# Type II Odontoid Fractures: Is the Anterior Screw a Good Solution for all Patients? A Case Series of 60 Consecutive Patients

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■ OBJECTIVE: **Type II odontoid fracture is the most common fracture type, and its treatment remains challenging. The objective of this study was to evaluate the results of anterior screw fixation for type II odontoid fractures in patients aged over and below 60 years.**

■ METHODS: **A retrospective analysis of consecutive patients diagnosed with type II odontoid fractures who were surgically treated using the anterior approach by a single surgeon was conducted. Demographic characteristics, including age, sex, type of fracture, time from trauma to surgery, length of stay (LoS), fusion rate, complications, and reoperation, were evaluated. Surgical outcomes were compared between patients over and below 60 years of age.**

■ RESULTS: **Sixty consecutive patients underwent odontoid anterior fixation during the analysis period. The mean age of patients was 49.58 ± 23.22 years. Twenty-three (38.3%) patients were aged over 60 years, and the minimum follow-up period was two years. Of the patients, 93.3% developed bone fusion, which was observed in 86.9% of patients over 60 years. Complications related to hardware failure occurred in six (10%) patients. Transient dysphagia was observed in 10% of the cases. Three (5%) patients required reoperation. Patients over 60 years had a significantly increased risk of dysphagia compared with those below 60 years ($P = 0.0248$). There was no significant difference between the groups regarding nonfusion rate, reoperation rate, or LoS.**

■ CONCLUSIONS: **Anterior fixation of the odontoid showed high fusion rates with a low rate of complications. It is a technique to be considered for treating type II odontoid fractures in selected cases.**

## INTRODUCTION

Odontoid fractures account for 9%–15% of all cervical spine fractures, and the incidence of this type of fracture is increasing owing to an aging population.[1] Type II fractures are the most common, and the elderly have twice the incidence of odontoid fractures compared with young adults.[2,3]

There are several treatment options for odontoid fractures, and there is still controversy regarding the best treatment, especially in elderly patients who have a higher surgical risk, worse bone quality, and a greater chance of nonunion with conservative treatment.[4]

The most commonly performed surgical techniques are the anterior approach, with the implant of a screw in the odontoid through the fracture line, and the posterior approach, usually with atlantoaxial fixation.[5]

In elderly patients, osteoporosis increases the risk of screw loosening and pseudarthrosis following anterior fixation.[4] There is a question regarding the increased risk of dysphagia in the anterior approach, implying greater morbidity. The posterior approach has been proposed more frequently in the elderly population[6,7] and has high bone fusion rates but is associated with loss of cervical rotation.[4] The incidence of complications in the anterior and posterior approaches is still controversial.[8]

**Key words**
- Anterior
- Fracture
- Fusion
- Odontoid process
- Screw
- Spinal fracture

**Abbreviations and Acronyms**
CT: Computed tomography
OR: Odds ratio

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This study aimed to evaluate the results of anterior screw fixation for type II odontoid fractures in patients aged over and below 60 years.

## METHODS

### Study Design

This was a retrospective cohort study of all patients diagnosed with type II odontoid fractures who underwent consecutive surgeries using an anterior screw.

### Inclusion Criteria

All patients diagnosed with type II odontoid fractures who were operated on consecutively via the anterior approach by the same surgeon (FLRD) between January 1998 and December 2020 and had at least two years of follow-up.

### Exclusion Criteria

The exclusion criteria were chronic odontoid fractures (≥6 months), Anderson and D'Alonzo type I and III odontoid fractures, Grauer type IIC fractures,[9] associated Jefferson fractures, atlantoaxial instability (traumatic or caused by degenerative processes), transverse ligament injury, tumors, infections, inflammatory disorders, congenital cervical diseases, and irreducible fractures.

### Data Collection

Demographic data, including sex, age at surgery, last follow-up date, the time between trauma and surgery, cause of trauma, clinical presentation, number of screws used, and length of stay, were collected. The fractures were classified according to the Roy–Camille classification and were divided into transverse fractures or fractures that pass from anterior superior to posterior inferior, with or without displacement.[10]

The outcome data collected included follow-up time, fusion rate, implant-related complications (screw loosening, breakage, pullout, misplaced screw, and pseudarthrosis), clinical complications, and reoperation.

