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ORIGINAL ARTICLE

Type II odontoid fracture in elderly patients treated conservatively: is fracture healing the goal?

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Abstract

Purpose Analysis of functional outcome of elderly patients with type II odontoid fractures treated conservatively in relation to their radiological outcome.

Methods A total of 50 geriatric patients with type II odontoid fractures were treated with Aspen/Vista collars. On admission, each patient was assessed assigning ASA score, modified Rankin Scale (mRS-pre) and Charlson Comorbidity Index (CCI). From 12–15 months after treatment, functional evaluations were performed employing a second modified Rankin Scale (mRS-post) together with Neck Disability Index (NDI) and Smiley-Webster pain scale (SWPS). Radiological outcome was evaluated through dynamic cervical spine X-rays at 3 months and cervical spine CT scans 6 months after treatment. Three different conditions were identified: stable union, stable non-union and unstable non-union. Surgery was preferred whenever a fracture gap > 2 mm, an antero-posterior displacement > 5 mm, an odontoid angulation > 11° or neurological deficits occurred.

Results Among the 50 patients, 24 reached a stable union, while 26 a stable non-union. Comparing the two groups, no differences in ASA ($p = 0.60$), CCI ($p = 0.85$) and mRS-pre ($p = 0.14$) were noted. Similarly, no differences in mRS-post ($p = 0.96$), SWPS ($p = 0.85$) and NDI ($p = 0.51$) were observed between patients who reached an osseous fusion and those with a stable fibrous non-union. No effects of age, sex, ASA, mRS-pre, fracture dislocation and radiological outcome were discovered on functional outcome. At logistic regression analysis, female sex and high values of CCI emerged associated with worse NDI.

Conclusions In geriatric type II odontoid fractures, pre-injury clinical status and comorbidities overcome imaging in determining post-treatment level of function. Hard collar immobilization led to a favourable functional outcome with mRS-post, NDI and SWPS values diffusely encouraging whatever a bony union or a fibrous non-union was obtained.

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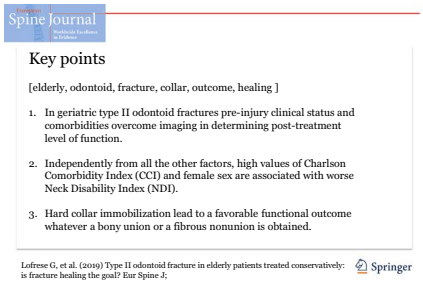
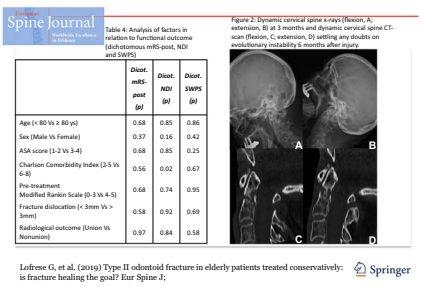
Extended author information available on the last page of the article

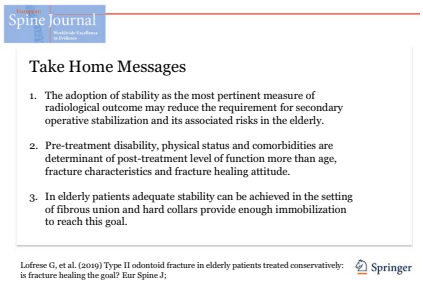
Graphical Abstract

These slides can be retrieved under Electronic Supplementary Material.





	Dicot. mRS-post (p)	Dicot. NDI (p)	Dicot. SWPS (p)
Age (< 80 Vs ≥ 80 ys)	0.68	0.85	0.86
Sex (Male Vs Female)	0.37	0.16	0.42
ASA score (1-2 Vs 3-4)	0.68	0.85	0.25
Charlson Comorbidity Index (2-5 Vs 6-8)	0.56	0.02	0.67
Pre-treatment Modified Rankin Scale (0-3 Vs 4-5)	0.68	0.74	0.95
Fracture dislocation (< 3mm Vs > 3mm)	0.58	0.92	0.69
Radiological outcome (Union Vs Nonunion)	0.97	0.84	0.58



