A New Method to Determine the Optimal Skin Incision for Anterior Cervical Surgery with CT Multiplanar Reformation Techniques

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SUMMARY – *An accurate determination of the optimal level of transverse skin incision is important. We describe a new technique to determine the level on the basis of computed tomography multiplanar reformations techniques, and conducted a randomized controlled trial to determine the accuracy of the new method. Eighty patients were enrolled and evenly divided into two groups. Patients in group A were marked by the traditional technique, whereas patients in group B were marked by the new method. Standard exposure procedures were performed. Intra-operative fluoroscopy confirmed if the intervertebral discs exposed were the intended ones. At the end of the study, intra-operative fluoroscopy confirmed that the intervertebral discs inserted with needles were not the intended ones in ten cases (25%) in group A. However, only three cases (7.5%) were wrongly located in group B. There was a significant difference between the two groups ($P = 0.03$). No severe complications were seen in either group. The current study provides a feasible method to identify the accurate level of transverse skin incision.*

Introduction

The Smith-Robinson approach is commonly used to access the cervical spine¹. It allows safe and direct decompression of ventral pathology of the spinal cord with a low incidence of serious complications^{2,3}. This approach can help minimize muscle damage, reduce blood loss, cut down the rates of wound complications and postoperative pain. An oblique incision at the medial border of the sternocleidomastoid is applicable, but this incision usually leaves an obvious scar to patients. Instead, a transverse skin incision seems to be a better choice.

However, an obvious limitation of the transverse skin incision is that the approach is not easy to extend, which means that an accurate determination of the optimal level of incision is of great importance. The traditional way is to identify the approximate level by means of palpating landmarks of the neck. But this method is not accurate enough, the exposed

levels could be wrong in some patients because of anatomical variations. Pre-operative fluoroscopy is another way to locate the levels. Although it overcomes the problems mentioned above, it takes up more operating room time, increases the radiation dose to patients and increases the overall cost. Besides, it is not feasible when the shoulders obstruct the lower cervical vertebrae in images in certain patients.

Before cervical surgery, computed tomography (CT) scan can help surgeons to distinguish calcium of the intervertebral disc, and has become a routine preoperative examination. Multislice CT not only increases the speed of the examination, but also provides more information⁴. With multiplanar reformation techniques, surgeons can obtain images in an arbitrary plane⁵. Our current study describes a new technique to mark the transverse skin incision with the help of sagittal reformation images of CT, and determine if this method is more accurate than the traditional technique.

Figure 1 Measurements on sagittal reformation CT images. A horizontal line passing through C6-C7 was drawn. The second line connected the superior border of the hyoid bone and the superior border of the sternum. The first distance was measured from the superior border of the sternum to the cross point (A), and the second distance was measured from the superior border of the sternum to the superior border of the hyoid bone (B). Ratio=a/b.

Figure 2 Skin marking of the neck before surgery. The distance between the superior border of the hyoid bone and superior border of the sternum was measured (B). The ratio calculated from the CT image was applied to determine the level of incision ($A=B \times \text{Ratio}$).

Materials and Methods

Study design

We prospectively enrolled 80 patients undergoing anterior cervical surgery between February 3, 2013, and December 20, 2013. The indications for surgery were one- or two-level cervical spinal cord or nerve root compression from spondylosis or soft disc herniation unresponsive to conservative treatment. They were diagnosed based on both neurological examinations and magnetic resonance imaging findings. Patients were excluded from the study if they had contraindications to surgery, or previous surgery on the cervical spine. This randomized prospective study was approved by the Institutional Review Boards, and informed consent was obtained from each patient.

Eligible patients were assigned randomly to two groups (group A or group B) by opening a sealed envelope. The envelopes were prepared beforehand and sorted randomly using random allocation software (computerized random number generators). Before surgery, one investigator opened the sealed envelope to reveal which group the patients belonged to, and completed the marking of cervical incision. For patients assigned to group A, the level of skin incision was marked by the traditional technique. For example, the hyoid bone is about at the C3 level, thyroid cartilage is at the C4 and C5 levels, and cricoid cartilage is at the C6 level. For patients assigned to group B, the level was marked by a new method described below.

New technique

All patients underwent CT scan preoperatively. Multislice CT of cervical spine was performed using a 64-slice CT scanner (Germany Siemens Somatom Sensation 64). CT parameters were set as follows: tube voltage, 120 kV; tube current, 138 mAs; matrix, 512×512; field of view, 200 mm; beam collimation, 0.6 mm; scan time, 8.59 seconds; rotation time, 1.0 seconds; and pitch, 0.9. The raw data were reconstructed at 3 mm slice thickness and 3 mm reconstruction interval using a high-resolution mediastinum algorithm to obtain the multiplanar reformation images in the syngo CT workstation. Patients were positioned with the neck extended backward as they would be for surgery. The sagittal reformation images were acquired to observe the hyoid bone, cervical vertebrae and upper boarder of the sternum.

