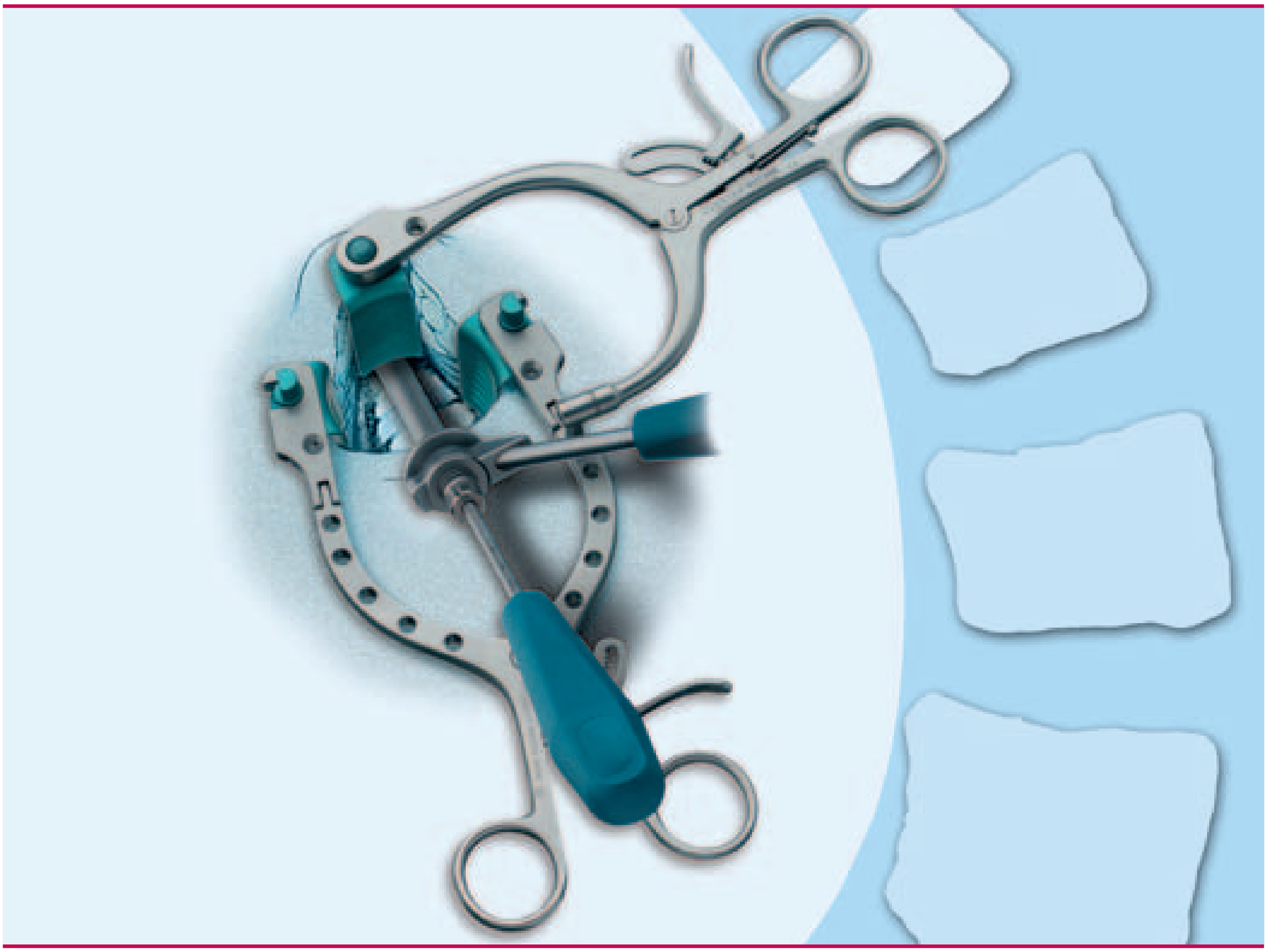
Aesculap Spine
Apfelbaum Odontoid Fixation

Anterior fixation od odontoid fractures



Surgical Technique
According to Ronald I. Apfelbaum, M.D.

B|BRAUN
SHARING EXPERTISE

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In this publication, Dr. Apfelbaum describes his surgical technique for treating Type II odontoid fractures from the anterior approach.

Aesculap instrumentation has been cleared by the FDA for spinal use.

Warning: The screws described are not approved for screw attachment or fixation to the posterior elements (pedicles) of the cervical, thoracic or lumbar spine. Nor have the screws described in this surgical technique been cleared by the FDA.

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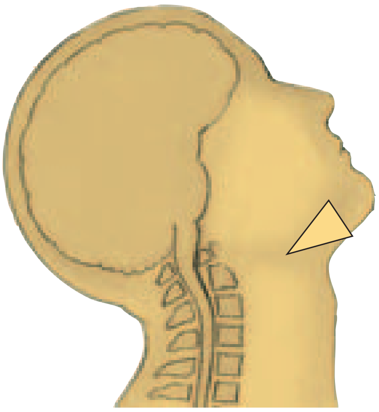


Introduction

Fig. 1 A

Fig. 1 B

Fig. 1 A, B
Type II odontoid fracture exhibiting retrolisthesis in extension. (Fig. 1 B)

Type II odontoid fractures [1] (Fig. 1) across the base of the odontoid can have a high nonunion rate when treated by external immobilization (7 [2] -100 [3] % in published series) with frequent reports of 21-45% nonunion, [4,5,6,7,8,9,10,11,12] and several in the 50-63% range. [13,14,15,16,17] Factors identified as predesposing to nonunion in various published series have included the degree of dislocation (67% nonunion if 6 mm or more [10] and 88% if greater than 4 mm [4] in two separate studies), comminuted fragments at the base of the dens, [18] age of patient (higher if over age 40, [4] if over 65 [7]) and direction of subluxation (higher if posterior) [7]. These studies, while not agreeing in absolute incidences of nonunion, point out the frequency of the problem.

Conventional neurosurgical treatment has included external immobilization via halo vest apparatus [19,20,21] or minerva type jacket and posterior C1-2 fusion as a primary procedure or in the case of failure to unite after a period of extended immobilization [22,23,24,25,26,27] While usually effective in stabilizing the C1-2 region, posterior fusion itself may require an additional period of immobilization and can fail to result in bony union.[28] More significantly, it eliminates the normal rotation at C2 which accounts for 50% of the normal cervical spinal rotation.[29]

A better surgical treatment is to place a fixation screw across the fracture site, [30,31,32,33,34,35,36] thereby reapproximating the fractured odontoid process to the body of C1-2 and stabilizing the C1-2 complex immediately while preserving full C1-2 functional capability. [37] This may be performed as a primary treatment or after failure of a trial of external immobilization.

To accomplish such a screw fixation in the past was difficult, involving extensive neck dissection [32,33] and potentially significant morbidity. The development of the instrumentation illustrated here, however, allows safe and efficient screw fixation using an easily mastered approach which greatly reduces the risks to the patient and has a high rate of success. [36] It is accomplished through a small low cervical approach, similar to that used for an anterior cervical discectomy. Specialized retractors and drill guides allow easy access to the area of pathology and biplane fluoroscopic control assures precise placement of the fixation screws. [36]

Patient Selection

The procedure has been employed in type II odontoid fractures of less than six months of age as well as those with remote or obscure origins, although with substantially less success in the latter. Patients should not have additional lesions which will reduce the chance of adequate fixation, such as fractures into the body of C2, which will not allow firm screw purchase. Nor should they have a disruption of the transverse ligament which will allow atlantoaxial translation even if the odontoid fragment is fixated. This can be suspected in Jefferson type atlas burst fractures with greater than 7 mm displacement of the lateral mass of C1 [38] and evaluated by MRI imaging of the region. [39] In our experience we have not encountered a case with both odontoid fractures and transverse ligament disruption. The presence of nonreduceable compression of the cord in this area would also be a contraindication and would best be treated by resection of the compressing lesion and subsequent C1-2 posterior fusion.

