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Clinical Article

Tracheostomy Following Anterior Cervical Discectomy and Fusion With Plating in Trauma Patients: Is It Safe?

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Conflict of Interest
The authors have no financial conflicts of interest.

ABSTRACT

Objective: This study aimed to evaluate the safety and necessity of tracheostomy after anterior cervical discectomy and fusion (ACDF) with plating, despite the close proximity of the two surgical skin incisions.
Methods: Sixty-three patients with traumatic cervical fractures or spinal cord injury (SCI) who underwent single-level ACDF and plating between January 2014 and June 2019 were included in this study. The patients included 45 men and 18 women, with a mean age of 48.5 years. A retrospective analysis of the patients' demographic data, level of injury, radiological findings, and neurological status was performed based on the American Spinal Injury Association (ASIA), open tracheostomy, and decannulation rate. Additionally, risk factors necessitating tracheostomy were statistically analyzed.
Results: Eighteen patients (28.5%) required subsequent open tracheostomy. Among them, 11 patients were successfully decannulated, four patients could not be decannulated during the follow-up period, and three patients died of unrelated complications. The median interval from ACDF with plating to open tracheostomy was 9.6 days (range, 5–23 days). On the basis of neurological status, ASIA A and B patients ($p<0.001$), high signal intensity on T2-weighted-magnetic resonance (MR) images ($p=0.001$), and major cervical fracture and dislocation were significant risk factors for tracheostomy ($p=0.02$). No patient showed evidence of significant soft tissue, bony infection, or nonunion during the follow-up period.
Conclusion: Independent tracheostomy did not increase the risk of infection or nonunion despite the close proximity of the two surgical skin incisions.

Keywords: Cervical vertebrae; Tracheostomy; Fracture dislocation

INTRODUCTION

Traumatic cervical fracture or spinal cord injury (SCI) is often related to severe neurologic deficits and respiratory dysfunction. In such cases, secondary respiratory failure is the main cause of morbidity and mortality.[2)]

Endotracheal intubation is usually necessary to maintain airway patency and control tracheal secretions. In patients with cervical fractures or SCI, the main indications for tracheostomy include weaning failure, impairment of respiratory drive, and difficulties in managing oral and tracheal secretions.[1,10)]

Tracheostomy can facilitate weaning in patients on mechanical ventilation for a long time, reduce duration of intensive care unit (ICU) stay, and decrease complications from prolonged tracheal intubation.[5)] It has been reported that about 21%–77% of patients with complete cervical SCI need tracheostomy.[6,12)]

Anterior cervical discectomy and fusion (ACDF) with plating is usually performed to decompress the spinal cord directly and stabilize the cervical spine, by a transverse incision of skin at the level of the thyroid or cricoid cartilage, usually between the C4-5 and C6-7 levels. Tracheostomy tubes are typically placed between the 1st and 3rd tracheal cartilages, which are very close to the C6 or C7 levels. The close proximity of the skin incisions in ACDF with plating and tracheostomy creates a potential risk of soft tissue or bony infection. However, there is a paucity of data on those patients requiring both ACDF with plating and further open tracheostomy, and the safety of these subsequent procedures.

The goals of this study were to characterize the clinical and radiological characteristics of patients who require subsequent tracheostomy after ACDF with plating in traumatic cervical fractures or SCI, and to evaluate the safety and result of tracheostomy including wound complications in these patients.

MATERIALS AND METHODS

This study enrolled 63 consecutive patients who underwent single-level ACDF with plating for traumatic cervical fractures or SCI between January 2014 and June 2019.

All patients provided informed consent for the use of their data in the study, and the Institutional Review Board (IRB) approved this study.

The patients comprised 45 men and 18 women with a mean age of 48.5 years (range, 32–81 years).

The mean follow-up period was 49.9 months (range, 10 days to 96 months).

