosing spondylitis
Adequately documented treatment
Radiological follow-up data available

No medical ethics approval was necessary for this review. Patients admitted after 2012 were not included, as they were enrolled in a prospective study that is currently being conducted.<sup>17</sup>

## Data collection

Data were gathered in a pre-developed Excel database. Two review authors (JH/CVL for LUMC, JH/MA for MCH and JH/WBS

**Table 2** Data collection protocol

Baseline Data and Potential Prognostic Factors		
Age, sex		
Baseline functioning	ASA score (estimated) Karnofsky score (modified/estimated), categorized in three groups <sup>20</sup>	1 healthy – 5 moribund 1= normal activity/work (80-100 % Karnofsky) 2= unable to work/able to live at home (50-70 %) 3= unable to care for self (0-40 %)
Fracture type according to	Medical records Review authors (blinded for medical records)	
Fracture dislocation/angulation		
Other occipitocervical junction/C1-C2 fractures		
<b>Treatment data</b>		
Primary treatment applied	Surgical Conservative	
Treatment strategy	'Fracture based' (LUMC/MCH) 'Primarily conservative' (UMCU)	
Treatment/follow-up duration		
Secondary/tertiary treatment		
<b>Outcome parameters</b>		
Osseous union (preferably by CT)	Evidence of bone trabeculae crossing fracture site and absence of sclerotic borders adjacent to fracture site	
Fracture stability (preferably by dynamic X-ray)	Maximum of 2mm movement at fracture site on dynamic X-ray, or considered stable if CT showed union <sup>21</sup>	
	1. (Nearly) complete recovery 2. Some improvement 3. Not changed 4. Some deterioration 5. Severe deterioration	
Clinical outcome (compared to baseline)		
Complications	None, failure of initial treatment, lack of patient's compliance, death (whether or not related to fracture/treatment), other	

**Table 3** Summary of demographic and baseline data of included patients

	All (n=105)	Surgical (n=18)	Conservative (n=87)	P-value
<b>Mean age (years)</b>	74.8	76.3	74.5	0.493
<b>Age groups (years)</b>				0.988
Age < 80	64	11 (17%)	53 (83%)	
Age ≥ 80	41	7 (17%)	34 (83%)	
<b>Sex</b>				0.794
Male	38	7 (18%)	31 (82%)	

Table Continued...

	All (n=105)	Surgical (n=18)	Conservative (n=87)	P-value
Female	67	11 (16%)	56 (84%)	
<b>Baseline Functioning</b>				
Average ASA score (range 1-5)	2.6 (n=45)	2.7	2.6	0.286
Average Karnofsky score (range 1-3)	1.7 (n=43)	1.8	1.7	0.704
<b>Fracture Type (medical records)</b>				0.017
Type II	55 (52%)	15 (83%)	40 (46%)	
Type III	39 (37%)	3 (17%)	36 (41%)	
Unknown	11	0	11	
<b>Fracture Type (review authors)</b>				0.156
Type II	60 (57%)	13 (72%)	47 (54%)	
Type III	45 (43%)	5 (28%)	40 (46%)	
<b>Fracture Dislocation</b>				0.63
No dislocation	57 (54%)	8	49	
Dislocated/angulated anteriorly	19 (18%)	5	14	
Dislocated/angulated laterally	1 (1%)	0	1	
Dislocated/angulated posteriorly	28 (27%)	5	23	
<b>Other C1/C2 fractures present</b>	18 (17%)	4 (22%)	14 (16%)	0.53

