의학석사 학위논문

자가뼈를 이용한 추관절 사이 골유합술을 통한 경추 1-2번 고정술의 효용성 연구

The result of interfacetal fusion using local bone combined with an atlantoaxial instrumentation

울 산 대 학 교 대 학 원

의 학 과

오영규

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지 도 교 수 노 성 우

이 논문을 의학석사 학위 논문으로 제출함

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오영규의 의학석사 학위논문을 인준함

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국문 요약

경추 1-2번 유합술에 대한 많은 연구들이 이루어졌고 다양한 방법들이 소개된 바 있으며 시대의 흐름에 맞추어 발전해 왔다. 전통적으로 와이어링 기술이나 또는 장골뼈 이식을 통한 골유합술이 있었으며, 가장 최근에 세계적으로 표화되어 사용되는 방법은 Goel 과 Harms에 의해 유명해진 경추 1번 측괴 나사못 고정술과 경추 2번 척추경 나사못 고정술을 이용한 방법이다. 그러나 우리는 과거 경추 1번 척추경 나사못 고정술의 유용성을 발표한 적이 있고, 여러가지 전통적인 방법들의 단점들을 피할 수 있을 뿐만 아니라 비교적 쉽고 간편한 방법인 경추1-2번 관절사이에 자가 골편을 수술부위 내에서 얻어 끼워 넣어 골유합술을 이뤄내는 방법을 소개하고자 한다.

2012년 3월부터 2019년 12월 사이에 우리 병원에서 경추 1-2번 관절사이 자가 골편을 이용한 골유합술을 시행받은 25명의 자료를 후향적으로 분석하였고, 수술후 최소 12개월의 추적관찰이 시행된 환자들이다. 모든환자의 의무기록을 분석하였으며 임상증상(뉴릭 등급, 후두신경통 발생 여부), 추적관찰 기간, CT 와 경추 x-ray를 통한 영상학적 소견에서 골유합여부를 확인하였다.

15명의 남성과 10명의 여성으로 구성되었으며, 평균 나이는 57.6세 였다. 경척추신경 압박원인으로는 치상돌기골 3명, 경추1-2번 불안정성 9명, 외상 9명, 류마티스염 3명, 골돌기발달 1명으로 분류 되었다. 수술 3개월 차에 3명의 환자는 뉴릭등급이 2단계 상승되었고, 21명의 환자는 1단계, 그리고 1명의 환자는 수술 전과 차이가 없었다. 총 7명의 환자가 수술후 CT를 촬영하였으며, 모두 골유합술이 이루어졌음을 확인할 수 있었다. CT를 찍지 않은 나머지 환자들은 역동성 경추 x-ray를 분석하였을 때 불안정성이 없음을 확인하였다. 모든 환자들에게 후두부신경통증은 나타나지 않았다. 이 연구를 통해 자가뼈를 이용한 추관절 사이 골유합술을 통한 경추 1-2번 고정술이 효용성이 있음을 입증하였다.

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Figure legends

1. Lt. C2 pedicle screw was inserted using direct visualization method

2. Lt. C1 pedicle screw was inserted using direct visualization method; the Penfield dissector No. 4 protected the vertebral artery by flipping it

3. C1-2 facet joint preparation using curette(Left) and Kerrison punch(Right)

4. Bone chips were inserted tightly into the C1-2 facet joint

5. Flowchart of the study summarizing enrolled patients. CT: computed tomography.

6. (A, B) Representative post-surgery flexion/extension X-ray. No movement is shown. (C, D) Representative post-surgery CT scan. Sagittal, coronal view. Trabecular bone bridging is shown.