Radiographs and computed tomography (CT) scans were performed preoperatively and at 30, 90, and 180 days, one year, and two years postoperatively. All patients preoperatively underwent craniovertebral junction magnetic resonance imaging to rule out transverse ligament injury.

All patients were maintained using a rigid cervical collar for three months postoperatively.

Fusion was defined as the presence of a bony bridge and definite continuity of the cortical bone observed on postoperative CT.

The participants were divided into two groups: patients aged <60 years and ≥60 years. The incidence of postoperative dysphagia, non-fusion rate (pseudoarthrosis or fibrous union), length of hospital stay, and reoperation rate were compared between the groups.

### Surgical Technique

The patients were placed in the supine position on a radiolucent operating table with a cushion under their shoulders to allow slight neck extension. The mouth was kept open with a gauze roll, and the head was held in a neutral position. It is necessary that the fracture has been previously reduced or that the reduction is performed intraoperatively with flexion or extension maneuvers of the head or with cervical traction. A classic cervicotomy was performed to access the cervical spine via an anterior approach at the C4–C5 level through a linear incision on the inner edge of the sternocleidomastoid muscle, dissecting the planes up to the C2–C3 space. Two image intensifiers were used for the lateral and anteroposterior imaging during the procedure. The initial hole for screw entry was placed in the inferior and medial portion of the C2 body with a 2.8 mm drill after removing a small portion of the C2–C3 disc and a small anterosuperior part of the C3 body. A thin Kirschner wire was then introduced towards the tip of the odontoid to guide the screw. Then, a cannulated screw of 3.5 mm in diameter and variable length (normally between 35 and 45 mm, which can be calculated in preoperative examinations) was introduced. Ideally, the screw should reach the upper cortical layer of the odontoid bone. The guide wire was removed after screw placement, and flexion and extension movements of the cervical spine were performed to confirm the immediate stability of the fixation (Figure 1).

### Statistical Analysis

Age and length of hospital stay were described as mean and standard deviation. Sex was expressed as a percentage, and the rates of non-fusion (pseudoarthrosis or fibrous union), dysphagia, and reoperation were described as proportions. Proportions were compared between patients <60 years and those ≥60 years using the one-tailed Fisher test. An analysis of the normality of the distributions of the length of stay between the groups was performed using the Shapiro-Wilk normality test, and they were then compared using the two-tailed Mann-Whitney test. Dysphagia, nonfusion, and reoperation rates were compared using odds ratios (ORs). Excel with the VBA analysis tools add-ins and R Core Team (2020) software (R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria https://www.R-project.org/) were used for statistical analyses.

## RESULTS

### Demographics and Operative Data

Sixty patients were treated consecutively between 1998 and 2020. Forty (66.6%) patients were male; the mean age was 49.58 ± 23.22 years (range 8–89 years). Twenty-three (38.3%) patients were ≥60 years of age (Table 1). The minimum follow-up period was two years.

### Time to Surgery and Length of Stay

The mean time from diagnosis to surgery was 19.13 ± 27.29 days (range 2–150 days). Twenty-five (41.6%) patients underwent surgery within 7 days after the trauma. Five patients previously underwent unsuccessful conservative treatment, being operated on days 30, 58, 70, 84, and 150 after the trauma, respectively. The average LoS was 5.12 ± 3.27 days (range 2–18 days). Forty (66.6%) patients were hospitalized for ≤5 days.

### Cause of Trauma

The most common cause of trauma was car accidents in 36 (60%) cases, followed by a fall from a standing height in 19 (31.6%)