Table 4 Summary of the main results

	Overall	Union	Stability
<b>Applied Treatment</b>		67 / 99 (68%)	86 / 98 (88%)
Surgical	12 / 17 (71%)	16 / 17 (94%)	
Conservative	55 / 82 (67%)	70 / 81 (86%)	
P-value	0.778	0.379	
<b>Treatment Strategy</b>			
'Fracture based' (LUMC/MCH)	33 / 49 (67%)	44 / 49 (90%)	
'Primarily conservative' (UMCU)	34 / 50 (70%)	42 / 49 (86%)	
P-value	0.945	0.538	
<b>Patient Age</b>			
Age <80	51 / 63 (81%)	61 / 62 (98%)	
Age ≥80	16 / 36 (44%)	25 / 36 (69%)	
P-value	0	0	
<b>Patient Sex</b>			
Male	26 / 36 (72%)	36 / 36 (100%)	
Female	41 / 63 (65%)	50 / 62 (81%)	
P-value	0.465	0.005	
<b>Fracture Type</b>			
Type II	32 / 56 (57%)	45 / 55 (82%)	
Type III	35 / 43 (81%)	41 / 43 (95%)	
P-value	0.011	0.043	
<b>Fracture Dislocation/Angulation</b>			
Yes	31 / 43 (72%)	40 / 43 (93%)	
No	36 / 56 (64%)	46 / 55 (84%)	
P-value	0.41	0.16	
<b>Presence of other C1/C2 fractures</b>			
Yes	13 / 17 (77%)	14 / 16 (88%)	
No	54 / 82 (66%)	72 / 82 (88%)	
P-value	0.394	0.973	

Table 5 Clinical outcome, secondary treatment and treatment/follow-up duration

	Applied Treatment			Age			
	All (n=105)	Surgical (n=18)	Conservative (n=87)	P-Value	< 80 Years	≥ 80 Years	
<b>Clinical outcome</b>				0.243			0.107
(Nearly) complete recovery	13	4	9		6	7	
Some improvement	3	0	3		1	2	
Not changed	5	1	4		4	1	
Some deterioration	7	4	3		4	3	
Severe deterioration	13	2	11		2	11	
<b>Secondary treatment</b>	19 (18%)	1 (6%)	18 (21%)				
<b>Median treatment duration in weeks (range)</b>		N.A.	13.0 (1-41) (n=42)				
<b>Median number of weeks of follow-up (range)</b>	24.0 (1-147) (n=104)	17.5 (9-110) (n=18)	24.5 (1-147) (n=86)	0.533			

**Table 6** Main results by age groups – (descriptive only because of small subgroups)

		Union		Stability		Complications			
		Yes	No	Yes	No	None		Failure initial treatment	Death
Surgical treatment	<80 years	8	3	11	0	11		2	
	≥80 years	4	2	5	1	5			2
Conservative treatment	<80 years	43	9	50	1	50	11		2
	≥80 years	12	18	20	10	24	6		9
Total	<80 years	51	12	61	1	61	13		2
	≥80 years	16	20	25	11	29	6		11

**Table 7** Inter-observer variability of Anderson and d'Alonzo classification

<b>Kappa (<math>\kappa</math>) = .588</b>		<b>Fracture Type According to Review Authors (Blinded Scoring)</b>	
Fracture type according to medical records		Type II	Type III
		Type II	Type III
Fracture type according to medical records	Type II	44	11
	Type III	8	31

clinical outcome could not be investigated due to insufficient data quantity.

## Prognostic factors

## Demographic factors

Patient <80 years were not treated differently than patients over  $\geq 80$  years (OR=1.008; CI.356-2.855). The outcomes in terms of union (OR=.188; CI.076-.468) and stability (OR=.037; CI.005-.304) of patients <80 were better than in patients  $\geq 80$  years. Median total follow-up duration was 24.5 weeks for patients <80 and 16.5 weeks for patients  $\geq 80$  years. No difference in clinical outcome between these age groups was found ( $p=.107$ ), possibly because of the relatively small groups.

No influence of patient sex on the applied treatment was found (OR=1.150; CI.405-3.266). Patient sex did also not influence the achievement of union (OR=.717; CI.293-1.753). Stability was, however, found significantly more in males compared to females (OR=1.240; CI 1.098-1.401, 7 missing).

## Baseline functioning

The average ASA and Karnofsky scores were equal in surgically and conservatively treated patients.

