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Brooks' posterior stabilisation surgery for atlantoaxial instability: review of 54 cases

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ABSTRACT

Purpose. To assess the effectiveness of Brooks' posterior stabilisation and fusion for the unstable atlantoaxial joint due to congenital dysplastic dens and trauma.
Methods. We retrospectively studied records of 54 patients (36 males and 18 females; age range, 3–58 years) who underwent Brooks' posterior stabilisation procedure between March 1975 and December 1999, at the Catholic University of Korea Medical Center and Dong-Shin General Hospital, Seoul. A single-stranded Kirschner wire was used to stabilise the first 19 cases (thin wires in 12 cases and thick wires in 7), and double-stranded wires were used in the next 35 cases (thin wires in 4 cases and thick wires in 31). After surgery, patients were immobilised in bed with light Halter traction of the head, followed by cervical bracing.
Results. Fusion was observed by X-ray postoperatively at 15 weeks in 48 patients. Reduction was achieved in 3 luxation cases (including the single case of rotatory fixation). Brooks' fusion failed in 4 patients with dens fractures and 2 with dens anomaly. Four dens fractures in cases of successful Brooks' fusion in Brooks' fusion did not unite. Wire failure occurred in 4 cases of thin single-stranded wire fixation, namely, 2 cases of dens fractures and 2 of dens anomaly.
Conclusion. Brooks' procedure is safe and has a high fusion rate when double-stranded strong wire fixation of the atlantoaxial joint is combined with meticulous bone grafting and subsequent cervical bracing.

Keywords: *atlantoaxial; Brooks; instability; posterior; stabilization*

INTRODUCTION

Atlantoaxial instability is induced by various causes and results in serious complications if it is not treated properly. It is infrequently induced by trauma, by rheumatoid arthritis, and by congenital dens dysplasticity or absence.[1–3] Atlantoaxial stability is main-

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tained by the normal binding ligaments of C1–2, transverse ligament, dens, and lateral joints.[4] If any of these structures are damaged or defective, stability can no longer be maintained.[4–6] There are a few reports, however, that deal with the selection of the most safe, secure, and cost-effective posterior stabilisation method for different unstable conditions. This study evaluated the Brooks' posterior stabilisation procedure on 2 different types of unstable atlantoaxial joints,[1,6,7–10] and assessed the effect of wire thickness, strand number, and postoperative external immobilisation on the stabilisation of the immobilised joints. We did not assess, however, the effect of the Brooks' fusion procedure on management of dens fracture, a topic that has been discussed in the literature.[9,11,12]

MATERIALS AND METHODS

Hospital records of 54 patients who underwent the Brooks' posterior stabilisation procedure between March 1975 and December 1999 at the Catholic University of Korea Medical Center and Dong-Shin General Hospital, Seoul were reviewed. There were 36 males and 18 females, whose ages ranged from 3 to 58 years. There were 45 cases of unstable type 2 odontoid fractures, 2 of anterior and left rotatory luxation, one of rotatory fixation, and 6 of dysplastic dens. Brooks' construct was used for fusion. Two different sizes of Kirschner wire for stabilisation were used: numbers 18 and 20. To stabilise C1–2 segments in the first 19 cases, a single-stranded wire between the posterior arch of the atlas and axis including the spinous process of C2 was used. A single thin wire was used in 12 cases, while a thick wire was used in the other 7 cases in the early period of the study. Double-stranded wires were used in the other 35 cases (thin wires in 4 cases and thick wires in 31 cases—the later series). In one case of rotatory fixation, segments C1 through 3 were stabilised with a single thick wire. Postoperatively, patients were immobilised in bed with light Halter traction of the head for 2 to 4 weeks in the early series, and one to 2 weeks in the later series. A cervical brace with a thoracic support was then fitted for 8 to 14 weeks. Serial X-rays were obtained at 0, 4, 6, 8, 10, 12, 14, and 20 weeks after surgery to assess wire fixation status and fusion, and once a year thereafter. Patients were followed up for 2 to 8 years.

RESULTS

Atlantoaxial fusion was achieved at a mean of 15 weeks after surgery (range, 14–18 weeks) in 48 patients, yielding a fusion rate of 89%. These included 3 cases of rotatory luxation (with the single case of rotatory fixation), for which reduction was achieved after Brooks' procedure. Brooks' fusion failed in 6 (11%) patients: 4 with dens fractures, and 2 with dens anomaly. One of the dens fractures with failed Brooks' fusion did not unite, and another 4 dens fractures did not unite despite successful Brooks' fusion.

