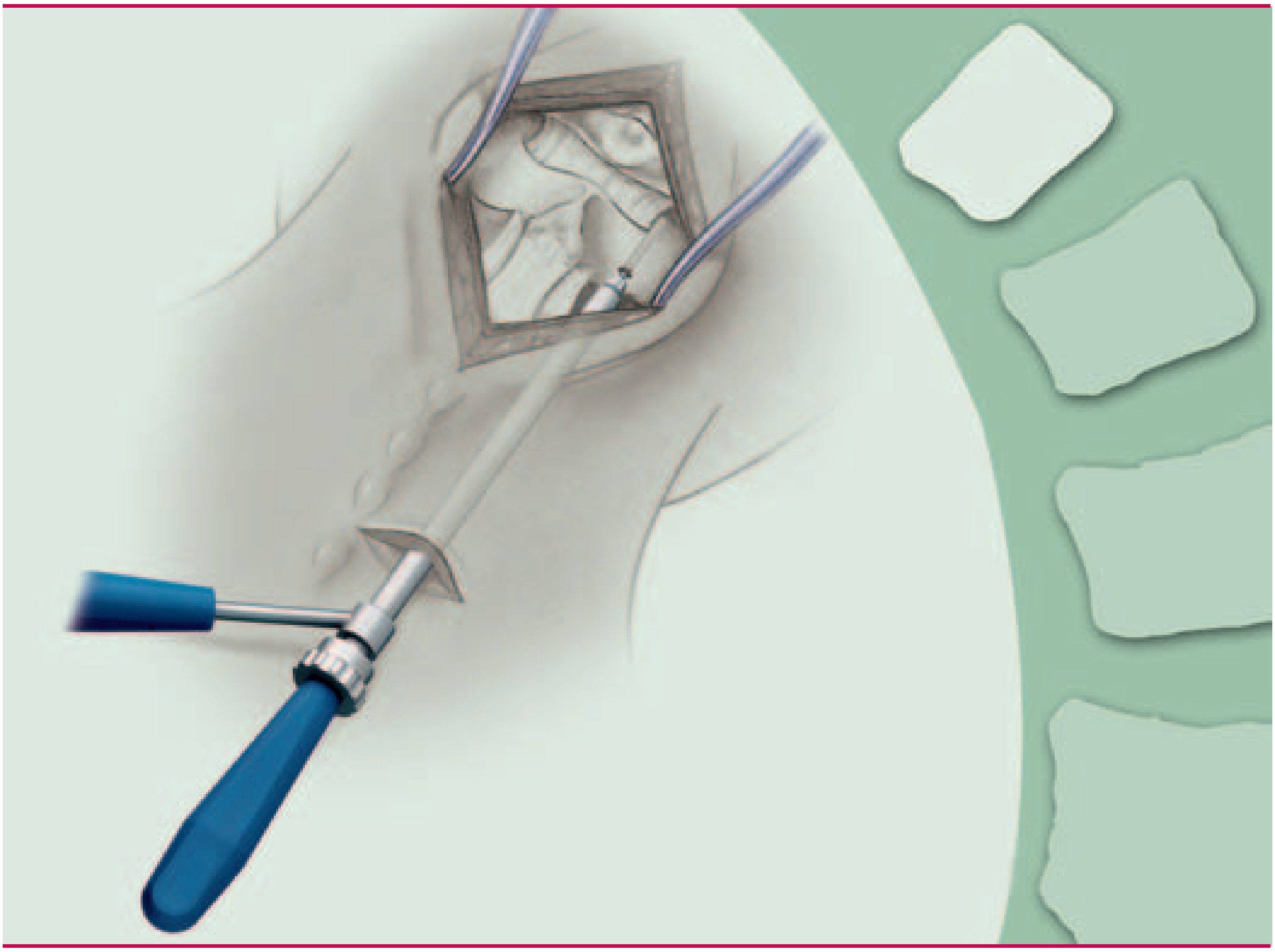
Aesculap Spine
Apfelbaum C1 – 2 Fixation

Posterior transarticular C1 - 2
fixation for atlantoaxial instability



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

B|BRAUN
SHARING EXPERTISE

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In this publication, Dr. Apfelbaum describes a surgical technique for the treatment of Atlantoaxial Instability using the posterior approach with internal screw fixation.

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.

April 1993
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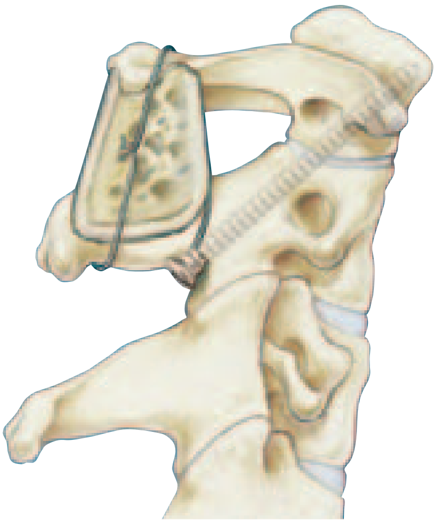
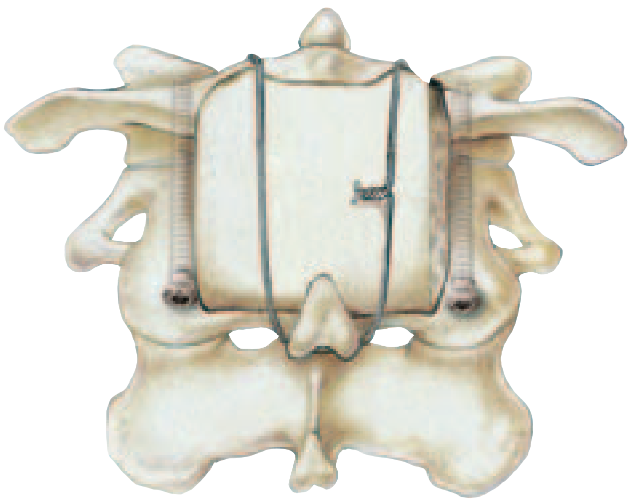
Introduction



The atlantoaxial joint is a complex structure which facilitates head rotation on the neck. To achieve this, the joint surfaces are in a flat plane with no intervertebral disc or loose capsular ligaments. In addition, the other strong spinal ligaments such as the ligamentum flavum and the anterior and posterior longitudinal ligaments are attenuated or absent.[1] The strong transverse ligament (transverse portion of the cruciate ligament) is essential to retain the odontoid process of C2 in the anterior part of the ring of C1. This allows the desired rotation but prevents anterior-posterior translation which would jeopardize the spinal cord.
Disruption or laxity of the transverse ligament results in atlantoaxial instability. This may occur due to trauma, local disease processes such as osteomyelitis, or due to local effects of systemic diseases such as rheumatoid arthritis. Atlantoaxial instability is also produced by trans-oral removal of the odontoid as might occur in treatment of basilar invagination with medullary compression or irreducible subluxation secondary to rheumatoid arthritis. Nonunion of the odontoid, either on a congenital or traumatic basis, negates the function of the transverse ligament and also results in atlantoaxial instability.