Keywords Elderly · Odontoid · Fracture · Collar · Outcome · Healing

Introduction

Odontoid fracture represents the most common cervical spine fracture for patients aged 65 years or over, and it is the most common spine fracture for patients older than 80 years of age [1]. Osteoporosis, scarce blood supply to the base of the odontoid and altered regional biomechanics predispose these patients to non-healing [2]. One of the main goals of treatment should be focused on rapid mobilization of the patients whatever the choice for odontoid stabilization. Much of the morbidity of type II geriatric odontoid fractures has traditionally been thought to be due to the risk of non-healing; thus, radiological osseous union has been used to determine the optimal treatment outcome [2, 3]. Some authors instead consider a stable non-union an acceptable result in the elderly [3, 4]. Considered the high rates of morbidity and mortality of surgical fixations in this subset of patients, the significant complications and the increased morbidity associated with halo vest immobilizations [5, 6], we analysed the functional outcome of patients aged 65 or over with type II odontoid fractures, reaching bony union or non-union after treatment with hard cervical collar.

Materials and methods

Study population

From January 2012 through December 2016, 204 consecutive patients were treated for type II odontoid fractures in four different trauma centres of Emilia-Romagna, Italy (Maggiore Pizzardi Hospital, Bologna; University Hospital, Ferrara; University Hospital, Parma; Bufalini Hospital, Cesena). Patients under 65 years or with missing/incomplete data were excluded from the study together with those ones treated surgically or with halo vest. Type III odontoid fractures, previous surgery involving the subaxial cervical spine, penetrating mechanism of injury and cognitive impairment were other exclusion criteria. Among the remaining 60 patients, 7 died before 6-month follow-up and 3 were lost at follow-up. At the hospital admission, all the 50 patients eligible for the study underwent a baseline cervical spine CT evaluation performed using a multidetector scanner. Images always contained multiplanar reconstructions (MPR), which were systematically reviewed to classify each fracture according to the Anderson and D'Alonzo and the Roy-Camille classifications. Dislocation of the odontoid process was measured whether necessary. The mechanism of injury was distinguished as low-energy trauma, motor vehicle collision and high-energy trauma. Aspen®/Vista® collars (Aspen Medical Products, Irvine, CA, USA), worn for 8–12 weeks, were preferred to optimize external immobilization while reducing the risk of decubitus. Because of the retrospective character of this study, with several surgeons being involved over the long observation period in different centres, there was no standardized protocol to direct the choice of nonsurgical or surgical treatment. Nevertheless, all the treating physicians preferred surgery in the presence of neurological deficits and whenever a fracture gap of more than 2 mm, an antero-posterior displacement of more than 5 mm or an odontoid angulation of more than 11° occurred [7–10]. Although the absence of formally shared criteria, these aforementioned conditions were considered signs of severe instability in which conservative treatments would not have been sufficient and surgery has been believed mandatory.

Functional and radiological assessment

On admission, each patient was clinically assessed adopting ASA score, modified Rankin Scale (mRS-pre) and Charlson Comorbidity Index (CCI), respectively, for estimating general physical status, degree of disability and mortality risk according to comorbidities. All patients were followed up as

outpatients at 1, 3, 6 and 12 months. From 12 to 15 months after treatment, functional evaluations were performed employing a second modified Rankin Scale (mRS-post) together with the Neck Disability Index (NDI) and the Smiley-Webster pain scale (SWPS), investigating general disability, neck-related disability and ability to return to work/former activity, respectively. Both NDI and SWPS were delivered as phone interview questionnaires by two different operators. In some cases, these questionnaires were administered as outpatients. The radiological outcome was evaluated through dynamic cervical spine X-rays at 3 months and CT scans of the cervical spine with MPR 6 months after treatment (Fig. 1). In cases with doubtful fracture healing attitude, dynamic cervical spine CT scans were obtained to rule out instability (Fig. 2). According to the evidences of both CT scan and dynamic X-rays, three different conditions were identified: stable union, stable non-union and unstable non-union. Union was defined by the evidence of bone trabeculae crossing the fracture line in the absence of loss of cortical continuity and sclerotic borders/bone resorption of fracture's fragments. Fracture stability was determined by the absence of secondary displacement of the odontoid process, proven through dynamic cervical spine imaging. In debatable cases, in which a dynamic cervical spine CT scan was performed, those fractures revealing an increase in displacement over 2 mm were considered unstable. Every fracture showing a radiological outcome characterized by the absence of osseous union and a secondary odontoid process displacement was classified as "unstable non-union".