Wires were broken in 4 patients in whom thin single-wire fixation was used (2 dens fractures that failed Brooks' fusion and 2 cases of dens anomaly). Reasons that caused wire breakage included the use of single-wire strand (n=4), inadequate postoperative immobilisation due to poor patient compliance with the brace i.e. unordered early weaning of brace by patients (n=3), and preoperative degree of instability (n=2; both were cases of congenital dens anomaly).

No patients developed surgery-related complications. In a patient in whom posterior ligaments between C2 and C3 were sacrificed during surgery, C2–3 junctional instability in the sagittal plane developed one year postoperatively.

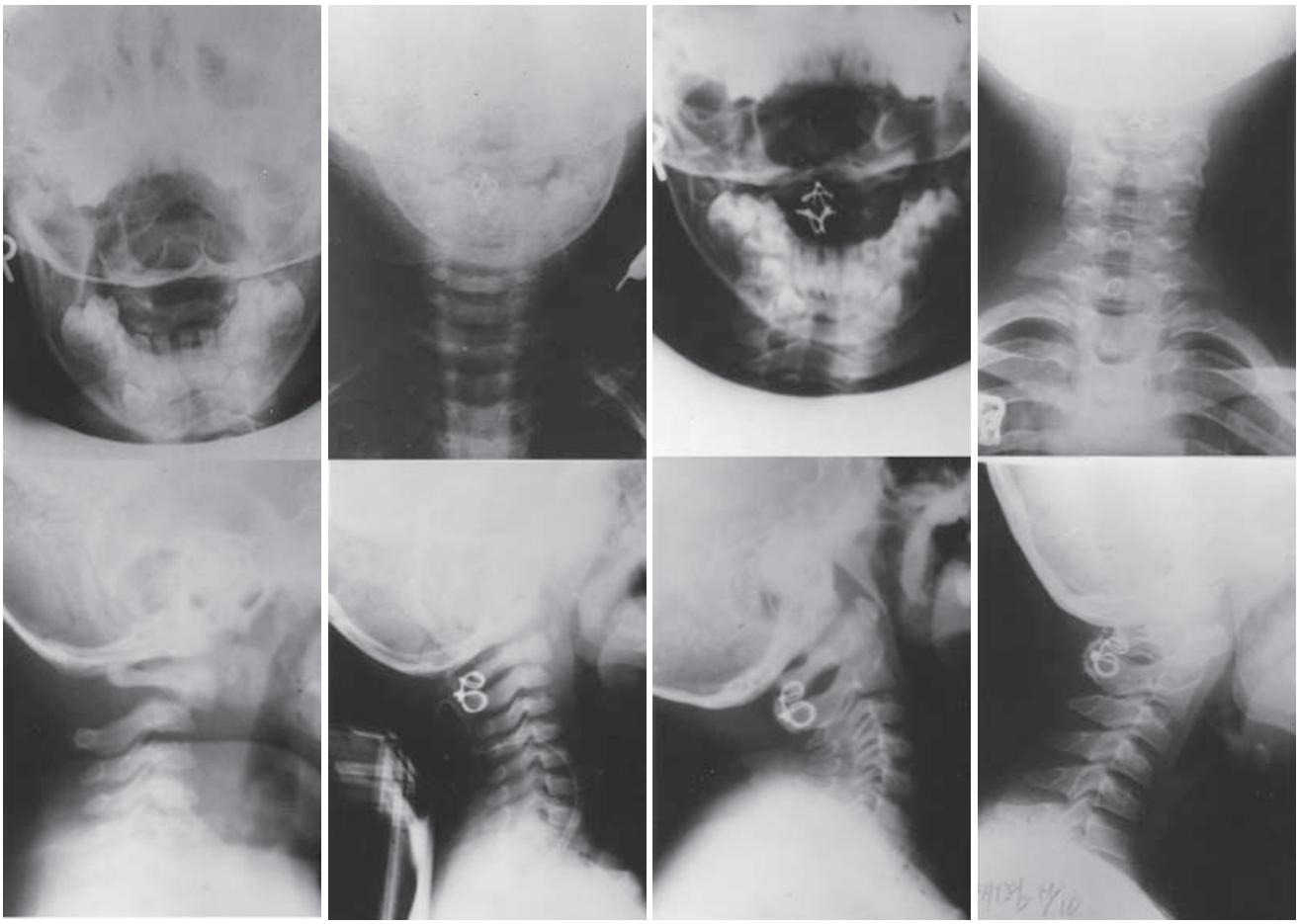
ILLUSTRATIVE CASES

Case 1

A 4-year-old boy sustained a severe neck injury from a fall from a window on the second floor. When he presented at the out-patient clinic, his neck was stiff, tilted, and rotated to left. Initial X-rays taken in July 1987 showed moderate anterior subluxation with slightly tilted and rotated head, for which a week later Brooks' procedure was performed to reduce the subluxation and stabilise the atlantoaxial joint (Fig. 1). Solid fusion was achieved without residual subluxation.