Surgical Technique

The patient is positioned supine on the operating table and the head is immobilized with gentle halter traction. A folded sheet or blanket is placed under the shoulders and if the fracture reduces in extension, the head is extended (Fig. 2). If it is not reduced in extension, the head is initially held in a neutral postion and will be extended once the guide tube is placed. The guide tube will control the alignment, placing the odontoid in its normal position, and allowing proper angulation for screw placement. Instability in extension requires special anesthesia attention during intubation. Nasotracheal intubation or fiberoptic guidance are often employed in these cases.

Fluoroscopic imaging in both the lateral and AP (transoral) planes is required. Two C-arm units are ideal (Fig. 3) and if available speed up the procedure. If two are not available, a single unit can be used , rotating it frequently from the AP to the lateral plane. A radiolucent mouth gag (a wine bottle cork notched for the teeth or alveolar ridge) is placed and once the initial images are obtained, the patient´s neck can be placed in the best position. After routine prepping and draping, a small unilateral midcervical (approximately C5) natural skin incision is made (Fig. 5). Too high an incision prevents proper trajecting to achieve screw placement in C2 along the vertical axis of the vertebral body. Under fluoroscopy, a straight instrument placed along side the neck can help define the trajectory and anticipate the correct level for the skin incision. Local epinephrine injection aids skin hemostasis. A standard Cloward type approach to the anterior spine is performed, dividing the platysma muscle horizontally, then sharply opening the sternocleidomastoid muscle fascia along the medial border of that muscle. Blunt finger dissection will then open natural planes medial to the carotid bundle and lateral to the trachea and esophagus to gain access to the prevertebral space.

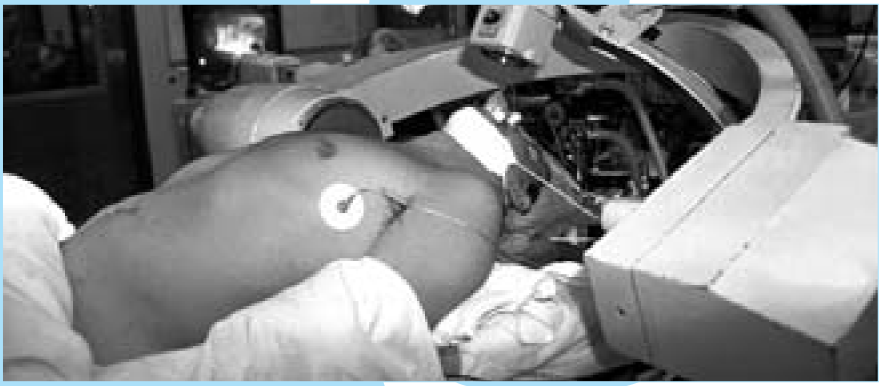


Fig. 2
Patient positioned on operating table. Note folded sheet under shoulders to increase neck extension in this patient whose fracture reduced in extension. Also note the placement of two C-arm fluoroscopic units for antero-posterior (transoral) and lateral fluoroscopic control.

Fig. 3
Close up of fluoroscopic unit placement in another patient who is not as hyperextended. In each case the best postion that can be tolerated is selected based on the lateral fluoroscopic images. Note mouth gag to facilitate transoral AP fluoroscopic view.

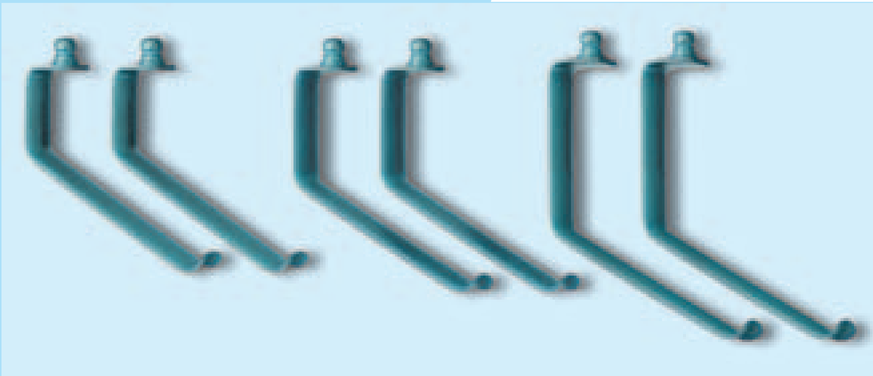


Fig. 4
Special retractor blades for creating a working "tunnel" up to C2. These blades are available in titanium, which is semiradiolucent, for improved anterior-posterior imaging capability.

The longus coli muscle fascia is incised in the midline and the muscle bellies elevated from the anterior surface at approximately C5-6. Caspar sharp tooth cervical retractor blades are inserted firmly under these muscles and connected to the special retractor blade holder (Fig. 5). Firm fixation here is important, as the superior retractor will work against this fixation. Poor placement can result in the blades rotating out of optimal position.

Next, blunt dissection in the prevertebral facial plane (anterior to the longus coli muscle) using a side to side sweeping motion with a small gauze pad ("peanut" or Kittner dissector) held in an angled clamp will quickly open the tissue plane up to C1. The superior angled retractor blade is then inserted into this space. Its size is chosen from among the six available sizes (Fig. 4) to reach up to C1 and fit the patient´s geometry, especially the size of the mandible. The retractor blade mates with a special retractor that attaches to one side of the previously placed lateral retractor (Fig. 5 and 6). A spring loaded set of interdigitating teeth allow adjustment of the angle of retraction. This is changed by manually separating the interdigitating teeth, rotating the retractor to the desired position, and allowing the teeth to reengage.