Statistical analysis

The statistical analyses were performed with MedCalc, version 15.4 (1993–2015 MedCalc Software bvba). The main analyses of differences in terms of demographic data, pre-injury level of function, comorbidity and radiological outcome were performed using a Student's *t* test for continuous variables and a Chi-squared test for categorical variables. The Mann–Whitney test was adopted to compare functional outcome between the group of patients with stable union and that one with stable non-union of odontoid fracture. Testing of the significance of changes of pre-injury level of function between patients with stable union and those ones with stable non-union was performed through repeated measures of analysis of variance (ANOVA). The same analysis was adopted to verify the impact of age on outcome both

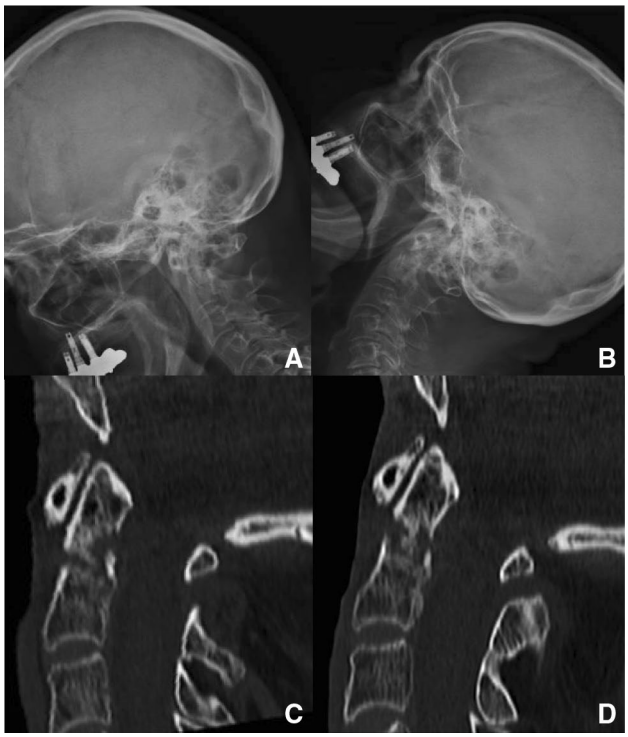


Fig. 2 Dynamic cervical spine X-rays (flexion, **a**; extension, **b**) at 3 months and dynamic cervical spine CT scan (flexion, **c**; extension, **d**) settling any doubts on evolutionary instability 6 months after injury

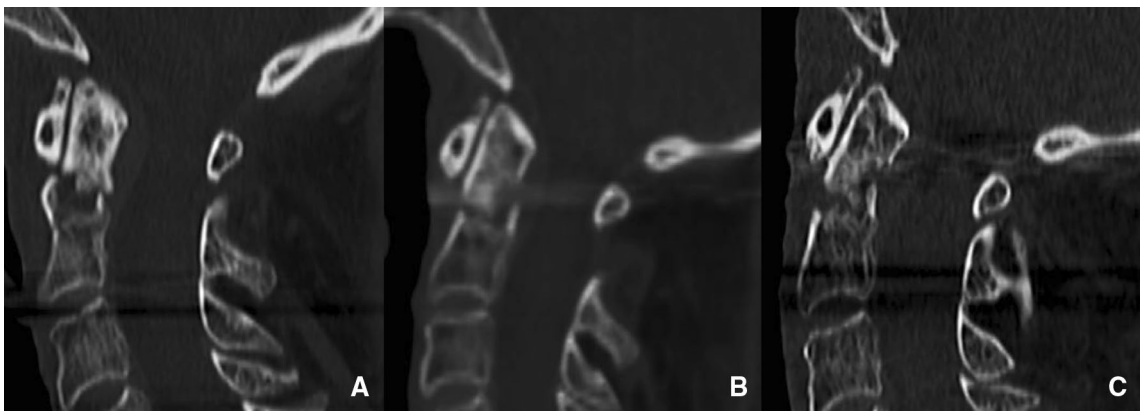


Fig. 1 Evolution of non-union of a geriatric type II odontoid fracture: post-traumatic (**a**), 3 months (**b**) and 6 months (**c**) CT scan

in stable union and in stable non-union. Analysis of contingency tables was performed to investigate the relation of patients' demographics, comorbidities, fracture's characteristics and radiological outcome with favourable/unfavourable functional outcome. Logistic regression analysis examined the impact of gender and CCI on dichotomous NDI (1–48% vs 50–100%) outcome. Results presenting $p \leq 0.05$ were considered statistically significant.

