

Efficacy of Postoperative Radiograph for Evaluating the Prevertebral Soft Tissue Swelling after Anterior Cervical Discectomy and Fusion

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Background: After surgery for degenerative spinal disease by the anterior approach, the degree of soft tissue swelling can be assessed simply using plain radiographs. However, there are little studies according to the surgical methods or extent of surgery, and no study had addressed the clinical meaning of swelling determined by plain radiography. The purpose of this study was to evaluate the clinical significance of prevertebral soft tissue swelling (PSTS) after anterior cervical fusion with plate fixation for the treatment of degenerative cervical spinal disorders.

Methods: One hundred and thirty-five patients that underwent anterior cervical fusion with plate augmentation for degenerative cervical spondylosis were included in this study. PSTS differences were analyzed with respect to numbers of fusion segments and location of fusion. Cases were divided into two groups based on the amount of PSTS, and incidences of dyspnea, dysphagia, dysphonia were evaluated.

Results: PSTS increments were significantly greater in patients that had undergone multi-level or high-level fusion. Complications of dyspnea, dysphagia and dysphonia were found more frequently in patients with marked PSTS group.

Conclusions: Increments of PSTS after anterior cervical fusion for degenerative spinal disorders are greater and incidences of complications are higher in patients that undergo multi-level or high-level fusion. Thus, measurement of PSTS using consecutive cervical lateral radiographs after anterior cervical surgery is clinically meaningful procedure.

Keywords: Cervical spine, Prevertebral soft tissue swelling, Anterior cervical discectomy and fusion

Cervical spine surgery by the anterior approach is currently used to treat diverse diseases of the cervical spine. However, many complications can occur. In particular, postoperative airway obstruction is a potentially life-threatening complication.

Cervical spine prevertebral soft tissue swelling (PSTS) has been observed on plain radiographs of the lateral cervical spine, and used as an indirect indicator for

identifying degrees of damage by trauma or pathologic conditions, such as a retropharyngeal abscess.¹⁻⁶⁾ After surgery for degenerative spinal diseases by the anterior approach, the degree of soft tissue swelling were assessed simply by using plain radiographs. However, few studies have been conducted according to the surgical methods or extent of surgery, and no study has addressed the clinical meaning of swelling determined by plain radiography.

In the present study, we evaluated soft tissue swelling observed in plain lateral radiographs after anterior cervical fusion surgery to identify the relationships between PSTS and the extent and location of surgery, and to explore correlations between PSTS and complications related to soft tissue damage.

Received August 4, 2011; Accepted November 1, 2011

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Clinics in Orthopedic Surgery • pISSN 2005-291X eISSN 2005-4408

METHODS

Materials

One hundred and seventy-six patients underwent anterior interbody fusion with cage and plate augmentation due to degenerative cervical disease between April 2004 and June 2007 at our institution. The exclusion criteria applied were: revision surgery, the performance of anterior and posterior combined fusion, and preoperative dysphasia or dysphonia. We enrolled 135 patients, 78 males and 57 females with a mean age of 54.8 years (range, 30 to 86 years). The mean follow-up period was 38.7 months (range, 25 to 84 months). In 48 cases, fusion was performed on a single segment, in 67 cases on two segments, and in 20 cases on three segments. In 86 cases, fusion was conducted below the C5, and in 49 cases above the C5 included.

Operation Method

Surgery was performed under general anesthesia in all patients. First, cancellous bone for bone grafting was harvested percutaneously using a trocar (diameter 7 mm; AO Synthes, Bettlach, Switzerland) via a 1 cm mini-incision placed at least 2 cm from the lateral side of the anterior superior iliac spine. A standard Smith-Robinson method was used to expose the cervical spine.⁷⁾ The cervical spine was approached from the left side unless the patient had undergone a prior approach from the left side. After complete decompression by removing osteophytes and remnant disc materials, endplate cartilage was removed with a high-speed burr and a curette until bleeding occurred. Lateral radiographs of the cervical spine were checked to determine cage size, plate lordosis, and screw insertion angles. Finally, a polyetheretherketone cage filled with cancellous bone graft was inserted into the intervertebral space and anterior plating was performed. Solis cages (Stryker, Kalamazoo, MI, USA) were used throughout. In addition, the Maxima Anterior Cervical Plate System (U&I Corporation, Uijeongbu, Korea) or the cervical spine locking plate (CSLP) system (Synthes Inc., Paoli, PA, USA) was used for anterior stabilization. Closed suction drain was routinely used and the drain was removed approximately 48 hours after surgery. After operations, a Philadelphia cervical orthosis was applied for 4 weeks and a soft collar was recommended for an additional 2 weeks.