Atlantoaxial instability often requires surgical stabilization, which is usually achieved by posterior fusion between the laminar arches of C1 and C2. A number of surgical techniques have been advocated [2,3,4] to achieve this. All employ bone grafting and wiring in various configurations to produce the desired fusion. The normal mobility at C1-2, primarily in rotation, coupled with pathologic translation movements may explain the significant failure rates of the various C1-2 posterior fusion constructs. [5] Elimination of motion, as well as placement of a bone graft under compression between the components to be fused, are considered key factors in obtaining successful fusion. External immobilization with a halo-vest or minerva jacket is often required and is recommended to restrict both normal and pathologic motion so that optimal bony fusion which produces stability is achieved. These devices, however, are not without their own significant medical and social morbidity.

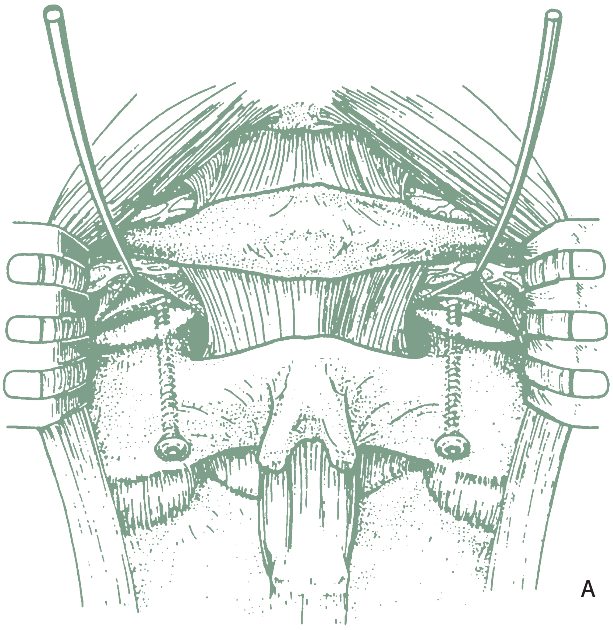
Introduction

In 1987, Magerl[6] reported a new technique of atlantoaxial stabilization which he pioneered in 1976. This was a transarticular screw fixation approach (Figure 1) that offered immediate stability, eliminating the need for any external immobilization apparatus. This construct has proven very strong in biomechanical testing.[7,8,9] Further experience with this technique in 161 patients operated at four separate centers was reported by Grob et al. in 1991.[10] Stable fusion occured in all but one patient. Screw malpositions were infrequent (15%) and did not result in cord or vertebral artery injury, but the latter has occurred in our experience and resulted in a fatal brain stem infarction. For this reason, we now insist on a preoperative CT scan with parasagital reconstruction (see pages 12, 13). Additional reports emphasize that the procedure is both effective and safe if these precautions are followed.[11,12]

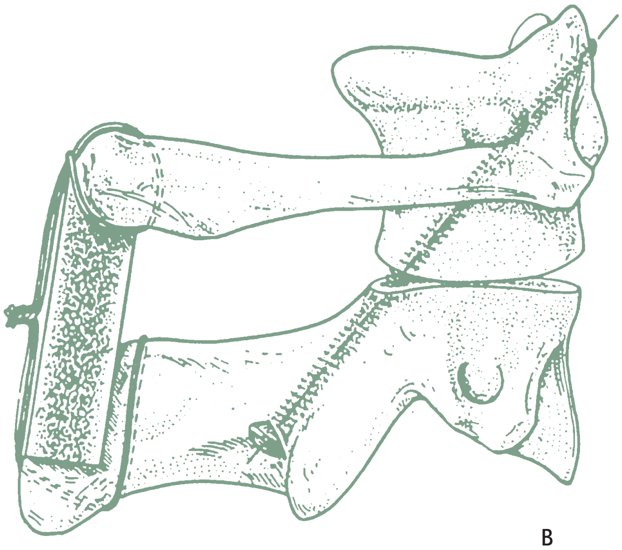
The technique involves standard exposure of the C1-2 area posteriorly and placement of screws bilaterally down the isthmus of C2 (pars inter-articularis) and across the C1-2 articulation to block movement and provide immediate internal fixation (Figure 2). Bone grafting in any of the usual techniques is then applied.

Due to the low angle of approach needed to place these screws, Magerl´s original technique required exposure of the entire cervical spine and at times the upper thoracic vertebrae. However, by using an appropriate guide tube introduced through a small stab wound, a much smaller incision can be employed. Other than this special guide tube, the instruments function identically to the instruments of the odontoid screw fixation instrument set. Once this system has been mastered, the technique can therefore be applied to either operation.

Fig. 2A



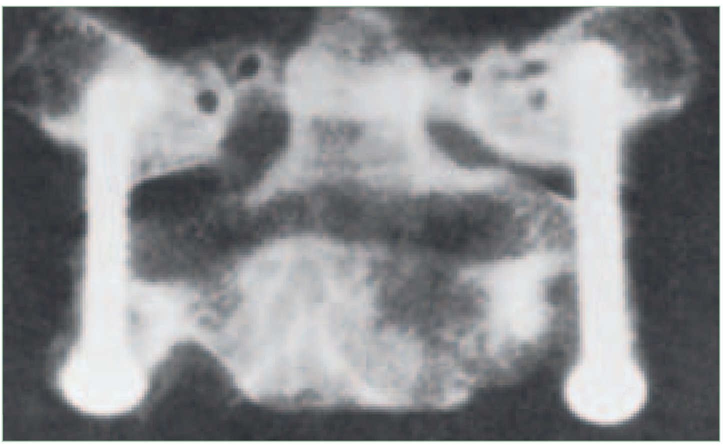
A



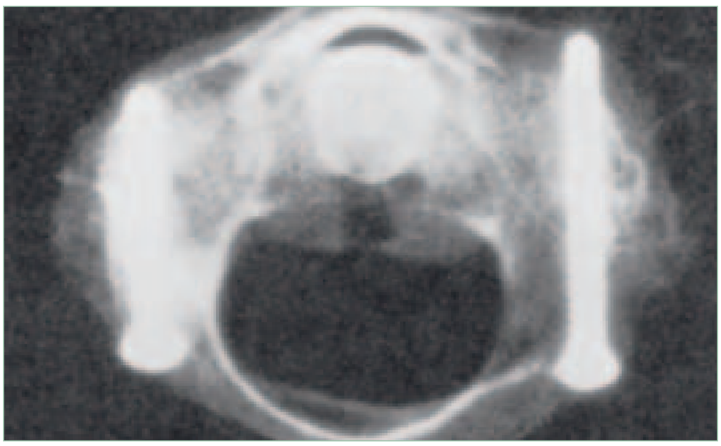
B

Fig. 1 A, B

AP and lateral illustrations from Magerl´s original text showing screw placement of transarticular screws at C1-2 to promote stable fusion. A posterior bone graft is then wired in place to achieve bony fusion (Fig. 1B) (From reference 6, used with permission of publisher).