Case 2

A 17-year-old male had chronic neck discomfort and gradually worsening numbness of the neck and upper extremities over a period of 4 years. He had no known history of neck injury. X-ray studies, which included myelograms, disclosed the unstable C1–2 due to os odontoideum, and a remarkably compressed cord on flexion (Fig. 2a and b). Brooks' posterior stabilisation and fusion surgery was performed, using double wires to stabilise the atlantoaxial joint and to avoid fusion failure due to wire breakage. Postoperative X-rays taken at 6 months (Fig. 2c) and 18 months postoperatively (Fig. 2d) showed well-united posterior



(a) **(b)** **(c)** **(d)**

Figure 1 Serial X-rays of a 4-year-old boy with stiff neck, tilted, and rotated to left X-rays **(a)** taken initially, showing anteriorly luxated C1 with tilted and rotated head; **(b)** taken immediately after Brooks' fusion, showing well-reduced C1 and stabilising wires; **(c)** taken at 2 years 6 months; and **(d)** at 8 years 8 months, showing good bony fusion with good maintenance of atlas.

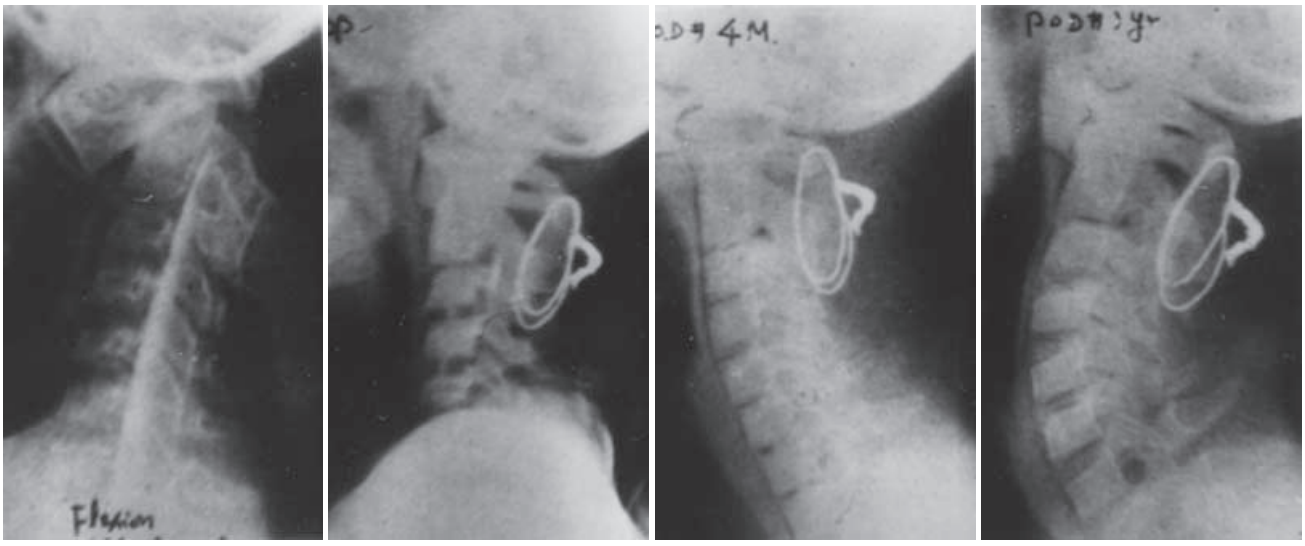
fusion, although there was mild residual forward subluxation of C1 over C2.

DISCUSSION

The atlantoaxial joint is the most complex and most difficult joint to analyse. The major motion is axial rotation,[8,13,14] which, in addition to flexion and extension (including some anterior-posterior translation) is the movement that is clinically the most important one to manage. The stability of this joint is infrequently affected by several causes, such as dysplastic dens, trauma, infection, and arthritis.[1,2,4,8,12] Once the atlantoaxial joint becomes unstable, stabilisation measures should be taken[3,7,10,11,15] or the joint becomes permanently unstable otherwise. There has been various means of treatment to handle different degrees of instability and displacement of atlas.[3,5,16,17] When atlantoaxial stability is lost by the causes listed above, it is thought that surgical stabilisation of the atlantoaxial joint is more reasonable and beneficial than conservative management.[3,9–11,15,16,18,19]