Chapter 1. Introduction

Atlantoaxial stabilization is used in various atlantoaxial diseases.[1-5] The C1 lateral mass and C2 pedicle screw construct was first introduced by Goel *et al*. in 1994, and later popularized by Harms *et al*., who applied screw and rod systems.[4, 6] Typically, a C1 lateral mass and C2 pedicle screw fixation is used; however, we have reported the efficacy and safety of a C1 pedicle screw using the free-hand technique.[7-9]

Traditionally, several wiring techniques have been used to secure the solid bony fusion at C1–2 by fixating the iliac bone block between the C1 lamina and C2 spinous process[10-13]. However, if decompressive C1 laminectomy is necessary, these methods cannot be applied. In addition, postoperative iliac bone harvest-related morbidity is a potential issue.[14-19]

A different bony fusion method that exposes the C1–2 facet joint was introduced by Goel *et al.* in 2002. This study suggested the use of C1–2 facet joint distraction with a specially designed cage for the treatment of basilar invagination.[20, 21] However, C2 nerve root sacrifice may be necessary to insert the cage inside the facet joint. This has been associated with postoperative occipital neuralgia[22, 23]. In addition, facet joint height distraction using this cage may not be necessary to treat general atlantoaxial instability without basilar invagination.

Thus, we inserted local bone chips harvested from the C2 spinous process inside the unilateral C1–2 facet joint without sacrificing the C2 nerve root following a free-hand technique C1–2 pedicle screw fixation. Here, we analyzed the fusion rate of the C1–2 facet joint and clinical outcomes after atlantoaxial stabilization with a minimum of 1 year follow-up.

Chapter 2. Materials and Methods

Patient Population

We retrospectively reviewed the data of 25 patients who underwent atlantoaxial stabilization surgery using C1–2 pedicle screws and interfacetal bone fusion by a single surgeon between March 2012 and December 2019. The minimum follow-up duration was 12 months.

Radiographic and Clinical Evaluation

The medical records of all patients were reviewed and clinical presentation, follow-up time, radiographic findings *via* CT and cervical X-ray in the lateral flexion/extension view (to assess the creation of a bridging trabecular bone and extent of bone fusion) were collected.

The assessed clinical outcomes were postoperative Nurick grade changes (to assess functional improvement) and occipital neuralgia occurrences. The clinical and radiological outcome measurements were reviewed preoperatively and 12 months postoperatively.

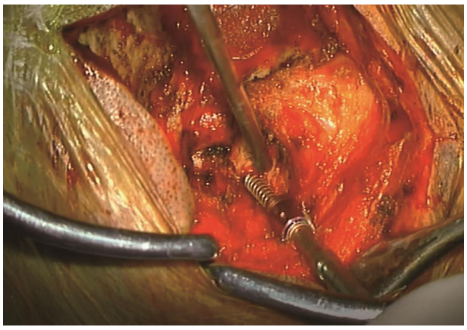
This study was approved by the Institutional Review Board. Patient consent was not required or sought because this was part of a retrospective study and did not include patient identifiers. This case series has been reported in line with the PROCESS Guidelines.[24]

Surgical Technique

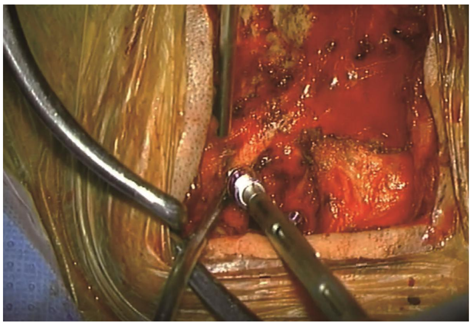
The surgical technique has been described previously.[7, 8] Briefly, patients were placed in the prone position on the Jackson spine table under general anesthesia. Patients were monitored intraoperatively with motor and sensory evoked potentials.

A midline skin incision was created extending from the occiput to the C3 spinous process, which exposed the C1 posterior arch and C2 lateral mass subperiosteally. The C2 dorsal element was carefully exposed to confirm the entry point and trajectory of the C2 pedicle screw. A pedicle screw was inserted at the C2 vertebra *via* the free-hand technique through direct visualization of the C2 pedicle (Figure 1). Next, after careful dissection over the C1 posterior arch to recognize the VA in the C1 vascular groove and C1 nerve root, a C1 pedicle screw was inserted *via* the free-hand technique with direct visualization of the C1 pedicle (Figure 2). All devices used for this procedure were Vertex screws (Medtronic Sofamor Danek, Memphis, TN, USA). Following this, a Penfield Dissector No. 4 was used to climb up between the C2 pedicle and venous plexus capsule without popping the venous plexus capsule exposed the C1-2 joint space. Finally, we inserted local bone chips harvested from the C2 spinous process into the unilateral C1–2 facet joint space after curettage using a curette and small size shaver, Kerrison punch for bone fusion (Figure 3, 4).

