Odontoid process fracture osteosynthesis with a direct screw fixation technique in nine consecutive cases

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The authors present their experience with surgical treatment of odontoid process fractures using a direct screw fixation technique via an anterolateral retropharyngeal approach. Nine consecutive patients have been operated on with this technique. There were two deaths unrelated to the surgery, and anatomical union with conservation of the craniospinal hinge mobility was achieved in the remaining seven patients. The direct screw fixation technique appears feasible, efficient, and logical.

KEY WORDS • odontoid fracture • spinal fixation • instrumentation

Odontoid process fractures may be treated by either external or surgical fixation, each method having its indications and its supporters. It is our view that a displaced fracture or one with secondary displacement is unstable. Several surgical techniques have been described involving a posterior, an anterior, or a lateral approach. Treatment via the posterior approach has included: the posterior wiring of C-1 and C-2 as described by Judet, with or without bone grafts; the use of Knodt hooks; and C1–2 fixation by means of a posterior screw. The anterior approach is generally transbuccal, with either a bone graft or plate fixation. The lateral approach allows for arthrodessis and can be very helpful when there is an associated Jefferson's fracture.

In an attempt to find a method to promote healing in the correct position without functional impairment of the occipitocervical hinge, we have approached the odontoid fracture through an anterolateral subhyoid presternoclavicular technique and have achieved generally satisfactory results. This method allows for direct screw fixation of the bone fragments as first described by Böhler. We report our experience with nine cases of odontoid process fracture, discuss repair of these fractures, and describe the direct screw fixation technique. All of the operations were performed by the same surgeon (G.M.B.).

Summary of Cases

Clinical Material

From 1969 to 1986, 303 patients with spinal fractures underwent surgery in our unit. These included 132 dorsolumbar fractures, 106 C3–7 fractures, 23 pedicular fractures of C-2, and 42 odontoid fractures. Since 1985, nine patients have presented with unstable odontoid fractures, and have been treated by direct screw fixation following reduction by cranial traction with Crutchfield tongs. These patients included eight men, ranging in age from 27 to 85 years, and a 19-year-old woman. The fractures were caused by a motor-vehicle accident in seven cases, a fall from a horse in one case (Case 4), and a fall following a heart attack and loss of consciousness in one case (Case 8).

All of the patients complained of moderate or severe cervical neck pain. Six patients had no neurological signs, two (Cases 3 and 9) had immediate severe tetraparesis, and one (Case 5) had right brachial paresis. Odontoid fractures have been classified by Roy-Camille, et al., into three types according to the direction of the fracture line: horizontal, oblique downward and backward, and oblique downward and forward. Our patients presented two of these types on x-ray tomography (Table 1): eight had odontoid fractures with horizontal disruption, and one (Case 6) exhibited an oblique fracture extending downward and backward. In Case 7, the odontoid process displacement occurred as a pathological fracture with an intraosseous cyst, histologically confirmed by drill biopsy at the time of surgery. In seven cases there was a fracture of the odontoid process alone; one patient (Case 5) presented with an associated fracture of the C-2 spinous process, and another (Case 9) had a fracture-dislocation of the C-5 vertebral body.
TABLE 1
Summary of clinical data in nine cases of odontoid fracture

