Bone Grafting of Atlantoaxial Joints and Occipitocervical or Atlantoaxial Fusion for the Reduction and Fixation of Basilar Invagination with Atlantoaxial Dislocation by a Posterior Approach: A Preliminary Study

Xin He, Yibin Meng, Jianan Zhang, Yunfei Hang, Junsong Yang, Qining Wu, Dingjun Hao

■ BACKGROUND: **Basilar invagination (BI) with atlantoaxial dislocation (AAD) is a complex disease to manage. We have developed a new technique of bone grafting the atlantoaxial joints and occipitocervical fusion using a posterior approach for the reduction and fixation of BI with AAD with complete retention of the C2 nerve root.**

■ METHODS: **Thirty-two patients underwent bone grafting of the atlantoaxial joints and occipitocervical fusion for the reduction and fixation of BI with AAD by the posterior approach in our department between January 2015 and February 2016. All patients underwent plain radiography, computed tomography (CT) scanning, and magnetic resonance imaging evaluation. The atlantodens interval and cervicomedullary angle were evaluated preoperatively and 5 days after surgery on sagittal reconstructed CT scans to evaluate BI with AAD. CT scans of sagittal reconstruction were acquired at each follow-up until bone fusion was confirmed.**

■ RESULTS: **All patients were followed up for 6–19 months. No patient required re-exploration for failure of implant fixation. At the last follow-up, all patients had achieved fusion (32/32). Japanese Orthopedic Association score, atlantodens interval, and cervicomedullary angle were significantly improved in these patients compared with preoperative measurements (*P* < 0.05). The duration of symptoms ranged from 5 days to 11 months (mean duration, 2 months). No serious complication was observed.**

■ CONCLUSIONS: **In this preliminary study, our operation technique could treat BI with AAD by using only a posterior approach, which could retain C2 nerve roots and fuse atlantoaxial joints. This technique may be extended to other diseases requiring treatment by C1-C2 fusion.**

INTRODUCTION

Ackermann[1] first described basilar invagination (BI) in 1790. The odontoid process projects into the foramen magnum in BI, and this condition is always complicated by craniocervical junction anomalies. Close observation and conservative treatment are the first choices for asymptomatic BI. However, BI with neurologic symptoms requires surgical treatment. In 1934, Ebenius[2] first presented the surgical technique for BI. BI associated with atlantoaxial dislocation (AAD) mainly has a congenital cause and requires a complex surgical technique. The surgical method for craniocervical junction anomalies was first described by Menezes et al.[3] Compression from the ventral or dorsal side determines the surgical approach.[4,5] Surgical approaches for treating BI with AAD include the transoral anterior combined posterior approach, anterior-only approach, and posterior-only approach.[6,7]

In 2004, Goel[8] reported a technique of atlantoaxial joint distraction and direct lateral mass fixation for BI with AAD, which achieved ideal clinical results. Even although they have improved the operation technique, they insist that C2 nerve root should be excised during the procedure of atlantoaxial joint exposure.[9,10] We have developed a new technique using a posterior approach, in which bone grafting and occipitocervical fusion of atlantoaxial joints is performed for the reduction and fixation of BI with AAD and the C2 nerve root is retained completely. The aim of this research is to report the application of this new technique and its preliminary clinical outcomes.

Key words
- Atlantoaxial dislocation
- Atlantoaxial joints
- Basilar invagination
- Posterior approach

Abbreviations and Acronyms
AAD: Atlantoaxial dislocation
BI: Basilar invagination
CT: Computed tomography
JOA: Japanese Orthopedic Association

Department of Spine Surgery, Hong Hui Hospital, Xi'an Jiaotong University College of Medicine, Xi'an, Shaanxi Province, China

To whom correspondence should be addressed: Dingjun Hao, M.D.
[E-mail: haodjspine@126.com]

Citation: World Neurosurg. (2017) 100:230-235.
http://dx.doi.org/10.1016/j.wneu.2016.12.131

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

PATIENTS AND METHODS

Patient Population

Between January 2015 and February 2016, 32 patients who had BI with AAD underwent surgery in our department. We collected and analyzed the relevant data prospectively. The patient data are summarized in Table 1. Our institutional review board approved the study, and informed consent was obtained from all patients. The Japanese Orthopedic Association (JOA) score was evaluated preoperatively and 5 days after surgery.

Radiographic Evaluation

All patients underwent plain radiography, computed tomography (CT), and magnetic resonance imaging evaluation. The atlantodens interval and cervicomedullary angle were evaluated preoperatively and 5 days after the surgery on CT scans of sagittal reconstruction to evaluate AAD and BI. At each follow-up in our study, CT scans of sagittal reconstruction were acquired until bone fusion was confirmed.