Inclusion and exclusion criteria

We included all adult patients who underwent single-level ACDF with plating for traumatic cervical fractures or SCIs. All surgeries were performed by the same spine surgeon, who is the senior author in this study. We excluded patients who required emergent intubation for mental deterioration before surgery, or who had multiple traumatic injuries, such as brain, tracheal, and thoracic injuries. However, patients with a history of cervical spine surgery were not excluded from the study. Patients who underwent posterior approaches such as laminoplasty or laminectomy were also excluded.

The decision to perform tracheostomy was made at the discretion of the attending spine surgeons or respiratory medical doctors. Decannulation was considered when 2 criteria were met: (1) the patient was not dependent on mechanical ventilatory assistance any more and (2) frequent suctioning was not required for reduced tracheal secretions.

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The American Spinal Injury Association (ASIA) Impairment Scale was used to assess neurological status. The ASIA scale includes the following injury categories: A, complete with no motor or sensory function; B, incomplete with preservation of sensory function below the level of injury, but without preserved motor function; C, incomplete with preservation of motor function below the level of neurologic injury, but at least 50% of this function expresses a muscle grade less than 3; D, incomplete with preservation of motor function below the level of neurologic injury, with at least 50% of this function being muscle grade 3 or greater; and E, normal motor and sensory function.[8]

Operative procedure

All patients underwent emergent surgical treatment (ACDF with plating) within 12 hours of injury.

After sufficient explanation of procedure-related risks, they underwent anterior surgery with ACDF, using a cage and cervical plating (Maxima® Plate Korea). A polyetheretherketone cage (Solis® Stryker, USA or Impix®; Medicrea, Lyon, France) with a demineralized bone matrix (DBM, CGDBM®; CGBIO, Seoul, Korea) was used. The cage was filled with DBM and osteophyte-derived bone dust obtained by drilling during surgery. In cases of traumatic fracture and dislocation of the cervical spine, gentle manual reduction of the locked facets was attempted with simultaneous monitoring of somatosensory evoked potentials under general anesthesia. Tracheostomy was performed surgically in all patients, under local anesthesia, in an operating room or ICU. The skin incision of the subsequent tracheostomy was usually placed midway between the cricoid cartilage and suprasternal notch, avoiding the pre-existing surgical site as much as possible.

Postoperative treatment

The patients started ambulation and rehabilitation as soon as possible after removal of drainage, while wearing a Philadelphia neck collar for 3 months. However, most patients with ASIA grades A and B could not ambulate because their activity levels were low, and they were hospitalized in the ICU.

Follow-up was determined by a combination of outpatient clinic visits and telephone interviews with family members. In patients who were hospitalized at another hospital, simple radiographs of their cervical spine and chest were obtained from their family members. In patients who could provide follow-up simple radiographs, satisfactory fusion criteria were defined as bridging trabecular bone, absence of a radiolucent gap between the graft and endplate, or absence of more than 2 mm on dynamic flexion and extension views.

Statistical analysis

Differences between means and proportions were analyzed using the χ^2 test for categorical variables and the unpaired t-test for variables between groups.

All calculations were performed using SPSS version 21.0 software (SPSS Inc., Chicago, IL, USA), and statistical significance was set at $p<0.05$.

RESULTS

Between January 2014 and June 2019, 63 patients (45 men, 18 women; mean age, 48.5 years) underwent single-level ACDF with plating for cervical spine fractures, subluxation, fracture

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and dislocations, or injuries to the cervical spinal cord (C3-4, 2 patients; C4-5, 9 patients; C5-6, 27 patients; C6-7, 14 patients; C7-T1, 1 patient).

Among them, 18 (28.5%) patients underwent subsequent tracheostomy to decrease pulmonary complications. The median interval from ACDF with plating to tracheostomy was 9.6 days (range, 5–23 days).

Univariate analysis of the risk factors for tracheostomy after ACDF with plating revealed significant differences among the three items. Patients with severe neurologic deficits (ASIA A and B) received a tracheostomy procedure in 89% of cases (16 of 18), whereas only two patients did not undergo subsequent tracheostomy (p<0.001). Patients with ASIA C-E had a significantly higher incidence in the non-tracheostomy group.

