ANTERIOR SURGERY FOR INJURIES TO THE LOWER CERVICAL SPINE (FROM C3 TO T1)

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Traumatological surgery of the lower cervical spine through an anterior approach has real advantages: no need to turn the patient (which is always dangerous in cases of severe instability, such as in bilateral dislocations), easy exposure of the anterior column of discs and vertebral bodies, bone grafting in the interbody spaces, which contributes to successful fusion, and straightforward stabilization by screw-plate fixation. Nevertheless, anterior cervical surgery has its limits, notably for lesions of the posterior arches, which are easier to reduce through a posterior approach.

HISTORICAL BACK-GROUND

Although Chipault appears to have approached the cervical spine of a patient with Pott's disease through an anterior approach as early as 1895, Robinson [1] was the first to describe the anterior cervical approach in 1955. Shortly after that, other authors performed anterior interbody grafts without osteosynthesis: Dereymaker [2] in 1956, Cloward [3] in 1956, Bailey [4] in 1960, and Verbiest [5] in 1962. These stand-alone grafts, although protected by strong external orthoses such as Minverva collars or halo jackets, can be complicated by secondary displacement of the graft, which occurred in as many as 100% of the traumatic cases reported by Stauffer [6], and as few as 13% of the cases published by Gregory [7]. Bohlman [8] reported pseudarthrosis in 5% of the cases of one-level grafts and in 16% of multiple-level grafts. Subsequently, numerous authors advocated use of osteosynthesis by screw-plates to avoid extrusion of the graft (Orosco in 1970, Bohler [9] in 1979 and Caspar [10] in 1982). Sénégas [11] developed a cervical plate, which we shall describe here, and published his first results in 1972 and 1976.

INSTALLATION - APPROACH

The trauma patient is placed in a strictly supine position, in some cases with traction by Gardner-Wells tongs and with the table slightly tilted so the feet are lower than the head. The shoulders are pulled caudally with adhesive bands to facilitate radiological views of the cervicothoracic junction. The image intensifier is installed and blocked in the proper position. It should permit verification on lateral views whenever needed during the procedure. If the legs are not lower than the head and if the neck is overly extended, extra- and intraspinal venous bleeding may be exacerbated, rendering decompression procedures in the spinal canal more difficult. The anaesthesiologist having poor access to the head and upper limbs, a firmly attached reinforced intubation tube should be used and blood pressure should be measured at one of the lower limbs (fig. 1).
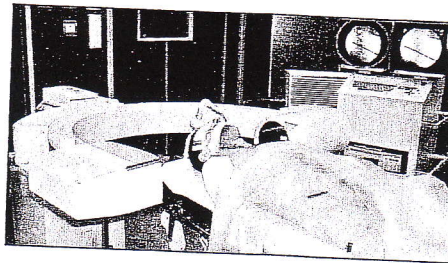

Fig. 1 : Peroperative installation

The anterior approach progresses anterior to the sternocleidomastoid muscle and carotid sheath. Right-handed surgeons generally operate through the right side and left-handed surgeons through the left. The exposure can be horizontal to access a single disc and vertical for two discs or more.

Vascular ligatures are rarely needed. The thyrolinguofacial venous trunk and the superior thyroid artery may be ligated to access C3-C4 and the inferior thyroid artery to access C6-C7. One must be careful not to section the hypoglossal nerve and lower (or recurrent) laryngeal nerve when exposing C7-T1, notably on the right side where it is more lateral and therefore more prone to iatrogenic injury.

THE CLASSIFICATION OF INJURIES WE USE IS THAT OF ARGENSON [12]

Among lesions that may be operated are:
- **Type A** lesions in compression (burst fractures, most often of C7 (A2) and tear-drop fractures of C5 or C6 (A3)),
- **Type B** lesions in flexion (severe sprains (B2) or bilateral dislocation (B3)),
- **Type C** in extension, especially without osteoarticular lesions, but involving subjects with narrowing of the cervical canal (C1),
- **Type D** in rotation (unilateral fracture (D1), dislocation-fracture of the lateral mass (D2) and unilateral dislocation (D3). In these lesions in rotation where the surgeon's attention is drawn to the lesion of the posterior arch, there is always rupture of the disc.

