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Original Article

A new source of structural autograft for ACDF surgery: cervical laminae

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Abstract: Study design: A prospective study and a technical note. Background: Autograft is considered to be the gold standard in achieving optimal fusion in anterior cervical discectomy and fusion (ACDF). In patients with combined postero-anterior cervical procedure, whether the cervical laminae harvested from laminectomy can be used as astructural bone graft in ACDF? Few studies have reported about this. Objective: To describe the clinical and radio graphic outcomes in patients undergoing combined postero-anterior cervical surgery using autologous laminae as bone graft in ACDF. Methods: Twenty-two patients (13 males, 9 females) with cervical spondylotic myelopathy underwent one-level combined postero-anterior procedure with anterior plate fixation from January 2010 to January 2014. All the patients received computed tomography scan before surgery and the heights of the target laminae and the middle intervertebral space were measured. Then, patients underwent combined postero-anterior surgery with laminectomy and ACDF. The structural laminae obtained from laminectomy were used as bone graft in ACDF. The clinical and radiographic outcomes of the patients were analyzed and the effectiveness and safety of the surgery was evaluated. Results: The average heights of the target laminae and the middle intervertebral space were 11.18±1.05 mm and 5.75±0.58 mm, respectively. Statistical significant difference was found between the heights of the laminae and the space (P<0.001). The mean operative time was 192±37 minutes with an average blood loss volume of 235±71 ml. All patients were followed up and the average follow-up period was 17.5±3.1 months. All patients had immediate postoperative resolution of symptoms and radiographic evidence of solid fusion 3 months later. Postoperatively, excellent results were reported in 62.5%, good results in 18.8%, and fair results in 18.8% of the patients according to Odom's criteria. Visual analog scale score of the neck and extremities pain was significantly decreased after the surgery (P=0.014). The average preoperative and postoperative lordosis angles of the cervical spine were24.42°±13.84° and 32.91°±7.79°, and the difference was significant (P<0.01). Little loss of the angle was noted at final follow-up (32.91°±7.79° *VS* 29.30±7.88, P=0.51). Anterior intervertebral space height was significantly increased (P<0.001) after the surgery and a little declined at final follow-up (P=0.43). No intraoperative complication was noted in the patients and three patients got self-limiting dysphagia postoperatively, who recovered spontaneously. Conclusion: In patients undergoing combined postero-anterior cervical surgery, structural autograft harvested from the laminae provides an alternative to anterior iliac crest grafting.

Keywords: Autograft, laminae, anterior cervical discectomy and fusion, spinal fusion

Introduction

Anterior cervical discectomy with fusion (ACDF) is regarded as a standard surgical solution for cervical spondylosis with myelopathy, radiculopathy, disc herniation or other ventrally derived cervical diseases refractory to conservative management. To promote fusion and maintain foraminal height, interbody grafts are implanted [1-4]. Currently, the gold standard for fusion substrate is the anterior iliac crest (AIC), which was reported with a high fusion rate of 83-99% [5, 6]. However, morbidity from the graft harvest alone has been reported to be 10-39%, often twicethe rate of the ACDF procedure itself [7], such as persistent pain and numbness, donor site infection, osteomyelitis, fracture of iliac crest and/or pelvis [8, 9]. Three ideal graft characteristics for successful fusion are osteogenesis, osteoinduction and osteoconduction [10, 11]. These properties create new bone, stimulate osteoblastic differentia-

Figure 1. The measurement of the lordosis angle of the cervical spine. The angle is made by the two intersecting lines parallel to the posterior wall of the C2 and C7 vertebral bodies.

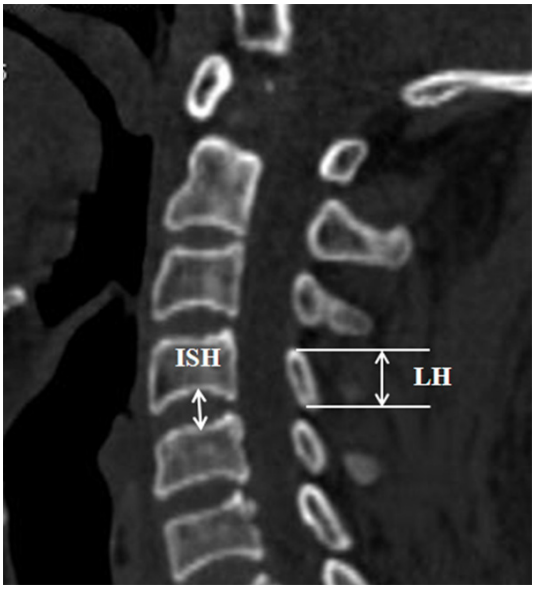

Figure 2. The measurement of the heights of the cervical lamina (LH) and the middle intervertebral space height (ISH).

tion of progenitor cells, and provide a scaffold for bone deposition, respectively. Only autograft possesses all of these features.