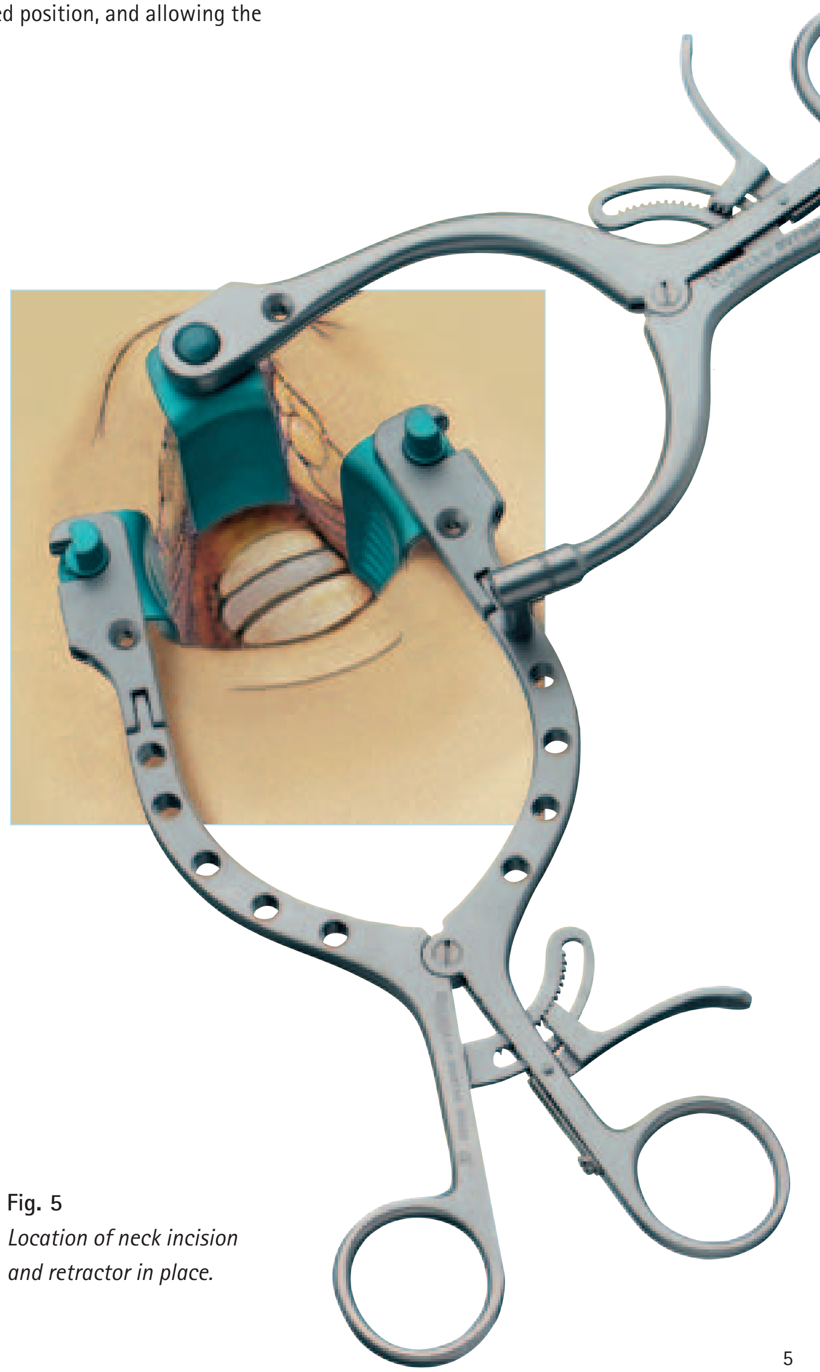


Fig. 5
Location of neck incision and retractor in place.

Surgical Technique

Once set, the retractor creates a tunnel within which to work (Fig. 6 A, B). While it is possible to visualize up to C2 in this tunnel using a headlight, in reality, the majority of the operation is accomplished primarily by fluoroscopic guidance.

An entry site for the fixation screw is then chosen in the inferior anterior edge of C2. If one screw is to be placed, this is usually in the midline. A paramedian site about 2-3 mm off the midline is used if two screws are to be placed. We use two screws when there is adequate dimension to the odontoid process to accept two screws. A 2 mm K-wire is then manipulated under biplane fluorscopic control to the desired entry site and impacted 3 to 5 mm into the bone (Fig. 6 B). Care is taken to get this placed precisely as it will guide all the subsequent steps in the procedure. If necessary a curette can help prepare an access path through the annulus of C2-3 to seat the guide wire properly.

Once the K-wire is impacted into the inferior edge of C2 at the desired entry point a 7 mm hollow core drill is passed over the wire and rotated by hand to cut a shallow groove in the anterior face of C3 and in the C2-3 annulus (Fig. 7 Insets A-D). This too is monitored fluoroscopically.

The inner and outer drill guides are then mated together and passed over the K-wire. The guide system is manipulated so the securing spikes are over C3 (Fig. 8, 11 B, C). To accomplish this, lock the handle to the shaft by tightening the knob at the end of the handle, then "walk" the spikes up to the desired vertebral level. If necessary, the K-wire is then shortened so less than 1 cm protrudes beyond the inner guide tube. The plastic impactor sleeve is then fitted over the guide tube assembly. Ensure the various adjustment levers and drill guide handle nestle into the slots of the impactor sleeve (Fig. 9 A).

Fig. 6 A
Surgeon´s view with retractor in place. Note lack of any inferior blade, which allows flattest possible trajectory to C2.

Fig. 6 B
Guiding K-wire in place.

Fig. 7 A

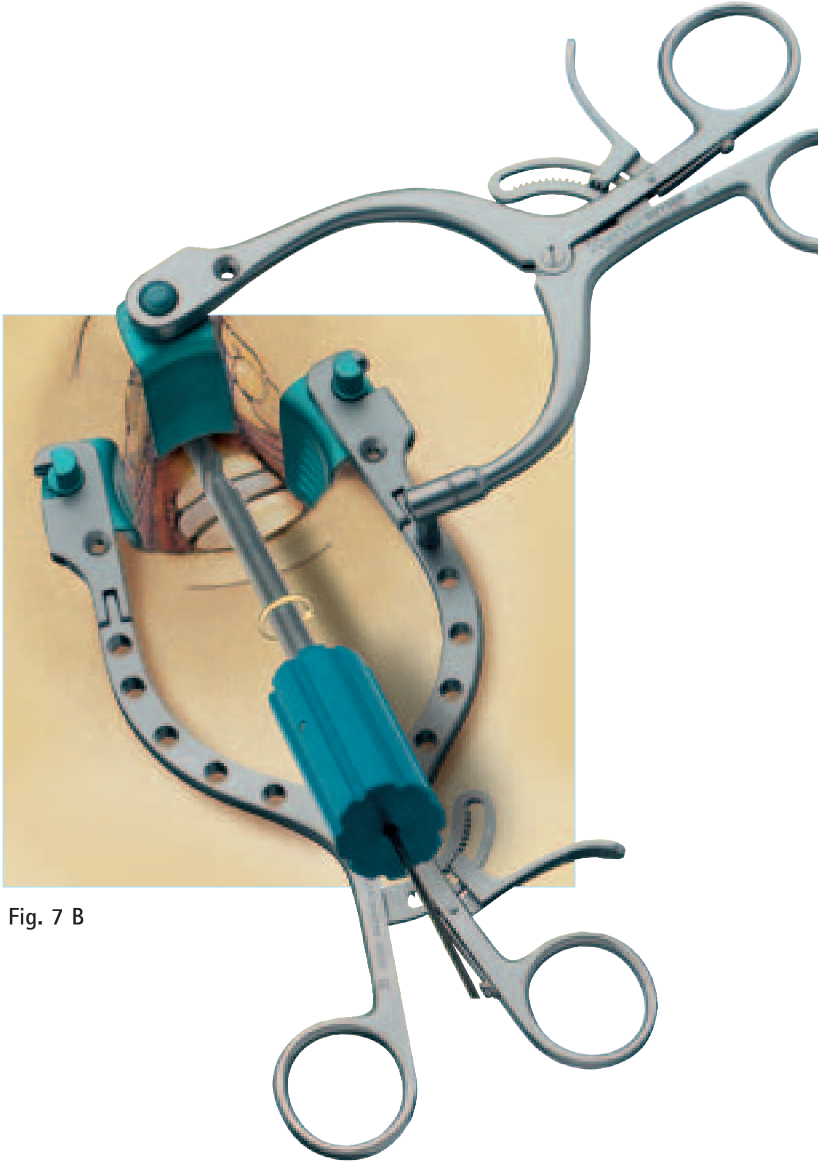


Fig. 7 B

Several sharp taps with the mallet will impact the spikes into C3 and secure the system (Fig. 9 B). The inner guide tube is then advanced out from within the outer drill guide until it contacts the inferior edge of C2 (Fig. 9 C), by depressing (releasing) its locking button.
The surgeon should then reposition the handle of the guide tube system to a comfortable location. This will allow the surgeon to maintain constant upward pressure on the guide tube to keep it engaged in the bone. The K-wire can then be removed without loss of positional stability and alignment. The alignment of C1 and the odontoid process relative to C2 and C3 can be perfected by lifting or depressing the guide tube assembly while maintaining constant upward pressure. In the case of a retrolisthed odontoid, depressing C2 under the odontoid allows further extension of the patient´s neck, while maintaining normal alignment. This allows drilling at an optimal angle.