CLINICAL SERIES

The clinical series presented is somewhat dated, but homogeneous. Between 1979 and 1999, 597 traumatic injuries of the lower cervical spine were operated through an anterior approach; 435 patients presented with neurological deficit (73%). The lesions included:

- 301 (51%) dislocations and severe sprains (types B2, B3 and D3)
- 119 (20%) tear-drop fractures (A3)
- 118 (20%) burst fractures (A2)
- 53 (9%) other lesions (mainly D)

In case of neurological symptoms, the anterior approach is logical because the lesion involved can often cause kyphosis and anterior compression upon the spinal cord and nerve roots.

For cases of trauma involving extension in patients with narrowing of the cervical canal, decompression through an anterior approach in a typically kyphotic cervical spine is performed by cutting a trench in the vertebral bodies of the compromised levels. Rarely done under emergent conditions, this is most often performed when neurological recovery comes to a halt.

SPECIFIC ANTERIOR PROCEDURES ACCORDING TO THE LESION TO BE TREATED

Comminutive fractures

In comminutive fractures of the vertebral body most often involving C7 (Type B2),

orthopedic treatment is usually an option for this essentially bony injury entailing transient instability. Nevertheless, in cases of neurological deficit or of severe instability, surgery will consist of a corpectomy and reconstruction by tricortical iliac crest graft stabilized with a titanium screw-plate.

Tear-drop fractures

The tear-drop fractures involved C5 in 62% of the 60 cases from our unit that Cariou included in his medical thesis written in 1996. The other levels involved were C6 (23%), C4 (10%) and C3 (5%).

It is important to determine what disc is affected to guide the choice of both the upper and lower levels of the arthrodesis. Surgeons should take into account an offset in the posterior vertebral body alignment and not hesitate to make perform intraoperative discography to look for leakage of the contrast agent, signifying a rupture of the disc (fig. 2). If
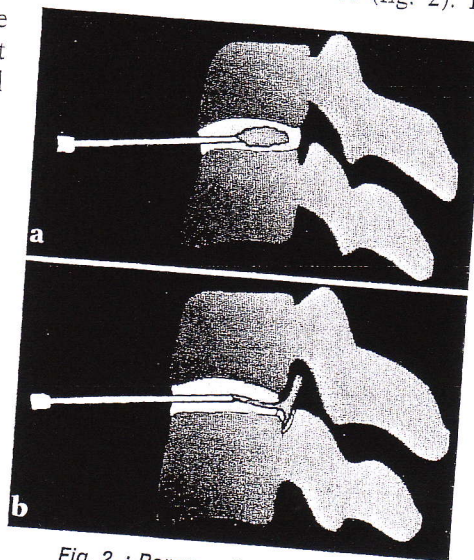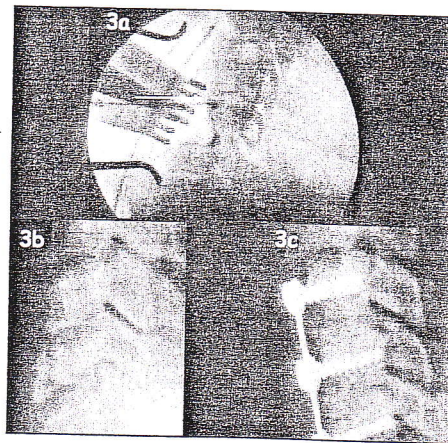

Fig. 2 : Peroperative discography
a) négative ; b) positive

there are neurological symptoms, total corpectomy down to the posterior wall to ensure good decompression should always be considered. In tear-drop fractures with no neurological symptom, if the superior disc is held to be intact, an interbody graft on the lower disc with a cervical plate can be proposed. Isolated injuries of the superior disc are exceptional. In case of doubt, a double disc space graft (fig. 3) or a partial anterior corpectomy is performed, associated in every case with plate osteosynthesis.