In patients with cervical spondylotic myelopathyand spinal stenosis, if the spinal cord was compressed both by the posterior hypertrophic ligamentum flavum and anterior herniated intervertebral disc, we usually performed combined postero-anterior cervical surgery. Posterior cervical laminectomy is effective to decompress the spinal cord. Whether the cervical laminae harvested from laminectomy can be used as a structural bone graft in ACDF in these patients? To our knowledge, few studies have reported about this. Hence, the present study was to describe the clinical and radiographic outcomes in patients undergoing combined postero-anterior cervical surgery using autologous structural lamiane as bone graft in ACDF.

Materials and methods

Patient selection

This study was approved by the medical ethics committee of the First Affiliated Hospital of Nanchang University. From January 2010 to January 2014, a total of twenty-two consecutive patient underwent combined postero-anterior cervical surgery with anterior plate fixation in our department were involved in the study. Written informed consent for participation in the study was obtained from all the participants. There were13 males and 9 females with a mean age of 49 years (range, 41-65 years). The operative levels consisted of C6-C7 (5 cases), C5-C6 (8 cases), C4-C5 (3 cases). The indications for surgery entailed failed conservative treatment for radiculopathy, myelopathy, or myeloradiculopathy stemming from a herniated nucleus pulposus and hypertrophic ligamentum flavum which needed single-level combined postero-anterior procedure. Patients with a history of previous cervical spine surgery, trauma, tumors, infections and more than two-level surgery were excluded from the study.

Preoperative measurement

All the patients took plain film radio graphs, computed tomography (CT) scan and magnetic resonance imaging of the cervical spine before surgery. The lordosis angle of the cervical spine was measured from the lateral radiographs, using the posterior tangent method of the odontoid process and the C7 vertebral body [12] (**Figure 1**). For the cervical segment that the surgery would be carried out, the heights of

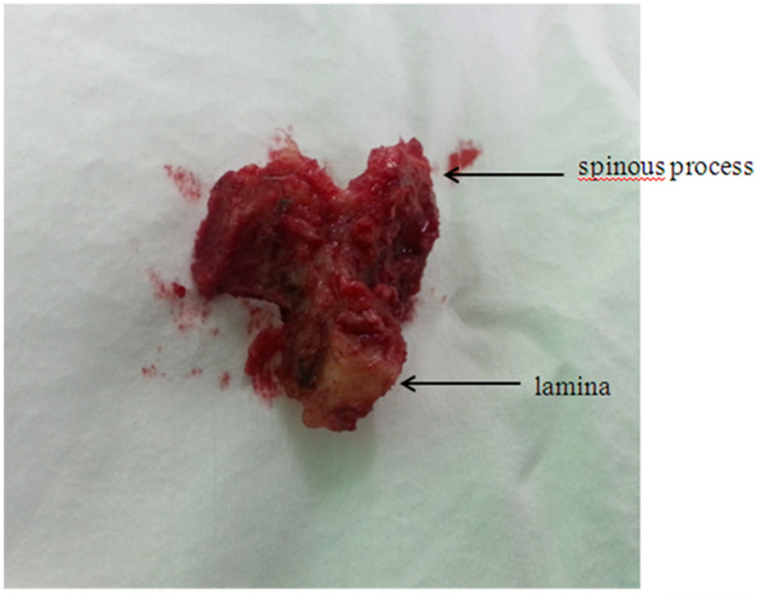

Figure 3. The structural cervical laminae with spinous process harvested from the posterior procedure.

the laminae (LH) and the middle intervertebral space heights (ISH) of the same level were measured on the sagittal CT planes. Space heights were measured by a perpendicular line from the middle of one cervical endplate to the endplate of the adjacent caudal vertebral body (**Figure 2**). Then, the heights of the laminae were compared with those of the middle intervertebral space.