Results

Study population

Of the total 60 patients eligible for the study, 7 died (12%). In all these cases no treatment-related complications were noted as co-determinants of death, while all of them reported significant comorbidities at the admission which resulted to be the cause of exitus in all the death certificates. Excluding the three patients lost at follow-up, the remaining 50 treated with hard collar immobilization were divided as follows: 24 who reached a stable bony union and 26 who obtained a stable fibrous non-union. All the fractures were classified as type II, and in seven cases, an associated fracture of the posterior arch of the atlas was recorded. Neither spinal cord injuries nor neurologic impairments were evident at the admission. The vast majority of patients ($n = 41/50$) sustained their odontoid fracture from a low-energy impact such as a minor fall, while motor vehicle collision was significantly more common in the stable non-union than in stable-union group ($n = 6/26$ vs $n = 1/24$). Minor head traumas without sequelae were recorded in five cases, fracture of C1 ring in three cases, while cranio-facial fractures, ribs fractures and fractures of extremities, respectively, in three, two and one case. All the three patients with concomitant fractures of the atlas reached a bony fracture union. The median fracture fragment dislocation resulted 3 mm in the stable-non-union group and 1.9 mm in the stable-union group (t test, $p = 0.05$) (Table 1) with 2 mm of maximum increase in displacement at the follow-up with dynamic cervical spine imaging. Comparing the two groups (stable union vs stable non-union), no differences in terms of ASA (t test, $p = 0.60$), CCI (t test, $p = 0.85$) and mRS-pre (t test, $p = 0.14$) were noted in terms of pre-treatment level of function (Table 2). None of the rates of the specific comorbidity assessed differed significantly between the stable-union group and the stable-non-union group. None of the patients had non-union with instability. The age was not correlated with the cause of injury (F [2,47] = 1.726, $p = 0.189$) and, assumed the same type of immobilization for all the patients enrolled, both age (t test, $p = 0.39$) and sex (Chi-squared test, $p = 0.22$) revealed no correlations with the radiological outcome.

Functional outcome

According to the NDI, no significant differences were observed between patients with fracture union and non-union with a median value of 16 and 17, respectively. Independently from the radiological outcome, a non-significant trend towards worse NDI values was observed in younger (65–79 years) patients (t test, $p = 0.18$). Adopting the same

Table 2 Pre-treatment comorbidity and level of function

	All ($n = 50$)	Stable union ($n = 24$)	Stable non-union ($n = 26$)	p
ASA score	3 (1–4)	3 (1–3)	3 (1–4)	0.60
Charlson Comorbidity Index	5 (2–8)	5 (3–8)	5 (2–8)	0.85
Pre-treatment modified Rankin Scale	2 (0–4)	2 (0–4)	3 (0–4)	0.14

Table 1 Patients' demographics and characteristics of trauma (expressed in mean and standard deviation and percentages)

	All ($n = 50$)	Stable union ($n = 24$)	Stable non-union ($n = 26$)	p
Age (mean year ± SD)	82.7 ± 6.9	83.6 ± 6.4	81.9 ± 7.4	0.39
Sex				0.22
Male	20 (40%)	7	13	
Female	30 (60%)	17	13	
Cause of injury				0.15
Low-energy trauma	41 (82%)	22	19	
Motor vehicle collision	7 (14%)	1	6	
High-energy trauma	2 (4%)	1	1	
Fracture dislocation (median mm and range)	2 (0–5)	1.9 (0–5)	3 (0–5)	0.05
Spinal cord injury	–	–	–	

age distinction, no substantial variations were documented among patients younger and older than 80 years in terms of mRS-post ($U = 118.5$, $p = 0.29$) and SWPS ($U = 212$, $p = 0.35$). No significant differences were observed between patients who reached an osseous fracture fusion and those with a stable fibrous non-union in terms of mRS-post ($U = 309.5$, $p = 0.96$), SWPS ($U = 303$, $p = 0.85$) and NDI (t test, $p = 0.51$). No collar-related complications such as decubitus ulceration were documented. None of the patients' change in functional level was owing to neurologic deterioration, and, although with the limitation of a median follow-up of 16 months (range 12–27 months) for all patients, none developed clinical myelopathy or spinal cord injury during that period (Table 3). From the analysis of contingency tables for mRS-post, NDI and SWPS, no effects of age, sex, ASA, mRS-pre, fracture dislocation and radiological outcome were discovered on functional outcome. A significant result was noted, instead, for the CCI, which revealed a role in contributing to the final level of function exclusively in terms of NDI (Chi-squared test, $p = 0.02$) (Table 4). When correcting for confounding variables at logistic regression analysis, both female sex and high values of CCI emerged associated with worse NDI (Table 5).

