Detailed Study of Graft Sinking and Worsening of the Fused Segment Angle in Patients With Cervical Disease Treated With the Williams-Isu Method

Kyongsong Kim,1 Toyohiko Isu,2 Atsushi Sugawara,3 Daijiro Morimoto,2 Ryoji Matsumoto,2 Masanori Isobe,2 Masahiro Mishina,1 Shiro Kobayashi,1 and Akira Teramoto4

1Department of Neurosurgery, Chiba Hokuso Hospital, Nippon Medical School, Inzai, Chiba; 2Department of Neurosurgery, Kushiro Rosai Hospital, Kushiro, Hokkaido; 3Department of Neurosurgery, Iwate Medical University, Morioka, Iwate; 4Department of Neurosurgery, Nippon Medical School, Tokyo

Abstract

Detailed changes involved in the worsening of the fused segment angle were assessed after application of the Williams-Isu method using autologous bone grafts from cervical vertebral bodies in 30 patients with cervical disease treated by single-level anterior fusion. The mean follow-up duration was 25.4 months. The fused segment angle was measured on serial radiographs. Whole cervical spine alignment changed from 12.8° to 9.9°. The alignment of the fused segment worsened by mean 3.3°. To elucidate the characteristics of worsening of the fused segment, the 30 patients were divided into 2 groups: Group I (n = 20) without and Group II (n = 10) with postoperative worsening of the fused segment. The loss in the fused segment angle was significantly greater in Group II (8.0°) than Group I (0.9°). Preoperative range of motion and disc height were significantly greater in Group II than Group I. Worsening of the fused segment angle occurred within 1 month in Group I, whereas stabilization was observed after 3 months in Group II. Graft subsidence was primarily posterior and inferior. Our results indicate that the preoperative range of motion and disc height of the fused segment must be considered to prevent worsening in that segment after anterior fusion. Such detailed information is useful for the selection and postoperative monitoring of patients eligible for treatment by the Williams-Isu method.

Key words: alignment, anterior fusion, cervical spine, fused segment, Williams-Isu method

Introduction

Anterior fusion of the cervical spine is a widely-used treatment for patients with cervical canal disease causing nerve root or cord compression. Anterior fusion for cervical canal disease uses autologous bone grafts from cervical vertebral bodies, a sandwich method that introduces a hydroxyl-apatite graft between the bone grafts, and bioabsorptive screws to prevent graft extrusion (Williams-Isu method).7,8,11–14) The advantages of this method are wide operative field, excellent graft fusion, absence of problems related to the iliac donor site, and direct observation of the nerve root. The risk of graft extrusion is low, so the period of postoperative collar fixation can be shortened. The sandwich method retains the fused segment angle and height.13,14,22)

On the other hand, the procedure requires special equipment and does not permit alignment correction.7,8,11–14) Cervical spine alignment manifests kyphotic changes at the fused segment after anterior fusion in nearly 50% of patients, and kyphotic changes involving the whole spine curvature are observed in 35%.19) We previously reported some worsening of the fused segment angle after the Williams-Isu method,12–14) which does not appear to affect the short or mid-term clinical outcome, but this problem must be solved.12–14,19)

The present study investigated the detailed temporal changes involved in the postoperative worsening of the fused segment angle in patients treated by the Williams-Isu method.
Materials and Methods

Thirty patients with cervical disease, 4 women and 26 men aged from 43 to 76 years (mean 60.0 ± 10.4 years), were treated by single-level anterior fusion using a combined Williams-Isu-sandwich method. To obtain strong autologous bone grafts, patients with advanced osteoporosis, heavy smokers, and long-term hemodialysis patients were excluded from this study. Follow-up period ranged from 20 to 36 months (mean 25.4 ± 4.9 months). All 30 patients were treated with ceramic material placed between the autologous bone grafts obtained from cervical vertebral bodies (Williams-Isu-sandwich method). The treated level was C4-C5 in 8 patients, C5-C6 in 20, and C6-C7 in 2. The patients were allowed to leave their bed wearing a soft collar within 3–4 hours after the operation. A neck collar was worn for a few days after surgery. All patients experienced symptom improvement without deterioration in the course of the follow-up period. No screw or graft extrusions, and no surgery-related infections or other complications occurred.

