C1-C2 Pedicle Screw Fixation for Atlantoaxial Dislocation in Pediatric Patients Younger than 5 Years: A Case Series of 15 Patients

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■ OBJECTIVE: **C1-C2 pedicle screw fixation has become popular for providing excellent bony purchase and avoiding neurovascular complications. However, it may be technically challenging in children. The objective of this study is to investigate the safety and efficacy of C1-C2 pedicle screw fixation for atlantoaxial dislocation (AAD) in pediatric patients younger than 5 years and to evaluate the preliminary clinical and radiographic results.**

■ METHODS: **During a 7-year period, 15 patients with a mean age of 3.4 years (range, 2–5 years) underwent C1-C2 pedicle screw fixation for AAD; at least 1 C1 pedicle screw was incorporated as part of the posterior atlantoaxial fusion construct. The cause, surgical technique, instrumentation, and clinical and radiographic results were analyzed.**

■ RESULTS: **Five patients had preoperative neurologic deficits and no neurovascular injury occurred during surgery. Anterior release using a retropharyngeal approach was performed in 4 cases. Fixation of 55 C1 and C2 pedicle screws was performed successfully without neurovascular complications. Anatomic and partial reductions occurred in 12 and 3 cases, respectively. Solid fusion was achieved in 14 patients (96.9%) during a mean follow-up of 37.6 months (range, 12–111 months). Two patients (13%) experienced complications: one had prolonged immobilization for a loose C1 pedicle screw, and one had unintended fusion caused by allograft absorption. All patients showed radiographic stability and symptom resolution.**

■ CONCLUSIONS: **C1-C2 pedicle screw fixation for AAD is safe and effective even in children younger than 5 years.**

INTRODUCTION

Pediatric atlantoaxial dislocation (AAD) may be congenital or acquired, and it may cause neck pain, limitation of neck motion, or severe spinal cord compression.[1,2] If conservative treatments are not effective for stabilizing or preventing progression of deformity, surgical intervention is usually required to achieve atlantoaxial reduction and spinal cord decompression.[3] However, screw placement may be technically difficult in very young children because of small bone size, congenital variations, possible growth potential, and immature ossification,[4] and thus, treatment of pediatric AAD remains challenging.

Traditional surgical wiring techniques, which are often supplemented with postoperative halo immobilization, are associated with complications and low fusion rates.[5] Transarticular screw fixation has been widely reported in adult series, but the procedure is technically demanding because of risk of vertebral artery (VA) injury, particularly in pediatric patients; in 1 clinical study, 4% of VA injuries occurred during screw insertion.[6] On the other hand, the novel technique of atlantoaxial stabilization using C1 lateral mass and C2 pedicle screws with a polyaxial screw–rod construct has been increasingly used in pediatric patients,[7-10] and this technique is considered to provide a more rigid and biomechanically sound construct than does transarticular screw fixation.[11]

Key words
- Anterior release
- Atlantoaxial dislocation
- Atlantoaxial fusion
- Efficacy
- Pediatric patients
- Pedicle screw
- Safety

Abbreviations and Acronyms
AAD: Atlantoaxial dislocation
AAF: Atlantoaxial fusions
ADI: Atlantodental interval
ASIA: American Spinal Injury Association
CT: Computed tomography
HRVA: High-riding vertebral artery
VA: Vertebral artery

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C1 pedicle screw technique by inserting the C1 lateral mass screw via the posterior arch, which was first described by Resnick and Benzel in 2002,[12] has recently become one of the most popular C1 fixation techniques for providing excellent bone purchase and avoiding neurovascular structures.[13-16] Although a previous study showed that a 3.5-mm screw can be placed in the C1 and C2 pedicle of children aged 6–8 years using an appropriate entry point, the same technique may be challenging in younger children.[17] In this retrospective study, we introduce the atlantoaxial pedicle screw fixation technique for treatment of AAD in 15 children aged 2–5 years, and we report the preliminary radiographic and clinical outcomes. To our knowledge, few data have been published on the use of this technique in pediatric patients younger than 5 years. All patients in this series underwent C1-C2 fixation and/or fusion incorporating at least 1 C1 pedicle screw.

METHODS

Patient Population

The study protocol was approved by our institutional ethics committee. Fifteen consecutive pediatric patients (10 boys, 5 girls; mean age, 3.4 years; range, 2–5 years) who underwent atlantoaxial fusion (AAF) from 2007 to 2015 were retrospectively analyzed. All surgeries were supervised by the corresponding author (J.S.). Demographic and clinical characteristics of the patients are shown in Table 1. Our indications for surgery were persistent neck pain resulting in limited range of motion with failed conservative treatment, manifestations of a neurologic deficit, and/or severe spinal cord compression. Preoperative assessment included cervical dynamic lateral flexion and extension radiography, computed tomography (CT), CT angiography, and magnetic resonance imaging. C1 heights and C2 pedicle widths were measured on CT scan imaging (Figure 1B). Atlantodental interval (ADI) was measured on lateral flexion radiographs. All patients underwent posterior AAF using bilateral C1 and C2 pedicle screws with a screw–rod construct after reduction, with or without anterior release. For anterior release, a retropharyngeal approach was adopted as described by Srivastava et al.[2] Contracted anterior structures, including the C1-C2 joint capsule, bilateral longus colli, and bilateral longus capitis, along with the anterior longitudinal ligament, were released and cut until ideal reduction was obtained by traction. Preoperative and postoperative neurologic status was evaluated

Table 1. Demographic and Clinical Data for the Study Group

Case	Sex/Age (Years)	Diagnosis	Reduction	Operation	Atlantodental Interval		American Spinal Injury Association Impairment Scale		Complication	Follow-Up (Months)
					Preoperative	Postoperative	Preoperative	Postoperative		
1	F/2.7	Aplasia/hypoplasia of the dens	Anatomic	AAF	8.3	0.8	E	E	No	98
2	M/3.5	Prior odontoid fracture	Partial	Combined	12.5	3.5	C	E	No	85
3	M/3.0	Os odontoideum	Anatomic	AAF	9.7	1.7	E	E	No	80
4	F/4.6	Os odontoideum	Anatomic	Combined	8.5	2.3	E	E	No	76
5	M/4.0	Axis abnormality	Anatomic	AAF	6.7	2.1	D	E	Screw loosening	39
6	M/3.7	Os odontoideum	Anatomic	AAF	9.4	1.5	E	E	No	26
7	F/3.0	Os odontoideum	Anatomic	AAF	5.0	1.1	E	E	No	20
8	M/4.4	Os odontoideum	Anatomic	AAF	7.4	2.7	E	E	No	20
9	M/2.0	C2 abnormality, cerebral palsy	Partial	AAF	10.3	4.3	C	E	No	19
10	F/2.1	AARFD	Anatomic	AAF	6.5	1.4	E	E	Allograft absorption	18
11	M/5.0	Previous odontoid fracture	Partial	Combined	13.2	4.2	D	E	No	17
12	M/4	Previous odontoid fracture	Anatomic	Combined	10.1	2.7	D	E	No	16
13	M/3.0	Transverse ligament laxity	Anatomic	AAF	7.7	0.6	E	E	No	15
14	F/4.0	Os odontoideum	Anatomic	AAF	5.3	2.5	D	E	No	14
15	M/2.5	Aplasia/hypoplasia of the dens/Down syndrome	Anatomic	AAF	11.4	2.2	E	E	No	12

F, female; AAF, atlantoaxial fusion; M, male; combined, anterior release and atlantoaxial fusion; AARFD, atlantoaxial rotatory fixed dislocation.