Physical examinations and radiological examinations, including plain radiography and MRI, were performed preoperatively in all patients. Plain radiography (anterior-posterior [AP], lateral, and flexion/extension lateral views) was repeated at 6 weeks and at 3, 6, 9, 12, and 18 months postoperatively, and then annually.

Methods

Measurement of PSTS

In all cases, plain radiographs of the lateral cervical spine were taken before surgery, immediately after surgery, and daily until 5 days after surgery. Plain radiographs of the lateral cervical spine were taken with patients standing with their chins facing forward and their heads placed naturally without tension. Films were centered at the shoulder and the radiation was aligned with the 5th cervical spine and located around 1.8 m from patients. In plain radiographs of lateral cervical spines, the AP diameters of the PSTS from the 2nd cervical spine (C2) to the 7th cervical spine (C7) were determined by measuring distances from the inferior margin of each vertebral body perpendicularly to the point where the air shadow of the airway began. In the cases of bony spur formation on the vertebra, we measured the distance from the non-spurred anterior margin of the vertebral body. The shortest lengths were used as a value. In the areas where the plates were fixed, the distances from the anterior margins of plates to a shadow were measured (Fig. 1). PSTS measurements from day 0 (the day of surgery) to day 5 after surgery were documented to monitor patterns of change. The values of soft tissue swelling change from the preoperative state to the days after the operation were used for analysis. The mean value of PSTS before surgery was 5.47 mm on C2, 5.16 mm on C3, 7.84 mm on C4, 15.36 mm on C5, 15.03 mm on C6, and 12.64 mm on C7. Two blinded observers independently measured the segment dimensions twice; average values



Fig. 1. Measurement method of prevertebral soft tissue swelling. The prevertebral soft tissue was measured between the anterior surface of each vertebral body and the air shadow of the airway.

were used in the analysis. To verify the reliabilities of measured values, intra- and inter observer consistencies were checked using interclass correlation coefficient (ICC). ICC (Cronbach's α) showed excellent correlation in intraobserver (0.81), interobserver (0.70) correlation.

Analysis according to the number and location of fusion segments

Correlations between operation time, number of fusion segments, and location of fusion areas were analyzed, based on degrees of soft tissue swelling at the C3 on day 2 after surgery, where changes in soft tissue swelling were the largest. Cases were divided into one level fusion group and two or more level fusion group for comparison purposes. Cases were also divided into two groups of above and below the C5. When the case included the level of C4-5, we regarded this case as above the C5 level group. 86 cases with a fusion range below the C5 and 49 cases with a fusion range, including the 3rd and 4th cervical spines above the C5 level, were compared.

Analysis according to PSTS and postoperative complications

Based on a mean soft tissue swelling change of 7.3 mm at C3 area on day 2 after surgery, where changes in soft tissue swelling were at their largest, subjects were divided into 71 cases with a swelling < 7.3 mm (group A) and 64 cases with a swelling > 7.3 mm (group B). Dyspnea was regarded to have occurred in cases where patients reported subjective symptoms during hospitalization after surgery or treatment, such as oxygen administration or bed lifting that was necessary because of the symptoms. Dysphagia was defined as being present when difficulties in swallowing liquid or solids persisted for at least three months after surgery.⁸⁾ Dysphonia was defined as the presence of persisting changes in phonation at least three months after surgery.⁹⁾

The degrees of longitudinal changes of soft tissue swelling were analyzed using a paired sample *t*-test. Differences in degrees of swelling relative to the number of fusion and the location of fusion were tested using ANOVA and an independent sample *t*-test. Pearson's correlation was used to analyze the correlation between the time when dyspnea occurred and the time of soft tissue swelling. Development of dyspnea, dysphagia, and dysphonia between the groups was analyzed using the chi-square test. SPSS ver. 12.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis, and significance was accepted for *p*-values of < 0.05.

RESULTS

Postoperative Progress of Soft Tissue Swelling

Based on PSTS measured at each segment after surgery, for upper spines (C2, C3, C4), there was significantly more soft tissue swelling during the measurement period compared with the preoperative state ($p < 0.01$). The degree of swelling was highest on days 2 and 3 after surgery, and then showed a gradually decreasing tendency. For lower cervical spines (C5, C6, C7), soft tissue swellings did not increase significantly immediately after surgery, but showed significant increases from day 2 ($p < 0.001$). Unlike upper cervical spines, soft tissue swelling persisted during the measurement period (Fig. 2). Before surgery, the PSTS of C3 was 4.8 mm on average and on day 2, it was 12.1 mm average when it was at its largest. Thus, the average maximum increase due to swelling was 7.3 mm.