Fig. 3 : Tear drop with positive peroperative discography at the upper level pointing at superior and inferior arthrodesis

Unilateral facet fractures

Unilateral facet fractures (D1 lesions) are operated if there is severe offset on lateral and oblique views, especially if the accident victim experiences ipsilateral cervicobrachial neuralgia. The ruptured disc can be seen through the ante-rior exposure. Its replacement by a monocortical iliac crest graft of proper height (the same height as the healthy adjacent discs in young subjects) will enlarge the intervertebral foramen and indirectly reposition the fractured superior facet.

Fracture-dislocations

In fracture-dislocations of the lateral mass (D2 lesion), as in tear-drop fractures, it is essential to know which discs (upper, lower, or both) are involved. Intraoperative discography is also useful in such cases, more so than MRI, which provides less information on the state of the discs. The interbody arthrodesis includes the lower disc or both discs.

Facet dislocation can complicate a fracture-dislocation of the lateral mass (fig. 4). Reduction through a posterior approach is often indicated in this type of lesion. Nevertheless, if the anterior approach is chosen, one should remember that none of the open reduction maneuvers, which we shall describe in the subchapter on dislocations, is effective because the pedicle is detached from the vertebral body. The disc and vertebral body can be exposed through a conventional anterior approach anterior to the carotid sheath and the dislocation can be accessed through a retrovascular approach. By passing behind the vertebral artery and between the two roots that frame the lateral mass involved, surgeons can reduce the dislocated facet with an osteophyte hook under image intensifier guidance.
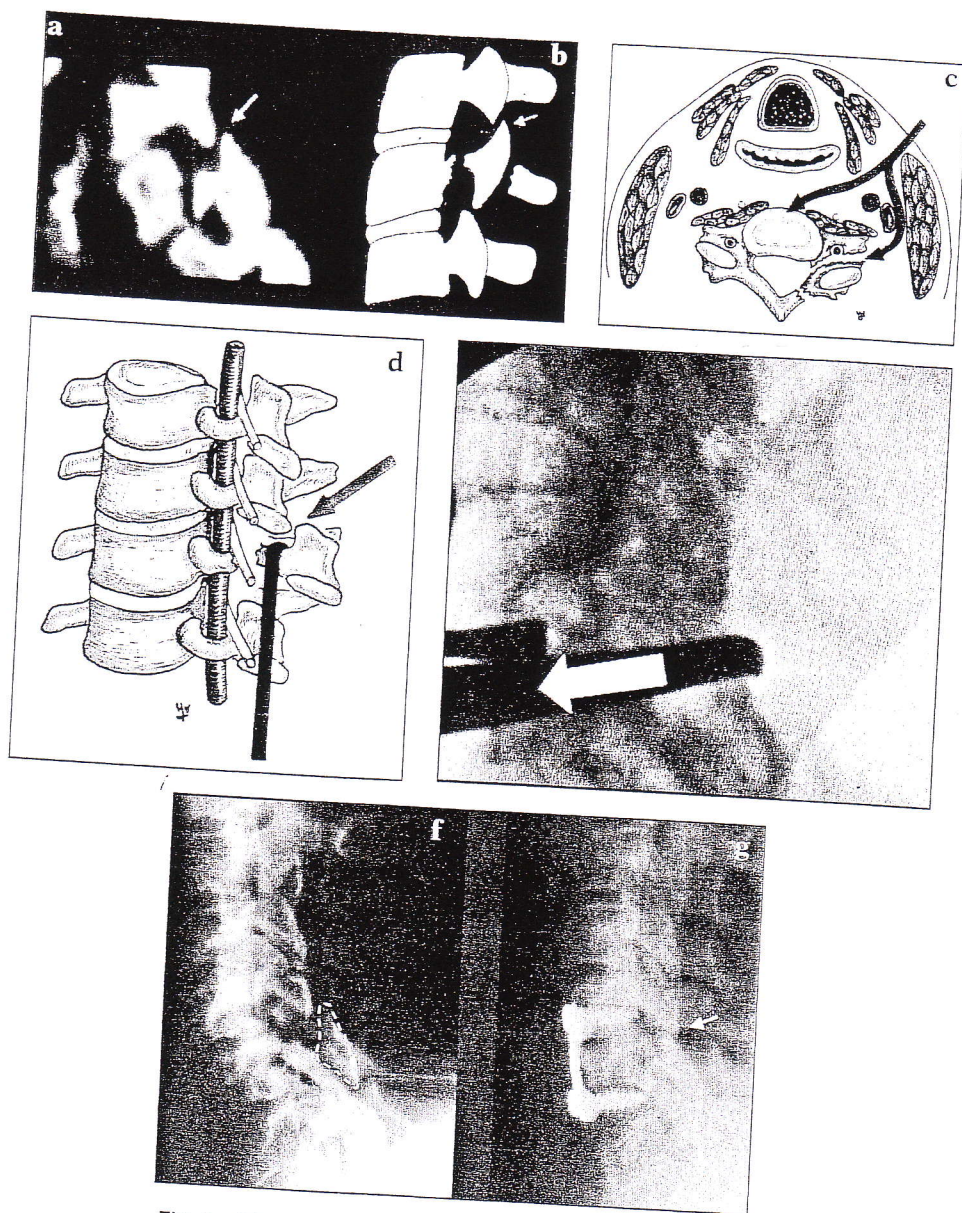
Fig. 4 : Dislocation-fracture of the lateral mass complicated by articular luxation:
a) preoperative CT scan
b) preoperative lesion
c) pre and retrovascular approach
d) reduction with osteophytes hook
e) control on lateral view
f) preoperative lateral X-ray
g) postoperative lateral X-ray

