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Case study

Advantages of an on-the-screwhead crosslink connector for atlantoaxial fixation using the Goel/Harms technique

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ABSTRACT

The goal of fixation surgery for atlantoaxial instability is to achieve solid bony fusion. Achieving bony fusion as early as possible is beneficial for patients. Although placement of a transverse cross-link connector (XL) provides greater biomechanical strength, XLs have not been able to be placed when performing the Goel/Harms procedure. Recently, placing a XL on the screw head (on-the-head XL [OH-XL]) has become a viable option during the Goel/Harms procedure. However, there is little evidence demonstrating whether applying an OH-XL achieves early solid bony union.

A matched-control study was conducted to investigate whether placing an OH-XLs in C1/2 fixation surgery provides earlier bone union or not. Eighteen patients who underwent atlantoaxial fusion with OH-XLs (X-group), and 17 age and sex-matched patients without OH-XLs (NX-group) were compared. Bony union was assessed using reconstructed sagittal and coronal computed tomography images.

Six months after surgery, six patients in the X-group and one patient in the NX-group achieved bony union ($p = .0338$). One year after surgery, 14 patients in the X-group and 4 patients in the NX-group achieved bone union ($p = .0010$). Two years after surgery, 17 patients in the X-group and 9 patients in the NX-group achieved bony union ($p = .0011$).

This is the first report of the clinical application of OH-XLs for the Goel/Harms procedure. OH-XLs yield earlier bony fusion; thus, placing OH-XLs is beneficial for atlantoaxial fixation surgery using lateral mass screws of the atlas.

1. Introduction

The goal of fixation surgery for atlantoaxial instability is to achieve solid bony fusion. Achieving solid bony fusion securely and as early as possible is beneficial for patients who undergo such procedures. Atlantoaxial fixation using a C1 lateral mass screw combined with a C2 pedicle, C2 pars, or C2 lamina screw are some of the standard surgical options [1–9]. These procedures were first reported by Goel et al. [3] and followed by Harms et al. [5]. Three representative screw placement techniques have been reported to date: the Goel/Harms technique [3,5], Tan's technique [10], and Lee's so-called "notching" technique [11]. The clinical use of transverse crosslink connectors (XL) has not been reported in any articles regarding these procedures to date. We introduced C1/2 fixation using a C1 lateral mass screw in 2004 and did not initially use XLs. Recently, placing an XL on the screw head (OH-XL) has become a viable option during the Goel/Harms procedure.

The use of XLs during instrumentation surgery provides stiffer screw/rod constructs [12–18]. In atlantoaxial fixation surgery, biomechanical testing has confirmed that the use of a screw/rod construct consisting of a C1 lateral mass screw and a C2 lamina screw provides a higher degree of stiffness when an XL is also used [14]. However, there is little evidence demonstrating whether applying XLs achieve earlier solid bony union. Evidence regarding

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earlier bony fusion with the use of XLs in the Goel/Harms procedure can help provide better treatments to patients.

Therefore, the purpose of this prospective, matched-control study was to investigate the time required for bony union in C1/2 fixation surgery with or without the use of an OH-XLs and discuss advantages of the OH-XLs for atlantoaxial fixation.

2. Methods

After review board approval in our institution, eighteen patients who underwent atlantoaxial fusion surgery using C1 lateral mass screws combined with a C2 pedicle screw or C2 lamina screw fixed in combination with an OH-XL were enrolled as the crosslink group (X-group). All patients were followed prospectively. Fig. 1 depicts the screw/rod construct with the included OH-XL. Seventeen age and sex-matched controls who underwent the same procedure without OH-XLs (non-crosslink group [NX-group]) were enrolled from the atlantoaxial fusion surgery database at our institution and an affiliate hospital.

2.1. Radiographical evaluation

Follow-up examinations of the both groups were routinely scheduled, and the data were prospectively analyzed. Computed tomography (CT) images were obtained pre- and postoperatively, and then at 6 months, 12 months, and every year thereafter.

Evaluation of the CT images was performed as follows. A radiologist provided the following definition of a bony union: bridging bone between the C1 posterior arch and C2 lamina and ankylosis at the lateral C1/C2 joint as assessed using sagittal and coronal reconstruction CT images. Once the patient's de-identified digital imaging and communications in medicine (DICOM) data were downloaded, two orthopedic spine surgeons evaluated the data. If the time required for bony union reported by the two evaluators were different, a final decision was made by discussion among the radiologist and evaluators.