On the basis of high signal intensity on T2-weighted MR imaging, of the 26 patients, 15 (83%) with high signal intensity underwent tracheostomy after ACDF with plating, and 11 patients who showed high signal intensity did not require tracheostomy after ACDF with plating (p=0.001).

Among the various preoperative diagnoses, the presence of fracture and dislocation was significantly higher in the tracheostomy group (p=0.02). However, smoking history and surgical level did not show significant difference between the groups (**TABLE 1**).

The final outcomes in the 18 patients who required tracheostomy were analyzed. One patient died soon after tracheostomy due to an unknown cause, and 2 patients died of unrelated complications during the follow-up period. The respiratory status of 11 patients stabilized and they were successfully decannulated. The mean interval from tracheostomy to decannulation was 60.3 days (range, 13–167 days). Four patients could not be decannulated and required maintained tracheostomy or continuous ventilator management during the follow-up period. Sixteen patients (89%) had culture-positive pneumonia at the tracheostomy site, and 5 patients were readmitted to the ICU from the ward for airway trouble.

TABLE 1. Characteristics of the enrolled patients who underwent ACDF with plating

Characteristics	Tracheostomy	No tracheostomy	p-value
Number of patients	18	45	
Age	50.2±34.1	48.0±20.1	0.80
Sex (male:female)	13:5	31:14	0.52
Smoking history	7 (39%)	17 (38%)	0.06
Levels			
C3-4	1 (6%)	1 (2%)	0.90
C4-5	3 (17%)	6 (13%)	0.35
C5-6	10 (55%)	27 (60%)	0.12
C6-7	4 (22%)	10 (23%)	0.49
C7-T1	0 (0%)	1 (2%)	1.00
Initial ASIA			
A-B	16 (89%)	2 (4%)	< 0.001
C-E	2 (11%)	43 (96%)	< 0.001
High signal intensity at T2-WI	15 (83%)	11 (24%)	0.001
Diagnosis			
Facet fracture or subluxation	5 (28%)	26 (58%)	0.33
Traumatic disc herniation	1 (6%)	6 (13%)	0.41
Fracture and dislocation	12 (66%)	13 (29%)	0.02

Data are mean ± standard deviation or number of patients
ACDF: anterior cervical discectomy and fusion, ASIA: American Spinal Injury Association, T2-WI: T2-weighted magnetic resonance images.

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No patient developed soft tissue or bony infection at the site of ACDF with plating even at the C6-7 levels after close placement of a tracheostomy tube (**FIGURES 1** & **2**).

Neurological deterioration after ACDF with plating and tracheostomy was not observed, and radiographs revealed satisfactory fusion in all surviving patients who were available for follow-up radiographs (**TABLE 2**).