In the post-processing workstation, sagittal reformation images of patients in group B were analyzed. First of all, a horizontal line was drawn. For one-level surgery, this line passed through the intended intervertebral disc; for two-level surgery, this line passed through the middle of the vertebral body between the two levels. The second line connected the superior border of the hyoid bone and the superior border of sternum, and then a cross point was made by the two lines. The first distance was measured from the superior border of the sternum to the cross point, and the second distance was measured from the superior border of the sternum to the superior border of the hyoid bone (Figure 1). The ratio between the two distances was calculated by a radiologist.

Before surgery, patients were placed in a supine position with the mandible raised to extend the neck. Skin markings were performed with a sterile skin marker: a point superior to the hyoid bone and a point superior to the sternum were marked at the midline of the neck. The distance between the two points was measured and the ratio calculated from the CT image was applied to identify the third point (Figure 2). When the third point was determined, a transverse incision could be marked from the midline to the right border of the sternocleidomastoid.

Surgical procedure

Patients in each group underwent the following surgical procedure. After sterilizing the skin and draping the patient, we performed a right-sided Smith-Robinson approach through a 3-5 cm transverse incision and made a standard dissection down to the anterior of the cervical vertebrae. The intervertebral disc just beneath or nearest the skin line was inserted with a needle. Then we performed intra-operative fluoroscopy to confirm if we had exposed the intended disc. All exposure procedures were performed by a single surgeon (YS) blinded to group assignment. If the exposed level was right, the corresponding results were recorded and anterior cervical discectomy and fusion (ACDF) or anterior cervical corpectomy and fusion (ACCF) was undertaken by standard technique.

Statistical analysis

In this study, the Mann-Whitney U test was used for numerical variables and chi-squared test for categorical variables. All statistical

analyses were carried out using the Statistical Package for the Social Sciences (version 13.0 for Windows; SPSS, Chicago, IL, USA). $P < 0.05$ was considered statistically significant.

Results

Eighty patients were enrolled in the study with 40 patients in each of the groups. Patients' age, gender distribution, body mass index (BMI), and number of levels were similar between the two groups (Table 1).

Table 1 Patient demographics.

	Group A	Group B	P value
Number of patients	40	40	
Age (year)	59.8	58.7	0.68
Gender			
Male	24	21	0.50
Female	16	19	
Body mass index	23.8	24.3	0.28
Number of levels			
One-level	30	27	0.46
Two-level	10	13	

All procedures were performed through a single incision. Intra-operative fluoroscopy confirmed that the intervertebral discs inserted with needles were not the intended ones in ten cases (25.0%) in group A. However, only three cases (7.5%) were wrongly located in group B. There was a significant difference between the two groups ($P = 0.03$).

After surgery, dysphagia occurred in 29 patients: 13 patients in group A and 16 in group B, but their symptoms resolved spontaneously within one week. Wound hematoma occurred in one patient in group A, without further surgical intervention. No severe complications were seen in either group.

Discussion

Cervical decompression and instrumentation surgeries have grown in popularity due to improvements in technology and surgical skill. Among different approaches for cervical surgery, the anterior approach, first described by Smith and Robinson, is most widely used¹.

In the current study, the number of intervertebral discs wrongly located in group A was significantly more than that in group B. The new method was more accurate compared with the traditional technique, and it proved to be a

feasible method in clinical practice. In addition, this method is based on multislice CT which is a routine examination for all preoperative patients. In comparison with other methods, it does not increase the overall cost or the radiation dose to patients.

In a previous study, Leonard et al. used a different method to identify the level⁶. They measured two distances based on the mandible and the clavicles from the pre-operative lateral radiograph. Then they calculated a ratio and applied it to anatomical measurements. This quantitative method is accurate and effective in clinical practice, but it has several limitations.

1. All measurements, taken from a neutral lateral radiograph, are based on the mandible and the clavicles. During the surgical procedure, the mandible rises and the clavicles move down in order to expose the neck better. This will definitely affect the accuracy of the measurements mentioned above.

2. Obese patients generally have short necks. On the radiograph, the intervertebral discs to be removed, especially C6-C7 and C7-T1, may be obstructed by the shoulders, which makes measurements hard to perform.

3. Sometimes, clavicles are not easy to distinguish from lateral radiographs.

With the help of multiplanar reformation techniques, we can recognize some anatomic landmarks easily. We chose the hyoid bone and sternum as landmarks of surface anatomy instead of the mandible and clavicle. During the surgical procedure, the distance between the hyoid bone and sternum does not change much even if the neck extends backward. This may contribute to a more accurate result.

We only performed one- or two-level surgical procedures by this method. For three- or more level surgery, we assume the oblique incision would be a better choice. Further, this technique cannot replace the procedure of intraoperative fluoroscopy, which is a gold standard to guarantee the correct intervertebral disc to be removed.

In conclusion, we described a new way to identify the accurate level of transverse skin incision. For experienced surgeons, surface landmarks combined with magnetic resonance imaging may be enough to determine the appropriate level of transverse incision. However, for an inexperienced surgeon, the current study provides a feasible method.

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