Comparison of Transarticular Screw Fixation and C1 Lateral Mass-C2 Pedicle Screw Fixation in Patients with Rheumatoid Arthritis with Atlantoaxial Instability

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BACKGROUND: **Many surgical procedures have been introduced to manage atlantoaxial instability caused by rheumatoid arthritis (RA) to prevent complications and improve fusion rate. We report the surgical outcome between transarticular screw fixation (TAF) and C1 lateral mass-C2 pedicle screw fixation (C1LM-C2P) in patients with atlantoaxial instability from RA.**

METHODS: **Between 2002 and 2012, 58 patients were enrolled in the study. According to surgical procedures, patients were divided into 2 groups: group I who received TAF ($n = 33$) and group II who received C1LM-C2P ($n = 25$). Bony fusion was assessed by radiologic comparison immediately after the operation and 1 year postoperatively. In addition, complications and clinical and functional outcomes were evaluated.**

RESULTS: **Overall, bone fusion was achieved in 32 patients in group I (97%). In group II, the fusion rate was evaluated in 100% of patients. Complications (regardless of neurologic deterioration) were cable loosening and screw malposition in group I and violation into the vertebral canal and spinal canal in group II. There was no statistical significance in fusion rate, clinical outcomes, or complications. The 12-month atlantodental interval after operation for the C1LM-C2P group was significantly lower than that for the TAF group after adjusting for all variables.**

CONCLUSIONS: **Two surgical techniques showed a good fusion rate by rigid fixation in the immediate postoperative period and fewer surgery-related complications in patients with RA. Because surgical complications are more likely during the learning curve (as with other surgical techniques), surgeons should carefully evaluate patients before surgery by radiologic and neurologic examinations.**

INTRODUCTION

Rheumatoid arthritis (RA) is a chronic inflammatory disease that has a worldwide prevalence in the adult population of 1%–2%.[1] It is characterized by symmetric progressive polyarthritis and subsequent joint destruction and is associated with high morbidity and mortality. Morbidity and mortality are particularly increased when the disease involves the upper cervical region.[2-4] When this situation occurs, the patients are at risk of myelopathy, vertebrobasilar insufficiency, and sudden death as a result of brainstem compression. In particular, the atlantoaxial joint is often affected by synovitis in the upper cervical region because the transverse ligament is affected during the early stage of disease, resulting in increased laxity. Later in the disease, the cartilage and bony structures of the joint itself are eroded.[5,6] This development leads to atlantoaxial instability (AAI).

Several methods for overcoming AAI have been presented. They include pharmacologic intervention and surgery. Kauppi et al.[7] reported that traditional disease-modifying antirheumatic drugs prevent AAI in patients with recent-onset RA. Several surgical approaches were also reported in the past, including the Gallie

Key words
- Atlantoaxial instability
- Bone fusion
- C1 lateral mass-C2 pedicle screw fixation
- Complication
- Rheumatoid arthritis
- Transarticular screw fixation

Abbreviations and Acronyms
AAI: Atlantoaxial instability
ADI: Atlantodental interval
C1LM-C2P: C1 lateral mass and C2 pedicle screw
C-3D CT: Cervical three-dimensional computed tomography
RA: Rheumatoid arthritis
TAF: Transarticular screw fixation
VA: Vertebral artery
VAS: Visual analog scale

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fusion, the Brooks fusion, and interlaminar clamping. However, more recently, 2 different screw systems that aim to fuse C1-2 have become widely used: transarticular screw fixation (TAF) and C1 lateral mass-C2 pedicle screw fixation (C1LM-C2P).[8-15] These screw systems are both associated with favorable fusion rates,[8,9,15-19] although the atlantoaxial segment generally has lower fusion rates than the subaxial cervical spine because of its high mobility (50% of total neck rotation and 12% of total neck flexion-extension occurs between C1 and C2).

Although many studies have compared the outcomes of surgical procedures in AAI, the patients were heterogeneous in terms of the cause of AAI and the studies reported only the rate of biomechanical instability correction. However, studies of the success of these surgical procedures in patients with RA only are warranted because it is more difficult to achieve C1-2 bone fusion in these patients. This situation is because their disease causes additional problems, including severe laxity of the ligament, poor vascularity, osteoporosis, and demineralization as a result of long-term use of steroid and cytotoxic agents.[20,21]

The aim of the present retrospective cohort study was to compare TAF and C1LM-C2P for AAI in terms of both clinical and surgical outcomes in patients with RA only.

