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Mortality, complication, and fusion rates of patients with odontoid fracture: the impact of age and comorbidities in 204 cases

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Abstract

Purpose The French Society of Spine Surgery (SFCR) conducted a prospective epidemiologic multicenter study. The purpose was to investigate mortality, complication, and fusion rates in patients with odontoid fracture, depending on age, comorbidities, fracture type, and treatment.

Methods Out of 204 patients, 60 were ≤ 70 years and 144 were > 70 years. Demographic data, comorbidities, treatment types and complications (general medical, infectious, neurologic, and mechanical), and death were registered within the first year. Fractures were classified according to Anderson–D'Alonzo and Roy–Camille on the initial CT. A 1-year follow-up CT was available in 144 patients to evaluate fracture consolidation.

Results Type II and oblique-posterior fractures were the most frequent patterns. The treatment was conservative in 52.5% and surgical in 47.5%. The mortality rate in patients ≤ 70 was 3.3% and 16.7% in patients > 70 years ($p = 0.0002$). Fracture pattern and treatment type did not influence mortality. General medical complications were significantly more frequent > 70 years ($p = 0.021$) and after surgical treatment ($p = 0.028$). Neurologic complications occurred in 0.5%, postoperative infections in 2.0%, and implant-related mechanical complications in 10.3% (associated with pseudarthrosis). Fracture fusion was observed in 93.5% of patients ≤ 70 years and in 62.5% >70 years ($p < 0.0001$). Pseudarthrosis was present in 31.5% of oblique-posterior fractures and in 24.3% after conservative treatment.

Conclusions Age and comorbidities influenced mortality and medical complication rates most regardless of fracture type and treatment choice. Pseudarthrosis represented the main complication, which increased with age. Pseudarthrosis was most frequent in type II and oblique-posterior fractures after conservative treatment.

Keywords Odontoid fracture · Epidemiology · Morbidity · Mortality · Fusion

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Introduction

Odontoid fractures belong to the most common cervical injuries, and their incidence increases in the aging population [1, 2]. Despite their frequency, there is no clear consensus regarding management strategies with regard to fracture type, patient's age, and comorbidities. In the elderly, poor bone quality and medical comorbidities contribute to increased surgical risk, whereas non-operative management is associated with a risk of pseudarthrosis [3]. Most studies explore mortality and complication rates retrospectively in the geriatric population only, and it remains difficult to determine whether the prognosis is mainly influenced by the fracture itself or by the general health status [4, 5]. Other studies focus on conservative versus operative management, or anterior versus posterior instrumentation techniques with regard to complication and fusion rates [6–9]. Although age might influence clinical decision-making, there is a lack of clinical evidence comparing younger and elderly patients.

The purpose of this prospective register study was to investigate mortality, complication, and fusion rates in patients with odontoid fracture, depending on age, comorbidities, fracture type, and treatment.

Materials and methods

The French Society of Spine Surgery (SFCR) conducted a prospective epidemiologic multicenter study on C1–C2 trauma in 11 university hospitals from July 2014 to October 2015. This study was observational and no treatment recommendation was given. Out of 417 included patients, 204 patients (48.9%) presented an isolated odontoid fracture. The diagnosis of odontoid fracture had to be established on computed tomography (CT) using a sagittal bone window. Patients with associated fractures or C1–C2 subluxations were excluded. Patients with a severe head injury or polytrauma were excluded, since other lesions might primarily influence mortality and complications. The prospective follow-up was scheduled at 6 weeks, 3 months, 6 months, and 1 year.

The electronic database KEOPS (SMAIO, Lyon, France) was used for data collection. Standardized questionnaires were assessed during hospitalization and at each follow-up visit. CT and radiographic imaging were uploaded to allow a blinded review by two senior spine surgeons. The following items were analyzed:

- Epidemiology: age, gender, comorbidities, American Society of Anesthesiology (ASA) score, and trauma mechanisms.
- Fracture: classification as type I, II, or III according to Anderson and D'Alonzo [10], the classification of Roy–Camille [11] describing the fracture line orientation: oblique-posterior, oblique-anterior, or transverse (Fig. 1).
- Treatment: conservative treatment (type of cervical collar or brace), surgery (anterior screwing, type and levels of posterior instrumentation, posterior grafting, and postoperative immobilization), and secondary surgical treatment if primary conservative treatment failed.