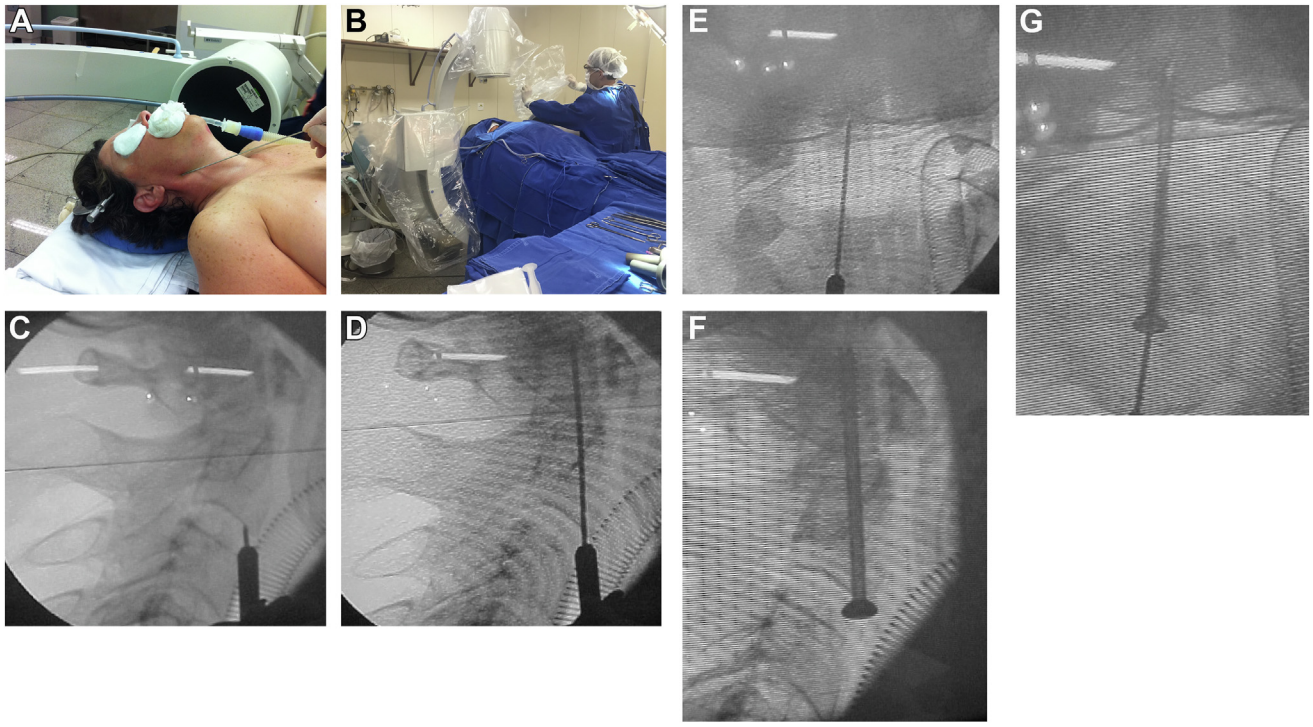


**Figure 1.** Surgical positioning with the mouth open using gauze and marking of the skin incision from the trajectory of the screw evaluated by radioscopy after confirmation of adequate fracture reduction (**A**). Biplanar fluoroscopy should be used to view the odontoid in profile and transoral anteroposterior view (**B**). The entry point of the Kirschner wire is in the inferior and medial portions of the body of C2 (**C**). The guidewire is inserted across the fracture line from the lower portion of C2 to the tip of the odontoid (**D** and **E**). The cannulated screw is then inserted for fixation (**F** and **G**).

cases, motorcycle accidents in two (3.3%) cases, bicycle accident in one (1.6%) case, falls from a horse in one (1.6%) case, and football trauma in one (1.6%) case. Of the 19 patients who were victims of falls from height, 18 (94.7%) were over 60 years of age.

### Type of Fracture and Number of Screws

According to Roy-Camille's classification, the most common type of fracture was transverse fractures (75% of cases); oblique fractures that pass from anterior superior to posterior inferior corresponded to 25% of the sample. Fifty-seven patients underwent surgery with only one screw and three with two screws (one patient aged <60 years and two patients aged ≥60 years).

### Complications

None of the patients experienced intraoperative complications. Complications related to hardware failure occurred in six (10%) patients (Table 2), and clinical complications occurred in two (3.3%) patients.

### Dysphagia

Dysphagia in the immediate postoperative period was observed in six (10%) patients. All cases of dysphagia were transient, with complete recovery within 30 days; no cases of aspiration pneumonia or re-intubation were observed.

### Fusion Rate and Clinical Results

Bone union was observed in 93.3% of patients for up to 24 weeks. Bone union was observed in 86.9% of patients aged over 60 years. All patients had excellent clinical results, with improved local symptoms and neurological deficits when present preoperatively (Figures 2 and 3). No deaths occurred during our study.