METHODS

This retrospective cohort study was approved by the institutional review board of Hanyang University Medical Center in Seoul, Republic of Korea (approval no. HYUH 2016-06-032-001) and was conducted according to the Declaration of Helsinki and its revisions.

Study Design

All consecutive patients with RA and AAI who underwent TAF or C1LM-C2P between January 2002 and December 2012 at Hanyang University Medical Center were identified by retrospective review of a prospectively collected medical database. Surgery was performed by 3 surgeons. All patients underwent only C1-2 level fusion. Patients with a traumatic lesion, os odontoideum, basilar invagination, occipitocervical fusion, and less than 1 year of follow-up were excluded. All patients were referred to our department when AAI developed during follow-up for RA in the rheumatology department of our hospital. All patients were followed up by scheduled visits to our department 1, 6, 12, and, in some patients, 24 months after surgery.

Preoperative Evaluation

All patients underwent the following radiologic evaluations before surgery. Cervical radiography with flexion/extension views was performed to assess the cervical alignment and the atlantodental interval (ADI). Fine-cut cervical three-dimensional computed tomography (C-3D CT) scans (1-mm slices) were used to predict the screw pathway and assess the course of the vertebral artery (VA). Cervical magnetic resonance imaging was performed to assess the status of the spinal cord and the atlantoaxial ligaments.

Management in Perioperative Period

When AAI was diagnosed in patients with RA, they were treated with several drugs to control the RA, including a cytotoxic agent (methotrexate), steroids, and antiinflammatory agents. One week before surgery, the patients stopped taking the agents to avoid perioperative complications such as hematoma and infection. The RA medication was restarted 2 weeks after the operation. All patients wore a neck brace for 3 months after atlantoaxial fusion.

Surgical Procedures

TAF was used for AAI in our institution until 2007, at which time we started to use C1LM-C2P for AAI. Thus, during the 10-year study period, patients were treated with TAF from 2002 to 2007, after which C1LM-C2P was used in 2008–2012.

Interlaminar Wiring. Both TAF and C1LM-C2P were combined with interlaminar wiring according to the Brooks method using an interlaminar spacer such as an allograft or titanium mesh cage. For the TAF cases, the titanium mesh cage was harvested with either bovine xenograft (Lubboc [Transphyto S.A., Clermont-Ferrand, France]) or demineralized bone matrices (DBX [Synthes, Paoli, Pennsylvania, USA]). Thus, under general anesthesia, the patient was placed in a prone position in which the neck was slightly flexed to achieve cervical alignment. After the operative site was prepared and draped in the usual aseptic fashion, the atlas and axis were exposed sufficiently by midline suboccipital incision. To place the interlaminar spacer, a titanium cable (Atlas cable [Medtronic Sofamor Danek, Memphis, Tennessee, USA]) was passed under the posterior arch of the atlas and coiled up the spinous process of the axis. The fusion bed was prepared by drilling on the inferior aspect of the C1 posterior arch, superior margin of the C2 lamina, and spinous process of the axis. The interlaminar spacer (a titanium mesh cage or an allograft) was anchored tightly between the C1-C2 space, and the titanium cable was tightened over it. Permanent tightening of the interlaminar wire and the inserted spacer was performed before TAF and after C1LM-C2P.

TAF. After reducing the C1-2 alignment by fastening the titanium cable, guide pins were inserted under C-arm guidance along their pathway, namely, through the dorsal elements of C2 and across the C1-2 articulation into the lateral mass of C1. The entry point was on the posterior margin of the inferior articular process of the axis and 3–4 mm lateral to the medial border of the facet. When the guide pins were located on the pathway, cannulated transarticular screws with a diameter of 3.5–4.0 mm were inserted.

C1LM-C2P. After the C1-C2 posterior structures were widely exposed with meticulous coagulation of the venous plexus in the C1-C2 articulation, the starting point for the C1 lateral mass was established 2 mm lateral to the connection point of the posterior arch and the lateral mass. If the C1 posterior arch was not thick enough, the C2 nerve was retracted caudally and the entry point was made directly on the posterior portion of the C1 lateral mass. A 2.7-mm drill was then passed gently through the C1 lateral mass with a straight or slightly convergent trajectory. After tapping the drilled pathway, screws that had a diameter of 3.5–4.0 mm and a length of 28–32 mm were inserted into the lateral mass. C2 pedicle screw fixation was performed as described by Chun et al.[22] Before marking the entry point, the medial border of the C2 pars interarticularis was identified to prevent screw malposition into the spinal canal. After identifying the transitional corner, which

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