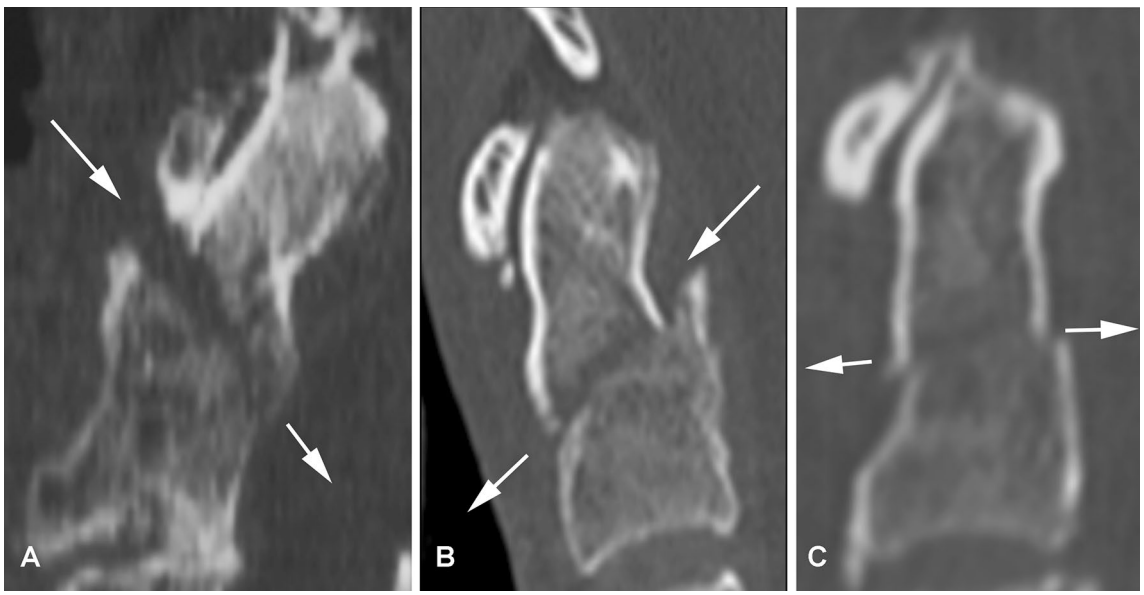

Fig. 1 Dens fracture classification according to Roy–Camille: oblique-posterior fracture is unstable in extension (**a**), oblique-anterior fracture is unstable in flexion (**b**), and transverse fracture is unstable in flexion and extension (**c**)

- Complications: general medical, neurologic, infectious, or mechanical.

Independent observers evaluated fracture fusion according to age, fracture type, and treatment. Sagittal and coronal thin cut CT images (0.6 mm–0.8 mm) were analyzed at 3-month follow-up. In the case of conservative treatment, the decision of stopping cervical immobilization was based on this imaging. If fracture consolidation was incomplete at 3 months, a second follow-up CT was requested until 1-year follow-up for final assessment. Fusion was then classified as complete, partial fusion, or pseudarthrosis (Fig. 2).

Functional scores were assessed: visual analog scale (VAS) for neck pain, neck disability index (NDI) and Euro-Qol-5D (EQ-5D). Complete reliable data sets were available in less than 30% of patients, especially in the geriatric population. Therefore, these scores should only be regarded as indicators resulting from a subset of patients. Because of incompleteness, it was decided to exclude this data from statistical evaluation.

Statistical analysis

Statistical analysis was performed using SAS software V9.3 (SAS Institute Inc, NC, USA). Qualitative variables were expressed as frequencies (*n*) and percentages. Qualitative variables were compared using a Chi-square test when application conditions were assumed. If not, a non-parametric Fisher's exact test was used. Quantitative variables were compared using a Student's *t* test. The significance level was set at 5%.