A conventional anterior cervical approach from the right side was performed for microscopic discectomy. Two blocks of bone tissue (width 15 mm, depth 15 mm) were removed from the cervical vertebral bodies above and below the intervertebral space with a spinal saw (Williams microsurgical saw; RCW Spine Co., Inc., San Luis Obispo, California, USA). The posterior parts of the vertebral bodies were then removed and the spinal cord and roots decompressed by removing the posterior osteophytes with an air drill and an ultrasonic bone curette (SONOPET). Anterior fusion of the 2 bone tissue blocks was achieved by placing the cancellous and cortical bone parts top to bottom, ceramic (Apaceram; PENTAX Co., Ltd.) was introduced between the bone tissue blocks, followed by suturing with three 3-0 interrupted Dexon sutures (Covidien Ltd., Mansfield, Massachusetts, USA) to form a single graft. To prevent graft extrusion and increase fixation, bioabsorptive screws (SUPER-FIXSORB 30; Takiron Co., Ltd., Osaka) were inserted into the 4 corners of the bone graft. The graft was fixed with a tap on a part of the graft. Graft extrusion can be prevented with screws with a head.

Lateral cervical spine radiographs were taken with the patient in the sitting position with the neck flexed, neutral, and extended. The angle formed by the line of the inferior rim of the C2–C7 vertebral bodies in the neutral position was compared on lateral radiographs of the cervical spine obtained before and after the operation (Fig. 1). The curvature of the fused segment of the cervical spine was also measured. The fused segment height, the height between the cranial endplate of the upper vertebral body and the caudal endplate of the lower vertebral body, corrected for the anterior-to-posterior length of the lower vertebral body, was also compared (Fig. 1). The disc height of the fused segment was also measured between the caudal endplate of the upper and the cranial endplate of the lower vertebral body. The post- and preoperative segment heights were expressed as a percentage for comparison. Mobility of the intervertebral disc was measured using the sliding method.

The position of the graft was also measured to evaluate graft sinking. The upper and lower vertical lengths were measured from the cranial or caudal
Table 1 Comparison of the fused segment between Groups I and II

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
<th>Statistical analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of cases</td>
<td>20</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Loss of angle (degree)</td>
<td>0.9 ± 0.9</td>
<td>8.0 ± 2.2</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Preoperative ROM (degree)</td>
<td>4.3 ± 3.7</td>
<td>11.2 ± 5.7</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Preoperative ROM to flexion (degree)</td>
<td>2.3± 2.4</td>
<td>9.2 ± 5.7</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Disc height (mm)</td>
<td>4.2 ± 1.0</td>
<td>5.0 ± 1.8</td>
<td>p &lt; 0.05</td>
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</table>

Values are mean ± standard deviation. ROM: range of motion.

Anterior fusion was confirmed in all patients. The whole cervical spine alignment changed from 12.8 ± 8.8° to 9.9 ± 6.7°. The alignment of the fused segment changed from 2.7 ± 3.9° to −0.6 ± 3.7°, with mean worsening of the fused segment angle of 3.3 ± 3.7°. The preoperative disc height of the fused segment was 4.5 ± 1.3 mm. Graft subsidence occurred in all patients. The upper and lower lengths from the endplate to the graft were reduced to 90% and 85%, respectively. The upper anterior and posterior, and lower anterior and posterior lengths from the graft to the fused segment edge were also reduced to 99%, 97%, 97%, and 91%, respectively. Graft subsidence was primarily inferior and posterior.

The 30 patients were divided into Group I without (n = 20) and Group II with worsening of the segmental angle (n = 10) (Table 1). Change in the fused angle ranged from 0–2° in Group I and from 5–11° in Group II. The reduction in the fused segment angle was 0.9 ± 0.9° and 8.0 ± 2.2° in Groups I and II, respectively (p < 0.05). The preoperative range of motion at the fused segment was 4.3 ± 3.7° in Group I and 11.2 ± 5.7° in Group II (p < 0.05). Preoperative range of motion to flexion at the fused segment was 2.3 ± 2.4° in Group I and 9.2 ± 5.7° in Group II (p < 0.05). The disc height of the fused segment was 4.2 ± 1.0 mm in Group I and 5.0 ± 1.8 mm in Group II (p < 0.05).

The upper and lower lengths from the endplate to the graft were reduced to 92% and 88% in Group I, and to 87% and 79% in Group II, respectively. The upper anterior and posterior, and lower anterior and posterior lengths from the graft to the fused segment edge were also reduced to 98%, 98%, 95%, and 94% in Group I, but were 102%, 93%, 101%, and 87% in Group II, respectively. Graft subsidence was primarily inferior and posterior, and was most pronounced in Group II.

The fused segment angle gradually worsened after surgery in both groups but became almost stable after 2 months (Fig. 3 upper). Group I showed this effect within 2 months from the operation, but became almost stable after 14 days (Fig. 3 lower). Group II
Fig. 4  Preoperative lateral radiographs, neutral (A), flexion (B), and extension (C), and postoperative neutral lateral radiograms obtained the day after (D) and 20 months after surgery (E) of a 75-year-old male without worsening of the fused segment (Group I). The preoperative range of motion at the fused segment was 3°. The fused segment exhibited no postoperative worsening. The upper and lower lengths from the endplate to the graft were reduced to 94% and 98%, respectively. The upper anterior and posterior, and the lower anterior and posterior lengths from the graft to the fused segment edge were also reduced to 94%, 106%, 95%, and 89%, respectively.

