



Original Article

Anterior fixation of odontoid fractures: results[☆]

João Pedro Ferraz Montenegro Lobo*, Vitorino Veludo Moutinho,
Antônio Francisco Martingo Serdoura, Carolina Fernandes Oliveira,
André Rodrigues Pinho

Department of Orthopedics, São João Hospital, Porto, Portugal

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ABSTRACT

Objective: To evaluate the clinical and radiological outcomes of the surgical treatment in patients diagnosed with odontoid fracture who underwent open reduction and internal fixation (ORIF) with screws.

Methods: This was a retrospective study with nine patients. Pain (visual analog scale [VAS]) and neurological status (Frankel scale) were assessed. The neck disability index (NDI) and the post-operative cervical range of motion were calculated. The cervical spine was radiologically evaluated (X-ray and CT) pre- and postoperatively.

Results: The mean age of patients was 70 years. All patients presented type IIb (Grauer classification) fractures, with a mean deviation of 2.95 mm. Two patients had subaxial lesions. The mean follow-up was 30 months. The mean time from trauma to surgery was seven days. The pre-operative Frankel score was E in all except one patient (B), in whom a post-operative improvement from B to D was observed. Post-operative pain was 2/10 (VAS). A total of 77% of patients presented a mild or moderate disability (NDI). Six patients regained full range of cervical movement, and bone union required approximately 14 weeks. Pseudarthrosis complications were observed in two patients (77% union rate), one patient presented screw repositioning and one case, dysphonia.

Conclusion: Delayed diagnosis is still an issue in the treatment of odontoid fractures, especially in elderly patients. Concomitant lesions, especially in younger patients, are not uncommon. The literature presents high fusion rates with ORIF ($\geq 80\%$), which was also observed in the present study. However, surgical success depends on proper patient selection and strict knowledge of the technique. This pathology presents a reserved functional prognosis in the medium-term, especially in the elderly.

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[☆] Work performed in the Department of Orthopedics, São João Hospital, Porto, Portugal.

* Corresponding author.

E-mail: joao.2523@hotmail.com (J.P. Lobo).

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Fixação anterior de fraturas do processo odontoide: resultados

R E S U M O

Palavras chave:

Lesão cervical
Fratura espinhal
Fixação de coluna
Processo odontoide
Parafusos ósseos

Objetivo: Avaliar os resultados clínicos e radiológicos do tratamento cirúrgico em pacientes com diagnóstico de fratura do processo odontoide submetidos a redução aberta e fixação interna (RAFI) com parafusos.

Métodos: Estudo retrospectivo com nove pacientes. Avaliada a dor (escala visual analógica [EVA]) e o estado neurológico (escala de Frankel). O Neck Disability Index (NDI) e a amplitude de movimento cervical pós-operatória foram calculados. A coluna cervical foi avaliada radiologicamente (Raio X e TC) nos períodos pré- e pós-operatório.

Resultados: A idade média dos pacientes foi de 70 anos. Todos os pacientes apresentaram fraturas do tipo IIb (classificação de Grauer), com desvio médio de 2,95 mm. Dois pacientes apresentaram lesões subaxiais. O seguimento médio foi de 30 meses. O tempo médio entre trauma e cirurgia foi de sete dias. O escore pré-operatório de Frankel foi E em todos, exceto em um paciente (B), no qual se observou uma melhora pós-operatória de B para D. A dor pós-operatória foi 2/10 (EVA). Um total de 77% dos pacientes apresentou incapacidade leve ou moderada (NDI). Seis pacientes recuperaram toda a amplitude de movimento cervical; a consolidação óssea levou aproximadamente 14 semanas. Foram observadas complicações de pseudartrose em dois pacientes (taxa de consolidação: 77%), um paciente necessitou reposicionamento do parafuso e um paciente, disfonia.

Conclusão: O diagnóstico tardio ainda é um problema no tratamento de fraturas do odontoide, especialmente em pacientes idosos. As lesões concomitantes, especialmente em pacientes mais jovens, não são incomuns. A literatura apresenta altas taxas de consolidação com RAFI ($\geq 80\%$), o que também foi observado no presente estudo. No entanto, o sucesso cirúrgico depende da seleção adequada do paciente e do conhecimento rigoroso da técnica. Esta patologia apresenta um prognóstico funcional reservado no médio prazo, especialmente em idosos.