Note: Manipulation to reduce a retrolisthesed odontoid can be safely accomplished by monitoring the changes in alignment flouroscopically.

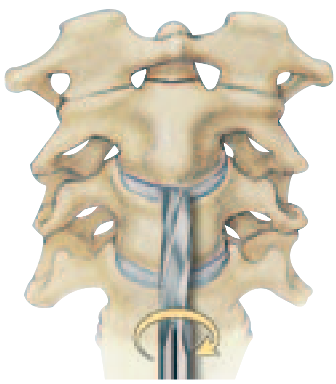


Fig. 7 C

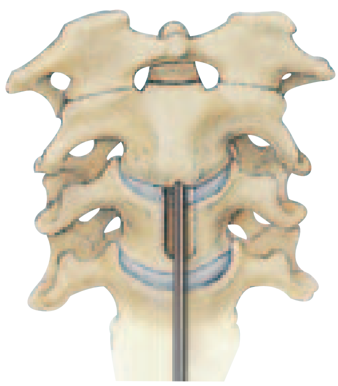


Fig. 7 D

Fig. 7
A-D. Hollow hand drill creates trough in face of C3 and C2-3 annulus.

Surgical Technique

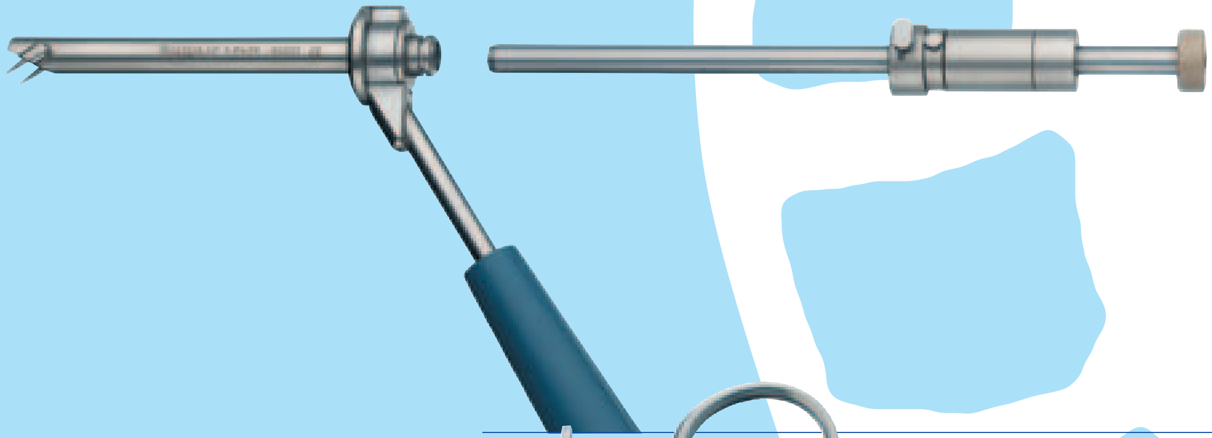


Fig. 8

Drill guide system – Inner and outer guide tubes mate together and are placed over K-wire.

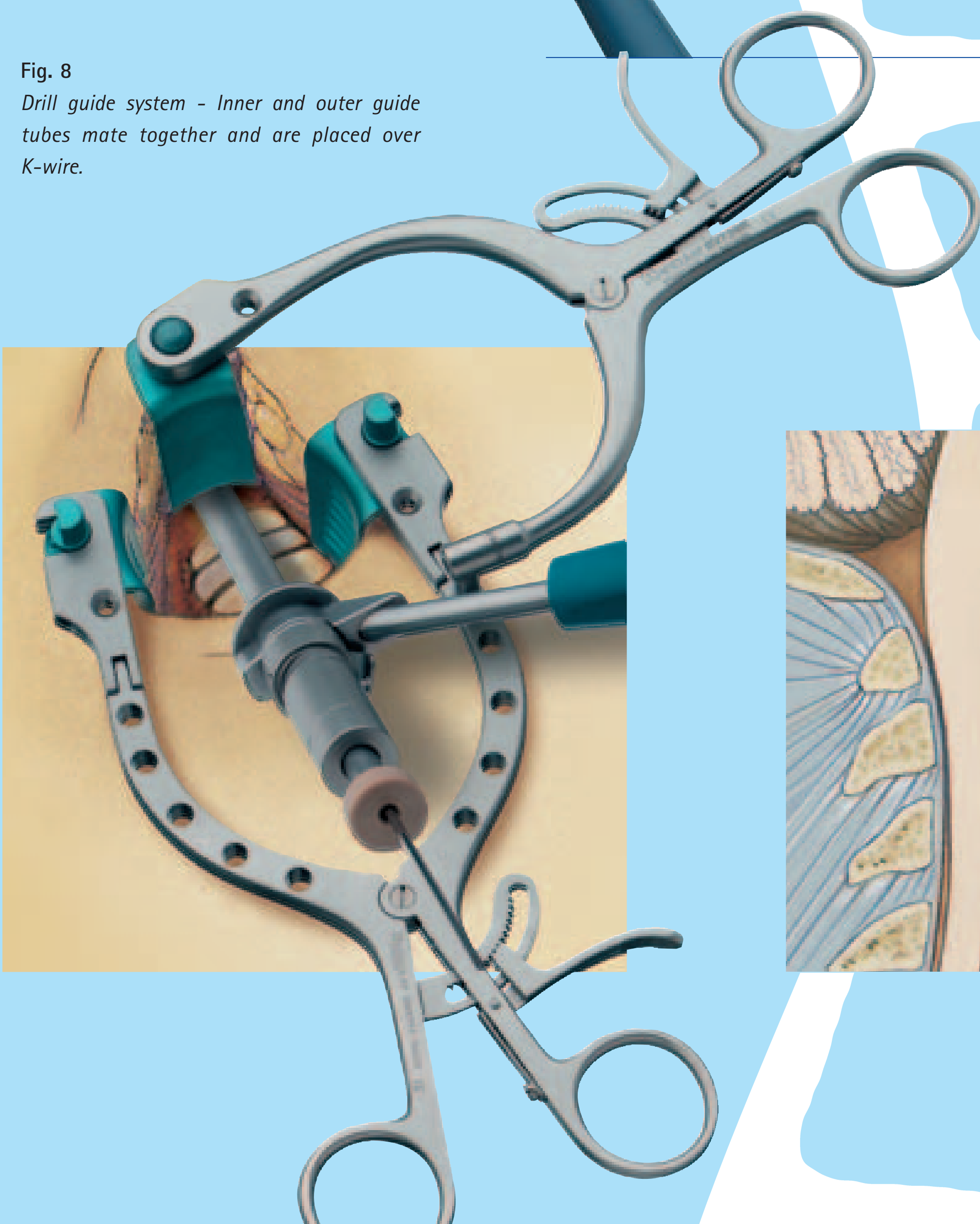


Fig. 9 A

Note: Align handle and buttons in slot of impactor so the mallet impact is translated to the collar of the outer drill guide (blue arrow) rather than to the buttons (yellow arrow).

Fig. 9 B, C

Spikes (yellow arrow) on outer guide tube are impacted into C3 to stabilize the system. Inner drill guide tube is then advanced (blue arrow) to inferior edge of C2 (Fig. 9 C) to allow for an accurate depth measurement.

