Analysis of the Fusion and Graft Resorption Rates, as Measured by Computed Tomography, 1 Year After Posterior Cervical Fusion Using a Cervical Pedicle Screw

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■ BACKGROUND: **We previously showed that cervical pedicle screw (CPS) placement is safe even with the freehand technique. The posterolateral fusion rate 1 year after CPS placement, as measured by computed tomography (CT), is reported here. The graft resorption rates when different graft materials were used were also analyzed.**

■ METHODS: **Between 2012 and 2015, 93 patients underwent posterior cervical fusion surgery with the CPS from C2 to C7. Of these patients, 56 consented to CT scans immediately and 1 year after surgery. These patients formed the present study group. The patients were categorized according to whether the graft material was local bone, allograft, or a mixture. Graft volume was measured at both CT scans. Graft resorption rate was determined by comparing the 2 scans. Radiologic fusion was assessed on the 1 year postoperative CT scan and radiography.**

■ RESULTS: **The reason for surgery was trauma ($n = 19$), degenerative disease ($n = 35$), tumor ($n = 1$), and spondylitis ($n = 1$). Surgery was performed with CPS fixation and decompression. Even although iliac bone grafting was not performed, the overall fusion rate was 98.2% (55/56). The single fusion failure case received a mixture of local bone and allograft. Although the allograft group showed the greatest graft resorption rate (91.5%), all patients in this group had a bony bridge that crossed the facet joint on the 1 year CT scan.**

■ CONCLUSIONS: **CPS placement yielded a posterolateral cervical fusion rate of 98.2%. Despite the high resorption rate of allograft only, this material yielded fusion rates that were similar to those of the other materials. Thus, the strong fixation power of CPS might compensate for the delayed fusion and high resorption rates of allograft bone chips.**

INTRODUCTION

The fusion materials and instrumental techniques used to achieve spinal fusion have developed rapidly and have decreased the morbidity associated with iliac crest harvest, which includes infection or chronic donor-site pain.[1-7] However, nonunion after spine surgery has been one of the major complications until now.[8,9]

We previously showed that cervical pedicle screw (CPS) placement is safe even when the freehand technique is used.[10,11] However, we have not yet reported the rate of fusion in the follow-up period. The present report details the rate of posterolateral fusion 1 year after CPS placement, as assessed by computed tomography (CT) and dynamic radiography. Whether iliac bone harvest is necessary for posterior cervical spine surgery if a pedicle screw is used rather than a lateral mass screw is discussed. In addition, the effect of using different bone graft materials on the amount of bone graft material resorption was assessed. Whether a high resorption rate impaired the fusion rate was determined.

METHODS

Between March 2012 and June 2015, 93 patients underwent posterior cervical fusion surgery with a CPS from C2 to C7. All patients then underwent immediate postoperative 1-mm thin-slice CT. Of

Key words
- Allograft
- Autograft
- Cervical pedicle screw
- Fusion
- Local bone
- Iliac bone
- Resorption

Abbreviations and Acronyms
CPS: Cervical pedicle screw
CT: Computed tomography

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the 93 patients, 56 also underwent 1-mm thin-slice CT scanning and dynamic cervical radiography minimally 1 year after surgery. These 56 patients formed the cohort of the present study. Of the remaining 37 patients, 32 refused the postoperative 1-year CT scan, and 5 died before the scan could be performed. This study was approved by the institutional review board.

Preoperative Characteristics of the Follow-Up Study Cohort

The initial diagnoses of the 56 patients in the follow-up cohort were trauma ($n = 19$), tumor ($n = 1$), spondylitis ($n = 1$), and degenerative disease, including cervical spondylotic myelopathy ($n = 12$), ossification of the longitudinal ligament ($n = 10$), and foraminal stenosis ($n = 13$). The trauma consisted of fracture, dislocation, or cervical cord injury associated with compressive lesion. The primary instrument choice was a pedicle screw that was placed by using the freehand technique if the outer diameter of the cervical pedicle exceeded 3.0 mm on an axial CT scan.