Results

Epidemiologic data

The cohort of 204 patients was made of 112 males (54.9%) and 92 females (45.1%). The average age was 73.8 ± 22.4 (16–100) years; 60 patients (29.4%) were aged ≤ 70 years (average 49.7 ± 24.1), whereas 144 patients (70.6%) were

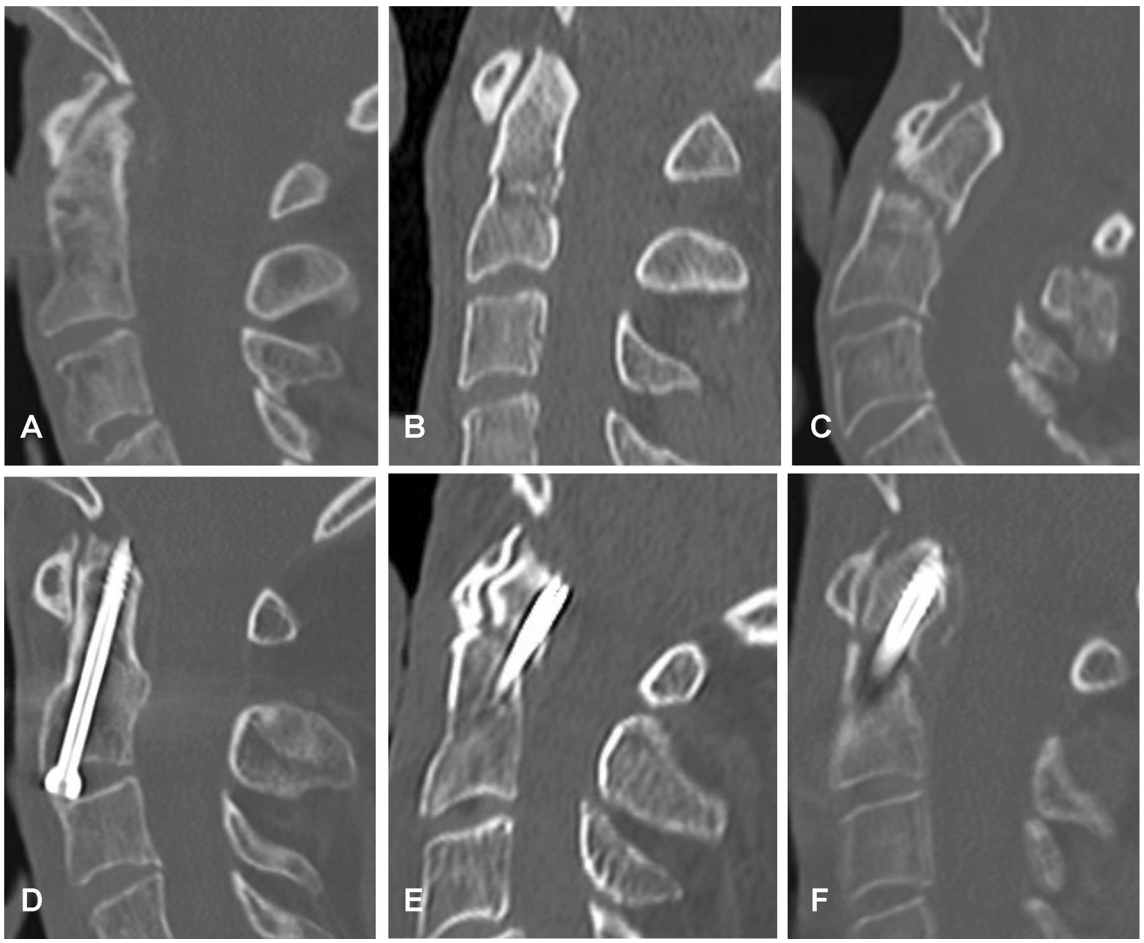

Fig. 2 Rating of fracture fusion after conservative (**a**–**c**) or operative (**d**–**f**) treatment: complete fusion (**a, d**), incomplete fusion (**b, e**), or pseudarthrosis (**c, f**)

aged > 70 years (average 81.2 ± 12.3). This cutoff at 70 years was further used for statistical comparison between younger and elderly patients.