Two patients had pseudarthrosis, both aged ≥60 years: a 74-year-old male patient developed screw breakage but without the need for reoperation, having been treated conservatively with a cervical collar for six months; an 87-year-old female patient underwent posterior C1—C2 fusion.

Two cases of fibrous union were observed: one in an 80-year-old female patient and the other in a 55-year-old male patient. Both patients were asymptomatic at the last follow-up visit.

### Reoperation

Three (5%) patients required reoperation: an 87-year-old female patient developed pseudarthrosis and underwent posterior C1—C2 fusion three months after the first surgery; misplacement of a screw due to intraoperative technical difficulty was observed in a 14-year-old male patient, who was reoperated the next day for screw repositioning, and a 78-year-old female patient presented with screw loosening due to psychomotor agitation in the

**Table 1.** Baseline Characteristics

| Characteristics | N = 60 | % |
|---|---|---|
| Age (years) (Mean ± SD) | 49.58 ± 23.22 | |
| Age | | |
| <20 | 4 | 6.6 |
| 20–40 | 22 | 36.6 |
| 41–60 | 11 | 18.3 |
| 61–80 | 16 | 26.6 |
| >80 | 7 | 11.6 |
| Sex (Male: Female) (% Male) | 2:1 | 66.6 |
| Cause of injury | | |
| Motor vehicle accident | 36 | 60 |
| Fall from height | 19 | 31.6 |
| Motorcycle accident | 2 | 3.3 |
| Bicycle accident | 1 | 1.6 |
| Soccer accident | 1 | 1.6 |
| Horse accident | 1 | 1.6 |
| Signs and symptoms | | |
| Neck pain | 45 | 75 |
| Neck pain and torticollis | 6 | 10 |
| Upper limb paresis | 3 | 5 |
| Dysesthesia | 2 | 3.3 |
| Torticollis | 1 | 1.6 |
| Quadriparesis | 1 | 1.6 |
| Brown-Séquard syndrome | 1 | 1.6 |
| Cranial nerve palsy (III, IV, VI) | 1 | 1.6 |
| Roy-Camille classification | | |
| Transverse | 45 | 75 |
| Anterior superior to posterior inferior | 15 | 25 |
| Time between trauma and surgery | | |
| ≤7 days | 25 | 41.6 |
| >7 days | 35 | 58.3 |
| Length of stay | | |
| ≤5 days | 40 | 66.6 |
| >5 days | 20 | 33.3 |

immediate postoperative period, having also been reoperated via the anterior approach within 24 h (Table 2).

### Comparison of Outcomes in Patients over and under 60 years of Age

Dysphagia was observed in five patients aged ≥60 years and in one patient in the group aged <60 years. Patients aged ≥60 years had a significantly higher risk of dysphagia than those aged <60 years ($P = 0.0248$). The OR of dysphagia between the two groups was 10.

Non-fusion was observed in three patients aged ≥60 years and one in the <60 years group. The OR for nonfusion between the groups was 5.4, but the difference did not reach statistical significance ($P = 0.13$).

Two patients in the ≥60 years group and one in the <60 years group underwent reoperation. The OR for reoperation between the groups was 3.4, and there was no significant difference in the reoperation rate ($P = 0.27$).

The average length of hospital stay for patients aged ≥60 years was 5.52 ± 3.25 days, while for those aged <60 years, it was 4.85 ± 3.30 days. There was no significant difference between the groups regarding the length of stay ($P = 0.2816$) (Table 3).

## DISCUSSION

### Types of Treatment for Odontoid Fracture

Surgical treatment of type II odontoid fractures remains the subject of discussion and controversy in the literature. Recently, surgical treatment has been proposed, even in elderly patients.[11,12] It is difficult to define which approach is the optimal treatment modality for odontoid fractures due to many influencing factors, including the degree of injury, patient condition, and even local economy level, which must be considered when choosing the surgical approach.[5] Conservative treatment with a cervical collar has been used less frequently because of the high rate of nonfusion,[13] and when no treatment is performed, the success rate is zero.[2]

Anterior fixation with a screw is an effective technique; however, osteoporosis in the elderly increases the risk of pseudarthrosis in this population,[4] and the posterior approach with C1–C2 fixation has been indicated more frequently in the elderly population.[6,7]

Although several classifications of odontoid fractures have been proposed,[14-17] the Roy-Camille and Grauer classifications help to determine the access route, considering the height and direction of the fracture line.[9,10] Type IIC fractures with an oblique line that passes from anterior inferior to posterior superior and anterior displacement are contraindications for anteriorly passing the screw.[18,19]

### The Time Between Trauma and Surgical Treatment

The earlier the surgical treatment of the fracture, the greater the potential for bone fusion.[19] In our series, 41.6% of patients underwent surgery ≤7 days after trauma.