Fig. 5  Preoperative lateral radiographs, neutral (A), flexion (B), and extension (C), and postoperative neutral lateral radiograms obtained the day after (D) and 24 months after surgery (E) of a 76-year-old male with worsening of the fused segment (Group II). The preoperative range of motion at the fused segment was 10°. Postoperatively, the fused segment was worsened by 9°. The upper and lower lengths from the endplate to the graft were reduced to 86% and 94%, respectively. The upper anterior and posterior, and the lower anterior and posterior lengths from the graft to the fused segment edge were also reduced to 106%, 89%, 102%, and 95%, respectively.

Discussion

The present detailed study of the serial changes in the fused segment divided the patients into Group I with less worsening of the fused segment angle than the overall mean and Group II with greater worsening than the mean (Figs. 4 and 5). Group I showed almost no difference in the pre- and postoperative fused segment angle (0.9°), whereas Group II showed a difference of 8.0°. Worsening in the fused segment angle occurred within 2 months in Group I, but became almost stable after 14 days. Worsening of the fused segment angle also occurred after 2 months in Group II, and became stable after 3 months. Graft subsidence occurred primarily in the inferior and posterior direction, and was greater in Group II. Our findings indicate that patients to be treated by the Williams-Isu method must be selected carefully.

Correction of the height and angle of the fused segment is difficult after anterior fusion without special instrumentation. Reported risk factors for subsidence include smoking, treatment of lower level discs, multilevel fusion, removal of a cortical end plate, presence of malalignment such as kyphosis or straight spine, and hypermobility at the operated disc level, but no statistically significant risk factor has been established. Previously we reported that worsening of the postoperative fused segment angle might be affected by the preoperative alignment of the cervical spine and the range of motion of the fused segment, indicating the importance of posterior static stabilizers. The posterior ligamentum and musculature are the primary static stabilizers of the cervical spine, by acting as im-

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portant posterior tension bands that stabilize the cervical spine in lordosis. Laminctomy after anterior fusion resulted in increased rate of kyphosis, indicating that the posterior tension band provided by the nuchal musculature is important for retaining alignment after anterior fusion. Therefore, the nuchal musculature must be protected because patients with preoperative kyphotic flexion posture are at increased risk for postoperative kyphosis. Among our patients, the preoperative range of motion and the disc height of the fused segment were significantly greater in Group II than Group I. In addition, the preoperative range of motion to flexion of the fused segment was also significantly greater in Group II. These results indicate again that the preoperative range of motion and the disc height of the fused segment must be considered.

The fused segment angle was stable in the early postoperative phase in Group I, but worsened after 2 months in Group II. The grafted bone was partly absorbed before fixation, and the angle of the fused segment deteriorated during this process. Subsidence tended to occur within 3 months despite the placement of a titanium cage, demonstrating that the loss in the fused segment angle is due not only to bone absorption during remodeling but also the above-cited risk factors. Although the precise etiology underlying the observed deterioration of the fused segment angle remains unclear, our current observations provide some indicators. The fused segment angle worsened within 14 days and was stable after 1 month in Group I. On the other hand, deterioration continued between day 14 and the 3rd month in Group II. If the fused segment angle deteriorated from 14 to 30 days on radiographs, neck movement should be restricted in patients treated by anterior fusion using the Williams-Isu method. In our study, graft subsidence was primarily in the inferior and posterior direction, and was marked in Group II. Loss in the angle of the fused segment may be possible to reduce by retaining the cortical endplates of the vertebral bodies adjacent to the corpectomy levels. Although our procedure requires removal of the endplates, retention may have affected the degree of subsidence in our patients. As the anterior part of the graft is located on the anterior cortical edge of the vertebral bone, the degree of anterior subsidence can be expected to be small.

Our study has some limitations. We did not evaluate the bone mineral concentration in our study population. Differences in the bone mineral status may have an effect on the deterioration of the fused segment, although we excluded heavy smokers, patients with advanced osteoporosis, and long-term hemodialysis patients from our study. The present study was retrospective, but the information yielded is useful for the selection of patients eligible for treatment using the combined Williams-Isu-sandwich method and during the postoperative follow-up period.

References

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Fused Segment After Williams-Isu Method


Address reprint requests to: Kyongsong Kim, MD, Department of Neurosurgery, Chiba Hokuso Hospital, Nippon Medical School, 1715 Kamagari, Inzai, Chiba 270–1694, Japan.
e-mail: kyongsong@nms.ac.jp