Registered comorbidities were distributed as follows: 76 patients had cardiac pathologies (37.3%), 75 hypertension (36.8%), 63 diabetes (30.9%), 58 vascular (28.4%), 29 respiratory (14.2%), 23 neuro-cognitive (11.3%), 16 gastrointestinal (7.8%), 7 hepatic and alcoholism (3.4%), and 6 terminal renal insufficiency (2.9%). The following distribution of ASA scores was registered: 42 patients were ASA I (20.6%), 87 ASA II (42.6%), 55 ASA III (27.0%), and 20 ASA IV (9.8%).

The trauma mechanisms differed when comparing younger and elderly patients. In 60 patients ≤ 70 years, mechanism was: 49 road traffic accidents (81.7%), 5 falls from greater heights (8,3%), 4 sports accidents (6.7%), and 2 aggressions (3.3%). In 144 patients > 70 years, the following mechanisms were registered: 101 falls from smaller heights (70.1%), 24 falls from stairs and greater heights (16.7%), and 19 road traffic accidents (13.2%).

Fracture types and treatment

The distribution of fracture types is demonstrated in Table 1. The Anderson–D'Alonzo type II and oblique-posterior fracture according to Roy–Camille were the most frequent patterns in younger and elderly patients. The average fracture displacement (gap between fragments on CT) was 2.7 mm (0 mm – 12 mm). A displacement > 2 mm was measured in 95 patients (46.6%).

Table 1 Distribution of fracture types in age groups younger and older than 70 years

	Patients ≤ 70 years, $n = 60$	Patients > 70 years, $n = 144$	P
Anderson-D'Alonzo			
Type I	0 (0%)	1 (0.7%)	0.991
Type II	50 (83.3%)	121 (84.0%)	
Type III	10 (16.7%)	21 (14.6%)	
Roy–Camille			
Oblique-posterior	25 (41.7%)	106 (73.6%)	0.0002
Oblique-anterior	16 (26.7%)	18 (12.5%)	
Transversal	19 (31.6%)	20 (13.9%)	

The distribution of conservative and operative treatments is displayed in Table 2. Conservative treatment consisted of wearing a Philadelphia collar during 3 months in most cases. In the anterior surgery group, one single dens' screw was usually used. In the posterior surgery group, the Harms technique for C1–C2 fixation [12] was mainly used with autologous bone graft or a substitute. Secondary posterior fusion was indicated if conservative treatment failed within the first 3 months because of secondary displacement or delayed union on CT. The main reason for secondary complementary posterior C1–C2 fusion after dens screwing in younger patients was delayed anterior consolidation within 3 months.

Mortality

Twenty-six of 204 patients (12.7%) died within 1 year. Age and comorbidities were the main predictors of mortality. In the age group ≤ 70 years 2/60 patients (3.3%) died versus 24/144 patients (16.7%) in the age group > 70 years ($p = 0.0002$). The average age of patients who died was 85.3 years vs. 72.1 years in patients who survived ($p = 0.0004$). There was no patient graded ASA I, 1 patient was ASA II, 13 patients were ASA III, and 12 ASA IV ($p = 0.0187$). All patients had at least two comorbidities.

The fracture pattern had no influence on mortality. In 26 patients who died, 21 had a fracture type II (87.5%) and 19 had an oblique-posterior fracture (79.1%). This pattern was most common in the global cohort. The treatment had no influence on mortality. In the age group ≤ 70 years, one patient was treated conservatively and the other surgically. In patients > 70 years who died, 12 were treated conservatively and 12 surgically.