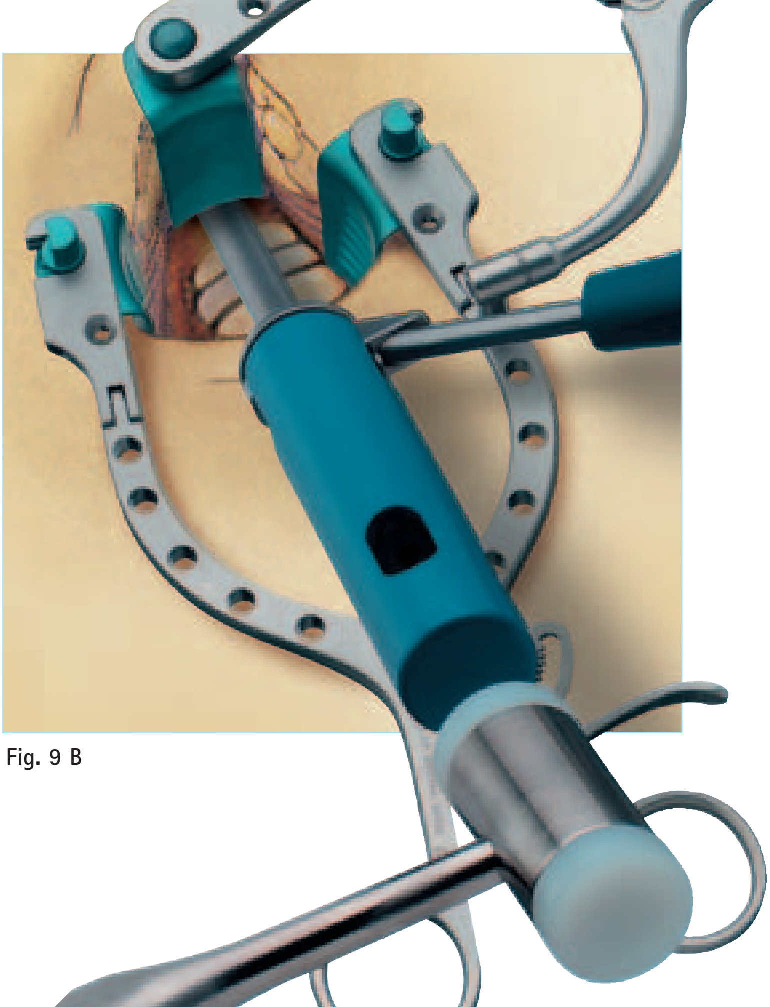


Fig. 9 B

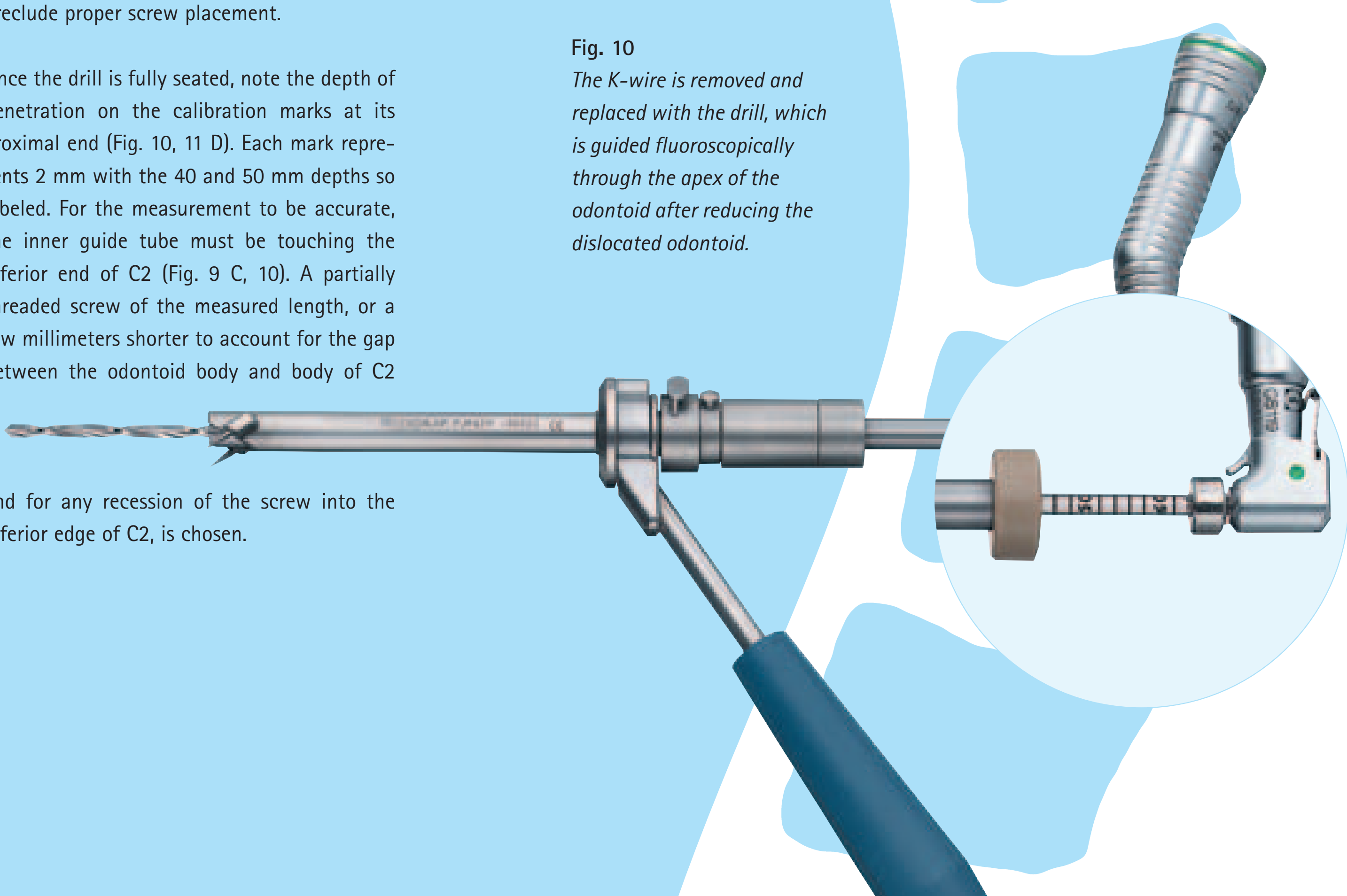
Fig. 9 C

Surgical Technique

Attach the calibrated drill to the Elan-E or Microspeed right angled drill driver and insert it through the guide tube into the entry hole created by the K-wire (Figs. 10, 11 A, B). Drill a pilot hole into C2 and the odontoid by cautiously advancing up through the bone while monitoring the progress on biplane fluoroscopy. Prior to crossing the fracture site, additional manipulation can be performed using the drill guide to either depress or elevate the C2-3 complex relative to the odontoid, until the perfect alignment is achieved. If needed, the head may also be manipulated to further optimize the odontoid-body of C2 relationship. The pilot hole is drilled to and through the apical cortex of the odontoid. The odontoid is firmly attached by its investing ligaments and will neither rotate nor be significantly displaced by this or subsequent maneuvers. The apical cortex is very dense and failure to penetrate it with the drill may preclude proper screw placement.

Once the drill is fully seated, note the depth of penetration on the calibration marks at its proximal end (Fig. 10, 11 D). Each mark represents 2 mm with the 40 and 50 mm depths so labeled. For the measurement to be accurate, the inner guide tube must be touching the inferior end of C2 (Fig. 9 C, 10). A partially threaded screw of the measured length, or a few millimeters shorter to account for the gap between the odontoid body and body of C2 and for any recession of the screw into the inferior edge of C2, is chosen.

Fig. 10
The K-wire is removed and replaced with the drill, which is guided fluoroscopically through the apex of the odontoid after reducing the dislocated odontoid.