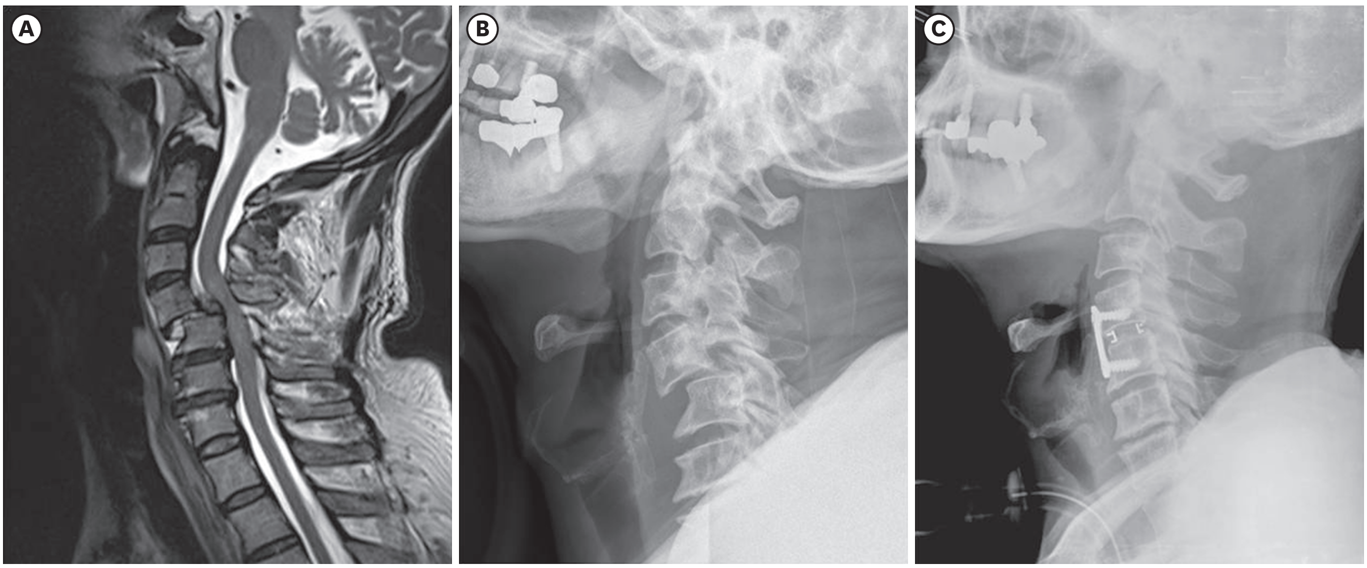

FIGURE 1. A 42-year-old male with C4-5 facet fracture and dislocation.
(A & B) Preoperative T2-weighted cervical sagittal MR imaging and lateral radiograph showing a facet fracture and dislocation at the C4-5 level. (C) Lateral radiograph shows a relatively remote distance between the 2 surgical procedures.
MR: magnetic resonance.