Table 2 Distribution of treatment types

Treatment	Patients ≤ 70 years, $n = 60$	Patients > 70 years, $n = 144$	P
Conservative	26 (43.3%)	81 (56.3%)	0.028
Surgical	25 (41.7%)	57 (39.6%)	
Secondary surgical	9 (15.0%)	6 (4.1%)	
Surgical approach	$n = 34$	$n = 63$	
Anterior	18 (52.9%)	39 (61.9%)	0.391
Posterior	16 (47.1%)	24 (38.1%)	

Table 3 Complications according to age

Complication	Patients ≤ 70 years, $n=60$	Patients > 70 years, $n=144$	P
General medical	8 (13.3%)	33 (22.9%)	0.021
Neurologic	0 (0%)	1 (0.7%)	0.453
Infection	2 (3.3%)	1 (0.7%)	0.058
Mechanical	4 (6.7%)	17 (11.8%)	0.042

Complications

Complication rates are presented according to age (Table 3) and treatment (Table 4). General medical complications were significantly more frequent in the age group > 70 years and after surgical treatment. Major complications were encountered in 41 patients: 13 respiratory (31.7%), 11 dysphagia (26.8%), 9 cardiac (22.0%), and 8 delirium (19.5%). Dysphagia and hoarseness were typically encountered after anterior screwing. The pulmonary complication rate (respiratory distress syndrome, and embolism) increased in surgically treated patients that underwent primary conservative treatment first. One patient presented an initial arm monoparesis and was then operated (Fig. 3). Infections were only encountered after surgery. Mechanical complications represented 19 dens screw loosenings associated to pseudarthrosis on CT (Fig. 4) and 2 intraarticular C0–C1 lateral mass screws after posterior instrumentation. Six patients with dens screw loosening were revised by posterior fixation. Pseudarthrosis was then analyzed separately according to treatment types.

Fracture fusion

A CT was available for 142 patients at 1-year follow-up. Fusion was rated complete in 65 patients (45.8%), partial in 38 patients (26.8%) and as pseudarthrosis in 39 patients (27.5%). Complete and partial fusions were grouped and further compared to pseudarthrosis. Age influenced fusion significantly ($p<0.0001$): fracture fusion was observed in 43/46 patients ≤ 70 years (93.5%) vs. 60/96 patients > 70 years (62.5%). Table 5 demonstrates pseudarthrosis rates per fracture type: it was most frequent in posterior oblique-posterior fractures ($p=0.001$). Pseudarthrosis occurred in 12/63 fractures (19.0%) with the initial displacement ≤ 2 mm vs. 27/79 fractures (34.2%) with the initial displacement > 2 mm ($p=0.054$). Table 6 demonstrates pseudarthrosis rates according to treatment: it was more frequent after conservative versus surgical treatment ($p=0.010$), and after anterior versus posterior surgical approaches ($p=0.042$).

Table 4 Complications according to treatment

Complication	Conservative, $n=107$	Primary surgical, $n=82$	Secondary surgical, $n=15$	P
General medical	15 (14.0%)	19 (23.1%)	7 (46.7%)	0.028
Neurologic	0 (0%)	1 (1.2%)	0 (0%)	0.412
Infection	0 (0%)	3 (3.7%)	0 (0%)	0.002
Mechanical	0 (0%)	19 (23.1%)	2 (13.3%)	0.014

