“Skip” corpectomy in the treatment of multilevel cervical spondylotic myelopathy and ossified posterior longitudinal ligament

Technical note

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Object. The authors reviewed the results of “skip” corpectomy in 29 patients with multilevel cervical spondylotic myelopathy (CSM) and ossified posterior longitudinal ligament (OPLL).

Methods. The skip corpectomy technique, which is characterized by C-4 and C-6 corpectomy, C-5 osteophysectomy, and C-5 vertebral body preservation, was used for decompression in patients with multilevel CSM and OPLL. All patients underwent spinal fixation using C4–5 and C5–6 grafts, and anterior cervical plates were fixated at C-3, C-5, and C-7.

Results. The mean preoperative Japanese Orthopaedic Association score increased from 13.44 ± 2.81 to 16.16 ± 2.19 after surgery (p < 0.05). The cervical lordosis improved from 1.16 ± 11.74° to 14.36 ± 7.85° after surgery (p < 0.05). The complications included temporary hoarseness in 3 cases, dysphagia in 1 case, C-5 nerve palsy in 1 case, and C-7 screw pullout in 1 case. The mean follow-up was 23.2 months. The final plain radiographs showed improved cervical lordosis and fusion in all cases.

Conclusions. The authors conclude that the preservation of the C-5 vertebral body provided an additional screw purchase and strengthened the construct. The results of the current study demonstrated effectiveness and safety of the skip corpectomy in patients with multilevel CSM and OPLL. (DOI: 10.3171/2009.7.SPINE08965)

KEY WORDS • skip corpectomy • multilevel cervical spondylotic myelopathy • ossified posterior longitudinal ligament

Abbreviations used in this paper: ACDF = anterior cervical decompression and fusion; CSM = cervical spondylotic myelopathy; JOA = Japanese Orthopaedic Association; OPLL = ossified posterior longitudinal ligament; VB = vertebral body.

The anterior cervical approach was first suggested by Dr. Leroy Abbott in 1952. This approach was used and subsequently described by Bailey and Badgley. In 1955, Robinson and Smith reported their anterior cervical fusion technique. During the late 1950s and 1960s, many approaches and techniques were reported to obtain a successful neural decompression and cervical spine arthrodesis. Evolution of new techniques, the introduction of microsurgery, and the use of new implants have contributed to this process, leading surgeons to use more aggressive techniques in patients with CSM and OPLL.

The existing literature indicates that the success rate usually is good for single- or 2-level cervical corpectomy, but not for multilevel corpectomy. The multilevel corpectomy is a challenging procedure. It is associated with a high complication rate (up to 70%), including strut graft fracture, graft pistoning, graft dislodgement, hardware failure, and pseudarthrosis.

In an early study, Zdeblick and Bohlmans reported a 33% construct failure rate, which required a reoperation in all cases. Similar failure rates were reported by other authors as well. Recent studies on biomechanical aspects of the multilevel corpectomy demonstrated the causes of failure. These findings have led surgeons to develop many anterior and/or posterior hybrid decompression and fixation techniques in such cases.

The skip corpectomy technique is one of the novel techniques used to obtain the optimum decompression and fixation in patients with multilevel CSM and OPLL.
The procedure consists of the following: C-4 and C-6 corpectomy; C-5 vertebral preservation; C-3–5 and C5–7 grafting; and instrumentation of C-3, C-5, and C-7 vertebrae. Theoretically, the skip corpectomy procedure is expected to decrease the rate of graft/hardware–related complications.

The aim of this study is tripartite: to describe the skip corpectomy technique in detail, to report the results obtained in patients with CSM and OPLL, and to review the existing clinical and biomechanical data.

Methods

The series consisted of 29 patients with multilevel CSM or OPLL. The skip corpectomy technique was applied on the basis of clinical and radiological evidence of spinal cord compression extending from C3–4 to C6–7. Clinical assessment was performed using the JOA scoring system as modified by Benzé et al.4 The radiological assessment was performed using plain anteroposterior, lateral, and flexion-extension cervical spine radiographs; cervical spine MR imaging; and cervical spine CT scanning. The plain radiographs were used to measure the cervical lordosis (C2–7), and to detect abnormal motion. The indications for skip corpectomy included spinal cord compression caused by multilevel CSM and OPLL, extending from C3–4 to C6–7 (Fig. 1A). The patients with continuous OPLL requiring C-5 corpectomy and the ones who required a posterior decompression were excluded.

