A clinical comparison of one- and two-screw odontoid fixation

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Object. The optimal treatment of Type II odontoid fractures is controversial. Various therapies have been used, including nonrigid immobilization, halo orthosis, posterior atlantoaxial arthrodesis, and odontoid screw fixation. Of these, odontoid screw fixation is the only treatment modality that provides immediate stabilization and preserves normal motion at C1–2. It has been suggested in cadaveric biomechanical studies that there is no advantage to using more than one screw for anterior odontoid fixation. The authors compared the clinical safety and efficacy of one- and two-screw anterior odontoid fixation.

Methods. The authors retrospectively reviewed the medical records and radiographs of 42 consecutive patients who had undergone fixation for treatment of odontoid fractures at a single institution between 1989 and 1995.

The group treated with a single screw consisted of 20 patients (11 males and nine females) with an average age of 54 years. The union rate in this group, as determined by postoperative dynamic radiographs, was 81%. The group treated with two screws consisted of 22 patients (13 men and nine women) with an average age of 64 years, whose union rate was 85%.

Conclusions. Anterior odontoid screw fixation is a safe and efficacious treatment for odontoid fractures. In the authors' experience there was no significant difference in the successful union rates achieved with either the one- or two-screw fixation techniques (81% and 85%, respectively; χ² = 0.09, p = 0.76).

KEY WORDS • odontoid fracture • odontoid screw fixation • atlantoaxial arthrodesis

The optimal treatment of Type II odontoid fractures is controversial. Traditionally, nonrigid immobilization, halo orthosis, and posterior C1–2 arthrodesis have been used to treat these fractures, with varying degrees of success.1,2,23,34 Recently, anterior odontoid screw fixation has gained popularity for the treatment of Type II odontoid fractures.1,3,6,13,14

Odontoid screw fixation was initially described as requiring two screws to fixate the dens.3 As clinical experience with this technique increased, it became evident that placement of the second screw can be technically difficult, if not impossible. It has been shown in cadaveric biomechanical studies that there is no significant biomechanical advantage in using more than one screw for odontoid fixation in the treatment of Type II odontoid fractures.15,31 However, clinical support for the use of a single screw is lacking and the clinical outcome of odontoid fixation by using one compared with two screws has not been directly studied. Therefore, we compared the union rates of 42 consecutive patients with Type II odontoid fractures who were treated with one or two odontoid screws at a single institution.

Clinical Material and Methods

We conducted a retrospective review of all patients who were treated with anterior odontoid screw fixation for Type II odontoid fractures at North Carolina Baptist Hospital/Bowman Gray School of Medicine of Wake Forest University between 1989 and 1995. Four surgeons performed or supervised the procedures, which were accomplished in the standard fashion by using biplanar fluoroscopy and 3.5-mm noncannulated partially threaded screws.

The decision to use one or two screws in a particular case was made according to the individual surgeon's preference and was largely dictated by the size of the patient's dens and the difficulty of placing a second screw. Postoperatively, all patients were placed in a hard cervical collar for 3 months. The patients' hospital charts, operating room records, clinic notes, and radiographs were retrospectively reviewed. Union rates were determined on follow-up dynamic radiographs obtained at subsequent clinic visits. We defined satisfactory union as the absence of dens movement independent of the C-2 vertebral body.
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Table 1

Comparison of outcomes in 36 patients treated with one- or two-screw fixation for odontoid fracture*

<table>
<thead>
<tr>
<th>Factor</th>
<th>One-Screw Group (20 patients)</th>
<th>Two-Screw Group (22 patients)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>age (yrs)</td>
<td>mean</td>
<td>54</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>range</td>
<td>17-77</td>
<td>20-86</td>
</tr>
<tr>
<td>procedure duration (min)</td>
<td>96</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>blood loss (ml)</td>
<td>72</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>satisfactory union (no.) of patients</td>
<td>81% (13 of 16)</td>
<td>85% (17 of 20)</td>
<td>NS</td>
</tr>
<tr>
<td>osseous union</td>
<td>63% (10)</td>
<td>70% (14)</td>
<td>NS</td>
</tr>
<tr>
<td>fibrous union</td>
<td>19% (3)</td>
<td>15% (3)</td>
<td>NS</td>
</tr>
<tr>
<td>nonunion</td>
<td>19% (3 of 16)</td>
<td>15% (3 of 20)</td>
<td>NS</td>
</tr>
</tbody>
</table>

* A total of six patients were excluded from the study. Abbreviation: NS = not significant.

Results

Forty-two patients underwent anterior odontoid screw fixation procedures for the treatment of Type II odontoid fractures. The average follow-up period for these patients was 8.5 months (range 3–34 months). The patient groups are compared in Table 1.