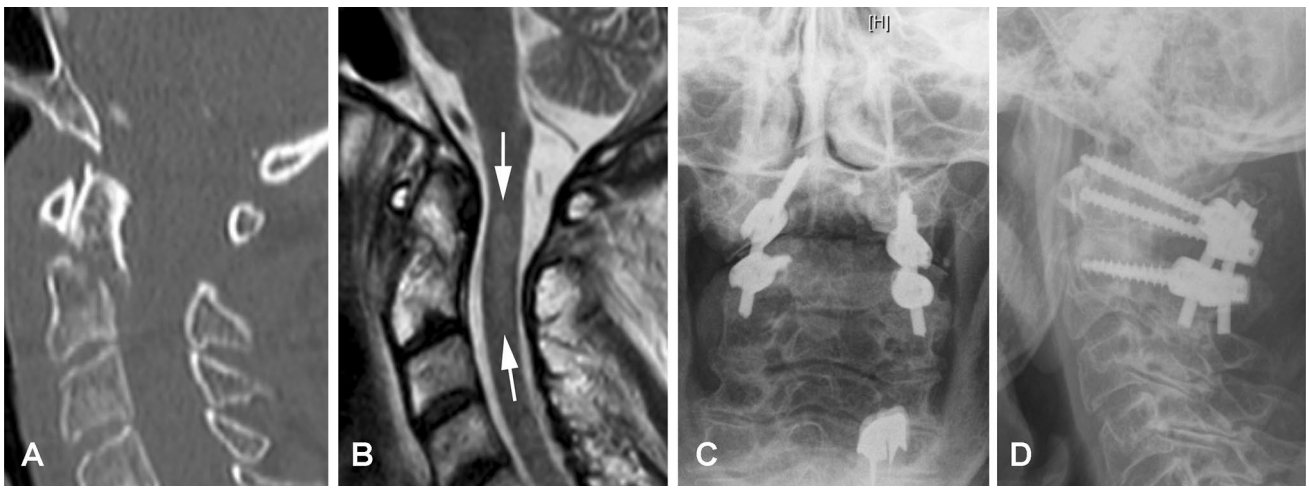

Fig. 3 Patient with initial arm monoparesis: emergency CT showing fracture displacement (**a**), MRI T2-weighted sequence showing spinal cord hypersignal (**b**), postoperative anterior-posterior (**c**), and lateral (**d**) radiographs

Fig. 4 Follow-up CT showing dens screw loosening and pseudarthrosis

Table 5 Fracture fusion on 1-year follow-up CT per fracture type

	Fusion, $n=103$	Pseudarthrosis, $n=39$	P
Anderson–D'Alonzo			
Type I	1 (100%)	0 (0%)	0.823
Type II	93 (72.1%)	36 (27.9%)	
Type III	9 (75.0%)	3 (25.0%)	
Roy–Camille			
Oblique-posterior	61 (68.5%)	28 (31.5%)	0.001
Oblique-anterior	17 (81.0%)	4 (19.0%)	
Transversal	25 (78.1%)	7 (21.9%)	

Table 6 Fracture fusion on 1-year follow-up CT per treatment

Treatment	Fusion, $n=103$	Pseudarthrosis, $n=39$	P
Conservative	81 (75.7%)	26 (24.3%)	0.010
Surgical	70 (85.4%)	12 (14.6%)	
Secondary surgical	14 (93.3%)	1 (6.7%)	
Surgical approach			
Anterior	47 (82.5%)	10 (17.5%)	0.042
Posterior	38 (95.0%)	2 (5.0%)	

Functional scores

The VAS score for neck pain was 4.6 ± 2.1 in conservatively treated patients ($n=28$) and 3.7 ± 2.3 in operated patients ($n=23$) on average at admission. At 1-year follow-up, VAS was 2.0 ± 1.5 in the conservative group ($n=21$) and 2.1 ± 1.1 in the surgical group ($n=18$).

The average initial NDI was 30.5% ± 20.1% in conservatively treated patients ($n=19$) and 36.3% ± 18.7% in operated patients ($n=18$). After 1 year, NDI scores were 20.9% ± 12.3% in the conservative group ($n=19$) and 26.8% ± 19.7% in the surgical group ($n=15$).

The average EQ-5D at admission was 0.60 ± 0.50 in the conservative group ($n=22$) and 0.64 ± 0.30 in the surgical group ($n=18$). At 1-year follow-up, respective values were 0.73 ± 0.30 in the conservative group ($n=15$) and 0.69 ± 0.30 in the surgical group ($n=13$).

Discussion

In the current literature, mortality rates after odontoid fractures are mainly reported in geriatric patients, although severely displaced fractures might also be lethal in younger patients. Cutler et al. [7] and Osti et al. [13] reported 1-year mortality rates of 6.8% and 8.6% respectively (12.7% in our cohort). The average ages of their cohorts were similar to our cohort, including patients above and below 70 years. In patients older than 70 years, mortality rates range between 5.4 and 35.3% within the first year (16.7% in our patients after 70 years) [2, 4, 5, 14–18]. Clark et al. [4] reported a median survival of 1.76 years in octogenarians. Chapman et al. [2] studied 322 geriatric patients and found that male sex and increased Charlson comorbidity index were associated with higher mortality on the multivariate analysis. This was confirmed by the studies of Stein et al. [18] and Woods et al. [19] who demonstrated that the number and severity of comorbidities had a major influence on mortality, which is in line with our findings. When comparing the mortality rates of younger and elderly patients, it appeared that the mortality rate was mainly related to age.