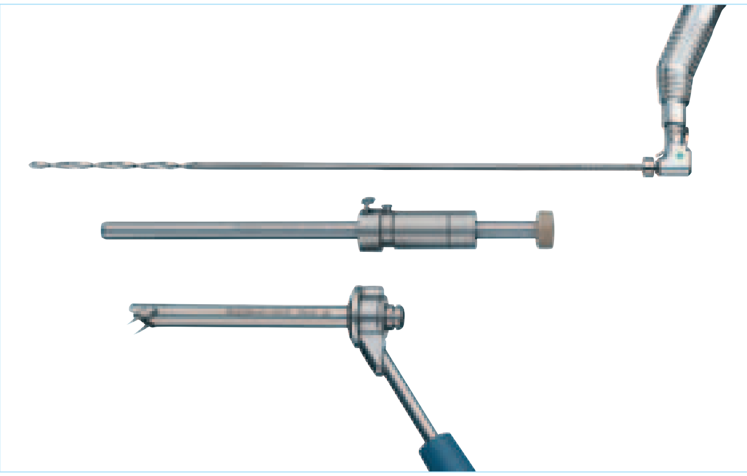


Fig. 11 A

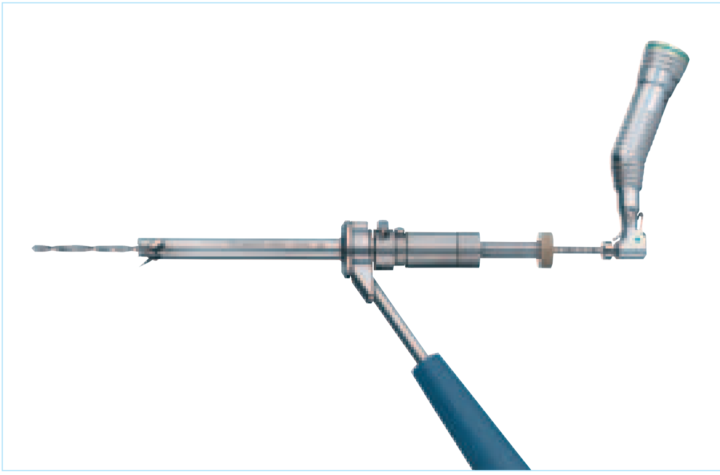


Fig. 11 B

Fig. 11

Components of the drill guide system

A *Drill and inner and outer guide tubes.*

B *All components mated together.*

C *Close up of fixation spikes on the outer guide tube.*

D *Close up of the calibration marks on the drill shaft that can be used to determine the depth of penetration (See text on page 10 for proper interpretation).*

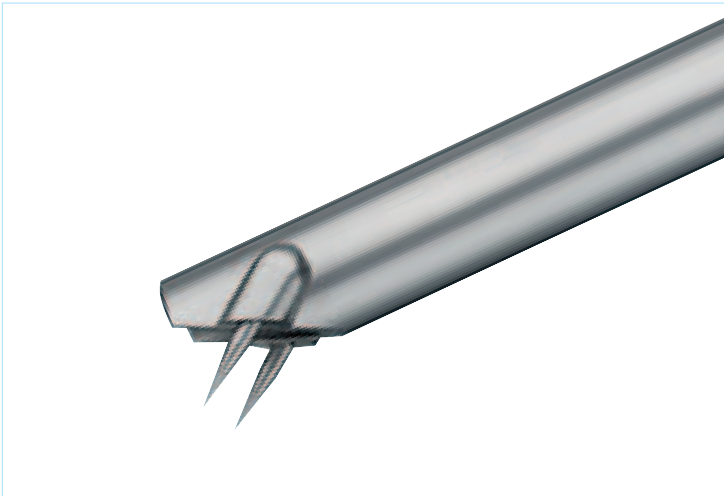


Fig. 11 C

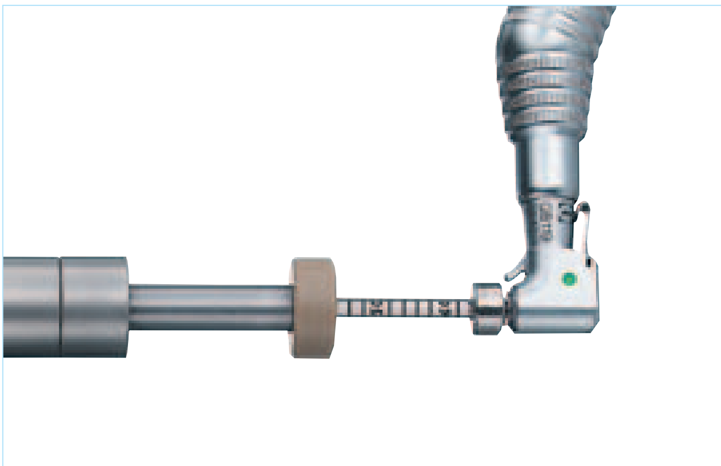


Fig. 11 D

Surgical Technique

After the pilot hole is drilled and the depth noted, the drill is withdrawn and the inner guide tube removed. The tap is then inserted (Fig. 12) and rotated by hand while monitoring its progress on biplane fluoroscopy. The tap cuts threads into the bone to accommodate the screw. The entire length of the pilot hole, including the distal odontoid tip cortex, should be tapped for proper screw engagement and prevention of bone fracture. The tap has a sliding sleeve to cover the exposed part of the thread beyond the drill guide to avoid any soft tissue injury. It also has a calibrated depth gauge, assuming the slide sleeve contacts C2, to reconfirm the screw depth.

Finally, a Titanium screw, which is fully MRI compatible, is inserted through the guide tube and into the tapped pilot hole. Firmly tighten the screw under biplane fluoroscopic monitoring (Fig. 13 A). The screwdriver has a holding mechanism to keep the screw engaged (Fig. 14). The screw should only be threaded distally so it can engage the odontoid distal cortex and "draw back" or pull together the bone fragments if possible. The screw threads engage the distal odontoid cortex, while the screw head bears against the inferior cortex of C2. In Some cases the screw threads may cross the fracture site in certain patients. In weak cancellous bone they have not prevented the "lag effect" from closing the fracture gap in acute fractures (Fig. 15 B, D).

We now use a 4 mm buttress threaded cortical bone screw. This requires a larger 3 mm pilot hole drill which has proven to be stiffer and directionally stable, thereby providing more precise control over the pilot hole by allowing easier correction of minor deviations from the optimal pilot hole path.