Table 1 shows the preoperative characteristics of the 56 patients. Seven were female and 49 were male. The patients were on average 59.8 years old (range, 29–83 years), and the mean follow-up duration was 20.2 months (range, 12–32 months). The mean fusion level from C2 to C7 was 2.3 (range, 1–5). In patients who lacked a condition that could affect normal bone homeostasis, the bone mineral density was measured if the patient was >50 years old if female or >60 years old if male. Of the 56 patients, 26 underwent bone mineral density analysis. Three patients had a T score of less than −2.5 and were considered to have osteoporosis. Of the 56 patients, 27 smoked and 13 had diabetes mellitus. One patient used steroids for an extended period to treat chronic obstructive pulmonary disease. There were 2 patients with leukemia, 1 with depression, 1 with amyotrophic lateral sclerosis, 1 with chronic obstructive pulmonary disease, 3 with cardiovascular disease, and 1 with tumor.

Table 1. Preoperative Characteristics of the Follow-Up Cohort

Characteristics	Total Number of Patients (n = 56)
Age (years), mean (range)	59.8 (29.0–83.0)
Sex, male:female	49:7
Osteoporosis (number of patients)*	3
Smoker, yes:no	27:29
Diabetes mellitus, yes:no	13:43
Steroid user, yes:no	1:55
Medical illness (number of patients)	
Leukemia	2
Tumor	1
Depression	1
Amyotrophic lateral sclerosis	1
Chronic obstructive pulmonary disease	1
Cardiovascular disease	2
Arrhythmia	1
Reason for surgery (number of patients)	
Trauma†	19
Foraminal stenosis	13
Cervical spondylotic myelopathy	12
Ossification of longitudinal ligament	10
Infection	1
Tumor	1

*Osteoporosis (*T* score <−2.5).
†The trauma led to fracture or dislocation or cervical cord injury associated with compressive lesion.

Surgical Techniques and Patient Classification According to the Different Fusion Materials

The entry point of the screw was determined from the sagittal and axial CT scan images: the entry point was defined as the notch level in the sagittal plane and medial to the lateral border of the superior articular process by one quarter of its width in the axial plane. The entry points were slightly modified depending on the CT anatomy of each patient. Our pedicle screw insertion technique is described in more detail in a previous article.[11] As described previously, the most important factors for the safe and accurate placement of CPSs are as follows: the planning of the screw entry point on the basis of information from the preoperative CT scan, the achievement of an adequate medial angle for screw insertion through the use of a curved small pedicle probe, the ability to detect pedicle breach with a ball-tip probe, the proper conversion to a lateral mass screw when a breach is detected, and the ability to properly interpret the intraoperative anteroposterior radiographic images after screw insertion. All these technical steps were performed in all patients to ensure that the CPSs were safely placed.[11]

During surgery, autologous local bone could be obtained for posterolateral fusion if central decompression was performed via laminectomy. Decompression was performed by using subtotal laminectomy (i.e., half the amount of laminae) at the most cranial and caudal levels, and total laminectomy at the middle level. To use lateral mass as a fusion bed, the junction between the lamina and lateral mass was cut with a 1.5-mm match head–type burr. Cancellous bone was exposed by drilling with a 3.0-mm match head–type burr on the posterior surface of the lateral mass and inside the facet joint. Autologous local bone chip and/or allograft bone chips (TBI Inc., San Rafael, California, USA; 30 mL) were used for posterolateral fusion (i.e., an onlay bone graft on the decorticated lateral mass and inside the facet joint). Thirty-one patients received both autologous local bone chips and allograft bone chips (30 mL) for posterolateral fusion. Six patients did not consent before surgery to the use of additional allograft bone because of the cost. For these patients, only local bone was used for posterolateral fusion. The pathology of the remaining 19 patients did not necessitate central decompression or laminectomy (fracture, dislocation, or foraminal stenosis), and thus only allograft bone chips (30 mL) were used for posterolateral fusion. Iliac bone harvest was not performed in any of the 56 patients.

The patients were classified into 3 groups on the basis of whether local bone ($n = 6$), allograft ($n = 19$), or a mixture ($n = 31$)