Severe sprains

Severe sprains (B2 lesions) are rarely complicated by neurological symptoms, even though some of our patients with cervical sprains reported dysesthesias in their fingers during the accident.

The diagnosis is made on bending films in flexion (because 94% of severe sprains occur in flexion). After ten days (or after two weeks if the subject is excessively painful and stiff), the patient is tested in hyperflexion for the concomitant presence of the following 3 criteria:
- a minimum offset of 3 mm or angle of 15° between the vertebral body posterior walls signifying the involvement of the disc,
- uncovering of more than 50% of the superior facet of the lower vertebra, which signifies a rupture of the articular capsule,
- interspinous process angle greater than 15° signifying a lesion of the interspinous and supraspinous ligaments (fig. 5).

These three associated signs are caused by the rupture of the entire group of ele-
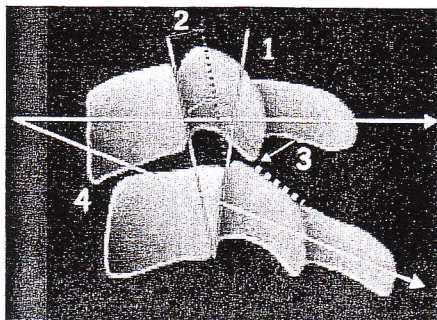
Fig. 5 : Severe sprain radiologic criterias on dynamic X-rays
1. > 15°
2. > 3 mm
3. > 50%
4. > 15°

ments of Junghanns' mobile segment leading to lasting instability, which indicates surgical treatment. The anterior approach allows one to establish whether the disc is disrupted. The disc space is filled with an iliac crest graft or a cage filled with bone rather than with bone substitute (fig. 6).
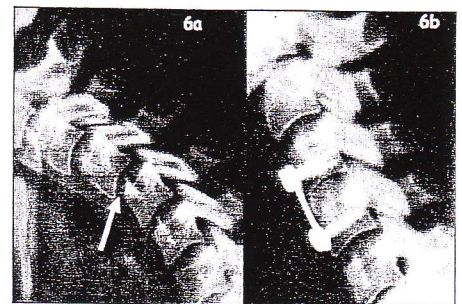
Fig. 6 : Severe spain pre and postoperative X-rays controls

Unilateral and bilateral facet dislocations

Unilateral and bilateral facet dislocations (type D2 and B3 lesions) are presented together because they were the object of a publication in Spine in 1998 [13]. Among the 168 dislocations studied in this series, 77 were unilateral and 91 were bilateral. They were situated between C5 and C7 in 126 patients (75%), at C2-C3 in 34 (20%) and at C7-T1 in 8 (5%). Having operated all these dislocations through an anterior approach, we observed 7 herniated discs (4% of the patients). This non-negligible incidence of associated disc herniation reinforces our belief that surgery through an anterior approach is safer than posterior surgery, which may exacerbate neurological status during the reduction maneuvers.