Surgical procedure

All the operations were carried out by two senior spine surgeons (ZL Liu and Y Shu) from our department in a similar fashion. Firstly, the patients were placed in prone position with general anesthesia. A laminectomy was performed at the target segment. The high-speed burr was used to reset the bilateral laminae from the lateral masses for decompression. Care is taken to keep the structural laminae integrity and use it for bone graft (**Figure 3**). Secondly, the patients were placed in supine position. Following confirmation and exposure of the same vertebral level as the posterior procedure, a discectomy was performed. Once the decompression and endplate preparation was performed, the interbody space was opened with a retractor for bone graft. The structural lamina harvested from the laminectomy was prepared and the spinous process was reset from it. Then it was inserted into the intervertebral space with the posterior of it toward the canal. The spinous process chips and local bone harvested from osteophy tewere also inserted into the space in front of the lamina. Application of an anterior rigid cervical plate (Medtronic Sofamor Danek, USA) was performed in all patients. Hemostasis was achieved and the wound irrigated and closedover top a deep drain.

Postoperative management and follow-up

After surgery, all patients were placed in a soft collar for 4 to 6 weeks. Patients were then weaned off the brace and slowly allowed to resume controlled neck exercises and to return tonormal activities as tolerated.

Cervical radiographs and CT scans were obtained within 3 days following the surgery. Patient's follow-up occurred at 3 months, 6 months, 1 year and 2 years postoperatively and all findings were recorded by the surgeons. The X-ray and CT scans were taken at each follow up. Lateral radiographs of the cervical spine were used to observe changes in lordosis angulation. The sagittal planes of CT were harvested to measure the middle heights of the fused disc space. Fusion was established by the presence of a bony bridge incorporating the graft and adjacent endplates on sagittal CT planes and when neither instrumentation motion nor radiolucencieswere evident encompassing the screws.

Clinical outcomes were evaluated at the last follow-up using Odom's criteria [13] (**Table 1**). The preoperative and postoperative pain of the neck and extremities were assessed by visual analog scale (VAS) score. Perioperative and postperative complications about the surgery were recorded.

Statistical analysis

All analyses were performed using SPSS Version 13.0 (Statistical Software for Social sciences, Chicago, IL). All data were expressed as

Table 1. Odom's criteria

Rating	Odom's criteria
Excellent	No complaints to cervical disc disease; able to continue daily occupation without impairment
Good	Intermittent discomfort related to cervical disease but not significantly interfering with work
Fair	Subjective improvement in symptoms but physical activities limited
Poor	No improvement or worse compared with the condition before the operation

