Treatment of Dens Fractures with Anterior Screw Fixation

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Based on an original article: *J Bone Joint Surg Am.* 2012 Oct 3;94(19):e144

Introduction

Direct anterior screw fixation of the dens preserves C1-C2 rotation, and the reported fusion rates range from 88% to 100%.^{1,2}

Appropriate patient selection is essential to the success of the technique; only Anderson and D'Alonzo³ type-II fractures are suitable for direct anterior screw fixation. Positioning the patient in a way that reduces the fracture and opens the corridor above the sternum is a key point for this technique. Use of two image intensifiers is recommended. The entry corridor above the sternum as well as the level of the skin incision should be checked with a rod on the lateral view before the procedure is started. We prefer osteosynthesis with a single cannulated screw, although use of two screws as allowed by anatomical constraints is an option.

A standard anterior approach to the cervical spine is performed. The perfect entry point for the screw is at the anterior-inferior edge of the end plate of C2. A Kirschner wire is then inserted in the appropriate position with the tip perforating the cranial, cortical bone of the apex of the dens. Subsequently, the canal for the screw is drilled, and the screw is implanted. The Kirschner wire, the drill, and the cannulated screw have to be placed under continuous, real-time, fluoroscopic control in two planes. Wound closure is performed by suturing the platysma and the skin. Inserting a suction drain is optional.

The procedure is performed with the following steps.

Step 1: Positioning of the Patient

Exact positioning of the patient and use of image intensifiers are mandatory to obtain perfect anteroposterior and lateral views of the axis.

- Use two image intensifiers during the operation. Perfect anteroposterior and lateral views of the axis must be achieved.

- The patient's mouth should be open during the operation.
- The fracture should be in a perfect (reduced) position before the operation starts.
- For perfect visibility, place only the endotracheal tube in the area of the larynx. Extend the cervical spine dorsally to obtain good access to the base of the axis.
- If dorsal extension is not possible—for example, if a patient has an extension fracture with posterior displacement of the odontoid—consider anterior translation of the head relative to the trunk.
- Fix the head in a maximally stable position. We use a Mayfield clamp.

Step 2: Surgical Approach

The surgical approach is standardized, and the pretracheal layer can be exposed without violating any essential anatomic structures (Video 1).

- For preoperative “simulation” of screw insertion, use a rod to check the entry corridor on the lateral fluoroscopic view and mark the appropriate level of the skin incision. Make a horizontal skin incision at the marked level. (Right-handed surgeons usually perform the incision on the right side of the patient.)
- Divide the platysma muscle longitudinally and identify the medial border of the sternocleidomastoid muscle.
- Incise the fascia medial to the sternocleidomastoid muscle, retract the muscle laterally, and develop the interval between the neurovascular bundle to the lateral side and the visceral bundle to the medial side by careful blunt dissection. Continue blunt dissection until the anterior part of the cervical spine can be palpated.
- Place a retractor to each side of the cervical spine to keep the pretracheal fascia exposed

- and incise the pretracheal fascia longitudinally.
- Confirm your position at the center of the base of C2 on anteroposterior and lateral fluoroscopic views.
- Expose the area about 1 cm cranial to the base of the dens and place a radiolucent retractor on the body of C2 to keep the surgical field exposed.

Step 3: Entry Point of the Screw

The perfect entry point is directly anterior-inferior at the base of C2; therefore, the anterior rim of the C2-C3 intervertebral disc must be penetrated.

- Check the anterior contour of the base of the axis on the preoperative computed tomography (CT) scan to detect an anterior ridge type (Fig. 1). If an anterior ridge type is identified, insert only a single screw in the center of the dens.
- Check the entry point (the center of the anterior part of the base of C2) on anteroposterior and lateral fluoroscopic views.
- For perfect screw positioning, slide the guiding wire along the anterior-superior edge of the superior end plate of C3 to the entry point.

Step 4: Screw Insertion

We use a single cannulated screw in most cases: insert the screw in the center of the dens with its tip perforating the cranial, cortical bone of the dens just posterior to the apex (Fig. 2).