This reduction always consists of 3 successive stages:

• Reduction by progressive traction (*stage 1*) using Gardner-Wells tongs with a progressive increase of weights, which should not exceed a maximum weight of 2 to 3 kgs + 2 kg per intervertebral level below the head. This traction applied to a conscious subject with moderate anterior flexion of the neck should not last more than two hours, the time necessary for the patient's work-up before general anesthesia (fig. 7).
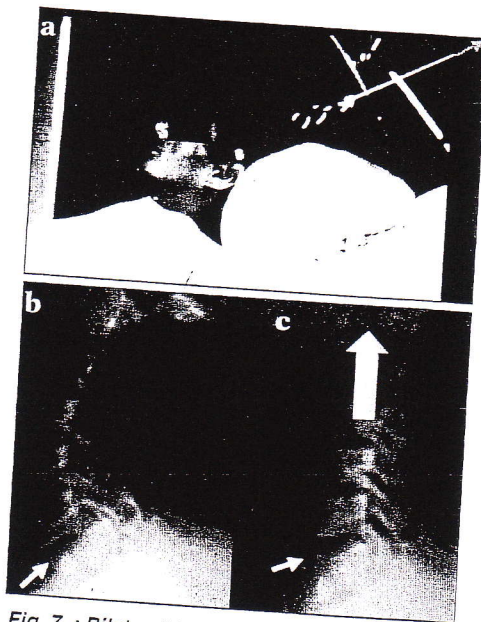
Fluoroscopic guidance is indispensable during the maneuver, which should not be attempted more than three times (fig. 8).
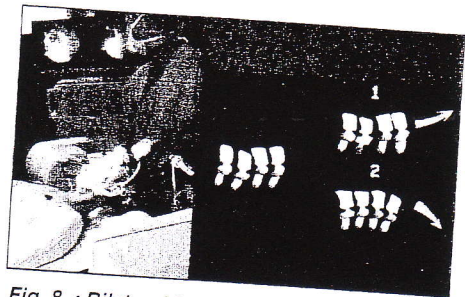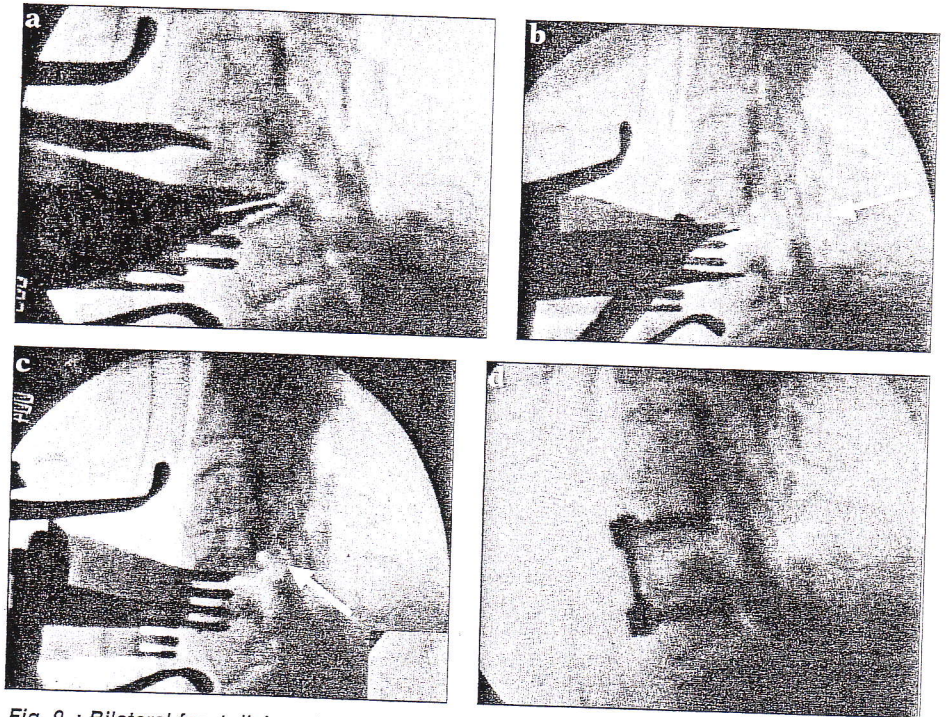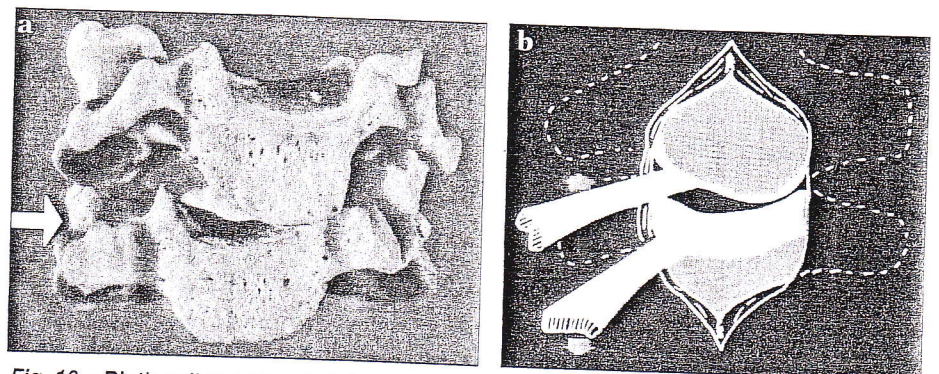