B



C

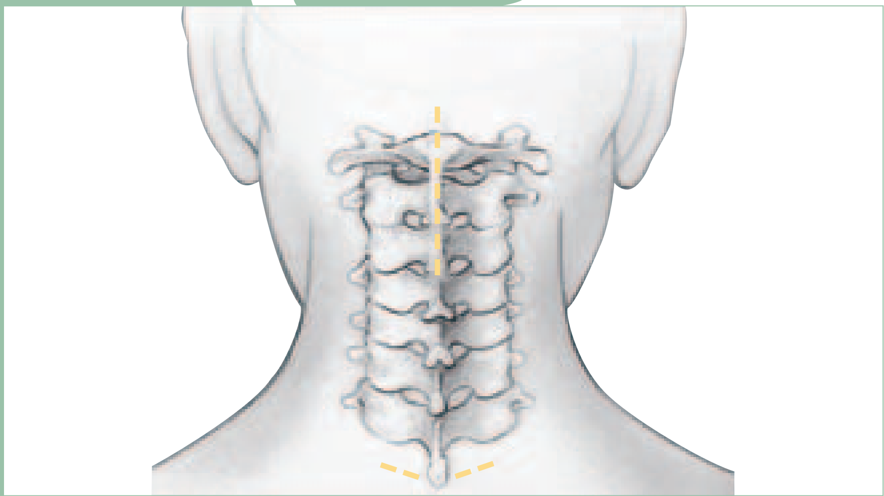
Fig. 2 A, B, C

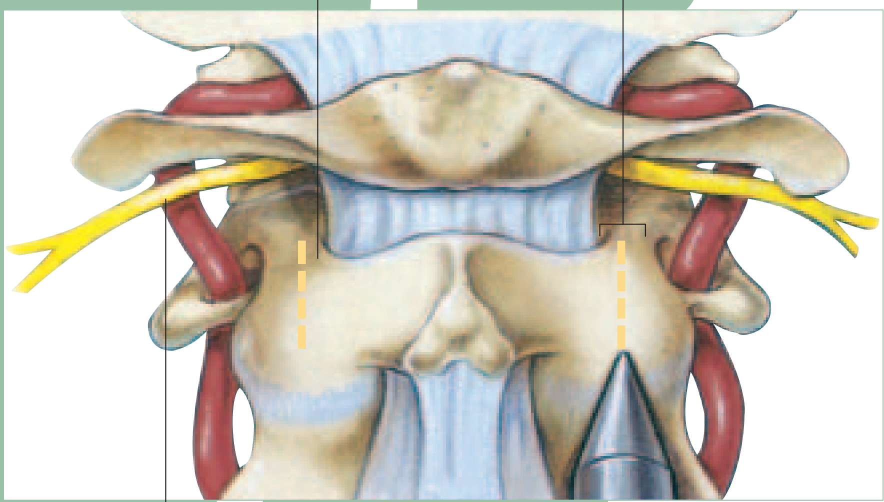
Radiographs of cadaveric atlas and fixation using Magerl´s technique to show location of the screws in 3 planes (From reference 14 used with permission of publisher).

Surgical Technique

The patient is positioned prone with the head supported in a pin head holder. Extending the lower cervical spine while flexing and posteriorly translating the skull and C1 ("military posture") will usually optimally reduce the C1-2 dislocation while allowing the best trajectory to C1-2 (Figure 3 A). C1-2 position is optimized using a C-arm lateral fluoroscopic image. Extension of the lower cervical spine and maximal flexion at the occiput C1-2 region usually flattens the cervical lordosis and reduces atlantoaxial subluxation by posteriorly translating the atlas. After exposure of the posterior elements of C1-2, the lamina of C2 is dissected free of soft tissue to the C2-3 facet joints (Figure 3 B). Using a small angled curette, the superior edge of the lamina of C2 is followed laterally to identify the lateral edge of the spinal canal which is the medial side of the C2 pedicle. This serves as the visual landmark for the medial limit of screw positioning. The dorsal surface of the isthmus can be followed anteriorly to the C1-2 articular joint by elevating the C2 nerve root and associated venous plexus. This allows determination of the proper screw alignment in a dorsal ventral plane.

An appropriate trajectory is visually determined by placing a drill or K-wire alongside the neck and aligning it fluoroscopically to the desired screw position. In this manner, an entrance site for the drill guide is established in the axial plane. Its sagittal coordinate is chosen to allow the screw to be placed in a strict parasagittal plane through the isthmus of C2 and crossing the C1-2 articulation into the lateral mass of C1. Note that the screw does not pass through the pedicle of C2, which would carry it into the C2 body, but rather dorsally through the isthmus (pars interarticularis) and across the C1-2 articulation. The desired placement is 1-2 mm lateral to the lateral edge of the spinal canal (Figure 3 C).





<Fig. 3 A

Patient position. Head is fixed in pin head holder. Translating head posteriorly with chin tucked down reduces atlantoaxial dislocation and allows lower spine to be kept in a straight or even flexed position. This facilitates the trajectory for C1-2 screw placement. The patient is positioned while monitoring vertebral position under lateral fluoroscopy.

Fig. 3 B

Site of surgical incisions. The stab wound sites for placement of the drill guide tube are determined fluoroscopically.

Fig. 3 C

Details of the surgical anatomy. The desired screw placement is just lateral to the lateral edge of the spinal canal. It will traverse the isthmus of C2 and the C1-2 articulation. The pedicle serves as a positioning landmark but the screw does not go down the pedicle.