### Fusion Rate

Fusion rates of 81–100% with surgical treatment are reported in the literature.[18] In a meta-analysis analyzing fusion rates in surgeries with anterior screws, Tian et al. found a fusion rate of 90% and non-union rates ranging from 0 to 62%. The authors observed dysphagia, reoperation, and dysphonia rates of 10%, 5%, and 1.2%, respectively.[20]

We obtained 93.3% bone fusion in our series, with 3.3% fibrous union and 3.3% pseudarthrosis. Our findings were similar to those of the largest series in the literature by Apfelbaum *et al.*, which showed 85% bone fusion and 3% fibrous union.[19]

Etebar and Cahill published an article entitled "Failure of transodontoid screw fixation," describing a failure in anterior

**Table 2.** Hardware Failures

| Patient | Age (years) | Sex | Complication | Associated Cause | Outcome |
|---|---|---|---|---|---|
| 1 | 80 | F | Fibrous union | Aging | Asymptomatic |
| 2 | 57 | M | Fibrous union | Prolonged preop conservative treatment (70 days) | Asymptomatic |
| 3 | 87 | F | Pseudoarthrosis | Aging, prolonged preop conservative treatment (84 days) | Re-op by PA |
| 4 | 74 | M | Broken screw/Pseudoarthrosis | Aging | Fusion after 6 m (collar) |
| 5 | 78 | F | Loosen screw | Associated TBI, psychomotor agitation, inaccurate technique (Klippel-Feil) | Re-op within 24 h |
| 6 | 14 | M | Misplaced screw | Inaccurate technique | Re-op within 24 h |

PA, posterior approach; Re-op, reoperation; TBI, traumatic brain injury.

fixation; however, the authors operated on a type IIC fracture.[21] Tyagi *et al.*, using an anterior screw in type IIC fractures, reported a 20% rate of pseudoarthrosis.[22] Other contraindications for using the anterior approach include transverse ligament injury, irreducible fractures, old fractures (≥6 months), pathological fractures, and type II odontoid fractures associated with Jefferson fractures.

Recent systematic reviews with meta-analyses comparing anterior screw versus posterior fusion demonstrated similar fusion rates, except for patients aged over 60 years.[5,23]