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Etiology &amp; Date of Injury</th>
<th>Type of Fracture</th>
<th>Cervical Neck Pain*</th>
<th>Neurological Deficits</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>59, M</td>
<td>traffic accident, 8/85</td>
<td>horizontal disruption posterior &amp; lt lateral displacement</td>
<td>++</td>
<td>none</td>
<td>good</td>
</tr>
<tr>
<td>2</td>
<td>27, M</td>
<td>traffic accident, 9/85</td>
<td>horizontal disruption, anterior displacement</td>
<td>++</td>
<td>none</td>
<td>good</td>
</tr>
<tr>
<td>3</td>
<td>62, M</td>
<td>traffic accident, 5/86</td>
<td>horizontal disruption, anterior displacement</td>
<td>++</td>
<td>severe tetraparesis</td>
<td>died 40 days later of infection &amp; respiratory complications</td>
</tr>
<tr>
<td>4</td>
<td>36, M</td>
<td>fall from horse, 8/86</td>
<td>horizontal disruption</td>
<td>++</td>
<td>none</td>
<td>good</td>
</tr>
<tr>
<td>5</td>
<td>67, M</td>
<td>fall from bicycle, 8/86</td>
<td>horizontal disruption, fracture of C-2 spinous process, posterior &amp; lt lateral displacement</td>
<td>+++</td>
<td>rt brachial paresis</td>
<td>neurological recuperation</td>
</tr>
<tr>
<td>6</td>
<td>59, M</td>
<td>fall from bicycle, 8/86</td>
<td>oblique fracture going downward &amp; backward, posterior displacement</td>
<td>++</td>
<td>none</td>
<td>good</td>
</tr>
<tr>
<td>7</td>
<td>75, M</td>
<td>traffic accident, 9/86</td>
<td>horizontal disruption, posterior displacement, intraosseous cyst of C-2 body</td>
<td>++</td>
<td>none</td>
<td>good</td>
</tr>
<tr>
<td>8</td>
<td>19, F</td>
<td>traffic accident, 10/86</td>
<td>horizontal disruption, anterior displacement</td>
<td>+++</td>
<td>none</td>
<td>good</td>
</tr>
<tr>
<td>9</td>
<td>85, M</td>
<td>loss of consciousness, 10/86</td>
<td>horizontal disruption</td>
<td>+++</td>
<td>severe tetraparesis</td>
<td>died 12 days later of cardiac failure</td>
</tr>
</tbody>
</table>

* Degree of pain: ++ = moderate; +++ = severe.

The results of direct screw fixation have been judged by anatomic and functional criteria. Anatomic results were considered good in all nine cases. From the functional point of view, no postoperative aggravation was noted. The patient who presented with a right brachial paresis had gradual improvement and disappearance of his symptoms. Of the two patients who were tetraparetic on admission (Cases 3 and 9), one died 40 days after admission due to complications of a respiratory infection. The other, an 85-year-old man, died of cardiac failure. Before death both showed evidence of neurological improvement.

Surgical Technique

The screw fixation procedure is performed through a subhyoid pre sternocleidomastoid approach. The patient is positioned supine. The head is placed on a radiotransparent headrest, with continuous traction applied with Crutchfield tongs. The head is slightly rotated to the left for a right-handed surgeon (Fig. 1 left). A support is placed under the shoulder to keep the cervical spine in hyperextension. Before surgery is begun, nonabsorbable suture material should be used to ligate the transverse venous and arterial vessel branches. The thyrolingual pharyngofacial venous trunks are found more frequently than their separate branches. Branches of the external carotid artery can be either retracted or ligated. In the lower part of the operative field lies the superior thyroid artery, well below the hypoglossal nerve; in the upper part runs the lingual artery, slightly deeper than the hypoglossal nerve. The nerve elements crossing the field are gently retracted: the superior laryngeal nerve downward and the hypoglossal nerve upward. The skin incision is vertical, starting one finger-width above the mandibular angle and extending 6 to 7 cm along the anterior border of the sternocleidomastoid muscle. The platysma is incised along the same line. The external jugular vein, if seen, is ligated. The superficial cervical aponeurosis is incised along the anterior border of the sternocleidomastoid muscle. The edges are retracted and the dissection is carried in this plane to the parotid gland, the lower pole of which is gently withdrawn in order to preserve the cervical branch of the seventh nerve. At the depth of the parotid gland is found the digastric muscle, extending obliquely downward and forward, passing 1 cm above the great horn of the thyroid bone. At the inferior border of the digastric muscle, level with the C-3 vertebra, the hypoglossal nerve is found.

Before continuing the dissection, nonabsorbable suture material should be used to ligate the transverse venous and arterial vessel branches. The thyroidoglossal pharyngofacial venous trunks are found more frequently than their separate branches. Branches of the external carotid artery can be either retracted or ligated. In the lower part of the operative field lies the superior thyroid artery, well below the hypoglossal nerve; in the upper part runs the lingual artery, slightly deeper than the hypoglossal nerve. The nerve elements crossing the field are gently retracted: the superior laryngeal nerve downward and the hypoglossal nerve upward. Upward
Internal fixation of odontoid fracture

Retraction of the posterior belly of the digastric muscle and of the hypoglossal nerve must be gentle to avoid any compression of the mandibular branch of the facial nerve against the mandible. Retropharyngeal dissection is carried out with a small swab rolled into a ball, in an ascending progression and past the medial line of the vertebral column. The C2-3 intervertebral disc is identified on the lateral fluoroscope; care should be taken to use radiotransparent retractors covered with rubber in order to decrease trauma to the surrounding elements.