Discussion

For type II odontoid fractures, there are no standard treatment guidelines and their management and aims are even more controversial in aged population. Functional outcome after collar management in this subset of patients has not been well defined, and it remains unclear for those patients who do not achieve fracture bony union after treatment [6]. This study provides a multiparametric assessment of

Table 3 Functional outcome

	All ($n = 50$)	Stable union ($n = 24$)	Stable non-union ($n = 26$)	p
Complications (treatment-related)				
Neck Disability Index	16 (0–58)	16 (0–48)	17 (0–58)	0.51
Post-treatment modified Rankin Scale	2 (0–4)	2 (0–4)	2 (0–4)	0.96
Smiley-Webster pain scale				0.85
Excellent	21 (42%)	11	10	
Good	22 (44%)	9	13	
Fair	6 (12%)	3	3	
Poor	1 (2%)	1	0	
Delayed myelopathy	–	–	–	

Table 4 Analysis of factors in relation to functional outcome (dichotomous mRS-post, NDI and SWPS)

	Dicot. mRS-post (p)	Dicot. NDI (p)	Dicot. SWPS (p)
Age (< 80 vs > 80 ys)	0.68	0.85	0.86
Sex (male vs female)	0.37	0.16	0.42
ASA score (1–2 vs 3–4)	0.68	0.85	0.25
Charlson Comorbidity Index (2–5 vs 6–8)	0.56	0.02	0.67
Pre-treatment modified Rankin Scale (0–3 vs 4–5)	0.68	0.74	0.95
Fracture dislocation (< 3 mm vs > 3 mm)	0.58	0.92	0.69
Radiological outcome (union vs non-union)	0.97	0.84	0.58

Table 5 Logistic regression analysis of factors affecting NDI outcome

Logistic regression analysis: dichotomous NDI	p	OR	95% CI for OR lower	95% CI for OR upper
Female sex CCI: 6 or 7 or 8	0.05	10.611	0.998	112,789
	0.008	12.671	1.893	84,810

functional outcome for a cohort of 50 elderly patients with type II odontoid fracture treated with hard cervical collar and stratified on the basis of radiological outcome (stable bony union vs stable fibrous non-union). Follow-up mortality rate was 12%, which is in line with the range from 4 to 42% reported in the literature [6, 11, 12] for nonoperatively treated type II odontoid fractures in elderly. The low mortality rate in our study may possibly be attributed to the emphasis on earlier mobilization of these patients soon after collar fitting [6].

Sex, age, mechanism of injury together with comorbidity and pre-treatment level of function did not affect fracture consolidation attitude, while, similar to other authors [13], we found that favourable functional outcome was positively correlated with advancing age, although this was outside statistical significance. All the fractures showed a displacement < 5 mm, and no differences were noted in terms of secondary neurological impairment and functional outcome between odontoid dislocation < 3 mm or > 3 mm. The 52% of stable fibrous union in our series is in the range reported in the literature for type II geriatric odontoid fracture [6].

Albeit many authors emphasize fracture's stability as the main goal to pursue with or without a proper osseous union [3, 14–16], some others still address their treatment strategy considering non-union of odontoid process as a life-threatening condition [17–22]. In our patient cohort, a similar distribution of stable non-union was noted between elderly and ultra-elderly and no significant differences in functional outcome were recorded between patients with stable union and those with stable non-union [6, 23]. Although with the limitation of a median follow-up of 16 months, neither complications nor crossovers to surgery occurred in both groups; thus, odontoid fracture stable non-union did not negatively influence the clinical course.

Consistent with the findings of other studies [14–16, 24], no patient developed delayed neurological sequelae, as consequence of non-union, or showed worsening of their clinical conditions during the follow-up [12].

While Vaccaro et al. and Schroeder et al. reported significantly improved NDI, Short Form 36 and mortality in patients treated operatively, we registered good and excellent functional outcome even with hard collar in asymptomatic patients with fracture gap, dislocation and odontoid angulation, respectively, < 2 mm, < 5 mm and < 11° [2, 25, 26].