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Introduction

Odontoid fractures comprise as many as 20% of all cervical fractures. The incidence of odontoid fractures increases substantially in older patients and represents the most common cervical fractures in patients older than 70 years.¹ These injuries usually result from low-energy impacts such as falls in the elderly or high-energy impacts such as motor vehicle accidents in the young and middle aged.² Type II fractures are the most common odontoid fracture, occurring in 65–74% of the cases. These fractures have similar biomechanical properties as transverse ligament injuries, i.e., a loss of the translational restriction of C1 on C2, creating the potential for spinal cord injury and severe late craniocervical deformities when healing is not obtained.³

Treatment strategies for odontoid fractures can vary from conservative management with an external immobilization (such as a cervical collar, Minerva, and other cervicotherapeutic orthoses, and halo orthosis), to operative management with anterior odontoid screw fixation (AOSF) or posterior cervical fusion with or without supplemental screw fixation.¹

Anterior screw fixation of odontoid fractures was first described in 1980 by Nakanishi and again in 1982 in a report by Bohler based on an 8-year experience.⁴ This procedure has the potential advantage of preserving cervical motion and

generally avoids the need for halo immobilization. It is technically challenging and has been associated with pseudarthrosis rates of up to 20%.⁴

There has not been a clear consensus among trauma spine surgeons on the need for operation and the ideal timing of such fixation in patient with an odontoid fracture. Moreover, the choice of management (operative vs. non operative, halo-vest immobilization vs. cervical orthosis) has been postulated to influence mortality. The halo vest, in particular, has been associated with an increased risk of complications and death in elderly patients.⁵

The authors proposed to evaluate the clinical outcome, imaging and complications after surgical treatment of patients diagnosed with odontoid fracture undergoing reduction and anterior fixation with screws during the period of 1 January 2009 to 31 December 2014.

Methods

Patient population

Retrospective study, over a 6-year period (2009–2014) with 9 consecutive patients who underwent direct anterior screw fixation in the context of C1–C2 instability Anderson and D'Alonzo Type IIb odontoid fractures. There were 7 male and 2 female patients who ranged in age from 27 to 94 years.

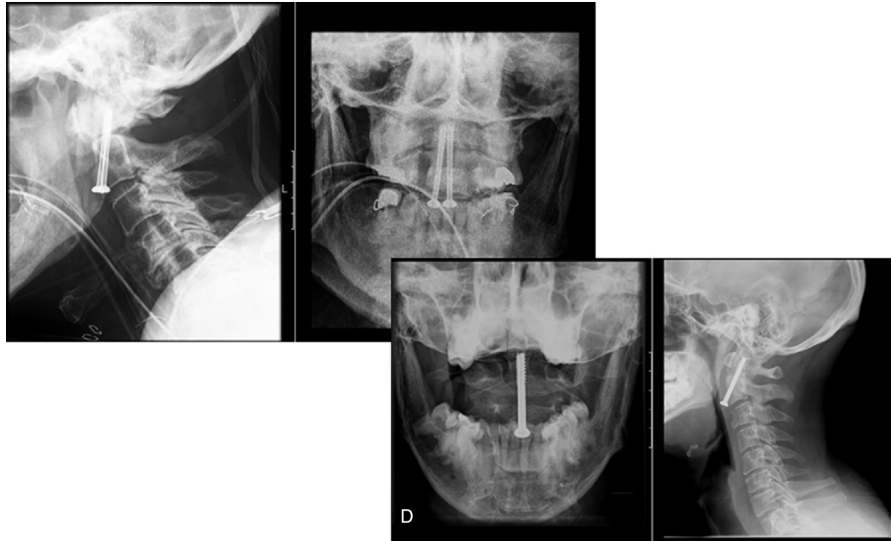


Fig. 1 – Examples of post op X-rays.

Clinical and neuroimaging evaluation

Clinical evaluation was made with a minimum of 2 years post op. Visual analog scale was used to evaluate pain and Frankel scale for neurological status. Neck disability index was used to evaluate the effect of neck pain in everyday life. A goniometer was used for analyses of post op cervical range of motion (CROM). All fractures were preoperatively assessed by evaluating the initial preoperative lateral, AP and open mouth odontoid X-ray films and CT scans of the odontoid (with the diameter of the odontoid process in the coronal plane in the region of transverse ligament of the atlas). Serial postoperative AP and lateral flexion–extension plain X-ray films of the cervical spine were obtained to evaluate fusion status (4 weeks, 3 and 6 months, 1 and 2 years). Postoperative CT scanning was also used to augment plain X-ray film studies in some cases. Anatomical bone fusion was considered successful if there was trabeculation across the fracture site, the absence of movement on lateral flexion–extension radiographic studies, and anatomical alignment of the fracture fragment.⁶