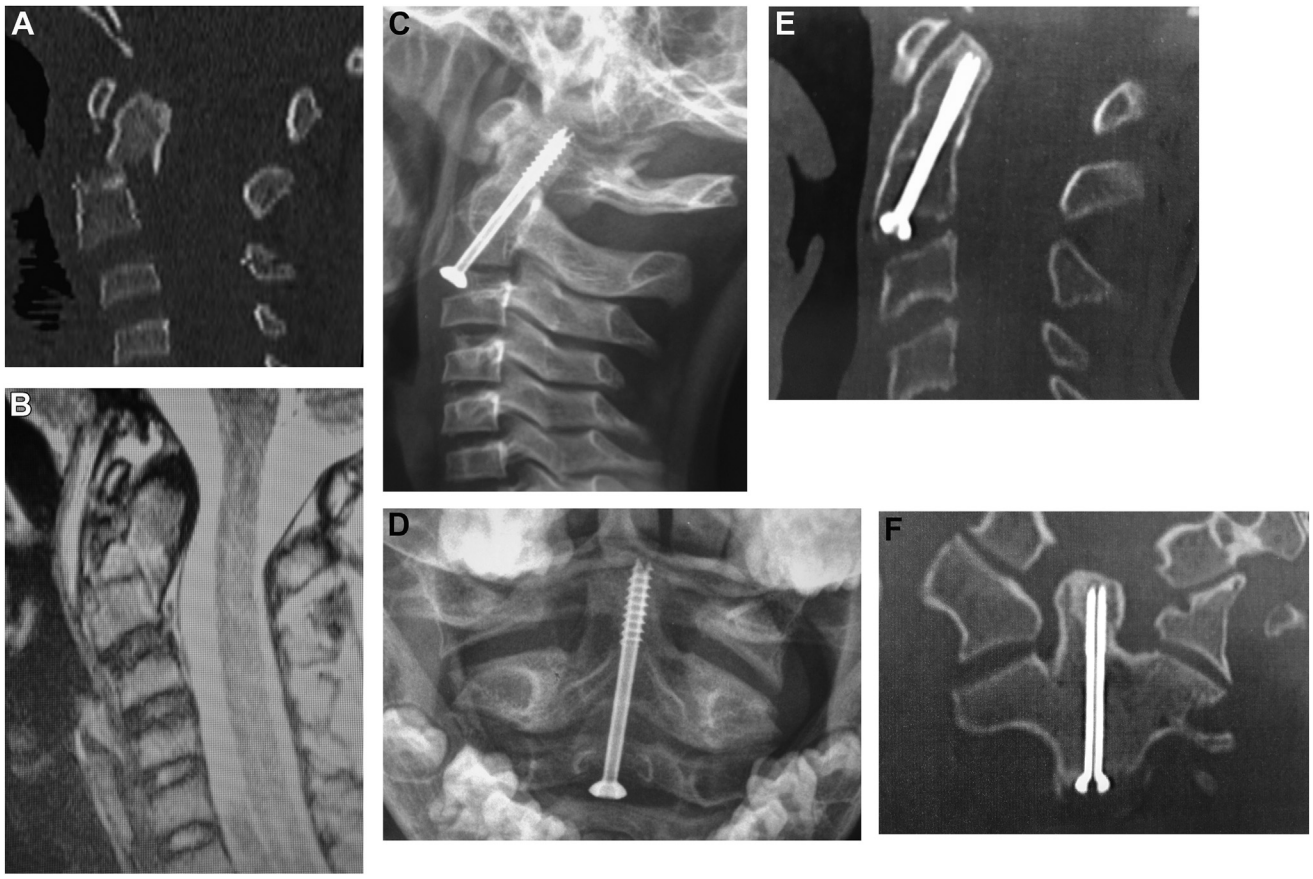


**Figure 2.** An 8-year-old male patient suffered a car accident and developed neck pain and torticollis. Sagittal computed tomography (**A**) and sagittal T2-weighted magnetic resonance imaging (**B**) showed a displaced transverse odontoid fracture. A lateral radiograph (**C**), transoral anteroposterior radiograph (**D**), and computed tomography in sagittal (**E**) and coronal (**F**) planes show bone fusion one year postoperatively.