One-Screw Fixation

The group treated with one screw consisted of 20 patients of whom 11 (55%) were male and nine (45%) were female (Fig. 1). Seventeen of these patients had acute fractures and three had chronic fractures (>3 weeks old). The average age in this group of patients was 54 years (range 17–81 years). Four patients in this group were excluded from follow-up analysis: one was lost to follow up and three more died within 3 months of the screw fixation. An 81-year-old patient died at home of multiple medical problems 10 days postsurgery; the other two deaths did not occur within the perioperative period and were also secondary to medical conditions unrelated to the screw fixation. The average duration of the procedure in the one-screw group was 96 minutes, with an average estimated blood loss of 72 ml. Of the patients in this group who were available for follow up, 13 (81%) demonstrated satisfactory unions. Ten patients (63%) had osseous unions (Fig. 1), and three (19%) had radiographically immature or fibrous unions. Of the three unsuccessful odontoid screw fixation procedures, two failed because of screw fracture. However, fusion was subsequently achieved in both of these patients in a somewhat retrospontylolisthesed position with no further intervention. The other patient in whom treatment failed had a pathologically mobile dens on postoperative dynamic radiographs but unfortunately was lost to follow-up review.

Two-Screw Fixation

The group treated with two screws consisted of 22 patients, of whom 13 (59%) were men and nine (41%) were women. The average age of these patients was 64 years (range 20–95 years). All but one of the patients had acute fractures. In this group, one patient was excluded from analysis because of perioperative death: this 95-year-old woman died in the hospital secondary to a pulmonary embolism. A second patient was excluded because of inadequate follow-up data. The average duration of the procedure in the two-screw group was 115 minutes, with an estimated blood loss of 71 ml. Of the patients in this group who were available for follow-up review, 17 (85%) of 20 demonstrated unions. Fourteen patients (70%) had os-
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FIG. 2. Plain anteroposterior (left) and lateral (right) cerebral radiographs demonstrating solid osseous union of an acute Type II odontoid fracture fixated with two 3.5-mm lag screws in an 60-year-old man who presented neurological-ly intact with neck pain after a fall.

FIG. 3. Plain anteroposterior (left) and lateral (right) cerebral radiographs demonstrating solid osseous union of an acute Type II odontoid fracture fixated with two 3.5-mm lag screws in an 60-year-old man who presented neurological-ly intact with neck pain after a fall.

Discussion

Type II odontoid fractures, as defined by the Anderson and D’Alonzo classification,² are the most common fractures of the C-2 vertebra. Traditionally, Type II fractures have been treated with placement of a halo orthosis.²,¹⁰,¹¹,¹³,¹⁴,¹⁸,³⁶,³⁷ However, the nonunion rate with rigid external immobilization varies widely, from 0 to 41%. Some contemporary spine surgeons recommend primary internal fixation and fusion in patients with Type II odontoid fractures.⁵-⁷,¹²-¹⁴,¹⁷,¹⁹,²²

The standard internal fixation technique for dens fractures has been posterior C-1–2 arthrodesis.⁴,⁵,²⁸ This method results in a high fusion rate but sacrifices cervical mobility; C-1–2 arthrodesis causes an almost 50% reduction in cervical rotation and a 10% reduction in flexion-extension.¹,²⁴,²⁸ The loss of cervical mobility is worse if the patient has an associated C-1 ring fracture, which would necessitate extension of the fusion to the occiput or delayed treatment of the dens fracture.³¹

Böhler eldest reported the use of stainless steel screws to stabilize odontoid fractures internally. This technique has several advantages over posterior C-1–2 fusion: the anterior approach is less traumatic because it takes advantage of anatomical tissue planes for the exposure; also, theoretically there is less risk to the spinal cord, spinal nerves, and vertebral artery. This technique does not require atlantoaxial arthrodesis; therefore, cervical mobility is not reduced.¹⁵ Provided that the transverse ligament is competent, this method is applicable to patients with posterior C-1 ring fractures, those who refuse halo treatment, and multitrauma patients who are not good candidates for treatment with halo orthosis.¹⁴,¹⁶,²⁴ Numerous authors have reported fusion rates for anterior odontoid screw fixation that are comparable to those for posterior C-1–2 arthrodesis.¹,⁴-⁶,¹²,¹⁴

In the original reports of odontoid screw fixation the use of two screws was described.³ In subsequent cadaveric studies it has been suggested that the minimum transverse diameter of the dens that will accommodate two ideally placed 3.5-mm screws is 9 mm.²⁷ It has been shown in radiographic investigations that the dens is too small to accommodate two screws in up to 66% of patients.²¹,²² This prompted some authors to suggest that a posterior atlantoaxial arthrodesis should be performed in these cases.²¹ Furthermore, clinical experience has shown that even if the odontoid process is large enough for two screws, the placement of the second screw can be technically challenging.