Surgical Technique

All patients underwent cervical traction during the period between hospitalization and operation, with the weights progressively increased to approximately 5–7 kg. To avoid iatrogenic injury, all patients underwent awake endoscopic intubation. General anesthesia was induced in the patients, and they were then placed in the prone position. During the entire course of the surgery, neurologic functions were monitored by somatosensory and motor evoked potentials. A posterior midline skin incision was made to expose the occipitocervical region, which includes the foramen magnum, arch of atlas (absence of arcus posterior atlantis in some cases), and C2 lamina. The operation procedure should ensure no harm to the vertebral artery and nerve root during the operation. To improve the accuracy of the operation, the entire process is assisted by microendoscopy. First, we exposed the atlantoaxial joints, and the tissue surrounding the posterior of the joint was then isolated by the retractor (Figure 1). The epidural venous plexus surrounding the C2 nerve complex is typically prominent and often friable. To avoid troublesome bleeding from the perivertebral venous plexus, we did not deliberately expose the C2 root. The C2 nerve complex tissue was then pulled upward to the atlas. To protect the root, a small piece of gelatin sponge was placed between the C2 root and the retractor, and the root was released at least 30 seconds after retraction for 5 minutes. Joint cartilage was widely removed by high-speed microdrill. We then used large pieces of corticocancellous bone from the ilium to strut and pack into the atlantoaxial joints. The large bone is chosen not only for fusion but also for increasing the joint gap, which could pull out the odontoid process from the foramen magnum (Figure 2). The odontoid process was moved downward and forward, and horizontal reduction was achieved. The caudal rim of the posterior arch of C1 and the cranial edge of the C2 laminae and spinous process were decorticated with a drill. We implanted C1 screws, a C2 pedicle screw, and rod instrument, and a piece of autogenous iliac corticocancellous bone was placed between the arcus posterior atlantis and the C2 vertebral lamina. C1 screw placement was conducted according to the method of Tan et al.[11] For cases with absence of the posterior atlantis, posterior atlantoaxial fixation is not possible; hence, we immobilized the harnpan and C2 for occipitocervical fusion (Figure 3). In this situation, the thickness of the skull was measured by CT before operation. We used a depth-limited drill when making the screw canal to avoid dural or neurologic injury. Occipital and C2 laminae and the spinous process were decorticated with a drill. Bone grafting was performed in the atlantoaxial joints as described previously. A piece of autogenous iliac corticocancellous bone was placed between the occipital and C2 vertebral laminae, the relationship of the occipital and the neck was adjusted, and the jackscrew was locked. The incisions were closed after irrigation, and a drainage tube was installed.

All surgeries in this study were performed by a surgeon with more than 20 years of experience performing spinal surgeries.

Table 1. Description of the Patient Population and Clinical Findings

Characteristic	Data	*P*
Number of cases	32	—
Age, mean ± standard deviation (years)	35 ± 12.0	—
Sex (male/female)	18/14	—
JOA score (preoperative)	11.9 ± 1.7	<0.001
JOA score (postoperative)	14.7 ± 2.4	
CMA (preoperative)	114.3 ± 11.7	<0.001
CMA (postoperative)	151.1 ± 9.6	
ADI (preoperative)	9.2 ± 1.5	<0.001
ADI (postoperative)	1.6 ± 1.2	

JOA, Japanese Orthopedic Association; CMA, cervicomedullary angle; ADI, atlantodens interval.

Statistical Analysis

Independent sample t tests were used to compare preoperative and postoperative JOA scores. The statistical tests were 2-tailed, and $P < 0.05$ was considered statistically significant. The statistical analyses were conducted using SPSS version 19 (IBM Corp., Armonk, New York, USA).

RESULTS

All patients were followed up for 6–19 months (9 ± 2.83 months). No patient required re-exploration for failure of implant fixation. At the last follow-up, all patients had achieved fusion (32/32, 100%). The duration of symptoms ranged from 5 days to 11 months (with a mean duration of 2 months). No intraoperative neurovascular injury or postoperative neurologic deterioration occurred. Twenty-six patients reported iliac pain postoperatively, but the pain gradually disappeared within 1 month. One patient had temporary C2 numbness but recovered well within 2 months postoperatively. We observed pain in the nuchal region in 1 case and delayed healing of the incision in 2 cases. The pain was relieved within 3 months postoperatively by the local muscular training process. The 2 wounds healed after positive wound dressing.