- Place the appropriate guiding wire (we use a 1.8-mm Kirschner wire) for the planned screw (we use either a 3.5-mm or a 4-mm cannulated screw) in the center of the dens with its tip in the cranial, cortical bone just posterior to the apex. Check the advancement of the guiding wire on the fluoroscopic anteroposterior and lateral views.
- Place a cannulated drill over the guiding wire under fluoroscopic control in two planes and advance the drill across the fracture gap. Do not perforate the cranial, cortical bone of the apex of the dens with the drill to avoid withdrawing the guiding wire together with the drill.
- Measure the screw length and compare it with the length measured preoperatively on the CT scan. The screw should perforate the cranial cortex of the apex of the dens.
- Insert the appropriate screw after you have confirmed that the fracture position and the position of the guiding wire are still perfect on the anteroposterior and lateral fluoroscopic views. Observe the screw and the position of the guiding

wire during screw insertion under fluoroscopic control in the anteroposterior and lateral planes.

- Make sure that none of the rotating devices (e.g., the drill chuck, hub, or handle) engage with the surrounding soft tissues during any of the above steps.
- Compression on the fracture gap is applied by the screw.

Step 5: Wound Closure

Precise and anatomic closure of the platysma determines the quality of the scar that will be visible after the operation.

- Perform wound irrigation after positioning the screw.
- Thorough hemostasis is crucial to minimize postoperative complications, such as excessive pressure on the airway by hematoma.
- Perfectly readapt and close the platysma.
- Do not close the deeper layers of the surgical approach.
- Introduction of a suction drain is optional; we usually do not use one.
- A subcuticular skin suture technique is preferable since it provides the best cosmetic result.

Step 6: Follow-up

The patient wears a rigid collar for six weeks, removing it for body care; radiographic evaluations should be performed regularly.

- Control the phonetic ability of the patient directly after the operation (laryngeal nerve). Tell the patient to talk as loud as possible for a minute. When his/her voice fades away, even if he/she has regained full consciousness, perform a laryngoscopic control.
- Observe the amount fluid that runs in the suction drain if one was applied. We usually do not apply a drain. If a drain is needed and bleeding does not cease (<10 mL/hr), monitor the patient in the intensive-care unit or consider a revision.
- Perform standard anteroposterior and lateral radiographic studies after two, six, and twelve weeks and after six and twelve months.
- Perform a CT scan at twelve weeks.

Results

In a study of sixty-nine patients with a fracture of the dens⁴, three of the thirteen patients who underwent direct anterior screw fixation⁵ had persistent instability and nonunion of the dens four months after surgery. Two

of the three cases with nonunion were oblique type-III fractures with anterior comminution. Because of the patients' young age (seventeen and nineteen years old), direct anterior screw fixation was performed against better judgment and experience^{5,6}.

What to Watch For

Indications

- Unstable Anderson and D'Alonzo³ type-II fractures in patients younger than seventy-five years old (Fig. 3).
- Unstable fractures of the dens are defined as fractures with initial displacement of >5 mm, initial angulation of the dens of >11° (Fig. 4), a fracture gap of >2 mm, and anteroposterior displacement of >2 mm on lateral flexion-extension sagittal radiographs (Fig. 5)^{6,7}.

Contraindications

- Patients more than seventy-five years old^{8,9}.
- Anderson and D'Alonzo³ type-III fractures (Fig. 6).
- Osteolytic defects in the dens fragment and/or the body of C2.

Pitfalls & Challenges

- Anterior ridge type has to be detected (Fig. 1)
- In patients with a reverse type II-fracture, extension of the cervical spine, which is necessary to obtain access to the entry point of the screw, may dislocate the cranial fragment of the dens

posteriorly. Consider anterior translation of the head in relation to the trunk in these cases.

- In patients with a short neck and a high thorax, the angulation for appropriate screw placement may not be achievable. Another technique such as posterior transarticular fixation should be considered in these cases.

Clinical Comments

- Direct anterior screw fixation is performed with a single cannulated screw in our institution since there is no evidence of higher fusion rates with the use of two screws. We know that sometimes anatomic conditions (the diameter of the dens or the contour of the anterior-inferior base) preclude insertion of two screws. Do you use one or two screws?
- On the basis of personal experience and reports from other institutions^{1,5}, we chose an age of seventy-five years as the threshold for whether or not to use direct anterior screw fixation or posterior transarticular fixation. However, biological age may substantially differ from chronological age. Should a patient's age be the determining parameter in the clinical setup, or are there other factors that are more specific, such as the bone quality seen on CT scanning?
- Direct anterior screw fixation is usually not suitable for Anderson and D'Alonzo³ type-III fractures; however, preservation of C1-C2 rotation is desirable in young patients. Is it acceptable to use direct anterior screw fixation to offer the patient a small chance of preserving the joint?