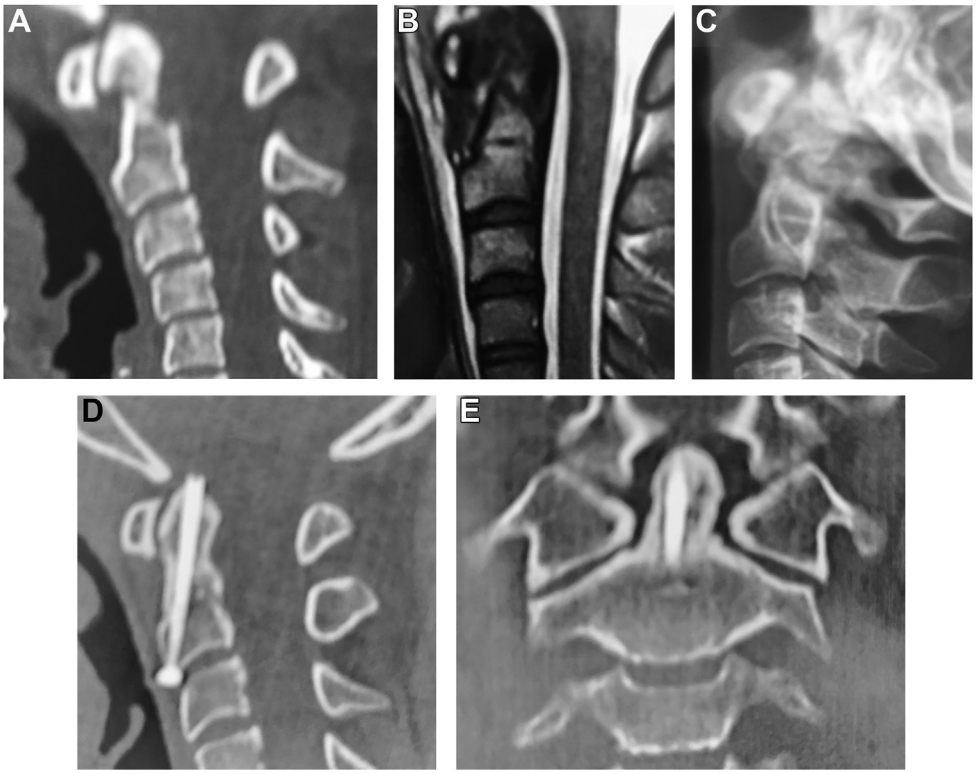


**Figure 3.** A 20-year-old female patient suffered a car accident. Sagittal computed tomography (**A**) and sagittal T2-weighted magnetic resonance imaging (**B**) showed a displaced odontoid fracture that pass from anterior superior to posterior inferior. The patient complained of neck pain, and a lateral radiograph after 140 days of conservative treatment with a cervical collar showed a non-union of the fracture (**C**). Control computed tomography in sagittal (**D**) and coronal (**E**) planes one year postoperatively showing bone fusion.

In our study, 23 patients were aged over 60 years, and an 86.9% rate of bone fusion was observed in this age group.

### Age and Odontoid Fracture

In some studies, the age of 60 years was considered by some authors as the limit for using the anterior approach.[24] However, with the improvement in life expectancy, this factor has not been considered in isolation.[12] In older patients, the anterior approach has shown excellent results.[25,26] We found no statistically significant difference between patients aged over and under 60 years regarding nonfusion rate, reoperation rate, or length of stay; however, older patients had significantly higher rates of dysphagia.

### Comparative Studies

Some studies have compared anterior and posterior approaches in treating odontoid fractures. In a comparative study with 142 patients (85 underwent anterior odontoid screw fixation and 57 underwent C1–C2 posterior fixation), Sawarkar *et al.* demonstrated fusion rates in the anterior approach for 95% of cases, with 11.7% morbidity and a 7% surgical revision rate. The posterior route presented 96.5% fusion, with a morbidity of 8.7% and a surgical revision rate of 3.5%. However, patients who underwent surgery via the posterior route showed a significant neck movement restriction. The authors concluded that anterior fixation shows excellent fusion rates and should be the first-line management in reduced/non-displaced acute type II, as it preserves cervical motion.[27]

Sousha *et al.* conducted a comparative study with 133 consecutive patients over 60 years of age with type II odontoid fractures, 47 of whom underwent anterior fixation, and 86 underwent C1–C2 posterior fixation using the Magerl–Gallie technique. The authors demonstrated the advantages of the anterior approach over the posterior approach in terms of surgical time (64.5 min vs. 116 min), bleeding volume (79 mL vs. 379 mL), and length of hospital stay (17.4 days vs. 30 days). However, the pseudarthrosis and reoperation rates were higher (25.5% vs. 3.5%) and (23.4% vs. 10.4%), respectively, with anterior fixation. The authors concluded that odontoid screw fixation is a less invasive surgery for type IIB odontoid fractures in elderly patients. However, posterior atlantoaxial fusion provides superior surgical outcomes regarding fracture healing and the need for surgical revision.[4]

**Table 3.** Comparison Between Patients Over and Under 60 years of Age

| | ≥60 years | <60 years | *P*-value | Odds Ratio |
|---|---|---|---|---|
| Number of patients | 23 | 37 | | |
| Mean age | 75.95 ± 7.38 | 33.18 ± 11.40 | | |
| Mean length of stay | 5.52 ± 3.25 | 4.85 ± 3.30 | 0.2816 | |
| Dysphagia | 5 | 1 | **0.0248** | 10 |
| Non-fusion | 3 | 1 | 0.13 | 5.4 |
| Reoperation | 2 | 1 | 0.27 | 3.4 |

Bold indicates statistically significant difference ($P < 0.05$).