After limited periosteal elevation of the prevertebral muscles, an opening is prepared with a square incision at the center of the C2-3 disc, immediately below the protrusion of the anteroinferior angle of the C-2 vertebral body. With a drill 2.7 mm in diameter operating at a slow speed a hole is then made in the C-2 body along the axis of the odontoid process under lateral and anteroposterior fluoroscopic control (Fig. 1 right). The length of the process is measured; it generally varies between 36 and 40 mm. The first 3 mm of the hole is rebored larger in order to fully lodge the head of the screw into the body of the C-2 vertebra. A screw 3.5 mm in diameter and of the desired length is placed under fluoroscopic control (Fig. 2). The patient's head is moved in flexion, extension, and lateral directions in order to verify the strength of the osteosynthesis. Closure is achieved in two layers over a Jost-Redon suction drain. The Crutchfield tongs are removed at the end of the procedure. The patient wears a specially molded two-piece plastic neck collar for 2 months, and physiotherapy is started to prevent any atrophy of the cervical neck musculature due to immobilization.

Discussion

Between 1969 and 1986, we treated 60 cases of odontoid fracture in our unit; 42 of these were operated on and the remaining 18 were treated with neck immobilization. Of the 42 surgical cases, 33 underwent a C1–2 posterior wiring procedure, modified according to the anterior or posterior displacement of the odontoid process prior to reduction. An iliac bone graft was placed between the posterior arches of C-1 and C-2 to reinforce fixation. The transbuccopharyngeal approach has not been used because of the risks of infection.

For cases of pedicular fracture of the axis and odontoid process fractures, we have preferred direct screw fixation since 1985. This procedure has been made possible by the complete reduction of the fracture displacement by cranial traction using Crutchfield tongs (Fig. 3). Obviously, if displacement persisted following traction, we would perform posterior lacing around the posterior arch of C-1 and the spinous process of C-2. This procedure is particularly necessary in cases of oblique downward and forward fractures, as displacement of these fractures tends to be aggravated by the operating position (cervical hyperextension). We have successfully operated on our last nine patients with the direct screw fixation technique. These patients had displaced fractures of the odontoid process, all of which
were reduced by cranial traction (eight fractures with horizontal disruption and one oblique fracture directed downward and backward). They all became stabilized in the correct position.

This technique has the advantage of insuring direct fixation of the fracture site in good anatomical position once reduction is achieved, thus preventing secondary pseudarthrosis. Furthermore, it offers ideal conservation of the craniospinal hinge mobility because no articular element is immobilized. It also prevents any hemorrhagic impairment of the muscular masses of the neck. Demanding a supine operating position with cervical hyperextension, it facilitates endotracheal intubation, respiratory movements, and anesthesia, allowing for surgery even in cases with associated thoracic lesions. The patient is fitted with a foam Schanz-type neck collar until a specially molded removable two-piece plastic collar is ready.

We have frequently noticed a transient dysphagia in the first 48 hours after operation. In no case was a problem encountered, either pre- or postoperatively, due to injury or compression of the vascular or nerve elements in the vicinity. In one case (Case 4) a small wound of the pharyngeal wall was made while drilling the intraosseous route. This was sutured with nonabsorbable suture material and healed uneventfully.

**Conclusions**

Based on this experience, our present attitude toward odontoid fractures is that stable, undisplaced fractures do not require operation and can be treated with external immobilization. Unstable or displaced fractures are initially treated with cranial traction to reduce the displacement. If they are oblique downward and forward they are best treated by posterior C1–2 wiring with interposition of a bone graft to insure solidity even in cases of pseudarthrosis of the odontoid fracture. Loss of C-1 and C-2 articular movement would cause a functional impairment. Transverse, oblique, unstable fractures downward and backward benefit from the direct screw fixation technique, which prevents pseudarthrosis or secondary displacement by coaptation of the fracture surfaces. Other advantages of this method are that there is no muscular damage, that the operating position is beneficial to respiratory control, and particularly that fixation of the fracture site is possible with preservation of mobility in the craniospinal hinge.

**References**


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