Operative technique

After general endotracheal anesthesia was induced, the patient was positioned supine on the operating table. X-ray fluoroscopy (2 devices – AP/Open mouth views + Lateral view) showed the fractures and its reduction. The C5–C6 disk space was identified by marking the thyroid and cricoid cartilage preoperatively, and then a skin incision was made between them. The carotid artery was laterally retracted after dissecting soft tissue carefully, and the trachea and esophagus were medially retracted. After exposing the anterior cervical spine, the antero-inferior margin of the C2 body was exposed. Under fluoroscopic control, 1 or 2 Kirchner wires of appropriate length where then inserted from the anterior aspect of the inferior margin of C2, through the central axis of the dens, to the opposing apical cortical bone. The Kirchner wires where then

replaced by one or two self-tapping 3.5-mm screws of appropriate length (Fig. 1).

Results

Nine patients who had type IIB odontoid fractures⁷ were treated consecutively by anterior odontoid screw fixation. No patients were excluded because of irreducible type IIB fractures. All patients were treated by anterior odontoid screw fixation, four using a single compression screw and five using two screws. There were seven men and two women, with a mean age of 70 years (range, 27–94 years) at the time of surgery. The average follow-up was 30 months. The mechanism of injury was a fall in seven patients and motor vehicle crash in two patients.

The diagnosis was made within 24 h after trauma in five patients. In the remaining four patient, the diagnosis was initially overlooked and was eventually made later. Two patients underwent operative fixation within one day of the injury, three days in one case, four days in one case, about one week in tree case and about two weeks in two cases (Table 1). Average time from trauma to surgery was seven days. The duration of surgery ranged between 45 min and 90 min. Two

Table 1 – Characterization of patients.

	Sex	Age	Trauma/diagnosis	Trauma/OOS
1	M	87	7 Days	14 Days
2	F	82	4 Days	9 Days
3	M	27	Same day	3 Days
4	M	84	Same day	9 Days
5	M	87	Same day	4 Days
6	M	83	5 Days	13 Days
7	F	94	7 Days	8 Days
8	M	45	Same day	1 Days
9	M	44	Same day	1 Days

Table 2 – Characterization of fracture and associated injuries.

	Type	Displacement (mm)	Angulation	Other injuries
1	IIB	5	Posterior (30°)	–
2	IIB	4.5	Posterior (9°)	–
3	IIB	1.5	0°	# C1, C6, C7
4	IIB	1.5	Posterior (5°)	–
5	IIB	5	Posterior (8°)	–
6	IIB	4	Posterior (4°)	–
7	IIB	1	0	–
8	IIB	1	0	–
9	IIB	3	Posterior (7°)	C5–C6

Table 3 – Details of odontoid anatomy, surgical technique and fusion rate.

	No. screws	Transverse diameter (Dens)	Entry point (mm) ^a	Union (months)
1	1	7	Inferior (1.6)	NU
2	1	7	Anterior (3.1)	3
3	2	8	Inferior (3)	6
4	2	8	Antero-inferior corner	3
5	2	10	Inferior (1)	3
6	2	7	Antero-inferior corner	NU
7	1	7	Anterior (5.5)	6
8	1	7	Anterior (5.6)	3
9	2	8	Antero-inferior corner	3

NU, non-union.

^a Distance (mm) to the antero-inferior corner of C2.

patients had associated fractures in the cervical spine. In case three, a combined odontoid fracture and fracture of C1, C6, C7, and in case nine there was also discoligamentar lesion of C5/C6.

The initial mean displacement was 2.95 mm (range, 1–5 mm). All fractures were displaced posteriorly (Table 2). The mean value of the transverse diameter of the odontoid was 7.6 mm with minimum value of 6 mm and maximum of 10 mm. Three patients had an anterior entry point of the screw relative to the antero-inferior corner of C2 (Table 3). An anatomic reduction of the dens was achieved in seven cases. In two patients, the dens fragment was left in slight posterior displacement. Bone consolidation average was 14 weeks. No radiographic signs of bone consolidation in two patients (77% consolidation). In terms of postoperative complications there were two cases of pseudarthrosis, one patient had screw repositioning and one case of dysphonia.