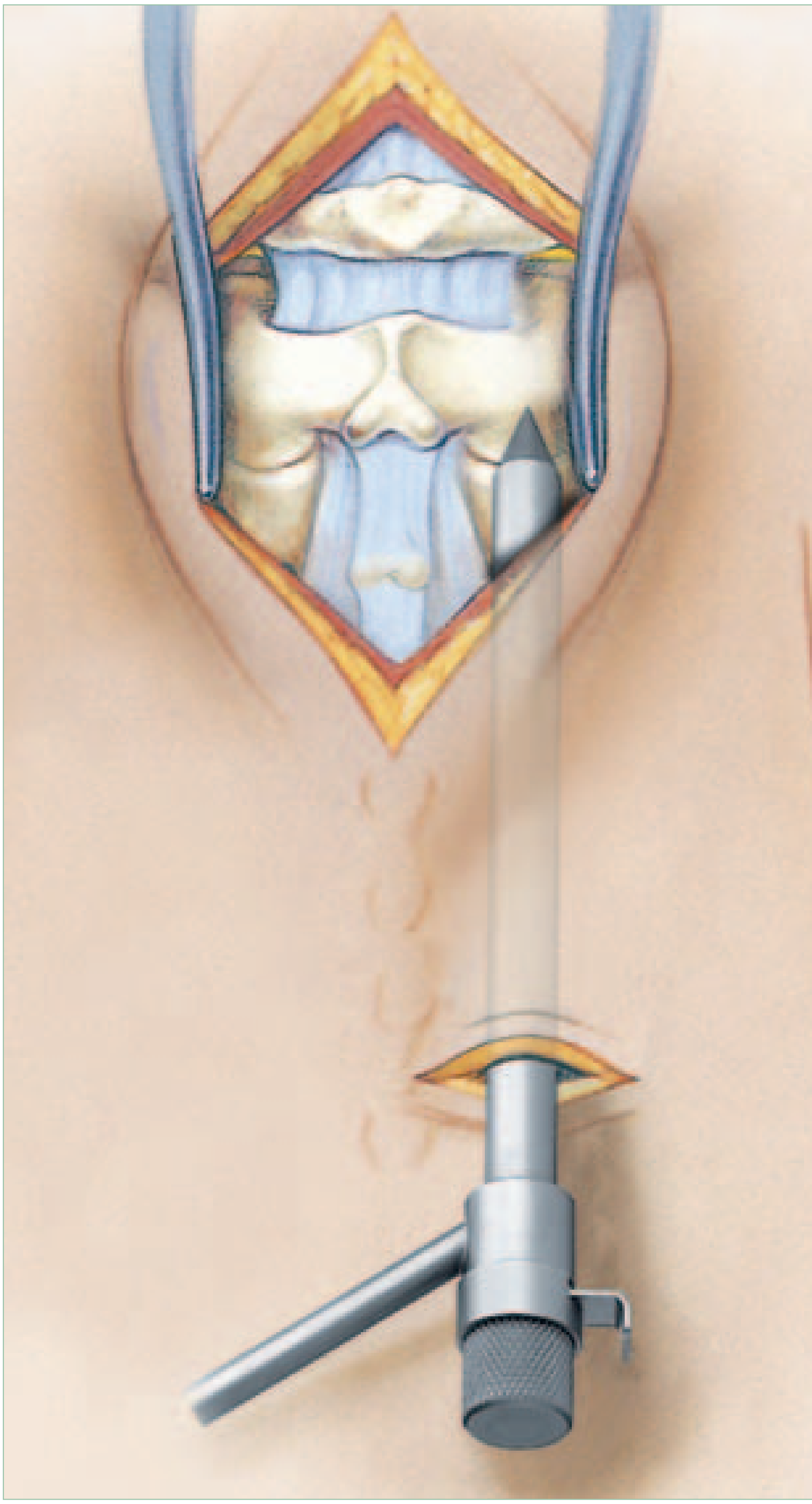


Fig. 4

Placement of the guide tube (with obturator) through a stab wound into the field.

Once the skin entrance site is determined (Figure 3 B), a 1.5 cm stab wound is made through the skin, subcutaneous tissue and dorsal fascia. It can be dilated with a hemostat and then the outer guide tube with its conical tipped obturator is worked through the tissue and into the surgical site.

Its position can be adjusted, due to the flexibility of the soft tissue, to place it at the precise entrance site for the screw, which is just above the inferior edge of the C2 inferior articular process. The obturator is then removed (Figure 5 A) and the inner drill guide placed (Figure 5 B). If desired, a sharp obturator is available to make a starter hole in the bone.

A pilot hole is then drilled under fluoroscopic control through C2 into the lateral mass of C1, crossing the C1-2 articulation (Figures 6 and 7). Standing back from the operative field by using a step stool helps eliminate parallax and allows more precise drill trajectory. On the lateral fluoroscopic image, this usually results in the drill pointing toward the anterior tubercle of C1. The depth of drilling is noted on the sliding sleeve of the inner drill guide (Figure 6 B).

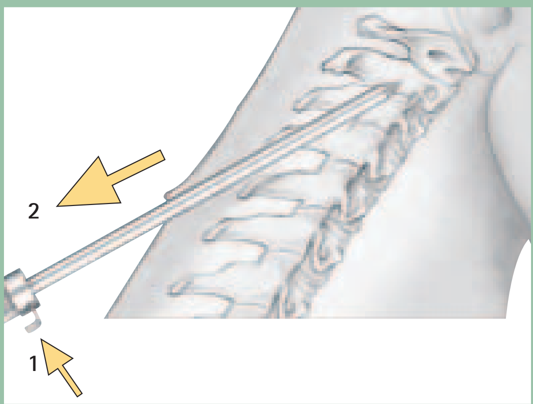


Fig. 5 A

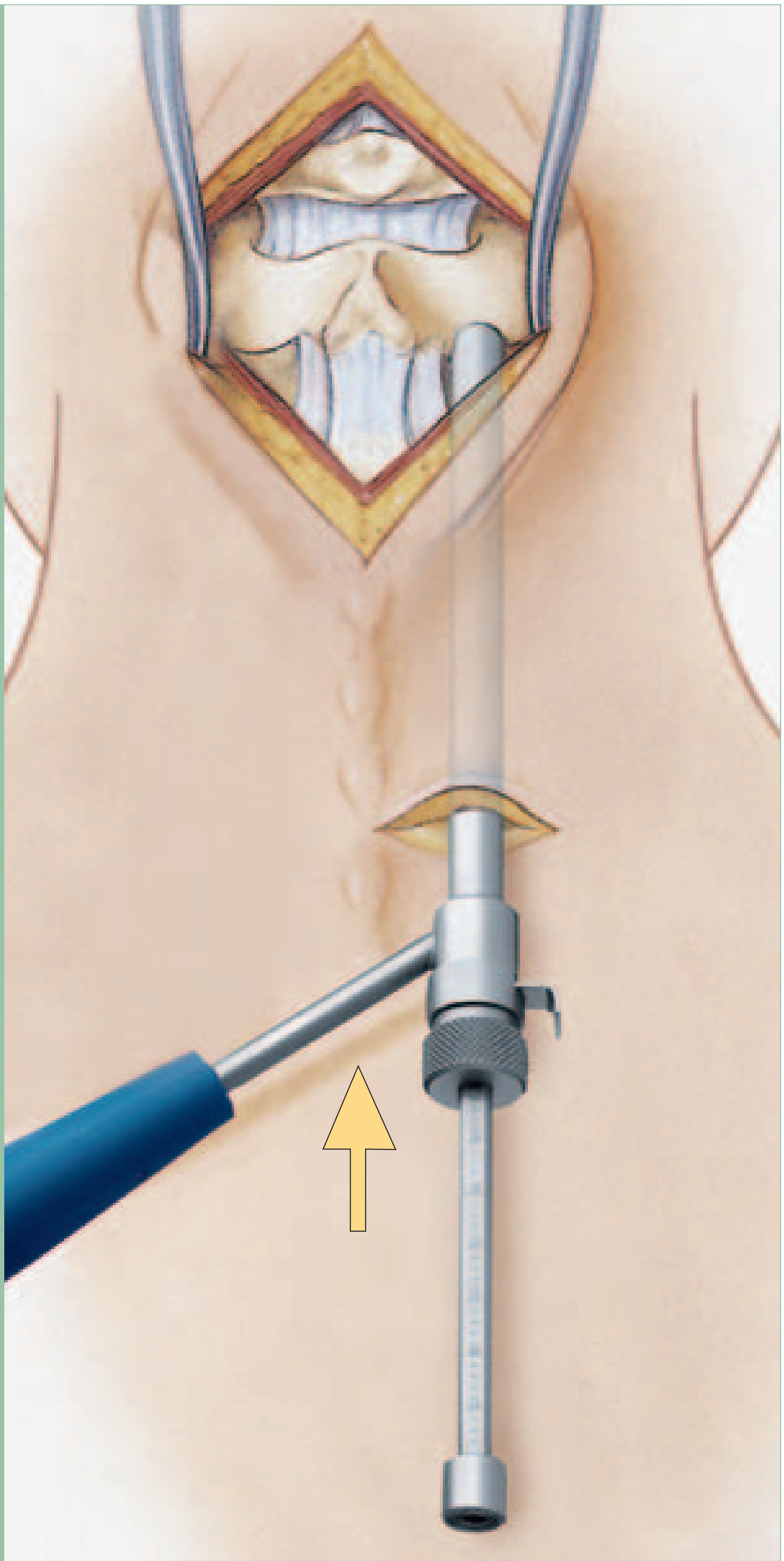


Fig. 5 B

Fig. 5 A, B

Guide tube in place as seen in sagittal (A) and dorsal (B) view. Once the guide tube/obturator assembly is worked through the soft tissue into the surgical site (5 A) the obturator is removed (Step 1, then 2) and replaced with the inner drill guide (5B).