Minimal trauma of an unstable atlantoaxial joint can lead to serious neurological injury.[1,5,8,9,17] Thus, posterior cervical fusion of C1–2 or C1 through 3 is recommended by many authors; surgical management is the definitive method of obtaining permanent stability, thereby allowing early mobilisation and reducing the cost of management. However, the main disadvantage of C1–2 fusion is the loss of axial rotation.[3,5,11,16,18]

Several methods are currently used to achieve posterior stabilisation:[3,8,18,19] the Gallie procedure, Brooks' procedure, the Halifax interlaminar clamp



(a) (b) (c) (d)

Figure 2 Serial X-rays and myelograms of a 17-year-old male **(a)**, **(b)** X-rays showing atlantoaxial instability due to os odontoideum, and cord compression at cervicomedullary junction, particularly on flexion; **(c)**, **(d)** X-rays taken at 6 months and 1 year 6 months after Brooks' fusion, respectively, showing well-united posterior fusion, but residual forward subluxation of atlas over axis.

(Osteon-ICS, New Jersey, United States),[8,19] and the one-piece frame. Brooks' fusion method was used in our institution because it gives good clinical results and is cost-effective according to our experience. Usually, postoperative immobilisation includes skeletal traction or head halter traction for 2 to 4 weeks, followed by stabilisation in a 4-post collar or Minerva cast for 8 to 14 weeks.[16,17]

The role of prophylactic surgical stabilisation for any condition, including the dysplastic dens and undisplaced fresh type 2 fracture of dens, is not yet established. In our series, prophylactic stabilisation surgery for dens anomaly was not performed. It has been generally recommended that if instability is greater than 5 mm in cases of dens anomaly, or if the patient shows clinical signs of neurological compromise, surgical fusion should be performed.[4,8,9] In our series, all 6 patients with dysplastic dens had neurological symptoms and significant instability, and thus met the criteria of surgical stabilisation.

The currently preferred method for fresh type 2 dens fracture is osteosynthesis of fractured dens by screwing, which guarantees fracture union and preservation of rotatory motion. The method has a high success rate, although the procedure demands delicate surgical skill. We have experienced a high fusion rate with osteosynthesis since we started the practice in 1992. However, posterior atlantoaxial fusion is still the preferred indication in cases of the non-united dens fractures.

For posterior atlantoaxial stabilisation, several fixation devices are available, but posterior wire fixation still has its clinical value in daily practice, because of its cost-effectiveness, and thus usefulness in less well-off communities.[3,5,15,18,19] In our institution, Brooks' construct has been used since 1975, because the procedure results in stability in both flexion and extension, while rotation is restricted by some combination of wire tension and bone block. Kirschner wire for posterior atlantoaxial stabilisation has been used because of its cost-effectiveness when compared with the newly marketed high-cost fixation devices. Furthermore, the rate of union of the fractured dens is high. A surgeon has recently recommended the temporary use of a Halifax device to stabilise the dens fracture until fracture healing;[16] the method resulted to manage the dens fracture, and the Halifax device was later removed to mobilise the C1–2 joint (JF Lin, written communication, 8 July 1999). Regarding selection of the proper size of the Kirschner wire, we recommend a single thick wire loop or double-stranded thin wire loops to reduce the chance of wire and fusion failure, particularly for cases of congenital dens anomaly.

Others have recommended the postoperative use of a cervical brace with thoracic support or the wearing of a halothoracic support for 6 weeks.[6,17] To the contrary, we prescribed bed-rest for 2 to 4 weeks postoperatively, and then 8 to 14 weeks of use of a cervical brace under strict supervision, according to

the degree of preoperative instability, to reduce the chance of fusion failure. Patients who do not comply with postoperative instructions tend to experience wire breakage or fusion failure. In our series, postoperative results were also affected by dens anomaly experienced by a high proportion of subjects. For these patients, fusion was more difficult to achieve than in patients with instability secondary to fracture.

Brooks' procedure thus should not be regarded as an obsolete one, because successful fusion can result from meticulous surgery with the use of strong thick wire for fixation, and proper autogenous iliac bone graft, together with appropriate postoperative cervical bracing. In cases of dysplastic dens with remarkable atlantoaxial instability, the combined Brooks' and Magerl procedures are recommended to reduce the fusion failure.[18] In contrast, Brooks' procedure alone is enough for atlantoaxial stabilisation secondary to dens fracture, because in cases of dens fracture, posterior ligamento-osseous complex and lateral joints are relatively well preserved without damage.

CONCLUSION

We confirmed that Brooks' construct for the stabilisation of the unstable atlantoaxial joint is biomechanically sound and safe. The method leads to a high fusion rate, given that double-stranded strong wire fixation of the atlantoaxial joint with meticulous bone grafting, and subsequent cervical bracing, are combined.

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