Frankel classification before surgery was grade E in all except one patient who had grade B. Postoperative improvement of patient with the grade B to grade D after surgery. Average values of post op pain where 2/10 (VAS). 44% of patients had a mild disability (NDI), 33% with moderate disability and only 1 patient with severe disability with a minimum of 2 year follow-up. Six patients regained full range of cervical movement. Three patients lost between 30% and 50% of neck rotation and one patient experienced limited movement in other planes (Table 4).

Discussion

Smith, Vaccaro and colleagues⁸ recently reviewed the trends in the surgical management for type II odontoid fracture at a regional spinal cord injury center and they concluded that the management of type II odontoid fractures in the octogenarian population are associated with substantial morbidity and mortality, irrespective of the management method. Our study was mostly composed of elderly patients and our clinical results show that most patients did not complain of neck pain (VAS 2/10), no patient suffered neurologic impairment but only 1 patient (≈11.1%) had no disability (NDI) after a minimum of 2 year follow up.

Theoretically, this operative technique does not limit neck rotation, although some recent studies show that there is some restriction of movement in at least one plane⁹ has it was shown in our study (Table 4).

In the series published in the literature of patients undergoing anterior fixation of odontoid fractures type II and type III, the average fusion rate is 80%. The risks associated with anterior fixation of odontoid with screws are directly related to the indications and surgical techniques.^{9,10}

Three basic requirements are needed for the patient to be considered a good candidate for anterior fixation of the odontoid. The first is the integrity of the transverse atlantal ligament, the second requirement is the good reduction of the fracture and alignment of the fragments and the third is the type of fracture.¹⁰⁻¹²

In general, most of the complications are related to incomplete fracture reduction with persistence of the posterior angulation of the fracture or incorrect location of the screw insertion when mistakenly placed in the anterior portion C2 body, instead of being introduced in the lower portion.¹¹

In this study most patients were old (≥65 years) and in contrast to the younger population, the mechanism of injury tends toward low-energy trauma such as simple falls. This is in part because cortical and cancellous portions of the dens become significantly less robust with age.¹³ The low-energy mechanism of injury and absence of severe neck pain at presentation increases the risk of delayed diagnosis.¹⁰ Usually, delayed fracture reduction cannot be easily achieved in the case of delayed diagnosis and the possibility of non-union is relatively high (2 cases of non-union with more than 13 days post injury).

The entry point of the screw is an aspect of the technique that is poorly described. The apical cortex is the densest area and for this reason it is essential that the fixation screw fully integrates the cortex and therefore a precise trajectory is required (lower cervical area).¹⁰ In our study three patients had an anterior entry point, with no difference in union rate compared with the others.

The transverse diameter of the dens is the smallest diameter and is the critical diameter for the placement of two screws as they are placed side by side in the coronal or the transverse plane. Initially, it was recommended using the two screw technique considering that it would provide superior mechanical stability. Odontoid diameters of some individuals may not be large enough to accommodate two 3.5-mm cortical screws. The diameter of the patients odontoid in this study was

Table 4 – Cervical range of motion.

	Flexion	Extension	Left lat flex.	Right lat flex.	Left rotation	Right rotation
Normal	50°	60°	45°	45°	80°	80°
1	20°	35°	N	N	45°	60°
2	N	N	N	N	N	N
3	N	N	N	N	N	N
4	N	N	N	N	66°	60°
5	N	N	N	N	N	N
6	N	N	N	N	40°	40°
7	N	N	N	N	N	N
8	N	N	N	N	N	N
9	N	N	N	N	N	N

measured with cervical CT and in 4/9 we could only place one screw safely. There were no differences in the union rate compared with 2 screw fixation. Two-screw fixation provides better stability in rotation and extension compared with one screw, but there are no significant differences in the union rate in the literature.¹⁴

Conclusion

Delayed diagnosis is still a handicap in the treatment of odontoid fractures and should always be suspected in elderly patients with neck pain after fall. It is necessary to be aware of the combination of concomitant lesions especially in younger patients.

The treatment of acute fractures of the odontoid type IIB using anterior screw fixation proved to be an effective method of treatment. Bone fusion of 77% is compared with other studies in the literature.

The success of this technique depends on proper patient selection, technical care in the perioperative period, the surgeon's experience and strict knowledge of the indications and contraindications of this technique. A part from any internal or external factor this pathology has (mainly in the elderly) a reserved functional prognosis in the medium term.

Conflicts of interest

The authors declare no conflicts of interest.

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