Fig. 6 A

A pilot hole is then drilled across the atlantoaxial joint and into the lateral mass of C1.

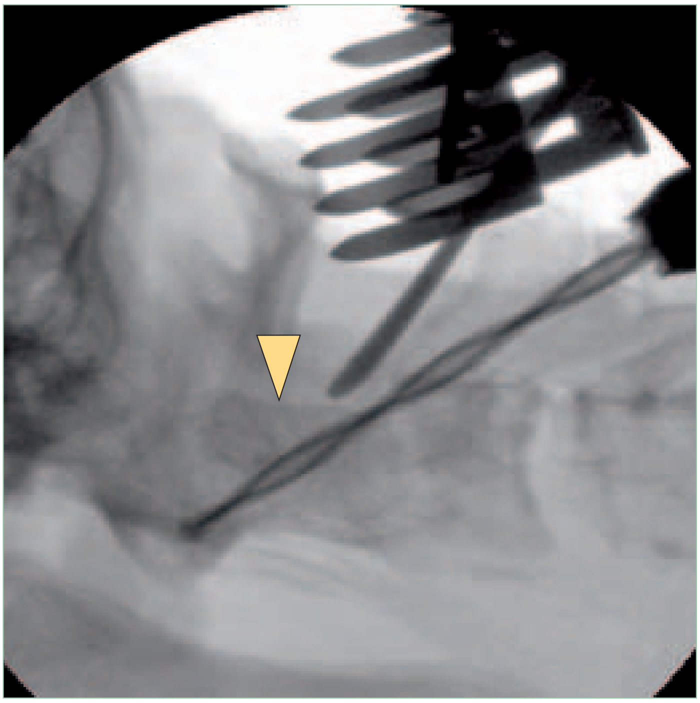


Fig. 7

Lateral fluoroscopic view of drilling process. The drill has crossed the C1-2 joint (arrow). A dissector placed on the pars helps orient the drill placement. The drill should be angled to pass just below this instrument.

Fig. 6 B

The depth can be read on the calibrated inner drill guide and will be accurate as long as the tip of the inner drill guide is in contact with the bone.

The drill is removed as well as the inner drill guide (Figure 8 A). The hole is then tapped along its full length (Figure 8 B and 9 A). The tap cuts threads into the bone to prepare it for the screw. This instrument fits through the outer drill guide, as does the screw which is placed next (Figures 8 C, 8 D and 9 B). The procedure is then repeated on the other side.

A Brooks, Gallie or Sonntag type posterior fusion is then placed (Figures 9 C, 9 D and 10) and the wounds closed. Subcutaneous stitches and sterile skin tape are usually sufficient for the trocar entry wounds. A cervical collar is usually not needed.

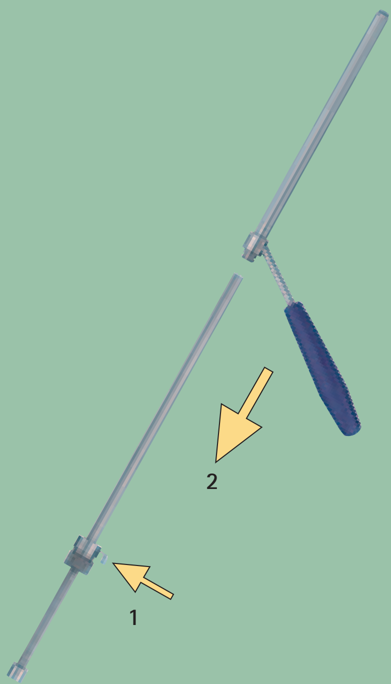


Fig. 8 A

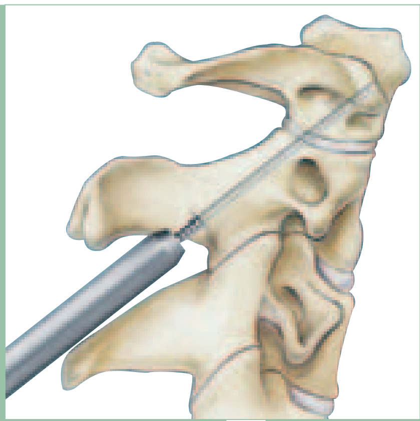


Fig. 8 B

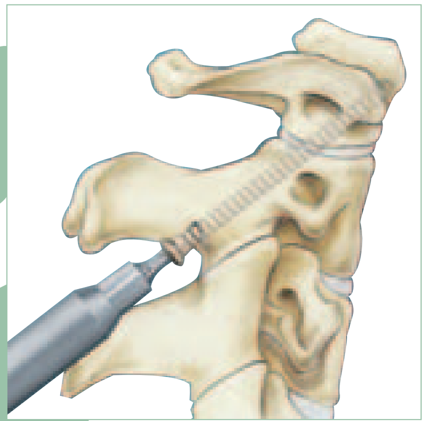


Fig. 8 C

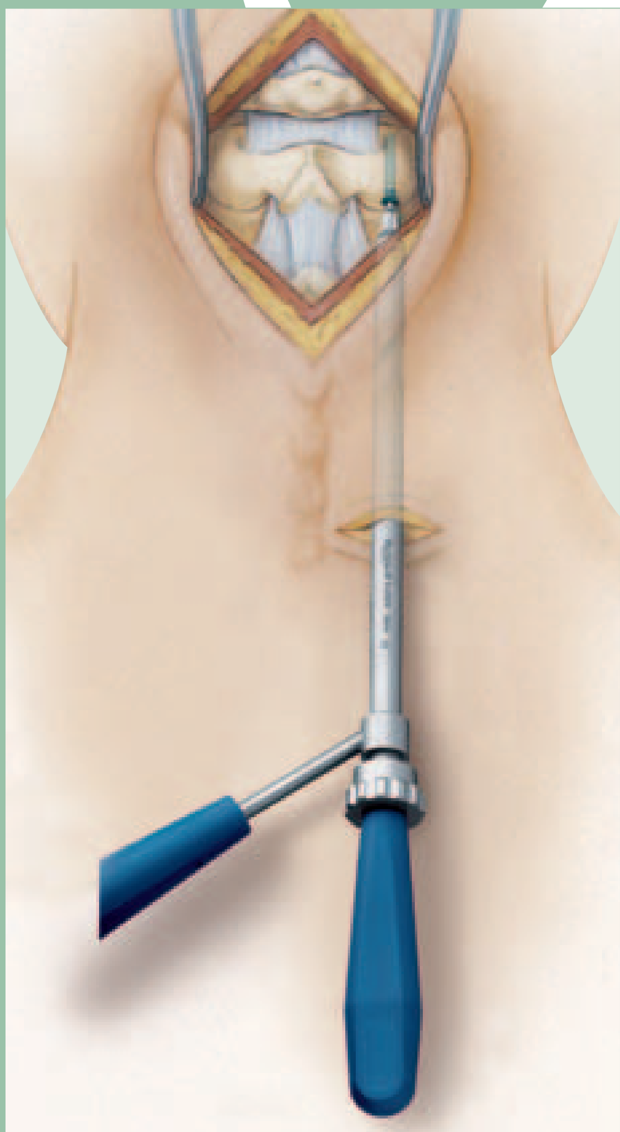


Fig. 8 D

Fig. 8
Once drilling is complete, the inner drill guide tube (A) should be removed (step 1, then 2). The pilot hole is then tapped (B) and the screw placed (C and D) through the outer guide tube.

