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Operative Techniques in
Orthopaedics

Acute Odontoid Fractures: Anterior Odontoid Fixation

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Fractures of the dens are common injuries. The classification of these fractures remains controversial. Anterior odontoid fixation is a safe and effective means of stabilizing some of these injuries. We review classification of these injuries, treatment options, and surgical indications. Anterior odontoid fixation is reviewed in further detail, with an emphasis on surgical indications and a discussion of surgical technique.
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Fractures of the dens comprise 18% to 20% of cervical injuries, of which 65% to 74% are Anderson-D'Alonzo type II fractures.[1,2] The injury mechanism typically consists of ground-level falls in the elderly or high-velocity accidents in the younger population. The initial neurological injury rate is low. For example, among type II fractures in the elderly, the neurological injury rate is 3%.[3] However, the mortality rate in the older population is high, with a reported 33% in hospital mortality rate for those patients older than 65 years.[3] Hanigan and coworkers[4] published a review of 19 patients older than 80 years and found a similar mortality of 30% within 3 weeks of injury. Furthermore, cardiopulmonary complications are common in this patient population but vary depending on the type of treatment.[3-5]

An initial classification system for odontoid fractures was described in 1971.[6] This classification was modified in 1974 by the scheme of Anderson and D'Alonzo.[7] Although widely accepted and time-tested, the Anderson classification has been criticized for the ambiguity between type II and III fractures and for not addressing the complexity in multiple subtypes of type II fractures.[8]

Three types of odontoid fractures are described in the original Anderson system. Type I fractures, fractures through the tip of the dens, are rare (none were identified in a review by Hadley and coworkers of 229 C2 fractures[9]) and typically are considered clinically unimportant. Type II fractures are common but are also the most debated subgroup. These fractures extend through the base of the dens whereas type III fractures extend into the C2 vertebral body. Clark and White[1], in a Cervical Spine Research Society multicenter survey, agreed with the Anderson scheme but found the degree of angulation and amount of displacement to be important distinctions that were not addressed. Indeed, many contemporary surgeons argue that type II fractures are a heterogeneous group and should be divided into subgroups. These subtypes include the "shallow" type II fractures that partly involve the C2 body. One unique subtype proposed is called the type IIA fracture, which is defined by comminution across the fracture site.[10] This heterogeneous group of type II fractures was recognized by Grauer and coworkers, who proposed a modified classification scheme in 2005.[8] Additionally, this classification better delineates between type II and III fractures. Three subtypes of type II fractures are defined. Type III fractures are defined by the extension of the fracture line through the superior C2 facet. In addition, the authors noted a moderate reproducibility of this classification system (Fig. 1) by using retrospective review of 52 fractures.

Not only is the classification of odontoid fractures controversial, but also there are no standards or guidelines for the treatment of type II dens fractures. Instead, only retrospective reviews or case–control series exist from which treatments are recommended. This discrepancy has created difficulty in deciding even between operative versus nonoperative treatment. In general, treatment typically is based on fracture subtypes, I through III. The most controversial are the type II fractures. Proponents of conservative care espouse the noninvasive features of rigid or nonrigid cervical collars, whereas those in favor of surgical care point out the high fusion rates with instrumented fixation. Factors that affect surgical decision-making within the type II subtype include fracture line