The Skip Corpectomy and Instrumentation Procedure

The skip corpectomy technique can be defined as C-4 and C-6 corpectomy, C-5 osteophysectomy, and decompression of posterior-superior and posterior-inferior aspects of the C-5 vertebra (Fig. 1B and C). Preservation of the C-5 VB and the use of this vertebra for screw fixation were the most important aspects of this technique. Reconstruction was performed using iliac crest autograft in 15 cases, and using fibular allograft in 14 cases. After placement of the C3–5 and C5–7 bone grafts, a fixed rigid ventral cervical spine plate was placed (Fig. 1D). The plate was contoured in lordosis. The intervening VB that was left after C-4 and C-6 decompression (that is, the C-5 VB) served as an intermediate point of construct fixation. The plate was first secured at the rostral and caudal ends (the C-3 and C-7 VBs). Next, screws were placed into the intervening (C-5) VB. As the C-5 VB screws were tightened, the spine was “brought to the cervical plate” (Fig. 1E).

The patients were mobilized the next day. A Philadelphia cervical collar was used for 2 months. The first control examination was performed 2 months after the surgery. For the purposes of this study, all the patients were called in for follow-up appointments and were then examined neurologically and radiologically. The mean follow-up duration was 22.3 months (range 16–86 months). Statistical analysis was performed using the Student t-test.

Results

There were 29 patients with osteophytes and OPLL compressing the spinal cord between C-3 and C-7. The main symptoms included neurological deficit due to myelopathy and arm pain due to radiculopathy. The mean cervical lordosis was measured as $1.16 \pm 11.74^\circ$. The mean preoperative JOA score was 13.44 ± 2.81.

A full decompression resulting in neurological improvement was observed in all cases. The only patient with neurological deterioration had a postoperative C-5 nerve root palsy. The mean postoperative JOA score was 16.16 ± 2.19. There was a significant difference between the pre- and postoperative JOA scores ($p < 0.05$).

The cervical spine was found to be straightened in 18 cases, lordotic in 4 cases, and kyphotic in 7 cases before the surgery. Postoperative evaluation of the cervical radiographs showed a straightened cervical spine in 3 cases and a lordotic cervical spine in 26 cases. The postoperative cervical lordosis improved to $14.36 \pm 7.85^\circ$ ($p < 0.05$), and $12.92 \pm 6.17^\circ$ ($p < 0.05$) at immediate and final postoperative evaluation, respectively. Fusion was detected in all cases, regardless of the graft type. Figures 2 and 3 show the neuroimaging findings in 2 patients who underwent skip corpectomy.

Based on chart reviews, procedure-related complications included temporary hoarseness in 3 cases and dysphagia in 1 case. A graft/hardware–related complication was observed in 1 case, in which a revision surgery had to be done due to a caudal screw pullout. The other complication was neurological (a C-5 nerve root palsy).

Discussion

This study demonstrated that the skip corpectomy increased bone purchase and served to strengthen the construct, and in turn decreased the rate of construct failure after multilevel decompression.

Cervical corpectomy is commonly performed in the presence of multilevel cervical degenerative disorders, and typically requires the use of long anterior strut grafts. This surgery is associated with good results in terms of neurological recovery. However, there are many limitations, risks, and complications that may cause the failure of the reconstructed cervical spine. Whereas ACDF procedures at 1 or 2 cervical spine levels have predictable results, procedures involving $\geq 3$ levels are associated with increased morbidity. Vaccaro et al.31 demonstrated high rates of early construct failure in multilevel fusions: 9% for 2-level corpectomy and 50% for 3-level corpectomy. A similar high rate of construct failure after multilevel corpectomy was reported by others as well.9,10,12,14,18,24,31,33,37 The reported high rate of failure indicates that reconstruction of a multilevel corpectomy defect in the cervical spine remains a challenge.

The evidence of failure of long constructs has also been investigated in biomechanical studies. Results of cadaveric biomechanical studies have shown that the longer plate generates greater motions at the fusion sites under physiological loads because of its longer lever arm,13 and that the stabilizing potential indices significantly decrease after fatigue for the 3-level corpectomy but not for the 1-level procedure.9,10,13,19 This explains the lower rate of construct failure in 1-level cervical corpectomies.
Cervical corpectomy results in a posterior shift of the center of rotation, because the anterior aspect of the spine is cut. Addition of an anterior cervical plate shifts the center of rotation to the anterior and changes the loading pattern. In other words, whereas the stand-alone strut graft is loaded in flexion and unloaded in extension, the addition of a plate completely reverses the loading pattern. The outcome is reversal of the loading pattern in anterior-plated long-strut graft so that loading of the graft does not occur under flexion moments, and excessive compression of the graft occurs under extension loads, resulting in the graft pistoning into the caudal vertebral endplate and subsequent plate kicking. It is of note that the load experienced in extension in anteriorly instrumented multilevel corpectomized cervical spine exceeds that seen with similar degrees of flexion of the noninstrumented,
strut-grafted spine. Application of a posterior plate, as an alternative, protects the graft from the excessive loads under extension.