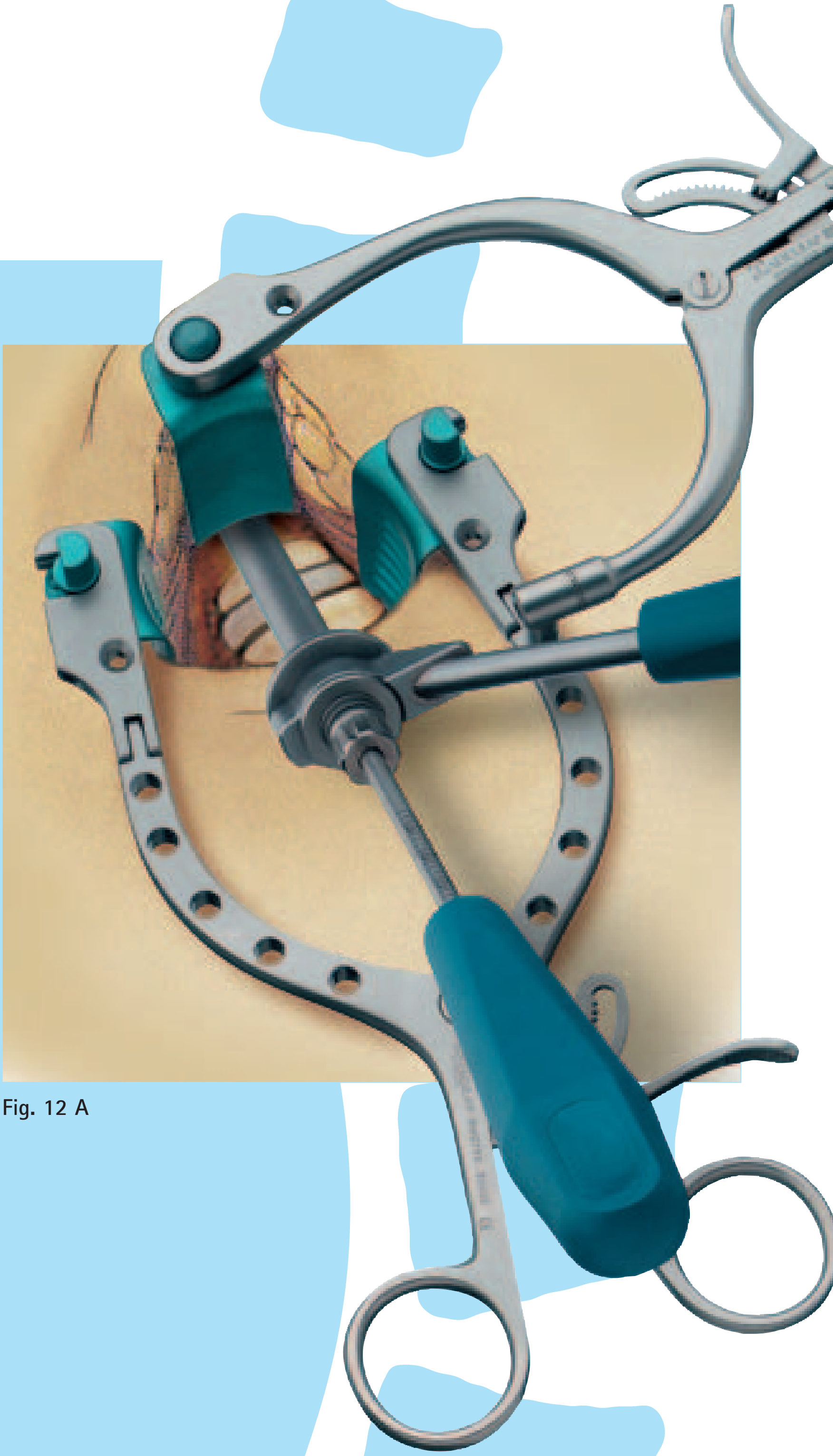


Fig. 12 A

Fig. 12 A
Inner guide is removed and tap inserted.

Fig. 12 B

Tap is used to cut threads into pilot hole.

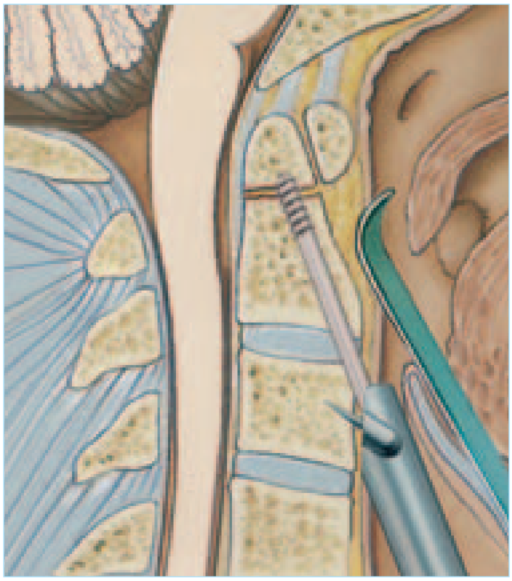


Fig. 13 A

Screw is inserted through guide tube - and advanced through the treaded pilot hole.

Fig. 13 B

The screw is then advanced to its final position using the screwdriver.

Fig. 13 C

Final screw position.

Surgical Technique

If the anatomy allows, [40] a second screw is placed adjacent to the first by repeating the above steps using an entry point slightly lateral to the first screw (Fig. 15 D). This may provide stronger fixation prior to bone union and will prevent rotation of the odontoid relative to the body of C2. A fully threaded screw may be used since no further drawing together of the bone fragments will usually occur.

The wound can then be irrigated, the retractor removed, hemostasis assured, and closure effected in layers. We use interrupted 3-0 absorbable sutures in the sternocleidomastoid muscle fascia, platysma muscle, and subcutaneous layer, with adhesive strips on the skin. No drains are placed.

Immediate stability can be confirmed by observing the lateral fluoroscopic image while the patient´s neck is flexed and extended.

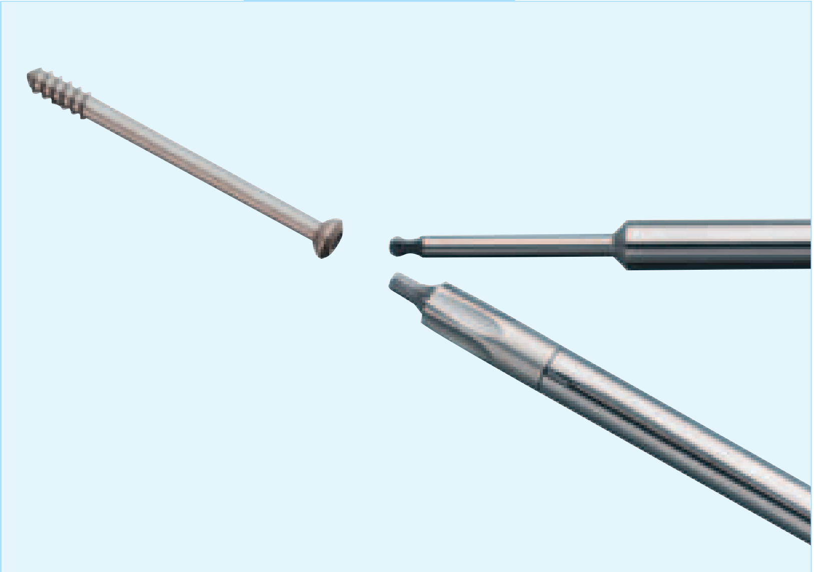


Fig. 14

Fig. 14

The lower screwdriver has a holding mechanism to secure the screw while inserting it through the outer guide tube. The upper screwdriver has a ball end, permitting screw re-engagement while not requiring direct axial alignment.

Fig. 15 A
Type II odontoid fracture with 4-5 mm anterolisthesis.

Fig. 15 B
Gap between odontoid and body of C2 as seen in AP (anterior-posterior) radiograph.