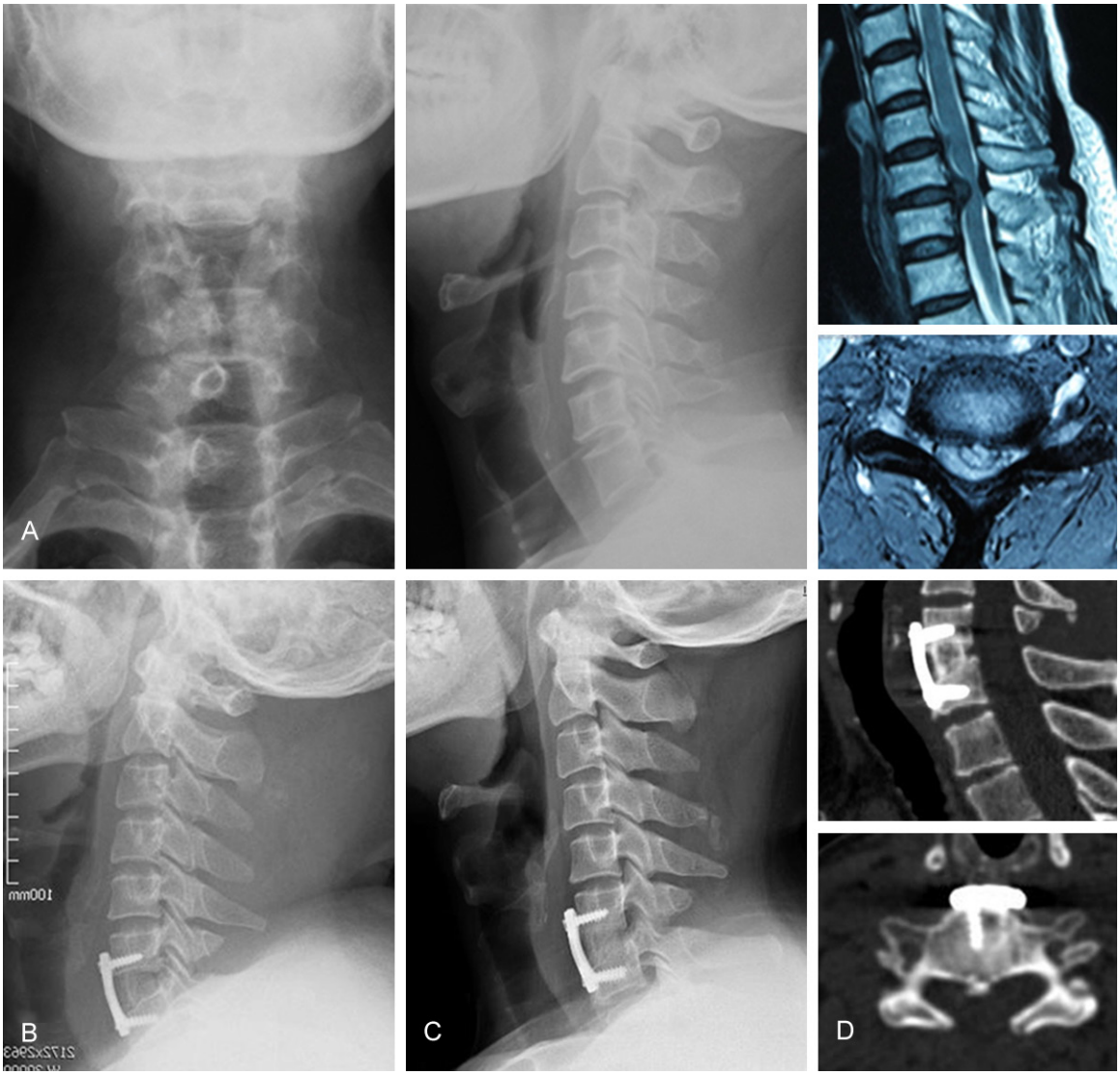

Figure 4. Illustrate example of a patient who underwent combined postero-anterior cervical surgery using autologous laminae as bone graft in one-level ACDF. A. Preoperative radiographs and MRI of a 45-year-old male patient with cervical spondylotic myelopathy. B. Immediate lateral view after the surgery. C and D. X ray and CT scan at 3 months postoperatively, showing stable bony fusion of C6/7.

mean values±standard deviation (SD). The data regarding the heights of the laminae and the middle intervertebral space before surgery were analyzed by *Student's t*-test. The statistical significance of lordosis angle, intervertebral space height and VAS score before and after surgery, and at the last follow-up were assessed using *paired Student's t*-test. Values of $P<0.05$ were considered to be significant difference.

Results

The mean operative time was 192±37 minutes with an average blood loss volume of 235±71 ml in the combined postero-anterior surgery. All patients were followed up and the average follow-up period was 17.5±3.1 months. All patients had immediate postoperative resolution of symptoms and radiographic evidence of solid fusion 3 months after the operation (**Figure 4**).

The average height of the lamina related to the surgical segment was 11.18±1.05 mm. The mean height of the middle intervertebral space of the same segment was 5.75±0.58 before surgery. The height of the lamina was 5.43 mm greater than that of the middle intervertebral space. Statistical significant difference was found between the heights of the laminae and the space (P<0.001). After the structural laminae implanting into the intervertebral space, the middle height of the space was immediately increased to 7.84±0.52 mm. The difference between the preoperative and postoperative intervertebral space heights was statistical significant (P<0.001). At the last follow-up, the middle height of the space was declined to 7.62±0.53 mm. However, there was no statistical difference between it and the immediately postoperative space height (P=0.43). The average preoperative and postoperative lordosis angles of the cervical spine were 24.42±13.84° and 32.91±7.79 and the difference was significant (P<0.01). Little loss of the angle was noted at the last follow-up (32.91±7.79 *VS* 29.30±7.88, P=0.51).