Fig. 9 A *Tap in place*

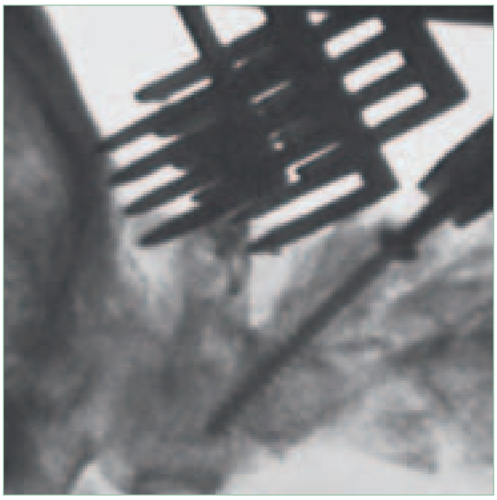


Fig. 9 B *Screw being tightened*

Fig. 9 C

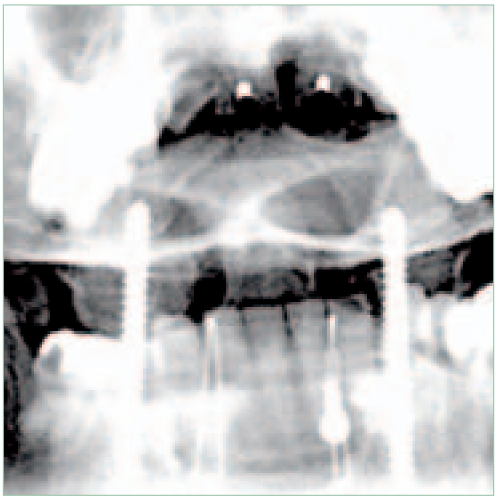


Fig. 9 D

Fig. 9 C, D
Graft in place along with fixation screws.

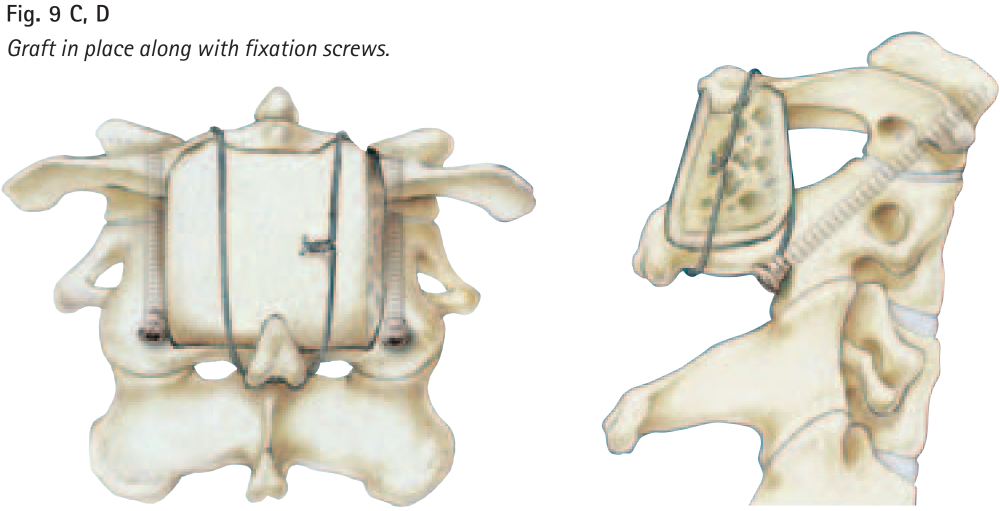


Fig. 10
Completed screw fixation and subsequent posterior bone grafting (Sonntag construct)

Discussion

Due to the immediate stabilizing effects of the screws, patients can be quickly mobilized and hospital stays are usually brief. There appears to be less postoperative pain than expected, which may also be due to the immediate stability produced by this procedure.

To avoid failure or injury to vital structures in this area, a thorough understanding of the anatomy and pathology is necessary. Appropriate preoperative studies can clarify this. We obtain thin section CT scans and reconstruct them parasagitally in the proposed plane of the fixation screw (See Figures 11 A, B and C). If the vertebral artery loops up and is in close proximity to the screw trajectory, the procedure is not attempted on that side. Also, if the disease process has significantly altered the normal anatomical relationships or destroyed the bone into which the screw will be placed, the procedure should not be attempted. These conditions on occasion will require that only one screw be placed. This is a weaker construct, so consideration should be given to the use of an external orthosis. Screw fixation should not be attempted if the fluoroscopic images are not satisfactory.

Fig. 11 A

Parasagittal reconstruction of CT scan through proposed screw path shows adequate bone to safely accept screw on patient´s right side.

