

Treatment of Dens Fracture in Adults
A Report of Thirty-Two Cases

Myung-Sang Moon, M.D., Ph.D., Jeong-Lim Moon, M.D., Ph.D., Doo-Hoon Sun, M.D., Ph.D., and Young-Wan Moon, M.D., Ph.D.

Abstract
Thirty-two adult patients with dens fractures (30 type II and 2 type III) were treated from 1983 to 2002 at the authors’ institutions. The age of the patients ranged from 23 to 58 years. The postoperative follow-up period ranged from 1 to 10 years. The objective of this retrospective study was to evaluate the effectiveness of the osteosynthesis after screw fixation and postoperative bracing. In the 32 cases, 19 patients underwent single screw and 13 underwent double screw fixation. Postoperatively, light head halter traction was applied with patients in bed for 1 to 4 weeks followed by a halo-vest for 8 to 14 weeks. Fractures healed in 9 weeks on average. There were no cases of delayed union. The overall results were excellent in 26 cases (81.3%), good in 5 (15.6%), and fair in 1 (3.1%) patient (who had a type II fracture). There were no difference in dens union patterns between those receiving one-screw and two-screw fixation, and there were no complications during or after the operative procedure. Postoperatively there were no restriction of motion in the neck and no residual neck pain. Direct osteosynthesis of the fractured dens with screws is an effective procedure for unstable type II and III fracture of the dens. Postoperative external immobilization with a cervical brace seems to be an important contributing factor to the equal fusion rates in both groups of patients.

Dens fractures are relatively frequently encountered in clinical practice.1-4 The incidence of this injury varies between children and adults; in patients under 7 years of age this fracture comprises up to 75% of cervical spine injuries whereas in adults it comprises between 10% to 15% of cervical injuries5,6 in developed countries.3,7 Despite the relative frequency of these fractures, the treatment remains controversial8,9 and recommended treatment options range from conservative to surgical. Recent advances in surgical technique now make direct surgical osteosynthesis possible by screw fixation of the fractured dens in adults, which gradually replaced the posterior stabilization procedure in cases seen in the developed countries.10-15 In this study, the adult patients who were treated by osteosynthesis and were followed for 1 to 10 years from 1983 to 2002 are presented.

Materials and Methods
Thirty-two patients ranging in age from 23 to 58 years are included in this retrospective study. Fractures were defined through plain radiographs according to the Anderson-D’Alonzo classification. In the doubtful cases, computed tomography (CT) was performed in order to confirm the diagnosis. The study group comprised 30 type II and 2 type III fractures (Table 1). None of the patients had cord compression.

Single screw fixation in 19 cases and double screw fixation in 13 cases was carried out under two image intensifier controls.

In the both groups, the patients were immobilized postoperatively in bed under light head halter traction for 1 to 4 weeks followed by halo vest immobilization for an additional 8 to 14 weeks.

Union of the fractured dens was defined as the obliteration of the fracture gap and absence of fracture
site motion on dynamic flexion-extension lateral cervical radiographs. To assess mobility and stability of the atlantoaxial joint, cervical motion studies were performed 3 months postoperatively. Fusion status and failure of the fixation devices were examined through serial postoperative radiographs which were taken postoperatively as well as at postoperative weeks 4, 8, 10, 12, 16, 20, and then once every year thereafter during the course of follow-up. Patients were followed for a period of 1 to 10 years.

**Outcome Assessment**

Outcome was assessed on the basis of the degree of neck pain and neck motion at the final follow-up. Outcomes were graded as excellent, good, fair, and poor (Table 3).

**Results**

The fractures united, on average, in 9 weeks; type II in 10 weeks and type III in 8 weeks (Table 2). There were no difference in union rates between those with one or two screws and there were no complications (there were no imprecise placement of screws or screw failures).

In the 32 patients, 26 (81.3%) had excellent, 5 (15.6%) had good results, and one (3.1%) had a fair result. In the 19 patients with single screw fixation, an excellent result was obtained in 14 patients (73.7%), good in 4 (21.1%), and a fair result in one patient (5.2%). In the 13 patients with two-screw fixation, excellent results were obtained in 12 (92.3%) patients and one (7.7%) patient experienced a good result. There were no differences in the union rates or the clinical results between those receiving one- or two-screw fixation.

**Discussion**

Dens fracture is the most common axis injury. The incidence of dens fracture increases with age. As a general concept, the management of dens fractures is based on three principles:

1. Timely diagnosis,
2. Reduction of the fracture, and
3. Sufficient immobilization to permit healing.

Age also should be considered when determining the course of treatment. However, before the introduction of modern fracture fixation techniques, dens fractures often were treated by supervised neglect because there were no promising methods for stable external fixation that permitted early patient mobilization. Combined primary skull traction and a subsequent collar or Minerva jacket and a primary collar or brace treatment were the only acceptable non-surgical treatment methods until the early 1970s.

With the introduction of the halo device, many surgeons relied on them as a sole means of treatment, replacing conventional cervical braces. However it is important to consider exactly how much stability can be provided to the atlantoaxial joint by halo immobilization.

Apfelbaum and colleagues fluoroscopically observed odontoid movement from 8 mm of anterior displacement to 8 mm of posterior displacement with each respiratory cycle in a patient in halo immobilization. This fact suggests to us that halo immobilization allowed mobility of the fracture site that, in turn, led to high rates of non-union. Therefore, there is a need for the development of better practice guidelines and treatment recommendations for these fractures.