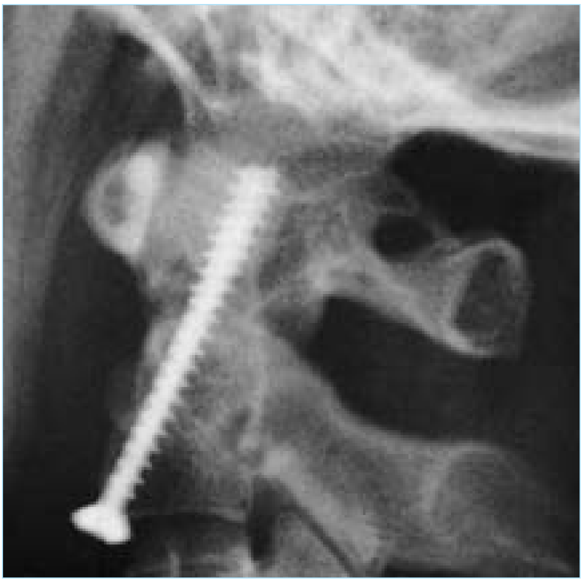


Fig. 15 C

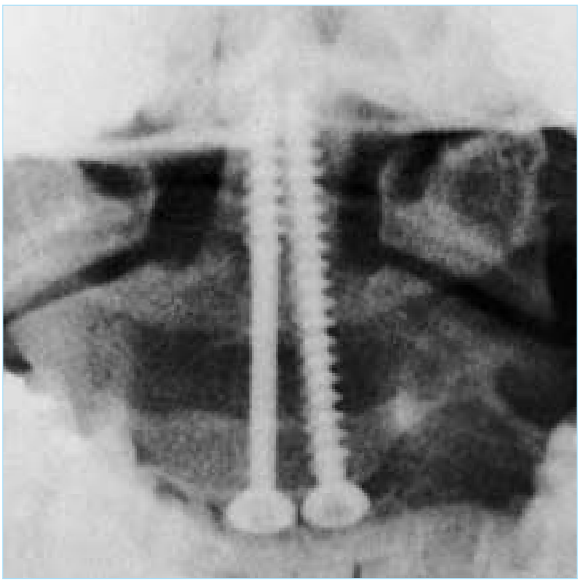


Fig. 15 D

Fig. 15 C, D
Good reduction and stabilization. Note closure of fracture gap (arrows Fig. 15 B) by lag effect of first screw, on patient´s right.

Chronic nonunited Odontoid fractures

In the case of chronic odontoid nonunion, the screw is inserted until just below the fracture site (Fig. 16 A). The guide tube is then removed and the special bifaced angled curettes (Fig. 17) are used to freshen up the fracture site and remove fibrous tissue. This is done by forcing one of the smaller curettes into the fracture site in the midline. Rotation of the handle will then curette both surfaces, upper and lower. Replacing the initial curette with the opposite angled one and then by each of the larger ones sequentially clears the space.

The screw can be reengaged with the ball driver (Figs. 13 B, 14), which allows ± 15 degrees insertion into the screw rather than by strict axial engagement, and the screw firmly tightenend (Figs. 13 C).

Fig. 16 A

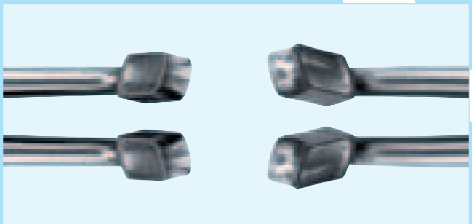


Fig. 16 B

Fig. 16 A
In chronic nonunions special bifaced curettes are used to freshen the fracture site.

Fig. 16 B
Close up of bifaced angled curettes for freshening fracture site. Two sizes are available with a left and right offset angle in each size - all are used sequentially.

Note: Achieving successful bony union in chronic nonunions with this technique is substantially less than with more recent fractures.[41] Therefore, this approach is offered as an alternative to try and preserve C1-2 motion, but is not the preferred technique for chronic nonunions.

Fig. 17 A

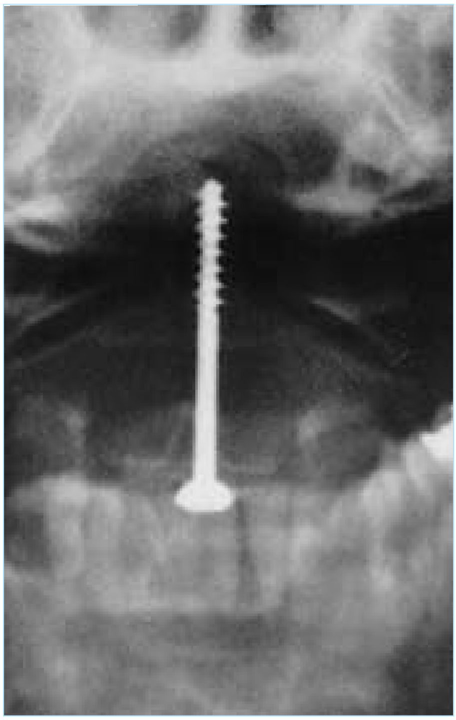


Fig. 17 B

Fig. 17 A, B

Excellent screw position and fracture reduction in an acute odontoid fracture. Dens has reapproximated body of C2 and no fracture line is evident. Fluoroscopically, immediate stability was demonstrated on flexion and extension views.

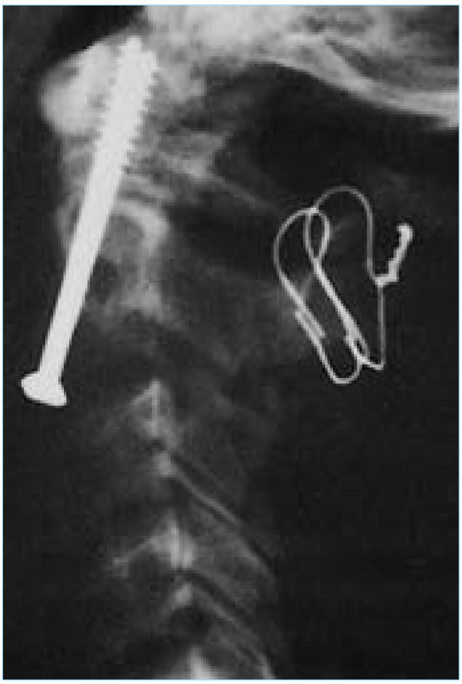


Fig. 18 A

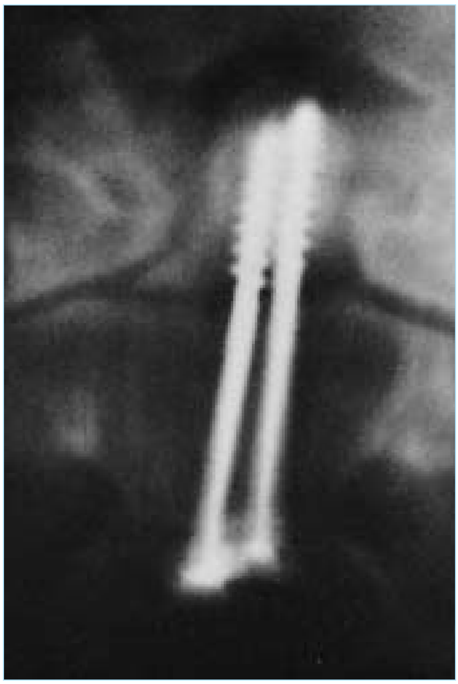


Fig. 18 B

Fig. 18 A, B

Case of chronic nonunion with failed posterior fusion. Note placement of two fixation screws.

Follow-Up Care

Except in unusual circumstances, no external orthosis or collar is used. The patient can be discharged in 1-2 days and promptly resume normal nontraumatic activities and employment. Follow-up radiographs are taken at one day and then monthly until bony union is achieved. Tomography or thin section CT's with sagital reconstructions may be required to define this better (Fig. 19), as the adjacent bones are quite dense and may mask initial bony union. While no longer needed once bony union occurs, we have not found it necessary to remove the screws.

Indications/ Contraindications

An Overview

INDICATIONS

1 Type II Odontoid Fracture
2 Some high type III odontoid fractures

USE CARE WITH

1 Oblique fractures steeply angled anteriorly
2 Associated fractures in body of C2

CONTRAINDICATIONS

1 Ruptured transverse ligament
2 Chronic nonunions with fusion of the odontoid to arch of C1 or clivus

ADVANTAGES

1 Immediate stability
2 Often eliminates need for external orthosis
3 Rapid return to work and normal lifestyle
4 Preserves normal C1-2 motion
5 Highest fusion rate
6 Most cost effective alternative

Fig. 19 A

Fig. 19 B

Fig. 19 C

Fig. 19
A Tomogram of odontoid fracture.
B Post op tomogram at four months shows early bony fusion.
C This is further solidified at six months.

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