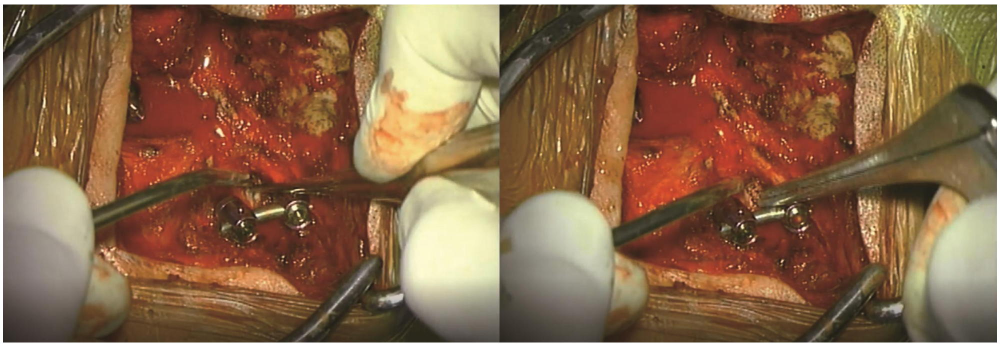
Finally, we checked the intraoperative AP and lateral X-ray images to identify the screw position and alignment.



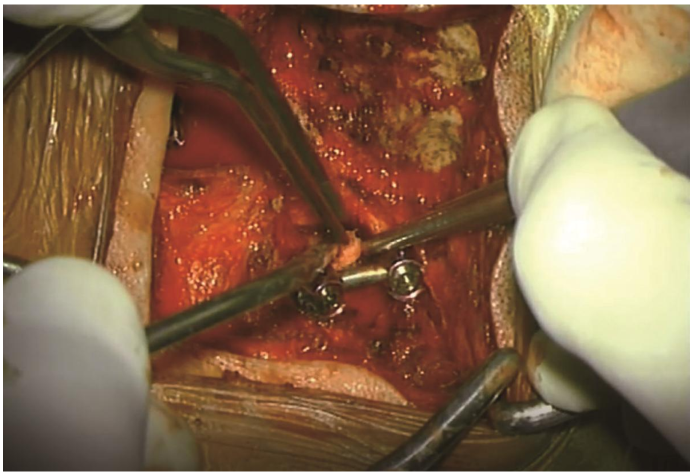
(Figure 1) Lt. C2 pedicle screw was inserted using direct visualization method



(Figure 2) Lt. C1 pedicle screw was inserted using direct visualization method; the Penfield dissector No. 4 protected the vertebral artery by flipping it



(Figure 3) C1-2 facet joint preparation using curette(Left) and Kerrison punch(Right)

