# Radiographic Evaluation of the Reliability of Neck Anatomic Structures as Anterior Cervical Surgical Landmarks

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BACKGROUND: **Accurate location of the skin incision is helpful to decrease the technical difficulty and save the operative time in anterior cervical spine surgery. Spine surgeons usually use the traditional neck anatomic structures (the hyoid bone, thyroid cartilage, and cricoid cartilage) as landmarks during the surgery. However, the reliability of these landmarks has not been validated in actual practice.**

OBJECTIVE: **To find out which landmark is the most accurate for identifying the cervical levels in anterior cervical spine surgery.**

METHODS: **The lateral flexion and extension radiographs of cervical spine in standing position from 30 consecutive patients from January 2015 to February 2015 were obtained. The cervical vertebral bodies from C2 to C7 were divided equally into 2 segments. The cervical segments corresponding to each of the surface landmarks were recorded on the flexion and extension radiographs, respectively, and the displacement of corresponding cervical segments from the flexion to extension radiographs for each landmark was calculated.**

RESULTS: **Based on the measurements, the main corresponding cervical levels for the mandibular angle were C2 on both of the flexion and extension films, for the hyoid bone were the C3—C4 interspace on flexion film and C3 on extension film, for the thyroid cartilage C5 on both of flexion and extension films, and for the cricoid cartilage C6 on flexion film and C5—C6 interspace on extension film, respectively. The ratios of displacement within 2 segments from flexion to extension were 83.3% (25/30) for mandibular angle, 56.7% (17/30) for hyoid bone, 66.7% (20/30) for thyroid cartilage, and 56.7% (17/30) for cricoid cartilage, respectively. The mean displacement from flexion to extension films were significantly less than 2 cervical segments for the mandibular angle but greater than 2 segments for the other landmarks. Significant differences were found between mandibular angle and the other 3 landmarks for the displacement from flexion to extension.**

CONCLUSIONS: **The angle of mandible was found to be the most accurate landmark for identifying the cervical level, which corresponded to C2 and C2—C3 disc space. The hyoid bone, thyroid cartilage, and cricoid cartilage were not reliable to predict the cervical levels.**

## INTRODUCTION

Anterior cervical spine surgery (ACSS) is a useful procedure for treating different cervical spinal disorders, such as cervical disc herniation, ossification of the posterior longitudinal ligament, and cervical vertebral fracture.[1,2] Since Cloward[3] and Smith and Robinson[4] reported the use of transverse skin incision in the cervical anterior approach, this incision became popular because of good cosmesis for patients. Accurate location of the skin incision in ACSS is important to protect neurovascular and visceral structures of the neck and to achieve adequate exposure for cervical decompression and fusion. Improper position of the skin incision may increase technical difficulty, operative time, and the risk of esophageal injury due

**Key words**
- Cervical
- Landmarks
- Mandibular angle
- Spine

**Abbreviations and Acronyms**
ACSS: Anterior cervical spine surgery

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to excessive retraction during the surgery.[5-7] Spine surgeons usually use fluoroscopy or navigation to confirm the location of the target cervical segment and help to make the incision; however, fluoroscopy or navigation used in the surgery would increase the radiation, which is harmful to patients.

During the past decade, several studies have reported the use of surface neck landmarks, such as hyoid bone, thyroid cartilage, and cricoid cartilage, to identify cervical spinal levels based on the study of preoperative radiographs.[8-10] However, the reliability of those techniques was controversial, because the intraoperative positions of cervical spine were different from preoperative ones.[11,12] Thus, it is unknown which landmark is reliable for predicting cervical levels no matter what position of the cervical spine; few studies reported about this. The purpose of this study is to determine which is the most accurate landmark to identify the cervical levels and provide information for making incision during ACSS.