Fig. 8 : Bilateral facet dislocations reduction stages : reduction under general anesthesia
a) peroperative view
b) traction + flexion (1) and secondary extension (2).

Fig. 7 : Bilateral facet dislocations reduction stages : gradual traction without anesthesia
a) traction with Garadner tongs in flexion with pillow under the head
b and c) : pre and postoperative X-rays controls

• Open reduction after discectomy (*stage 3*). An interbody distractor is put into place and a osteophyte hook is applied to the posterior wall of the lower vertebra to help push the dislocated vertebral body posteriorly (fig. 9). In some cases, we removed the superior disc to increase the amount of distraction.

• In case of unilateral dislocation (which can be an intermediate stage before complete reduction of a bilateral dislocation), it is necessary to distract the dislocated side, where paradoxically the distance between the vertebral bodies is greater. The image intensifier is used to follow as the articular processes slip back into place (fig. 10).

• Reduction under general anesthesia (*stage 2*) in the surgical unit by manual traction in flexion for bilateral dislocations or flexion-tilting with contralateral rotation for unilateral dislocations.

With this protocol, reduction was achieved in 100% of the bilateral dislocations: stage 1 was successful in 43% of cases, stage 2 in 30%, and stage 3 in 27%. For the unilateral dislocations, reduction

Fig. 9 : Bilateral facet dislocations reduction stages : open reduction
a) intersomatic distractor
b) facet top are in contact
c) reduction is obtained
d) final anterior arthrodesis

Fig. 10 : Rigth unilateral facet dislocation
a) the distance between the 2 vertebral bodies is paradoxically greater on the rigth
b) distraction must be done on this side

was obtained in only 93% of the patients: stage 1 was successful in only 23%, stage 2 in 36%, and stage 3 in 34%. In every case after reduction (and even in the 5 patients with unilateral dislocation that was not reduced) a graft and a plate were applied with good clinical results.

We shall end this chapter by listing the complications of the overall series of 597 cases. There were:
- 6 kyphoses (1%)
- 9 pseudarthroses (1.5%)
- 17 screw breakages (3%)

However, only 12 of these complications led to revision surgery (2%).

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