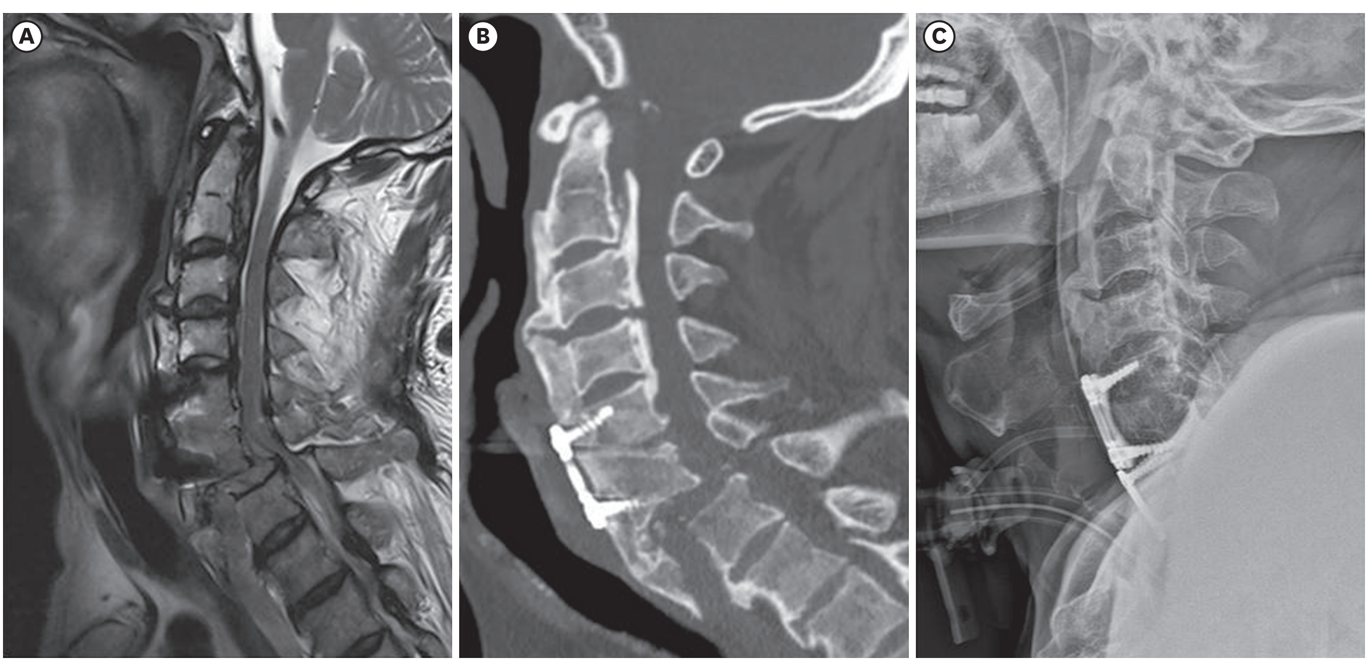

FIGURE 2. A 53-year-old male with C6-7 facet fracture and dislocation, with previous C5-6 ACDF with plating.
(A & B) Preoperative sagittal MR and CT revealed a facet fracture and dislocation at the C6-7 level, with severe cord compression. (C) Lateral radiograph reveals the close proximity of the 2 surgical procedures at the C6-7 level.
ACDF: anterior cervical discectomy and fusion, MR: magnetic resonance, CT: computed tomography.

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TABLE 2. Demographic data of the tracheostomy group

Case	Age/sex	Involved level	Diagnosis	Time from surgery to tracheostomy (day)	ASIA preop postop	Decannulation	Time from tracheostomy to decannulation (day)	Culture in tracheostomy	Remarks	Follow-up radiographs
1	84/M	C5-6	Fracture & dislocation	10	A			-	Death in 10 days (unknown cause)	NA
2	25/M	C5-6	Fracture & dislocation	5	A	Yes	45	+		Fusion
3	29/F	C5-6	Fracture & dislocation	6	A			+	Death in 68 days (MI)	NA
4	27/F	C5-6	Facet fracture	8	B	Yes	79	+		Fusion
5	44/M	C6-7	Fracture & dislocation	6	B	No		+		Fusion
6	71/M	C6-7	Subluxation	23	B	No		+		Fusion
7	58/M	C5-6	Facet fracture	5	A	Yes	87	+		Fusion
8	42/M	C4-5	Fracture & dislocation	7	A	Yes	29	+		Fusion
9	44/M	C5-6	Fracture & dislocation	10	A	Yes	13	-		Fusion
10	73/F	C4-5	Facet fracture	13	C			+	Death in 10 months (MI)	NA
11	60/M	C3-4	Fracture & dislocation	6	A	Yes	167	+		Fusion
12	42/M	C5-6	Fracture & dislocation	17	B	Yes	94	+		Fusion
13	73/F	C5-6	Subluxation	9	E	Yes	54	-		Fusion
14	38/M	C6-7	Fracture & dislocation	5	B	No		+		NA
15	29/M	C5-6	Fracture & dislocation	13	B	Yes	38	+		Fusion
16	72/F	C5-6	Facet fracture	10	A	Yes	37	+		Fusion
17	39/M	C4-5	Fracture & dislocation	14	B	Yes	20	+		Fusion
18	53/M	C6-7	Fracture & dislocation	9	A	No		+	Previous ACDF C5-6	NA

ASIA: American Spinal Injury Association, MI: myocardial infarction, NA: not-available, ACDF: anterior cervical discectomy and fusion.

DISCUSSION

Traumatic cervical spine fractures with accompanying SCI are serious lesions usually accompanied by permanent neurological deficits and respiratory failure.[9] The main goals of surgical treatment of traumatic cervical spine fractures with or without SCI include prevention of further disability, minimizing neurologic sequelae, and return to functional ability.[14] For cervical fractures and SCI, the anterior approach has some advantages, including technical familiarity, simplicity, short fusion construct, and more importantly, easy decompression of the spinal cord in patients with traumatic disc herniation.[3]

Apart from motor weakness, respiratory failure remains the main cause of morbidity and mortality in patients with cervical fractures accompanying SCI.[2] Moreover, approximately two-thirds of these patients experience respiratory complications that may require tracheostomy and mechanical ventilatory support.[4,11] However, few studies exist in the literature regarding the safety and efficacy of open tracheostomy following instrumented ACDF; therefore, no standard clinical protocol exists, leading to wide variance for practical application. In fact, despite the simultaneous need for 2 surgical procedures, many spine surgeons are hesitant to perform tracheostomy following ACDF because of the concern of soft tissue or bony infection owing to the close proximity of two skin incisions.