High values of CCI appeared associated with worse NDI, thus emphasizing how age-related comorbidities play a crucial role, and how in the elderly, assumed a fibrous or osseous fracture stability, pre-injury clinical status overcomes imaging in determining post-treatment level of function [27].

Similarly, worse neck disabilities concerned female sex. This evidence should be further investigated, in order to define whether neuropsychological aspects, gender-related characteristics of the cervical tension band or specific daily activities can contribute to this association.

The 86% of the patients reported a good or excellent SWPS and with a median NDI of 16% and 17%, respectively, in stable-union and stable-non-union group, differently from other authors [20], and we did not notice disabling levels of residuals neck pain due to the mobilization with hard collar.

Overall immobilization with this cervical orthosis led to a favourable functional outcome with mRS-post, NDI and SWPS values diffusely encouraging whatever a bony union or a fibrous non-union was obtained [6, 23]. Aspen Vista collars granted an adequate compromise between the need for providing a satisfactory cranio-cervical immobilization and the purposes to minimize orthosis-related complications, to allow early mobilization promoting maximum respiratory function and preservation of mental health [28].

In the debated topic of odontoid fractures in the elderly, our study emphasizes once again the lack of correlation between clinical and radiological healing processes [3, 6, 20]. According to other authors [13], we consider an aggressive radiological follow-up as a key point to switch timely to the surgical strategy whether necessary [14]. At the 6-month assessment with dynamic cervical spine imaging (X-rays or CT scan), fracture fragment stability, defined as the absence of secondary odontoid process dislocation, appeared in our patients as the necessary and sufficient condition to start a gradual weaning from the cervical orthosis. In this sense, the use of dynamic cervical spine CT scan to avoid underestimation of non-union rate and to settle any doubts on evolutionary instability, after inconclusive functional X-rays, gives strength to the study [23].

We did not note an association of radiographic union with optimal functional outcome, and, according to other studies [3, 22], we demonstrated that adequate stability can be achieved in the setting of fibrous union, rather than bony union [15, 16] and that hard collars provide enough immobilization to reach this goal [29]. Since a stable non-union may represent a satisfactory target for elderly patients and fracture's characteristics and comorbidity have to be considered in decision making, conservative strategy in type II geriatric odontoid fractures appears as the result of a sort of specific treatment algorithm, which future multicentric studies could help to conceive providing a larger sample of this patient subgroup.

Limitations of this study lie in its retrospective design, in the relatively low patient sample size and in its mean age of 82.7 years with high rate of octogenarians, who often fell in the (anesthesiologist-driven) tendency to prefer nonsurgical minimally invasive treatment and whose deaths appeared always related to complications from underlying medical conditions. Further limitations are the absence of a standardized protocol of treatment and the median follow-up of 16 months, which could have led to underestimate the risk

of late onset myelopathy whose progression, in patients with established non-union, may take several years [22, 29].

Conclusion

The adoption of stability as the most pertinent measure of radiological outcome may reduce the requirement for secondary operative stabilization and its associated risks in the elderly patients [20].

Therefore, in aged population, nonoperative treatment of ununited odontoid fractures may be a reasonable management strategy, provided that a fibrous union imparts some measure of stability, there are few symptoms, and there is low risk of neurological impairment [14, 15, 29]. Nevertheless, a close follow-up treatment protocol should be considered for patients who are poor candidates for surgical fusion [6]. All the patients had the indication to wear collar even during their bed rest as well as in sitting or standing position. Since no collar-related complications were observed and nobody worsened their level of function, the prolonged immobilization with collar has not negatively compromised the advantages obtained adopting such conservative treatment, so 8–12 weeks of external immobilization appeared useful with a clinical benefit in terms of all the parameters of functional outcome analysed. Probably, this period could be shortened, but it is difficult to establish in advance a time interval in which the partial mechanical silence provided by the collar results sufficient to generate that stiff fibrous union, which guarantees adequate stability to the fracture.

Our study is the first evaluating post-treatment mRS, NDI and SWPS in geriatric type II odontoid fractures treated with cervical collar related to pre-treatment clinical conditions, comorbidity and level of function. Through the analysis of these multiple parameters, although in the setting of a retrospective cohort study, we add quality to the evidences on lack of correlation between radiological and functional outcome, supporting stronger the recommendation for hard collars when treating nonoperatively geriatric odontoid fractures.

Compliance with ethical standards

Conflict of interest The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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