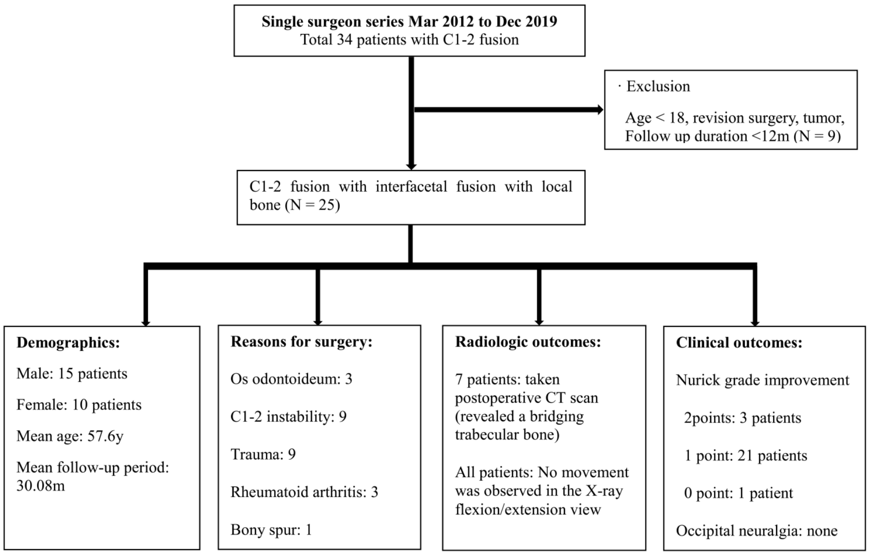


(Figure 4) Bone chips were inserted tightly into the C1-2 facet joint

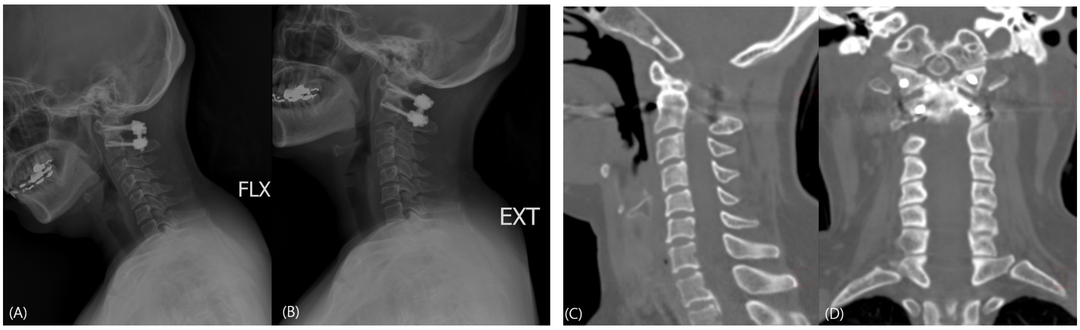
Chapter 3. Results

We collected data from 25 patients who underwent interfacetal fusion using local bones combined with atlantoaxial instrumentation using the free-hand technique for C1–2 pedicle screw fixation (Figure 5). These included 15 men and 10 women, with a mean age of 57.6 y (range, 27–85 y) at the time of surgery. The mean follow-up period was 30.08 mo (range, 13–50 mo). Three patients underwent surgery for myelopathy due to os odontoideum, 9 for C1–2 instability, 9 for trauma, 3 for rheumatoid arthritis, and 1 for bony spur, C1–2. The preoperative Nurick grade was 1 in 11 patients, 2 in 11 patients, 3 in 1 patient, and 5 in 2 patients.

At 3 mo post-surgery, 3 patients showed improved Nurick grades by 2 points, and 21 patients had improved by 1 point. There was no difference in Nurick grade in 1 patient. Seven patients had CT scans at 1 y post-surgery, and all showed a bridging trabecular bone. No movement was observed on X-ray flexion/extension view at 1 y after surgery in all 25 patients (Figure 6). Additionally, no patients complained of postoperative occipital neuralgia.



(Figure 5) Flowchart of the study summarizing enrolled patients. CT: computed tomography.



(Figure 6) (A, B) Representative post-surgery flexion/extension X-ray. No movement is shown. (C, D) Representative post-surgery CT scan. Sagittal, coronal view. Trabecular bone bridging is shown.

Chapter 4. Discussion

Traditionally, techniques to wire the lamina of C1 and C2 vertebrae and interlaminar clamp techniques for atlantoaxial fusion have been performed with simultaneous autologous iliac bone harvest.[12] Additionally, these are combined with advanced posterior C1–2 instrumentation techniques; however, this has not resulted in better fusion rates.[25, 26] Therefore, two posterior screw fixation techniques that utilize C1–2 trans articular and C1 lateral mass screws with C2 pedicle screws have been introduced. The latter has recently gained popularity because of its relatively lower risk of vertebral artery damage and ease of use.[6, 12, 27]

Goel *et al.* first introduced the C1 lateral mass and C2 pedicle screw with a rigid plate technique to treat atlantoaxial instability, followed by modification by Hams *et al.*[4, 6] Advances in instrumentation have led to 95–100% successful stabilization and fusion rates in most studies.[28] One review has described diverse fusion techniques, such as a wiring, on lay-graft, and joint decortication; and materials, such as iliac or local bone grafts, and BMP. High fusion rates indicate excellent fusion tendencies if the anatomical structure is fixed with relatively strong C1 lateral mass and C2 pedicle screws.[28] Therefore, we hypothesized that the simplest method is unilateral joint decortication and local bone use, harvested from the C2 spinous process in the same surgical field. This technique was successfully performed, as reported in this study.