Postoperatively, excellent results were reported in 62.5% (10 cases), good results in 18.8% (3 cases), and fair results in 18.8% (3 cases) of the patients according to Odom's criteria. Visual analog scale score of the neck and extremities pain was significantly decreased-from 7.3 preoperatively to 2.4 postoperatively (P=0.014). No patients required prescription analgesics at the follow-up visit. No intraoperative complication was noted in the patients. Three patients (18.8%) presented self-limiting-dysphagia postoperatively, who recovered spontaneously before discharge. No other postoperativeor radiographic complications were noted in this series.

Discussion

Since the middle of 1950s, ACDF has been a widely accepted procedure for the treatment of degenerative disc disease and spondylosis of the cervical spine. Autograft bone as a fusion substrate in ACDF has been considered by most spine surgeons to be the gold standard. The an terior iliac crest is a popular site for obtaining autologous bone graft and has been used with significant success. However, in current practice, significant donor site morbidity about AIC has been reported [7-9]. Silber et al [14] reported that 26.1% of patients suffered persistent pain and 15.7% experienced numbness at the harvest site in one-level ACDF. Many other complications have been observed including chronic pain, infection, hematoma, pelvic fracture and/or instability, arterial injury, ureteral injury, reoperation and poor cosmesis [8, 9]. For these reasons, many surgeons choose to use allograft, bone graft substitutes, or even discectomy without grafting to avoid donor site morbidity [15].

Allograft bone is a commonly used alternative to autograft with a major advantage in avoidance of donor site morbidity. However, the risk of disease transmission [16], higher incidence of kyphotic deformity [17] and delayed union [17, 18] compared to autograft have been reported in many studies. An alternative substituteis the development of the synthetic cage. Cages immediately increase the space height, restore cervical lordosis, and decrease or eliminate the risk of graft fracture, or resorption [19, 20]. However, these benefits must be weighed against the significant increased cost of synthetics as well as potentially poor osteoinductivity and the limited contact area available for bony fusion. As we mentioned above, three ideal graft characteristics for successful fusion are osteogenesis, osteoinduction and osteoconduction [10, 11] and only autograft possesses all of these features. When the cervical spinal cord was compressed both by the posterior hypertrophic ligamentum flavum and anterior herniated intervertebral disc, we usually performed posterior laminectomy combined with ACDF for decompression. So, we used the laminae as bone graft in ACDF in these patients.

Previous study indicated that an intervertebral graft of 2 mm above the baseline thickness of the disc was most appropriate [21]. In the present study, the average height of the lamina was 11.18 mm, which was 5.43 mm greater than the height of the middle intervertebral space based on the measurement. So, in our opinion,

the height of the lamina is adequate for a single-level bone graft fusion. The middle height of the intervertebral space was significantly increased after the surgery and a little declined at the final follow-up, and the autologous graft got solid fusion at 3 months after the surgery in this study. The mean postoperative lordosis angle of the cervical spine was 32.91° and little loss was noted at the final follow-up. It was indicated that the autologous laminae could effective restore the height of the intervertebral space and the lordosis angle of the cervical spine according to our study.

The clinical outcomes were satisfactory with 81.3% of the patients winning excellent and good results at the last follow up in the present study. All the patients had immediate postoperative resolution of symptoms and radiographic evidence of solid fusion. Complications were encountered only in three patients with self-limiting dysphagia. No severe complications, such as nerve or spinal cord injury, cerebrospinal fluid leak or developing kyphosis of the spine were occurred. Thus, the results of the present study suggested that autologous laminate harvested from posterior laminectomy used as bone graft in ACDF was effective and safe.

Although this study demonstrates satisfactory results about using autologous cervical laminae as a structural bone graft in ACDF, some limitations are presented in it, including a small sample size and short term follow-up. In addition, the procedure described in the study is just indicated for one-level cervical spondylosis. Whether multiple level cervical spondylosis could be used by this technique is not clear and much work is needed to do.

Conclusion

Structural autograft harvested from the laminae provides an alternative to AIC grafting in patients undergoing single-level combined postero-anterior cervical surgery. It confers the advantages of autograft fusion without the complications associated with AIC graft harvesting.

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Disclosure of conflict of interest

None.

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