Based on clinical experiences and biomechanical facts, many alternative techniques have been developed to avoid graft/plate–related problems in cases of multilevel corpectomy. Based on evidence of the high stress in the lower end of the construct, the use of a buttress (junctional) plate alone was recommended. However, Riew et al. and Macdonald et al. reported a high rate of complication after the use of a buttress plate alone in multilevel corpectomy. They recommended that the buttress plate be supplemented with posterior fixation. Others focused on 360° fixation accomplished using long plates. However, the 360° procedure is a lengthy, sometimes staged procedure. Different combinations of multilevel ACDF with or without corpectomies are other alternatives. As alternative anterior approaches to 3-level corpectomy, Rhee and Riew proposed the following techniques: 1) multilevel ACDF; 2) single corpectomy combined with additional ACDFs; and 3) 2 single-level corpectomies separated by an intact intervening vertebra. Singh et al. compared the biomechanical aspects of different hybrid discectomy and corpectomy models, and reported that the increased rigidity afforded by segmental fixation may significantly decrease the likelihood of plate dislodgement in patients with anterior instrumentation alone. The addition of intermediate points of fixation also provides a better translational stability.

Our experience revealed that the skip corpectomy is indicated and is applicable in compressions extending from C3–4 to C6–7, particularly when the areas of compression at the C-5 level are confined to the adjacent disc spaces. This is so because skip corpectomy allows optimal decompression of C3–4, C4–5, C5–6, and C6–7 intervertebral disc levels, and C-4 and C-6 VB levels. However, the limited work angle does not allow for optimal decompression of the posterior aspect of the C-5 VB, as seen in continuing OPLL cases. It is of note that the surgeon may change strategy during the surgical procedure and can add a C-5 corpectomy if he or she is not satisfied with the decompression behind the C-5 VB. Such an additional
“Skip” corpectomy in patients with CSM

C-5 corpectomy means a 3-level corpectomy and should be combined with a posterior stabilization procedure. The skip corpectomy technique achieves 4 healing surfaces, which are less than in the equivalent number of multilevel ACDFs (8 surfaces), while avoiding problems associated with long-strut grafts. The fixation is obtained at the top, bottom, and middle of the constructs. This technique was suggested in recent years.1,2,21 Ashkenazi et al.2 reported their results after skip corpectomy, which they called hybrid decompression, in 13 cases. They reported fusion in all cases and found mechanical failure of the construct in only 1 case (7.7%). Using this technique, Agbi and Paquette1 reported a successful outcome in 4 cases. The results of the current series are in line with those reported by Ashkenazi et al.

This technique is biomechanically superior to the one in which anterior plating is used alone for 3-level corpectomy. In a recent biomechanical study, Yüksel et al. (unpublished data, 2006) compared the skip corpectomy with the standard 3-level corpectomy. They reported that the skip corpectomy allowed a slightly smaller range of motion during lateral bending and axial rotation than standard 3-level corpectomy. However, there were still high pullout forces at superior and inferior vertebrae screws during axial rotation. They concluded that skip corpectomy provided better stability during lateral bending and axial rotation movements of the neck, and because of high pullout forces seen in the superior and inferior screws during the axial rotation, the patient’s axial rotation should be restrained. With the aid of a Philadelphia cervical collar, the axial movements were restrained in our series, and only 1 instrument-related problem was experienced.

The size of the grafts is another advantage of the skip corpectomy. Whereas a 1- or 2-level corpectomy can be reconstructed using iliac crest graft, a 3-level procedure requires a long fibular graft. Skip corpectomy allows the use of 2 short iliac crests or fibular grafts.

The technique also has the advantage of adding stability to the construct without requiring an additional surgical approach. Although the addition of a second approach provides the greatest stability for the construct, it comes with the expense of increased operating time and the potential for higher surgical morbidity.

Conclusions

The skip corpectomy allows for effective decompression in most patients with CSM and OPLL extending from C3–4 to C6–7. This study underscores the importance of fixation of intervening VBs, which contribute to a more stable construct with a lower risk of failure.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Manuscript submitted January 10, 2009.
Accepted July 30, 2009.

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