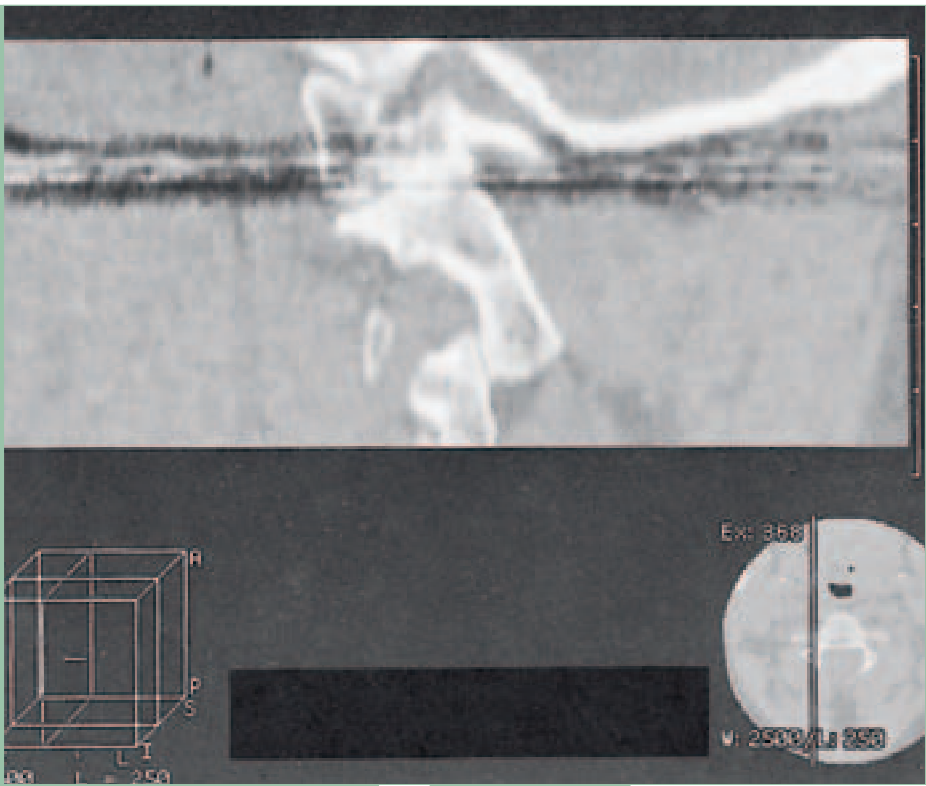


Fig. 11 A

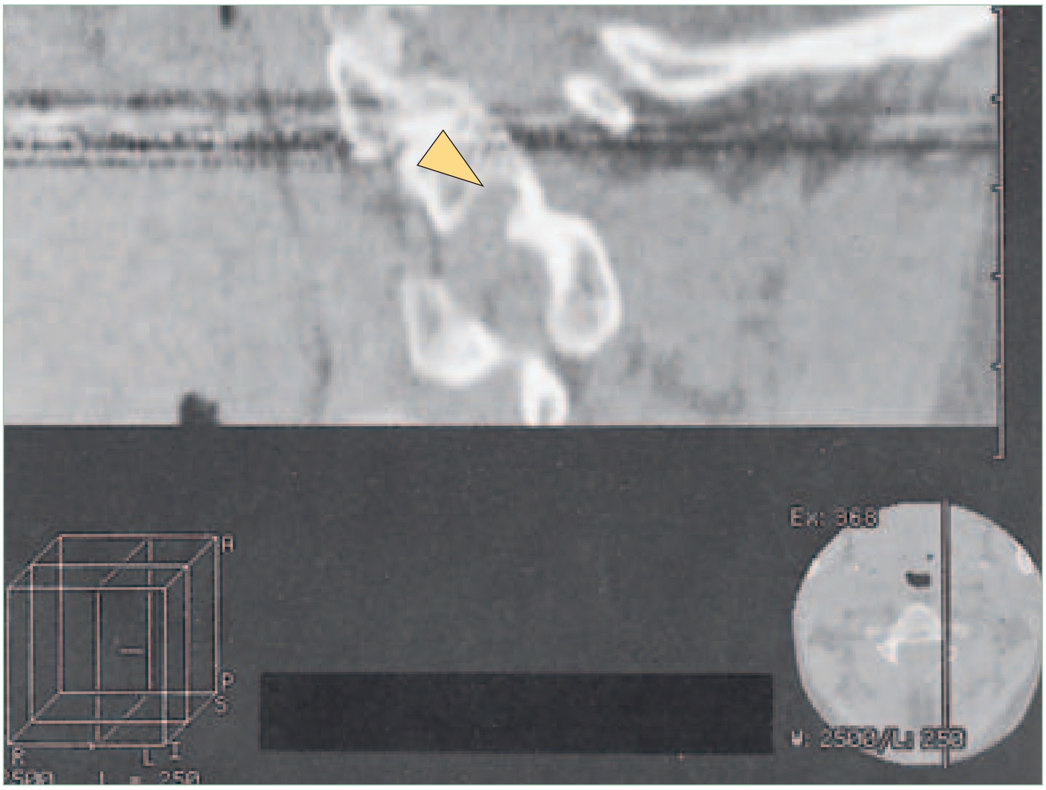


Fig. 11 B

Similar reconstruction on left side shows ectatic vertebral artery that has eroded into the bone (arrow) and might likely be injured by screw placement. Therefore, no screw was placed on that side.

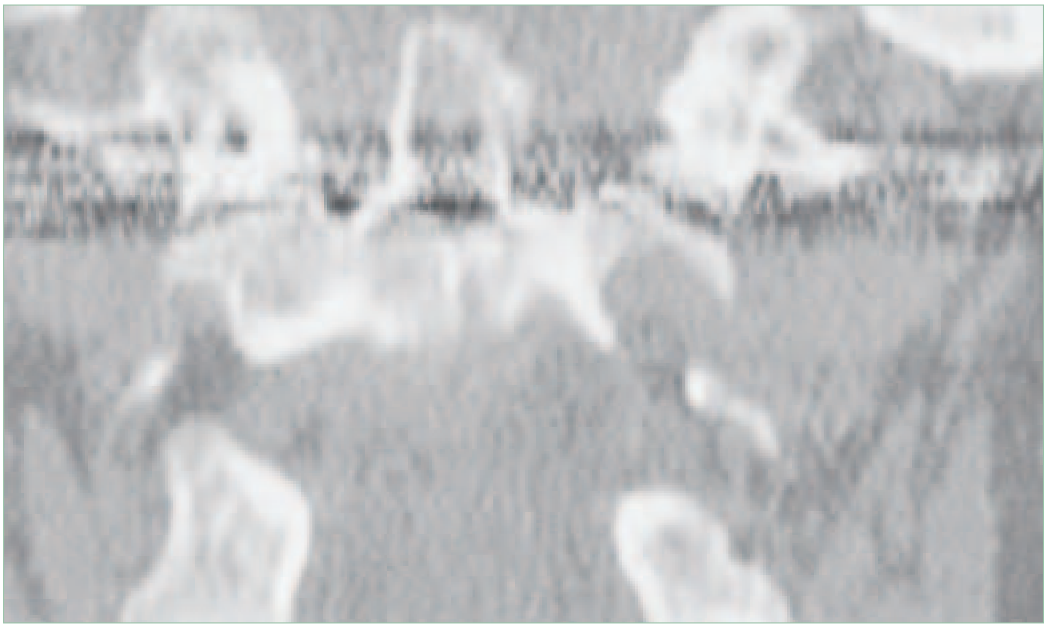


Fig. 11 C

Coronal reconstruction confirms the erosion of the bone.

Discussion

While we have used partially threaded screws in some of our initial cases, there is no lag effect expected. Therefore, fully threaded screws are preferred. We have employed this procedure in patients with incompetent transverse ligaments due to rheumatoid arthritis or trauma (Figure 12 A-F) or after transoral odontoid resection.

Fig. 12 A
Normal alignment in extension.

Traumatic rupture of transverse ligament in a diving accident.

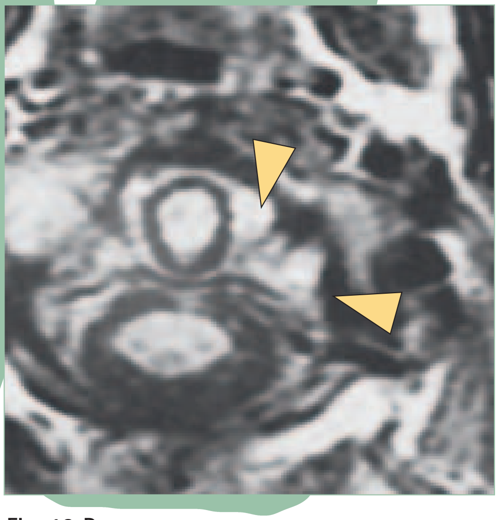


Fig. 12 D
T1 MRI shows blood at the site of ligament tear (arrows).

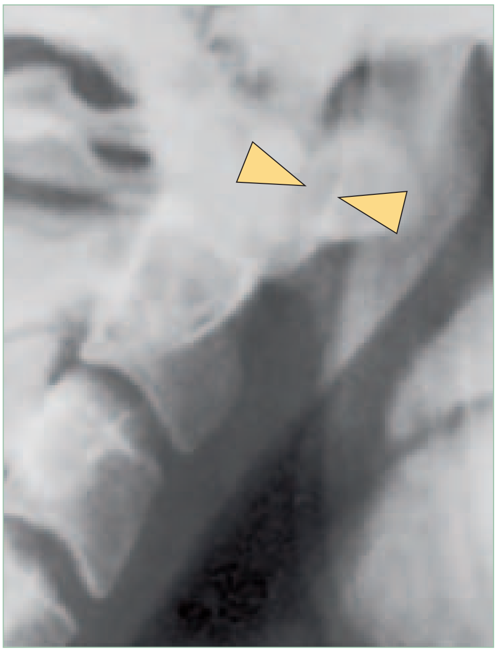


Fig. 12 B
Widened predental space in flexation (between arrows).