2.2. Surgical procedure and post-operative treatment

Under general anesthesia with an orally placed endotracheal tube, the patient was placed in the prone position and secured to a surgical table with Mayfield tong connectors. The patient was positioned in the 30° head-up position with slight flexion in the upper cervical spine. Screws were inserted under fluoroscopic guidance. When the medullary canal of the posterior arch of the C1 was confirmed by lateral plain radiography (Fig. 2), screws were inserted via the posterior arch of the C1 [10]. If the medullary canal was not visible on plain radiography or was not suitable for insertion, we attempted insertion using the notching technique [11] or Goel/Harms technique [3,5] (Fig. 2).

Decortication of the posterior arch of C1 and the lamina of C2 was performed with a high-speed bur until punctate bleeding occurred. Usually, the C1/2 joint was not exposed and decortication was not performed except in cases requiring C1 posterior arch resection (Fig. 3). In these cases, intra-articular decortication of the C1/2 joint was performed using a high-speed bur (Fig. 3).

Three-layered bone grafting was routinely performed in all patients, beneath the OH-XLs (Fig. 4). After unicortical cancellous bone blocks and cancellous bone strips were harvested from the iliac crest, the harvested cancellous bone strips were morselized. After decortication, the morselized bone was placed on the dura mater between the rostral surface of the decorticated C1 posterior arch and the caudal surface of the decorticated C2 lamina and the surface of the C1/2 joint. Then, a unicortical cancellous block was placed on the decorticated C1 posterior arch and the decorticated C2 lamina. Finally, the morselized bone was placed on the block again. After bone grafting, OH-XLs were placed and final tightening

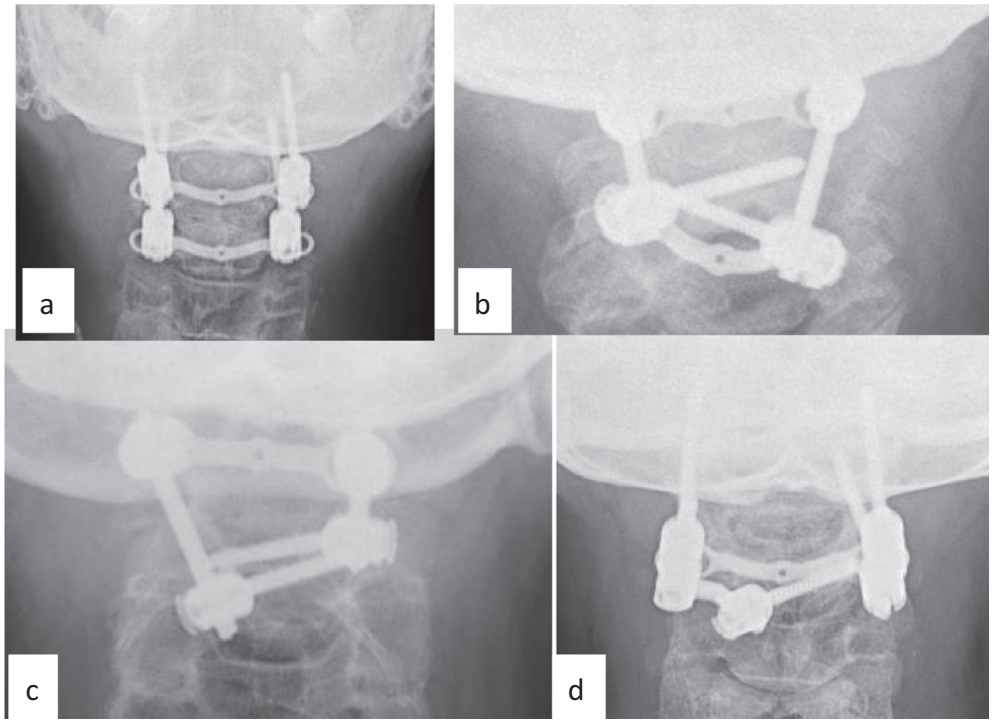

Fig. 1. Combinations of various screwing techniques and transverse connectors a: Combination of bilateral C1 lateral mass screws and bilateral C2 pedicle screws with two transverse connectors on both C1 and C2 screw heads. b: Combination of bilateral C1 lateral mass screws and bilateral C2 lamina screws with two transverse connectors on both C1 and C2 screw heads. c: Combination of bilateral C1 lateral mass screws and bilateral C2 lamina screws with one transverse connector on the C1 screw-head. d: Combination of C1 lateral mass screws, C2 pedicle screw, and C2 lamina screw with one transverse connector on the C1 screw-head.