The average ASA scores at baseline of patients who achieved union and/or stability were not different from those who did not (ANOVA-analysis:  $p=.267$  for union,  $p=.281$  for stability). The average Karnofsky score at baseline of patients who achieved union was not different from patients who did not (ANOVA-analysis:  $p=.051$ ), but showed a better condition of patients who achieved stability ( $n=34$ ) than those who did not ( $n=6$ ; ANOVA-analysis:  $p=.008$ ).

## Fracture characteristics

The review author's fracture scoring identified 60 type II and 45 type III fractures. Out of 60 patients with type II fractures, 13 underwent surgical and 47 conservative treatments; out of 45 patients with type III fractures, 5 underwent surgical and 40 conservative treatments (OR=2.213; CI.726-6.743).

The inter-observer variability between the fracture scores of the authors and the initial patient records was  $\kappa=.588$ , indicating moderate reliability of the Anderson and d'Alonzo classification (Table 7).<sup>18</sup>

Fracture dislocation or angulation was present in 48 (46%) patients (10 surgically, 38 conservatively treated). No influence of the presence of fracture dislocation/angulation was found on the achievement of

## Clinical outcome

Clinical outcome could be established with certainty in only 41 patients. No difference in clinical outcome between surgically and conservatively treated patients was found based on these data ( $n=243$ ). The influence of the quality of healing (union/stability) on

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union (OR=1.435; CI .606-3.398) and stability (OR=2.609; CI .660-10.303).

No influence of the presence of other C1/C2 fractures was found on the achievement of union (OR=1.685; CI.502-5.651) and stability (OR=.972; CI.192-4.925). When corrected for the applied treatment, still no difference between patients with and without other C1/C2 fractures was found on union (p=.140) and stability (p=.567).

### Treatment strategy (LUMC/MCH vs UMCU)

Patients were treated with 'fracture based approach' (LUMC/MCH) in 52 cases, of which 17 (33%) were in fact primarily treated surgically. In 7 cases, primary surgery was performed because it seemed most suitable given the fracture characteristics (e.g. dislocation). One patient received surgery at his own request. In 9 of the 35 patients primarily treated conservatively, this was based on specific fracture characteristics (e.g. non-displaced). Motivations were unclear in 35 of the 52 cases. 13 (25%) patients received surgery as secondary treatment.

Patients were treated with 'primarily conservative' approach (UMCU) in 53 cases, of which 52 (98%) were in fact primarily treated conservatively. In 42 cases, the surgeon's preference was decisive. One patient underwent surgery because he would not endure external immobilization. Motivations were unclear in 10 cases. 4 patients (8%) underwent secondary surgery and 2 patients (4%) received halo-vests as secondary treatment.

Outcomes between these strategies did not differ for union (OR=1.030; CI.444-2.392) and stability (OR=.682; CI.201-2.316). No conclusions could be drawn on difference in clinical outcome due to the relatively small patient numbers.

### Secondary/tertiary treatments

Secondary treatment was necessary in 20 patients, of which 18 patients were primarily treated conservatively (12 with halo-vest, 6 with cervical collar). The average moment for secondary treatment was 16.2 weeks after starting the initial treatment (range 1-48).

One patient who was primarily treated with odontoid screw fixation had to undergo secondary posterior fixation. Another patient who was primarily treated with posterior fixation had to undergo secondary odontoid screw fixation, after which he achieved fracture stability but no union.

18 conservatively treated patients had to undergo secondary treatment, consisting of surgery in 16 cases and halo-vests in 2 cases. After secondary treatments, 12 of 16 patients achieved union (75%, 2 missing) and 15 of 16 patients achieved stability (94%, 2 missing).

Three patients required tertiary interventions by way of surgery at 18, 30 and 34 weeks respectively, after they had already undergone surgery as secondary treatment.