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Based on our study, we found that subequent tracheostomy performed 5–23 days after ACDF with plating did not cause clinically significant cross-contamination.

No patient developed deep wound infection or hardware infection at the ACDF site after tracheostomy, even with close proximity of the two skin incisions at C6-7 levels and as further evidence, there was satisfactory tracheostomy site wound healing after decannulation.

We also found that a greater number of patients with more severe cervical SCI (ASIA A or B) required tracheostomy and observed a strong association between the need for tracheostomy and the ASIA classification on univariate analysis. Similarly, Winslow et al.[13)] reported that tracheostomy was required more frequently in patients with motor deficits (28%) than in those without neurologic deficits (3%) in a study of patients with isolated SCI.

In terms of the relationship between imaging assessment and the need for tracheostomy, the current study revealed that hyperintensity on T2-weighted MR images could be a significant risk factor for requiring tracheostomy after ACDF with plating. This finding on MR imaging suggests more severe injury to the spinal cord. Cervical fracture and dislocation is one of the most devastating injury involving the cervical spine and are usually accompanied by both anterior and posterior discoligamentous instability. The present study also noted significant differences in the presence of cervical fracture and dislocation. This is probably because damage to the spinal cord is more severe in cases of fracture and dislocation.

Theoretically, complete paralysis caused by an injury above the C4 level results in motor paralysis of the diaphragm, which is prone to cause respiratory insufficiency. The C3 cord contains the phrenic nucleus. However, in our study, a significant difference in injury level was not noted, although neurological levels of injury above C4 are known risk factors for requiring tracheostomy. It is well known that the diaphragm is required for approximately 65% of breathing movement and is innervated by nerves originating from C3-C5 (primarily from C4), and injury to the spinal cord at a higher level will immediately necessitate ventilator support.[6)] In our study, the injury level itself, if severe neurological injury was absent, was not related to the need for tracheostomy after ACDF with plating. This might be related to small number of patients. Several studies have reported that the risk of tracheostomy after cervical SCI is associated with old age and smoking history. However, the current study found no significant differences with age or smoking history.[7,15)] To decrease the potential infection in this population, we believe careful preparation of the skin and the skin incision of subsequent tracheostomy away from the pre-existing surgical site as much as possible. It is also important to perform tracheostomy as soon as possible pulmonary complications develop.

This study has several limitations. First, this was a retrospective study with a relatively small sample size over a 7-year period, and the significance of parameters was evaluated using only univariate analysis. Second, this study could not examine the original respiratory status of patients. Finally, the decision to perform tracheostomy and decannulation was left to the entire discretion of the patients' primary physicians, including spine surgeons, respiratory medical doctors, or rehabilitation doctors.

Despite these limitations, this study identified the safety of tracheostomy following ACDF with plating. Significant differences requiring tracheostomy were identified in terms of the following three items: severe neurological motor paralysis (ASIA A or B), presence of fracture and dislocation, and high signal intensity on T2-weighted MR imaging. In this series, we did

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not find serious infection or impaired wound healing of the ACDF with plating in spite of the close proximity of the surgical wounds of the ACDF with plating and tracheostomy site.

CONCLUSION

The risk factors for subsequent tracheostomy following ACDF with plating were severe neurological deficits, presence of fracture and dislocation, and high signal intensity on T2-weighted MR imaging. Our data support the fact that if necessary, open tracheostomy can be safely performed following anterior cervical decompression and stabilization without serious infections or significant complications.

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