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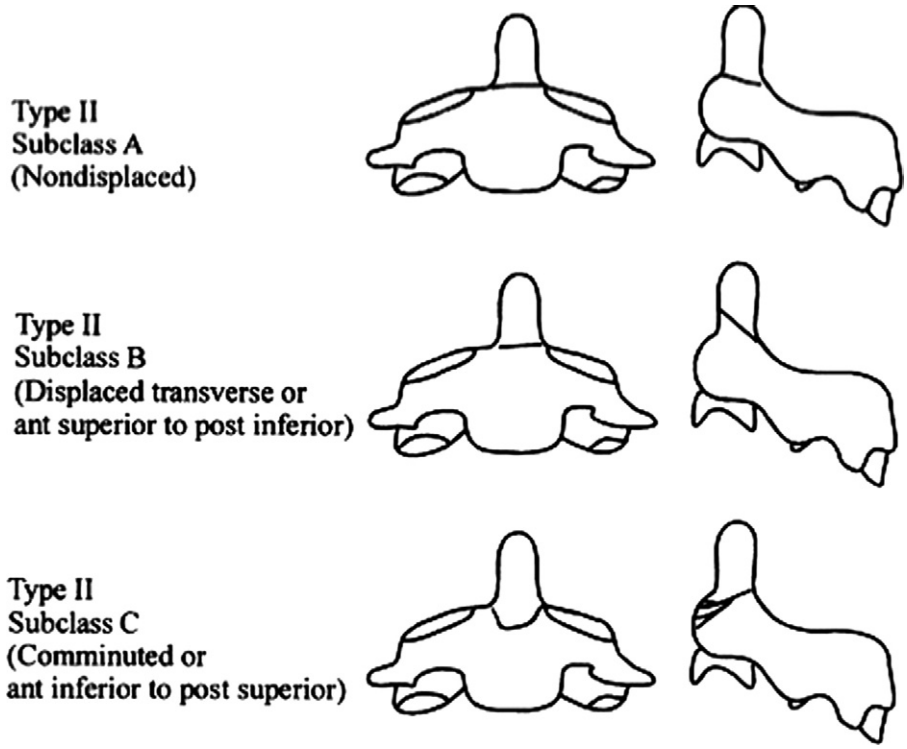

Figure 1 Grauer and coworkers[8] subdivision of type II odontoid fractures based on fracture morphology. Reprinted with permission from Grauer et al.[8]

angle (transverse and oblique orientation), amount of displacement, and degree of comminution.

History of Anterior Odontoid Fracture Fixation

Nakanishi and coworkers began using this technique in 1978.[11] Since then, both single- and dual-screw techniques have been described. In 1999, Subach and coworkers[12] published a retrospective review of 26 patients (mean age, 35 years) with type II dens fractures treated with a single cortical lag screw and postoperative nonrigid bracing. The fusion rate was reported to be 96%, whereas the complication rate caused by surgical technical difficulties (for example, poor placement of screw) was 8%. Overall, fusion rates of 80% to 100% have been described with anterior screw fixation of both type II and "shallow" type III fractures.

Some surgeons have advocated a double-screw technique. A prospective review of 30 patients with type II fractures treated with two 2.7-mm self-tapping titanium screws showed a fusion rate of 100% and no major complications.[13] However, the authors did admit that the dual-screw technique is technically challenging. Others have published a fusion rate of 87% with both single- and dual-screw dens fixation.[14] Nevertheless, Sasso and coworkers noted anterior odontoid fixation with 1 or 2 screws to be biomechanically equivalent[15]; thus, the popularity of the 2-screw technique has waned.

Various modifications of the anterior technique have been described, including multiple variations of retractors[16-18] and placement of screws using fluoroscopic-based navigation systems.[19] Additionally a cadaveric study using bioresorbable odontoid screws has been performed.[20] An endoscopic-assisted anterior screw fixation also has been described. However, that case resulted in pseudoarthrosis.[21] More recently, percutaneous odontoid screw fixation has been described.[22]

Surgical Indications

Most authors agree than acute odontoid fractures with greater than 6 mm of displacement that cannot be reduced and stabilized in a halo or fractures associated with neurological deficit should be treated surgically. Historically, the common surgical treatment for type II fractures was posterior C1 to 2 fusion, including techniques such as Brooks, Gallie, and Sonntag fusions. More recently, C1 to C2 transarticular screws, and C1 lateral mass with C2 pars/pedicle screws have been advocated.[12] Fusion rates as great as 96% in type II fractures treated with posterior cervical fusion have been described (Fig. 2).[1] Nevertheless, posterior C1 to C2 fusion is associated with significant loss of neck motion. Typically, 50% of axial rotation and 10% of flexion-extension of the neck are lost with a C1–C2 arthrodesis.[23] As a result, posterior fusion is more commonly used in chronic rather than acute dens fractures. Additionally, patients with significant kyphotic deformities, osteoporosis (where anterior screw purchase is suspect), Grauer Type IIC (reverse obliquity fractures),[8] and those with significant comminution may warrant a posterior C1 to C2 fusion.

For the repair of a significant number of acute dens frac-