### Complications and mortality

In the surgically treated group, 2 of 18 (11%) patients died (at 9 and 10 weeks, respectively, both >80 years). Secondary treatment was necessary in two patients, of whom one died. No major complications were recorded in the remaining 15 patients.

In the conservatively treated group, 11 of 87 (13%) patients died (range 1-125 weeks, 8 >80 years). Secondary treatment was necessary in 18 patients. No major complications were recorded in the remaining 58 patients.

For the thirteen patients who died, the median moment of death was 10.5 weeks after admittance.

## Discussion

The presented cohort of elderly patients with odontoid fractures is one of the largest in the available literature and thereby adds to the knowledge on the topic<sup>12</sup>. No difference in union and stability between different treatments was observed. Since this is a retrospective study, findings are probably subjected to concessions to the optimal treatment strategy as judged by the treating physician (e.g. surgery for severest cases in LUMC/MCH). Data on clinical outcome are scarce, but do not demonstrate a difference between the groups. No definitive recommendations for the choice between surgery and conservative treatment strategy can thus be made.

Patients between 55-80 years achieved significantly more union and stability compared to patients >80 years, regardless of the applied treatment. This supports the common hypothesis of deterioration of treatment outcome with advancing age.<sup>3</sup>

Patients with type III fractures showed both more fracture union and -stability compared to patients with type II fractures. These difference most likely results from larger bony contact areas and more adequate vascular supply of type III fractures, resulting in better fracture healing.<sup>3</sup> There is, however, no strong evidence that different fracture types should be treated differently. Moreover, the Anderson and d'Alonzo classification was found to suffer from evident inter-observer variability.

Contrary to the common presumption, the presence of odontoid fracture dislocation/angulation or multiple C1/C2 fractures did not negatively influence treatment outcomes. A possible explanation is that the presence of dislocation/angulation or multiple fractures made treatments last longer and thereby showing the same results as patient with non-displaced/single fractures. Moreover, the presence of dislocation or multiple fractures is a common reason for primary surgery in the 'fracture based approach' of the LUMC/MCH, which may have caused heterogeneity in favor of the conservatively treated group. Male patients achieved slightly more fracture stability than female patients, for which no explanation or confounders were found. No difference in union was found between the sexes.

At baseline, average Karnofsky scores showed a better condition (i.e. healthier) of patients who achieved stability than those who did not. Karnofsky scores were comparable between patients who achieved union and those who did not. Likewise, baseline ASA scores were not predictive for the achievement of union and stability. Hence, no strong evidence was found to support claims of better outcomes for healthier patients.

The treatment duration and total follow-up period did not differ between treatments and treatment strategies ('fracture based' versus 'primarily conservative' strategies). The most common complications were failure of the initial treatment. 11 conservatively treated patients died, of which 8 were over 80 years of age. Although these numbers are too small to allow further analysis, there seems to be a higher mortality risk in patients over 80 years.

### Strengths and limitations

The presented patient cohort is one of the largest available so far and thereby adds to the knowledge on the topic. The number of particularly the patients who were primarily treated surgically was, however, relatively small. This limited the analyses that could be performed. The retrospective nature of this study limits the reliability

of the data that were found (e.g. missing data and interpretation of data by non-direct observers).

## Conclusion

No difference in the achievement of fracture union, -stability or clinical outcome between surgically and conservatively treated patients was found. This may, however, be explained by group heterogeneity due to different selection mechanisms. Advanced age ( $\geq 80$  years) had a negative influence on treatment outcome in all treatment groups. Type III fractures showed better healing compared to type II fracture. No strong evidence was found for better outcomes in patients who are healthier at baseline or for worse outcomes in case of multiple/dislocated fractures.

## Implications for research

Prospective studies with appropriate sample size may find prognostic factors for the success of either one of the treatments and evidence on the relation between fracture healing and clinical outcome.<sup>17</sup> This would also provide a better understanding of the goal of treatment: to achieve fracture union, -stability, a favorable clinical outcome, or a combination of these.

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## Conflicts of interest

None.

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