The impact of surgical versus nonsurgical treatment on survival is also debated in the literature. Molinari et al. [16] reported a 20% postoperative mortality rate vs. 12.5% after conservative treatment. In contrast, the meta-analysis of Deng et al. [14] reported a postoperative mortality of 5.4% vs. 10.1% after nonsurgical management, whereas the meta-analysis of Yang et al. [20] did not evidence significant differences in elderly patients. Dhall et al. [15] demonstrated that the patient mortality was similar: 10.3% postoperatively versus 13.0% after nonsurgical treatment. Chapman et al. [2] indicated a slight advantage for operated patients within 30 days; however, there was no difference at 2-year follow-up.

Perry et al. [5] and Woods et al. [19] demonstrated that mortality rates were identical after 1 year and at long-term follow-up. Our study confirms that the choice of treatment has no influence on mortality.

Acute respiratory distress syndrome and pneumonia represent common medical complications after odontoid fracture in geriatric patients with an incidence between 4 and 36.4% [7, 21]. Dysphagia and aspiration events are typically seen in elderly patients with dementia and might favor pulmonary complications [5]. Dysphagia and hoarseness represent complications that are mainly reported after dens screwing with an incidence between 10 and 27.9% [4, 22]. The need for a feeding tube is more likely after anterior surgery compared to conservative management [2]. An altered mental status or postoperative delirium is reported between 12 and 41.9%, which subsequently increases the risk for decubitus ulcera [4, 15, 21]. The incidences of decompensated cardiac insufficiency, arrhythmia and stroke, myocardial infarction, and cardiac arrest are rated between 1 and 2% [7]. When considering all medical complications, their incidence was found significantly higher after surgery compared to conservative management [5, 14–16], which is concordant with our findings. Furthermore, patients undergoing surgery are more likely to require longer hospitalization and less likely to return home [2, 15, 23]. Therefore, the risks of surgery in an elderly population should be carefully considered on a case-by-case basis [3].

Neurologic complications and delayed myelopathy represent rare events [5]. Ryang et al. [21] reported an incidence of 4% for arm paresis and ataxia respectively. In these cases of highly unstable fractures, a C1–C2 fusion was recommended. A similar management including emergency CT and MRI diagnostics followed by posterior fusion was indicated in the single case presenting neurologic symptoms in our study.

Postoperative septic complications are exceptional after anterior screwing, whereas the incidence of surgical site infection ranges between 0.2 and 2% for posterior fusion [7, 21, 22]. This rate was slightly higher in our cohort and infection occurred only after posterior instrumentation.

Mechanical complications occur more often after anterior surgery in elderly patients [22]. Dens screw loosening was regularly associated with pseudarthrosis in our patients. Osti et al. [13] described risk factors for dens' screw failures: severity of osteoporosis, degenerative atlanto-odontoid joint with sclerotic bone of the dens, posterior oblique fractures with comminution, incomplete fracture reduction, and suboptimal screw trajectory. Dens' screw loosening represents a risk for unplanned hospital readmission [24]. The need for revision surgery ranges between 3.6 and 13.6%. It is more frequent after anterior surgery compared to posterior fusion [8] or dens screwing combined with anterior transarticular atlanto-axial screw fixation [17]. If surgery is considered in elderly patients, C1–C2 fixation might, therefore, be preferred to dens screwing.

It is often debated whether odontoid fractures should be treated conservatively or surgically to achieve consolidation. However, pseudarthrosis is frequent in elderly patients as the bone of the dens is mainly cortical and poorly vascularized [6, 25]. Our study demonstrated that age influences the fusion potential significantly. Tian et al. [22] showed that age was the main predictor for fusion versus pseudarthrosis on multivariate meta-regression analysis. Our study showed that type II and oblique-posterior fractures had a higher risk for pseudarthrosis compared to the other types. Osti et al. [13] and Aldrian et al. [26] demonstrated that the amount of comminution and the residual displacement might play an additional role. It remains difficult to analyze exact fusion rates and associated factors from the literature, since bony union is not systematically assessed on CT. Huybregts et al. [1] reported fusion rates in geriatric patients between 66 and 85% after surgery, and between 28 and 44% after conservative treatment in a systematic review. Reinhold et al. [23] showed similar findings with fusion rates of 76.2% in the