Analysis according to the Number and Location of Fusion Segments

Degrees of PSTS increases were not found to be significantly correlated with operation time ($p = 0.33$), but significant differences were observed between numbers of operated segments and PSTS increases as 6.38 mm in one level fusion group and 8.2 mm in two or more levels fusion group ($p = 0.03$). Regarding fusion areas, a mean PSTS increase of 5.64 mm was found in cases with areas below C5 and of 9.08 mm in cases above C5 ($p < 0.01$).

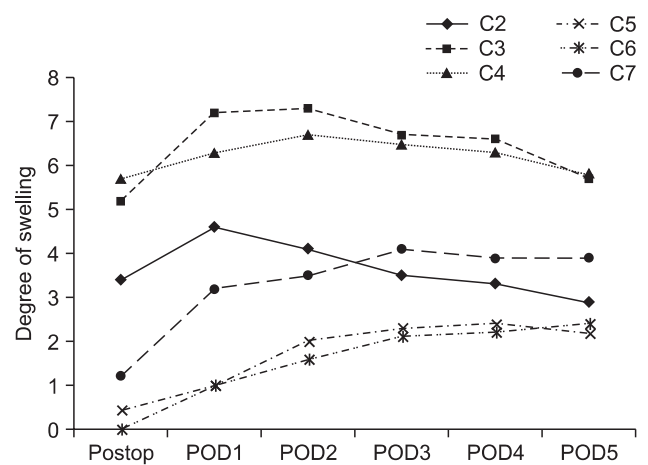


Fig. 2. The histogram shows the time course of prevertebral soft tissue swelling (mm) in the postoperative period. Postop: operation day, POD1: day 1 after operation, POD2: day 2 after operation, POD3: day 3 after operation, POD4: day 4 after operation, POD5: day 5 after operation.

Table 1. Demographic Data according to Prevertebral Soft Tissue Swelling

Variables	Group A	Group B	<i>p</i> -value
Sex (M:F)	37:34	41:23	0.21
Smoking	19	20	0.70
Age	51.56 ± 11.07	53.64 ± 11.90	0.29
Operation time	84.10 ± 23.87	89.02 ± 18.28	0.18
Fusion level	1.63 ± 0.66	1.97 ± 0.67	0.004

Analysis according to PSTS and Postoperative Complications

The incidences of complications (dyspnea, dysphagia, and dysphonia) that occurred in groups A and B were analyzed and compared. No significant differences were observed between these two groups in terms of age, gender, operative time, or smoking history (Table 1).

In the analysis of relationships between increases in PSTS and the occurrence of complications after surgery, group B showed significantly more occurrences. Complication of dysphagia was found in 3 cases in group A and 13 cases in group B ($p < 0.01$). Dysphonia was found in 0 cases in group A and 6 cases in group B ($p = 0.02$). Dyspnea was found in 4 cases in group A and 12 cases in group B ($p = 0.03$) (Table 2). The time when dyspnea mainly occurred (average of 1.3 days after operation) and the time when soft tissue swelling was most severe (average of 2.48 days after operation) were not the same and there was no correlation ($p = 0.32$).

DISCUSSION

Soft tissue swelling after anterior surgery for degenerative cervical spinal disease occurs in almost all patients, and this is identified by increases in the width of prevertebral soft tissues on plain radiographs. Many studies have attempted to determine whether cervical spine areas have been damaged by measuring the widths of prevertebral soft tissues in trauma patients. Weir¹ advised that the normal range of PSTS at C3 was 2.6-4.8 mm, Templeton et al.⁴ defined a PSTS of > 10 mm in the retropharyngeal space as abnormal, Miles et al.⁵ defined a PSTS size of larger than half of the diameter of the vertebral body in the retropharyngeal space as abnormal, and Pope and Riddervold defined a PSTS of > 7 mm at C2-3 as abnormal.⁶ However, few studies have reported the abnormal range of PSTS observed after surgery for degenerative cervical spinal diseases. Sanfilippo et al.¹⁰ advised that most swell-

Table 2. Analysis according to PSTS and Postoperative Complications

	Group A	Group B	<i>p</i> -value
PSTS	4.15 ± 5.6	11.32 ± 3.9	
Dysphagia	3	13	< 0.01
Dysphonia	0	6	0.02
Dyspnea	4	12	0.03

PSTS: prevertebral soft tissue swelling.