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Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. None of the authors, or their institution(s), have had any financial relationship, in the thirty-six months prior to submission of this work, with any entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, no author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

References

1. Aebi M, Etter C, Coscia M. Fractures of the odontoid process. Treatment with anterior screw fixation. *Spine (Phila Pa 1976)*. 1989 Oct;14(10):1065-70.
2. Nakanishi T, Sasaki T, Tokita N, Hirabayashi K. Internal fixation for the odontoid fracture. *Orthop Trans*. 1982;6:176-83.

3. Anderson LD, D'Alonzo RT. Fractures of the odontoid process of the axis. *J Bone Joint Surg Am.* 1974 Dec;56(8):1663-74.
4. Konieczny MR, Gstrein A, Müller EJ. Treatment algorithm for dens fractures: non-halo immobilization, anterior screw fixation, or posterior transarticular C1-C2 fixation. *J Bone Joint Surg Am.* 2012 Oct 3;94(19):e144(1-6).
5. Böhler J. Anterior stabilization for acute fractures and non-unions of the dens. *J Bone Joint Surg Am.* 1982 Jan;64(1):18-27.
6. Apuzzo ML, Heiden JS, Weiss MH, Ackerson TT, Harvey JP, Kurze T. Acute fractures of the odontoid process. An analysis of 45 cases. *J Neurosurg.* 1978 Jan;48(1):85-91.
7. Roy-Camille R, Saillant G, Judet T, de Botton G, Michel G. [Factors of severity in the fractures of the odontoid process (author's transl)]. [Article in French] *Rev Chir Orthop Reparatrice Appar Mot.* 1980 Apr-May;66(3):183-6.
8. Müller EJ, Wick M, Russe O, Muhr G. Management of odontoid fractures in the elderly. *Eur Spine J.* 1999;8(5):360-5.
9. Müller EJ, Schwinnen I, Fischer K, Wick M, Muhr G. Non-rigid immobilisation of odontoid fractures. *Eur Spine J.* 2003 Oct;12(5):522-5. Epub 2003 May 14.

Figures

Fig. 1

Axial CT scan of a C2 “ridge type.” The arrow is pointing at the anterior ridge. With an anterior ridge type, only one single screw in the midline can be placed safely. If two screws are used with an entry point of about 5 mm lateral to the midline, the screws do not find purchase in the base of C2. Even though the screws look fine on lateral image-intensifier views, they are located anterior to the anterior-inferior cortex.

Fig. 2

A thirty-eight-year-old man sustained an unstable fracture in a bicycle accident and was treated with direct anterior screw fixation. **Fig. 2-A** Preoperative sagittal CT scan. **Fig. 2-B** Postoperative sagittal CT scan. **Fig. 2-C** Postoperative lateral cervical spine radiograph. **Fig. 2-D** Postoperative anteroposterior radiograph.

Fig. 3

Flowchart of treatment rationale.

Fig. 4

Stability testing. **Fig. 4-A** Initial displacement of $>5\text{ mm}$ (arrows) indicates instability. **Fig. 4-B** Initial displacement of $<5\text{ mm}$ (arrows) indicates stability. **Fig. 4-C** Initial angulation of $>11^\circ$ (red lines) indicates instability. **Fig. 4-D** Initial angulation of $<11^\circ$ (red lines) indicates stability. **Fig. 4-E** Initial fracture gap of $>2\text{ mm}$ (arrow) indicates instability. **Fig. 4-F** Initial fracture gap of $<2\text{ mm}$ (arrow) indicates stability.

Fig. 5
Sagittal flexion/extension cervical spine radiographs of two patients. The black lines indicate the center of the cranial and the caudal fragment. Flexion (**Fig. 5-A**) and extension (**Fig. 5-B**) views of a patient who sustained an unstable fracture, with the center lines separated by >2 mm. Flexion (**Fig. 5-C**) and extension (**Fig. 5-D**) views of a patient who sustained a stable fracture, with the center lines separated by <2 mm.

Fig. 6
Schematic diagrams of dens fractures. Each fracture line separates a cranial fragment (Cr) and a caudal fragment (Ca). **Fig. 6-A** Anderson and D'Alonzo³ type-II fracture. There is good anchorage of the screw in the cranial and caudal fragments. **Fig. 6-B** Anderson and D'Alonzo³ type-III fracture with anterior comminution. There is poor anchorage of the screw in the caudal fragment, which is much smaller in this type of fracture than in a type-II fracture such as that shown in Fig. 6-A.