## MATERIALS AND METHODS

### Patient Selection

A study was performed on 30 consecutive patients (15 men and 15 women) who underwent cervical spine radiographic tests in the outpatient clinic because of cervical diseases from January 2015 to February 2015 at our hospital. The study protocol was given ethical approval by the human research ethics committee of the hospital. Patients meeting the following criteria were included in this study: 1) age between 20 to 40 years; 2) underwent both cervical flexion and extension radiographs in standing position, without severe cervical degeneration; 3) no cervical vertebral body and disc destruction. Patients with cervical kyphosis, previous cervical surgery, congenital spinal anomalies, cervical tumor, and tuberculosis were excluded from this study.

### Radiographic Measurement

All lateral cervical spine radiographs of the included patients were obtained. The anterior landmarks and the corresponding cervical spinal levels were displayed clearly on the films. For the measurement, several lines were drawn on the films as follows: first, each of the cervical spinal vertebral body was equally divided into 2 segments from C2 to C7, including the upper and lower segments, and each of the cervical interspaces was defined as one segment (Figure 1). Second, a line connecting the tip of the odontoid process and the center of C7 vertebra was drawn as the sagittal vertical axis of cervical spine. Third, a horizontal line was set perpendicular to the sagittal vertical axis from the middle of each surface landmark to the cervical spine on both of the flexion and extension radiographs (Figure 2). The surface landmarks included in this study consisted of the angle of mandible, hyoid bone, thyroid cartilage, and cricoid cartilage.

According to the horizontal line, the cervical segments corresponding to each of the surface landmark were recorded on both of the flexion and extension radiographs, and the displacement from the flexion to the extension radiographs for each landmark was calculated. If the displacement was greater than 2 segments (1 vertebra), it was determined that this landmark was not reliable to predict the cervical spinal levels. On the contrary, if the displacement was less than 2 segments, the landmark was determined to be reliable for identifying the cervical spinal levels.

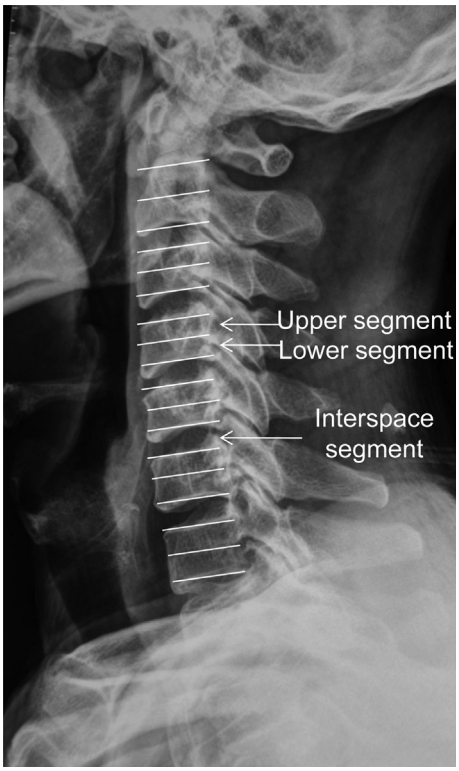


**Figure 1.** Cervical vertebral bodies from C2 to C7 were equally divided into 2 segments, and cervical interspace was defined as one segment for the measurement.

### Statistical Analysis

All data were presented as mean ± standard deviation in this study. All statistics were conducted with SPSS 17.0 software (SPSS Inc., Chicago, Illinois, USA). The data were analyzed with the Student's t test for continuous variables and $\chi^2$ test for categorical variables. Values of $P < 0.05$ were considered to be statistically significant.

## RESULTS

The mean age of the patients was 32 years. Based on the measurement, the cervical spinal levels corresponding to the position of the surface landmarks on the lateral flexion and extension radiographs are displayed in Table 1. For the angle of the mandible, most of the corresponding spinal levels were C2 on both of the flexion and extension films. The majority of cervical spinal levels corresponding to the position of hyoid bone were C3–C4 interspace on flexion film and C3 on extension film. For the thyroid cartilage, the corresponding spinal levels on both of flexion and extension films were C5. The reference level for

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