In a literature review, Joaquim and Patel concluded that both anterior and posterior approaches are available, and indications and contraindications should be patient-specific. Both approaches have demonstrated success in achieving fracture stability; however, posterior instrumented treatment has the highest reported union rate while minimizing significant dysphagia associated with anterior approaches. Although atlantoaxial posterior fixation had higher fusion rates, it eliminated normal C1–C2 rotatory motion. Approximately 50% of normal cervical rotary motion and 10% of cervical flexion-extension motion occur in the C1–C2 joint.[8] For this reason, some authors consider that posterior fixation should be reserved for patients in whom anterior fixation has failed or is not feasible.[28]

### Dysphagia

The anterior approach has recently been criticized for its high incidence of postoperative dysphagia. In our series, we observed a dysphagia rate of 10%, with all patients evolving with complete improvement in the first postoperative week. Five of the six patients with dysphagia were over 60 years old, and the risk of dysphagia was significantly higher in older patients ($P = 0.0248$).

In a systematic review, Tian *et al.* reported a dysphagia rate of 4–17%.[20] Some authors suggest that the risk of dysphagia after anterior surgery should be considered when deciding on the surgical route only in elderly patients.[1] Cutler *et al.*, in a series with a mean age of 73.9 years, demonstrated the need for reintubation in the anterior approach in 4.9% of cases.[29]

The posterior route with C1–C2 fusion has also been associated with dysphagia. In a series of octogenarian patients who underwent C1–C2 posterior fixation for odontoid fractures, Clark *et al.* demonstrated a dysphagia rate of 27.9%, with 9.3% of the patients being reintubated.[30]

### Operative Morbidity and Mortality

This series recorded no mortality during the pre- and postoperative periods. In a systematic review of patients aged ≥65 years with odontoid fractures, White et al. found no difference in mortality between the anterior and posterior approaches. There were also no differences in pulmonary complications between the groups.[31]

In a review analyzing databases of patients who underwent anterior fixation between 2007 and 2012, Cutler *et al.* found perioperative complications in 37.9% of patients; the mean age of the patients was 73.9 years, and the mortality rate was high (6.8%).[29]

Pommier et al., in a systematic review analyzing mortality, union or nonunion rates, and complications, reported low mortality and high fusion rates in the surgical group. The authors concluded that surgical treatment did not seem inferior to conservative therapy.[32]

### Hospital Stay

In our series, 20 (33.3%) patients were hospitalized for more than five days, and there was no statistical difference regarding the length of stay between patients over and under 60 years of age. The length of hospital stay in our series was shorter than that in the series by Cutler *et al.*, in which 45.6% of the patients were hospitalized for more than five days. However, the mean age of the patients in their study was higher (73.9 years).[29]

## STUDY LIMITATIONS

This study had some limitations. This retrospective study was conducted at a single institution. Data, such as surgical time and blood loss, were not evaluated. However, it is known that the blood loss and surgical time of the anterior approach are significantly lower than that of the posterior approach.

Despite the limitations of this study, all patients were operated on by the same surgeon using the same surgical technique. Prospective, multicenter, and head-to-head comparative studies with a larger number of patients are needed to define better the differences between the benefits and risks of each surgical technique.

## CONCLUSIONS

Most patients with type II odontoid fractures were adequately treated with anterior fixation.

The risk of dysphagia was higher in patients aged ≥60 years, but all cases were transient. There were no significant differences in non-fusion rates, length of stay, or reoperation between patients aged ≥60 years and <60 years.

## CRediT AUTHORSHIP CONTRIBUTION STATEMENT

**Fernando Luiz Rolemberg Dantas:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Visualization. **François Dantas:** Conceptualization,

Methodology, Investigation, Writing — original draft, Writing — review & editing, Visualization. **Gustavo Agra Cariri:** Investigation, Supervision, Visualization. **Antônio Carlos Vieira Caires:** Investigation, Supervision, Visualization. **Marco Túlio Domingos Silva e Reis:** Investigation, Supervision, Visualization. **Ricardo Vieira Botelho:** Investigation, Supervision, Methodology, Visualization, Writing — review & editing.

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The manuscript does not contain information about medical device(s)/drug(s).

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