Fig. 5 Displaced and unstable type II, oblique-posterior fracture with comminution

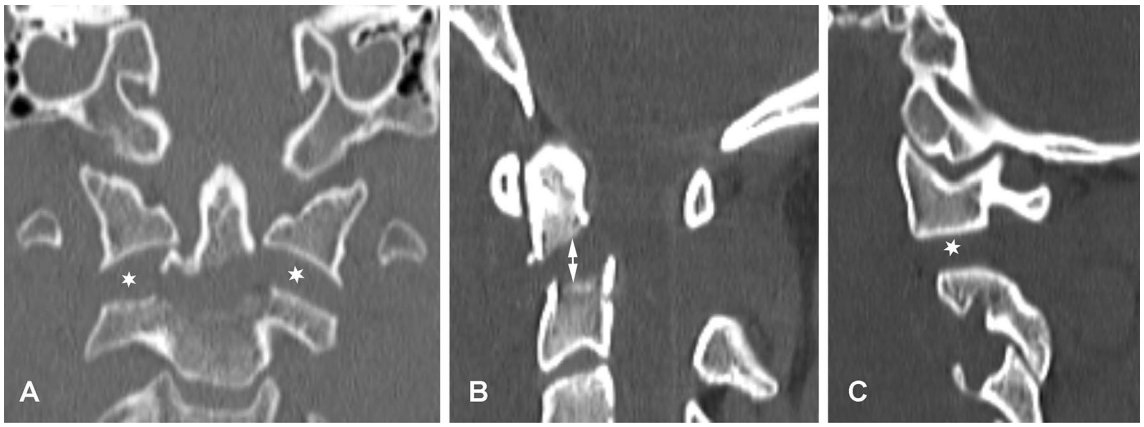

Fig. 6 Dens' fracture with vertical instability: evidenced by C1–C2 lateral mass (stars) and fracture gap (arrows) distraction > 3 mm on coronal (**a**) and sagittal (**b, c**) CT reconstructions

operative group versus 58.3% in the non-operative group. Yuan et al. [9] demonstrated the fusion rates of 90.9% after anterior screwing and 96% after posterior C1–C2 instrumentation in patients below 70 years. The meta-analysis of Shen et al. [25] indicated a protective effect of posterior arthrodesis on fracture consolidation in the elderly, whereas the significance was limited in younger patients. The clinical significance of fracture consolidation remains questionable in geriatric patients, as complication rates are higher after surgery and mortality remains similar in the operated and non-operated patients. Furthermore, Molinari et al. [16] showed that fracture healing and stability did not correlate with improved outcomes with respect to pain, function, and satisfaction. Therefore, surgery might be indicated in geriatric patients if the fracture is unstable and at risk for pseudarthrosis. Apart from large displacement and comminution (Fig. 5), attention should be paid to vertical atlantoaxial instability (Fig. 6), which represents a clear indication for C1–C2 fusion [27].

Conclusion

Age and comorbidities influenced mortality rates most regardless of fracture type and treatment choice. Medical complications were more frequent in the postoperative course of geriatric patients. The risk for pseudarthrosis increased with age. Pseudarthrosis was most frequent in type II and oblique-posterior fractures after conservative treatment.

Based on our findings and the literature, type I, III, and non-displaced type II fractures can be managed conservatively in most cases. In younger patients, displaced type II fractures (including early secondary displacement) should be managed by anterior screwing in oblique-posterior and transverse fractures, and by posterior C1–C2 instrumentation in oblique-anterior fractures. In elderly patients, the risk of surgery should be carefully considered. A fibrous non-union might be well tolerated and acceptable. If the fracture is severely displaced, comminuted, or unstable, posterior fixation might be preferred to anterior screwing, especially in the context of poor bone quality.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval Ethical approval (Reference FC 2018-28) was obtained for this observational study.

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