Among the three dens fracture types, type II is the most common, comprising 65% to 94% of odontoid fractures. There have been many controversies over the treatment of type II fractures. The reason has been the high non-union rate; type II dens fractures have a

<table>
<thead>
<tr>
<th>Table 1 Fracture Types in 32 Adult Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td>III</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2 Union Time According to Type of Fracture and Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Types of fracture</strong></td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Single screw (19 adults)</td>
</tr>
<tr>
<td>Two screws (13 adults)</td>
</tr>
<tr>
<td>Total cases</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3 Outcome after Osteosynthesis in Two Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcomes (%)</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Excellent</td>
</tr>
<tr>
<td>Double screws</td>
</tr>
<tr>
<td>Total cases</td>
</tr>
</tbody>
</table>

*Type II
significant rate of non-union of approximately 32% (ranging from 31% to 96%) and the non-union rate of type III fractures is approximately 13% (ranging from 6% to 48%).

Non-union rates in conservatively treated patients vary partly because of the different approaches to treatment and partly because some patients refuse primary skull traction. In a report by Althoff, 24 (51%) of 47 conservatively treated patients developed union and 23 non-union (49%). He reported that there was a statistically significant higher rate of bone union in the patients treated more than six weeks in skull traction than in those treated with a primary collar or Minerva jacket. Schatzker and colleagues concluded that mobility of the odontoid process might be an important factor in the development of non-union. Shearing forces created by loading at the fracture site is thought probably to be the most important factor in increasing non-union.

Several factors for non-union of type II fractures are listed as contributory:

1. Intrasynovial presence of fracture site;
2. Damage to the blood supply to the odontoid, which is mainly via the right and left posterior and anterior ascending arteries of the axis;
3. Difficulty in maintaining reduction of the fractured dens by conservative means;
4. Degree of initial fracture and instability;
5. Oblique fracture; and
6. Patient age.

For this reason, surgical stabilization has been strongly recommended for the severely displaced fractures, re-displacing fractures under brace treatment, as well as for patients who cannot tolerate prolonged brace treatment.

Before the introduction of direct anterior screw fixation for odontoid fractures, surgeons relied on posterior stabilization methods which were not primarily aimed at the osteosynthesis of the fracture site.

To improve primary union rates and obviate the need for halo immobilization or an atlantoaxial fusion, a technique of direct screw fixation of the odontoid was developed by Nakanishi and colleagues and Bohler independently. Recently, osteosynthesis of the fractured dens by screw fixation has become more popular. Direct fixation is indicated in fracture patterns that present a high rate of nonunion and in some patient unable to tolerate a halo orthosis. Both one- and two-screw techniques have been advocated. Direct internal fixation was reported to provide 50% of the stability of the unfractured odontoid. Osteosynthesis by single screw or double screw fixation is generally recommended for the unstable type II fracture even with minimal displacement, re-displaced fractures, and severely displaced fractures in a young patient. The use of two screws has proven to be better able to counter the rotational forces created by the alar ligament.

Also, to reduce the complication rates of this procedure, contraindications for the use of odontoid screws were studied; potential contraindications include: 1. odontoid fracture with concomitant one or both atlantoaxial joints involved; 2. a long oblique fracture; 3. an “atypical” type II fracture with oblique fracture line; 4. established non-union; 5. pathological fractures; and 6. osteoporosis.

However, Apfelbaum and colleagues reported that the only variable that exerted a significant effect on anatomical bone union was the orientation of the odontoid fracture. These investigators stressed the importance of the orientation of the odontoid fracture after anterior screw fixation for the facilitation of anatomical bone union; they reported an anatomical bone union rate of 50%, a non-anatomical union rate of 25%, and non-union rate of 25%. Imprecise placement of screws can be a

Figure 1 Preoperative radiographs of type II dens fracture in a 25-year-old male patient treated with single anterior screwing (A, B). Fracture was well united in 14 weeks without any complications (C, D).
factor leading to non-union. Thus, there were high non-anatomical union and non-union rates. Screw fixation for odontoid non-union still remains controversial because direct odontoid fixation is associated with a high rate of complications; a 24% incidence of major complication has been reported\textsuperscript{11,14,20,22}; the incidence of malreduction as 19%, and pseudarthrosis as 12%, and, although infrequent, there are instances of implant failure reported in the literature.\textsuperscript{3,15}

In the current series, however, there were no difference in the outcomes in the two groups, no non-union and no implant failures; this could be attributed to surgical skill, accurate placement of screw(s) under biplanar fluoroscopy (image intensifiers) and the strictly supervised postoperative bracing.

As yet, however, there is no distinct pattern of agreement regarding the manner in which dens fractures should be surgically managed in any age group, including in the elderly. For patients with a painful or unstable non-union, posterior spinal fusion should be considered.\textsuperscript{17}

**Conclusion**

In summary, it is recommended to select the preferred method of treatment on an individual basis according to the fresh or old fracture which brings successful C1-2 stability through fracture union, based on benefits-demerits analysis for the patient’s well-being. Based on the results of the current study, we recommend osteosynthesis as a primary procedure for unstable type II and III dens fractures followed postoperatively by a cervical brace. Direct osteosynthesis of the fractured dens is indicated for new type II and III fractures and for cases in which conservative treatment has failed.

**References**

7. Moon MS, Ok IY, Lee KS, Ha KY, Kim SS, Sun DH, Kim