Goel *et al.* have reported that their technique exposes and decorticates the C1–2 joint capsule and inserts fragments of autologous bone graft harvested from the iliac crest or a cadaveric bone bank into the joint space.[6, 20] Next, they inserted a specially designed titanium spacer distracting the C1–2 joint after C2 nerve root resection. In addition, they inserted autologous iliac bone grafts into the joint space to treat basilar invasination. These means that the C1-2 joint distraction using spacer would be only necessary for the misaligned anatomical joint reduction not for the solid bone fusion in this relatively well fusion occurring environment, although some authors advocated this joint spacer use only for the purpose of the union.[30, 31]

We hypothesized that C2 nerve root resection is mandatory for the additional insertion of the spacer due to a greater incidence of postoperative occipital numbness.[23, 32] The C1 lateral mass screw may cause C2 nerve root irritation; therefore, we chose a free-hand C1 pedicle screw to avoid this complication.[7, 9, 23] Biomechanical studies have shown that the C1 pedicle screw is stiffer than the C1 lateral mass screw, which results in better fusion.[33-35] These enabled us to preserve the C2 nerve root and retract, instead of resect, to insert small sized local bone chips into the C1–2 joint space for the solid bone fusion. This technique avoids the use of a spacer, such as a cage filled with the bone graft. In addition, the inferior side of the C2 nerve root approach into the joint space was not associated with significant venous plexus bleeding, which can occur at the C1 lateral mass exposure.[36, 37] Furthermore, surgery time was reduced.[8]

We performed unilateral fusion because the facet joint has a relatively high fusion rate and this approach can reduce surgical time and venous bleeding. Among the two facet joints, we selected a site without vertebral artery anomalies with less venous plexus development. These technical tips enabled a 100% fusion rate, even with unilateral C1–2 joint decortication. Furthermore, there was no postoperative occipital neuralgia.

We used the C2 spinous process as the fusion material to preserve and minimize donor site (iliac bone) morbidities. This led to satisfactory fusions and fewer donor site complications compared with other reported techniques. [14-19, 38, 39]

Chapter 5. Conclusion

This study showed that interfacetal fusion with C1–2 pedicle screws using the free-hand technique was efficient and simple. Prospective studies with validated radiographic and clinical outcome metrics are necessary to determine all the risks and benefits of this technique.

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Abstract

Background

Many studies have described different C1–2 fusion techniques that have evolved over time. We introduced an easy and effective C1–2 fusion technique using local bone chips combined with atlantoaxial instrumentation.

Objective

To identify the efficacy of interfacetal fusion using local bone combined with atlantoaxial instrumentation by assessment of clinical outcomes and fusion rate.

Methods

We retrospectively reviewed the data from 25 patients who underwent atlantoaxial stabilization surgery using C1–2 pedicle screws and interfacetal bone fusion by a single surgeon between March 2012 and December 2019.

Results

The demographics were 15 men and 10 women with a mean age of 57.6 y (range, 27–85 y) at the time of surgery. Three patients underwent surgery for myelopathy due to os odontoideum, 9 for C1–2 instability, 9 for trauma, 3 for rheumatoid arthritis, and 1 for bony spur, C1–2. At 3 mo post-surgery, 3 and 21 patients showed 2-point and 1-point improvements in Nurick grade, respectively. There was no difference in Nurick score in 1 patient. Seven patients had a CT scan at 1 year after surgery, which revealed a bridging trabecular bone. No movement was observed in the X-ray flexion/extension view at 1 year after surgery in all patients. Additionally, no patients complained of postoperative occipital neuralgia.

Conclusion

This study showed that interfacetal fusion with C1–2 pedicle screws using the free-hand technique was efficient and simple.