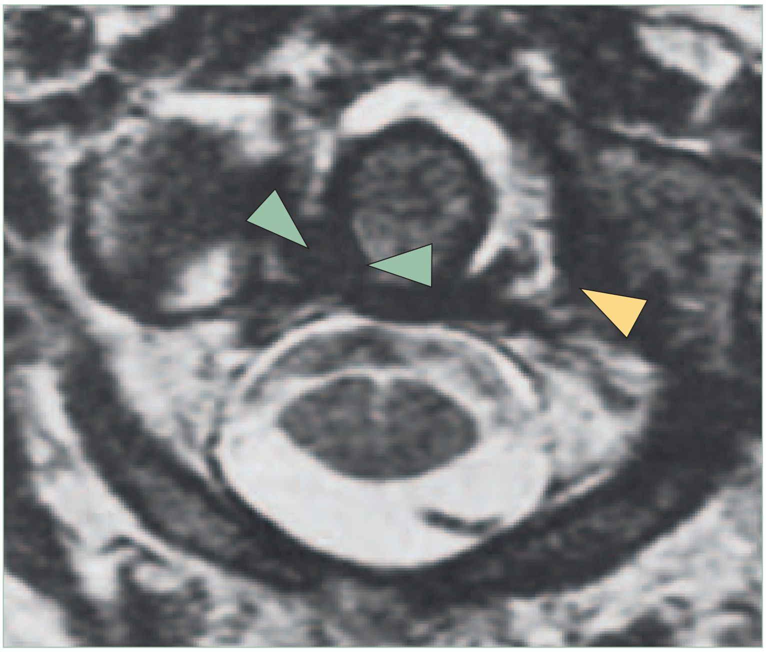


Fig. 12 C
T2 MRI shows disruption of the transverse ligament on the left side (yellow arrow). The frayed end of the ligament (black) is surrounded by a halo of blood (white). Compare this with the intact ligament on the left (green arrows) which is in continuity with the bone (also black).[15]

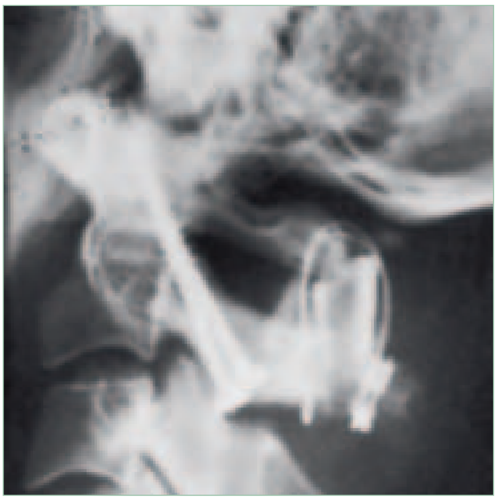


Fig. 12 E

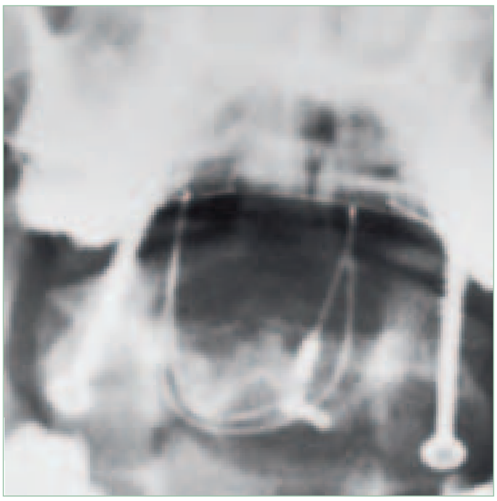


Fig. 12 F

Fig. 12 E, F
Postoperative radiographs of the screw fixation and Sonntag fusion.

Discussion

The technique has also been used to stabilize the C1-2 complex in cases of congenital ligamentous laxity (Larsen´s syndrome) (Figure 13) or os odontoidium. A number of our patients had failed prior C1-2 fusions.

Fig. 13
Patient with Larsen´s syndrom (congenital ligamentous laxity) and significant C1-2 instability.

Fig. 13 A
Good reduction and placement of Sonntag fusion.

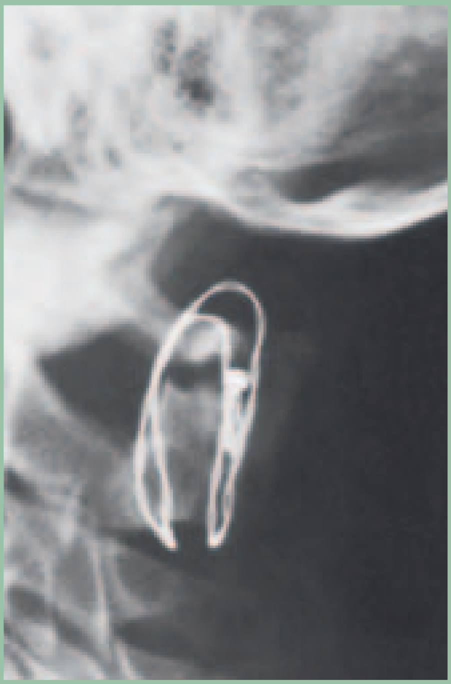


Fig. 13 B
Failure of fusion to unite after 5 months (in halo).

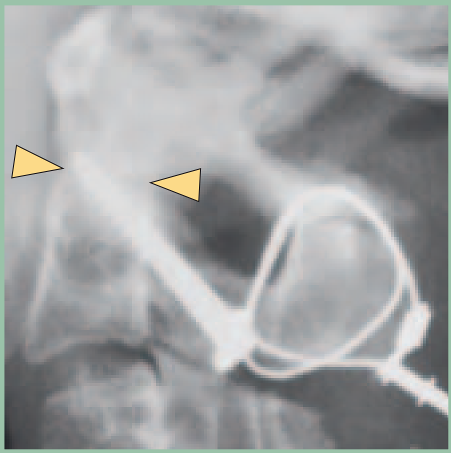


Fig. 13 C
Revision with C1-2 screw fixation. Despite low screw trajectory dictated by bony anatomy, the screw crosses the C1-2 articulation (see arrows) and securely immobilizes this joint.

Fig. 13 D
Solid fusion 3 months later.

Indications/Contraindications

An Overview

INDICATIONS

1 Disruption of transverse ligament:
   A) Trauma
   B) Local Infection
   C) Rheumatoid Arthritis

2 After transoral odontoidectomy.

3 Os odontoideum

4 Chronic nonunions of odontoid.

CONTRAINDICATIONS

1 Ectasia of vertebral artery into the body of C2.

2 Altered anatomy or bony destruction in the region of the proposed screw placement.

3 Inadequate fluoroscopic images.

Conclusions

This relatively simple procedure is facilitated by the instrumentation described in this manual. It allows us to offer our patients immediate stability and freedom from the necessity of using an external immobilizer while enhancing the success of the fusion. Fusion rates have been close to 100%.[6] Careful evaluation of the patient´s anatomy, with proper pre-operative imaging as well as attention to the technical details of the procedure, are necessary to perform it safely.

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