The technical difficulties inherent in placing two screws into the dens has led some surgeons to use a single screw to stabilize odontoid fractures. This concept has been supported in cadaveric studies, which demonstrate that there is little, if any, biomechanical difference between using one or two screws to stabilize Type II odontoid fractures. These studies reveal that either one- or two-screw fixation restores approximately 50% of the prefracture dens strength and offers approximately the same stability as primary Brooks C-1–2 wiring.⁹,¹⁵,³² The clinical relevance of these cadaveric studies has remained untested. Some authors have suggested that even though the biomechanical strength of one- and two-screw odontoid fixation may be equivalent, one-screw fixation may allow increased torsional instability (that is, dens rotation about the screw), which could result in a lower fusion rate.²⁵,³¹

Our study provides a direct clinical comparison of the union rates of Type II odontoid fractures treated with placement of one compared with two odontoid screws (Fig. 3). There was no significant difference between suc-
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Successful union rates in the two groups following treatment. Two patients in the one-screw group experienced screw fracture. Although we believe that these screws fractured secondary to initial nonunion, it should be noted that both of these patients subsequently formed osseous unions in a more retro spondylolisthesis position without further intervention. No patient in the two-screw group experienced screw fracture.

Because of the small number of chronic fractures treated (four) and the fact that two of these patients died of medical complications in the follow-up period, we can draw no firm conclusions regarding the efficacy of using one as opposed to two odontoid screws for the treatment of chronic Type II dens fractures.

Regarding the actual procedure, we found that there were no significant differences in blood loss between the two groups but that insertion of two screws took an average of 19 minutes longer than single-screw insertion.

In the entire study group we found an overall incidence of fibrous union of 17% (six of 36 patients). However, we found no significant difference between the incidence of fibrous union in the one- and the two-screw groups (19% and 15%, respectively; χ² = 1.075; p = 0.3). The issue of nonosseous union is significant because it has been documented that unhealed Type II odontoid fractures can lead to adverse consequences, including spinal cord injury. Although the pathophysiological origins are not completely understood, several mechanisms have been proposed to explain this phenomenon. One theory is that repeated direct spinal cord trauma from an anterior pannus or retro spondylolisthesis dens causes the injury. In another theory it is suggested that the myelopathy is secondary to either arterial or venous microvascular dysfunction caused by the Type II odontoid fracture. However, although we agree that these mechanisms may play a role in the development of myelopathy in patients with Type II odontoid fractures, we believe that our patients with no clear radiographic evidence of bone spanning the fracture line and who do not demonstrate pathological dens motion (the so-called fibrous unions) are not completely analogous to patients with unhealed Type II odontoid fractures. In our patients with fibrous union, the dens is in a normal or near-normal anatomical position, and they show no pathological dens motion on dynamic radiographs. We believe that the absence of pathological dens motion will prevent a large pannus from forming at the fracture line and that the near-normal anatomical position of the dens will prevent spinal cord injury by direct bone impingement. We do recognize that in some of these patients the spine may never adequately fuse or may develop a pseudarthrosis that would subject the instrumentation to increased strain and eventual failure, which could lead to spinal cord injury. However, we do not automatically resort to atlantoaxial arthrodesis in patients with fibrous unions. Instead we follow them closely for clinical signs or symptoms of myelopathy and radiographic evidence of instrumentation failure, instability, and pseudarthrosis. So far none of these patients has required reoperation for neck pain or myelopathy, although we recognize that additional follow-up time is needed to make definitive statements regarding their ultimate outcome. We agree with the recent assertion by Crockard, et al., that any patient who develops myelopathy should be treated with anterior transoral decompression and posterior atlantoaxial arthrodesis to prevent future irreversible neurological deterioration.

In the entire study group there were a total of four deaths (9.5%) within 3 months of surgery, including two perioperative deaths (4.8%). It is important to note that none of these patients died or sustained permanent injury as a result of the odontoid screw fixation procedure. Furthermore, a mortality rate as high as 29% has been reported for elderly patients with Type II odontoid fractures.

Conclusions

Anterior odontoid screw fixation is a safe and efficacious method for the treatment of Type II odontoid fractures, provided that the transverse ligament is intact. Overall, we found that Type II odontoid fractures were successfully treated with odontoid screws in 83% of cases. In this series we demonstrate that there is no statistically significant difference (p = 0.76) in the overall union rate of odontoid fixation for Type II fractures treated with one or two screws. There was also no statistically significant difference (p = 0.3) in the rate of nonosseous union between the patients treated with one or two odontoid screws. This clinically confirms the results of cadaveric biomechanical studies regarding the stability of single-screw fixation of Type II odontoid fractures.

References


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