ings disappear within 6 weeks and that large abnormal swellings should be monitored or treated, but they did not mention the normal range or a treatment method. The general progress of swelling peaks at day 2 or 3 after surgery and thereafter decreases.¹¹⁻¹³ Sanfilippo et al.¹⁰ advised that although soft tissue swelling was observed even at two weeks after surgery, it normalized at 6 weeks. Similarly, in our study, degrees of swelling progressed and peaked on day 2 at the anterior 3rd. cervical spine at an average of 12.1 mm. When quantifying swelling, the diameters of prevertebral soft tissues measured in the middle of the area between the lower end plate of the C3 and C4 reflect the most sensitive swelling.¹³ It was noted that the lower vertebral levels experienced little change postoperatively when compared with the upper cervical spine. This is most likely because of the more constrained anatomy of the lower cervical spine. The potential retropharyngeal space appears to be much greater in the pharynx and hypopharynx than in the more distal trachea/esophageal portion of the neck. Therefore, greater consistency would be found between the preoperative and postoperative measurements. Furthermore, in our study, differences in results were also compared based on PSTS anterior to the C3 on day 2 when changes in PSTS were at their largest. In this study, we identified that the multiple level fusion and upper level fusion showed significant correlations with degrees of swelling. In comparing single level and two level fusions, Suk and colleagues^{11,12} reported that a difference in postoperative degrees of swelling was not evident, but advised the possibility that results might differ when more than two levels are involved. In addition, they advised that when surgery is performed at an area proximal to the 5th cervical spine, soft tissue swelling is severe in the C2 and C3 areas, whereas Andrew and Sidhu¹³ advised that although swelling increased greatly in the upper level fusion, it was not related to the location. We found that if PSTS reflects the degree of damage to soft tissues occurring during surgery, its degree would be higher for multiple segment surgery. Therefore, degrees of damage to soft tissues occur-

ring during surgery in degenerative cervical spinal disease may also be indirectly identified using plain radiographs as with acute cervical spine trauma patients. Although airway obstruction rarely occurs after cervical spine surgery, it is potentially fatal, and has been reported with swelling and hematoma.¹⁴⁻¹⁶⁾ In our study, re-intubation after surgery was not observed in airway obstruction, dyspnea that required treatment was observed in 13% of the 135 study subjects, and its incidence was higher in those who showed more severe PSTS. However, the time when dyspnea mainly occurred (between day 0 and day 2) and the time when soft tissue swelling was most severe (days 2 or 3) were not the same, and thus, the degrees of soft tissue swelling cannot be safely used to predict the development of dyspnea.

Dysphagia is a complication that occurs relatively frequently after anterior cervical spine surgery. Although no clear mechanism has been suggested, swelling by traction, hematoma, damage to the pharyngeal nerve plexus and to the hypoglossal nerves during surgery in the upper area have been suggested as risk factors.¹⁷⁻²⁰⁾ In addition, damaged soft tissues may adhere to the larynx or esophagus during the healing process and induce dysphagia.^{21,22)} Bazaz et al.⁸⁾ reported that after anterior cervical spine surgery, swelling occurred more frequently in females and those patients that underwent multiple segment surgery. No significant differences were shown between revision surgery and primary surgery, and between the locations of surgery. The present study shows that soft tissue swelling was not significantly different in males and females, but that it increased markedly when multiple segments and upper level surgery cases were included. Furthermore,

dysphagia frequently occurred in patients that experienced marked soft tissue swelling.

Dysphonia after surgery in the anterior cervical spine occurs less frequently than dysphagia, and is known to be caused by traction damage to the laryngeal nerves.^{17,19)} However, laryngeal swelling could also be a cause, and both are more likely to occur when damage to soft tissue during surgery is more severe. In our study, dysphagia and dysphonia persisting for at least three months after surgery occurred in 12% and 4% of our study subjects, respectively, and these frequencies were significantly related to PSTS.

The limitations of this study are that corrections were not made for other factors, such as, the degrees of traction during surgery, which might affect postoperative soft tissue swelling or the occurrence of complications. Furthermore, patterns of complications relative to PSTS severity were not quantitatively analyzed. Nevertheless, for the first time, the present study describes the links between PSTS and the complications associated with surgery, and thus, sheds light on the clinical relevance of PSTS.

Increments in PSTS after anterior cervical fusion for degenerative spinal disorders are greater and incidences of complications are higher in patients that undergo multi-level or high-level fusion. Thus, the measurement of PSTS using consecutive cervical lateral radiographs after anterior cervical surgery is a clinically meaningful procedure.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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