



# The Inaccuracy of Surface Landmarks for the Anterior Approach to the Cervical Spine in Southern Chinese Patients

Tin Sui Ko, Michael Siu Hei Tse, Kam Kwong Wong, Wing Cheung Wong

*Department of Orthopaedics and Traumatology, Kwong Wah Hospital, Hong Kong*

**Study Design:** Observational study.

**Purpose:** To assess the correlational accuracy between the traditional anatomic landmarks of the neck and their corresponding vertebral levels in Southern Chinese patients.

**Overview of Literature:** Recent studies have demonstrated discrepancies between traditional anatomic landmarks of the neck and their corresponding cervical vertebra.

**Methods:** The center of the body of the hyoid bone, the upper limit of the lamina of the thyroid cartilage, and the lower limit of the cricoid cartilage were selected as representative surface landmarks for this investigation. The corresponding vertebral levels in 78 patients were assessed using computed tomography.

**Results:** In both male and female patients, almost none of the anatomical landmarks demonstrated greater than 50% correlation with any vertebral level. The most commonly corresponding vertebra of the hyoid bone, the lamina of the thyroid cartilage, and the cricoid cartilage were the C4 (47.5%), C5 (35.9%), and C7 (42.3%), respectively, which were all different from the classic descriptions in textbooks. The vertebral levels corresponding with the thyroid and cricoid cartilage were significantly different between genders.

**Conclusions:** The surface landmarks of the neck were not accurate enough to be used as the sole determinant of vertebral levels or incision sites. Intra-operative fluoroscopy is necessary to accurately locate each of the cervical vertebral levels.

**Keywords:** Surface landmarks; Cervical spine; Anterior approach; Spine; Anatomy

## Introduction

Surface landmarks on the neck and their corresponding vertebral levels are important for physical examinations and surgery of the cervical spine. When utilizing the anterior approach to the cervical spine, selecting the proper site for skin crease incision is critical for simplifying the approach to the target vertebra. The hyoid bone, thyroid

cartilage, and cricoid cartilage are described as reliable surface landmarks on the anterior neck in standard textbooks of anatomy and spinal surgery. For example, the hyoid bone and inferior border of the cricoid cartilage are understood to correspond with C3 and C6 vertebra, respectively [1-4]. However, some inconsistencies exist between the descriptions of different textbooks: The upper limit of the thyroid cartilage corresponds with the C4

Received Oct 28, 2017; Revised Mar 28, 2018; Accepted Apr 29, 2018

Corresponding author: Tin Sui Ko

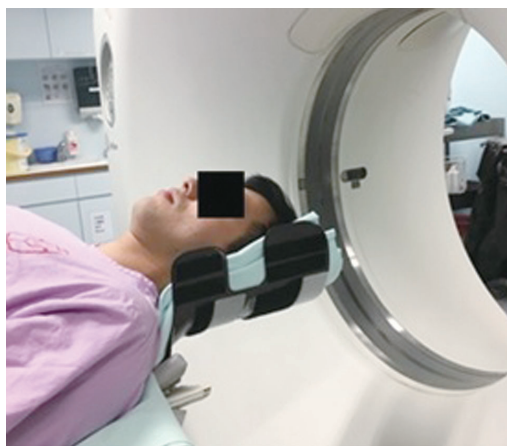
Department of Orthopaedics and Traumatology, Kwong Wah Hospital, 25 Waterloo Road, Hong Kong

Tel: +852-23322311, Fax: +852-35175168, E-mail: isaackoisaacko@gmail.com

vertebra by Moore et al. [3] and Ellis and Mahadevan [4], but Standring and Gray [1] offers the possibility of corresponding with the C3/4 intervertebral disc. Additionally, most textbooks and classical descriptions were based on research from Caucasian or other non-Asian cadavers. As such, we designed this study to investigate the vertebral levels corresponding to anterior surface landmarks on the neck in Southern Chinese patients using radiological imaging.

## Materials and Methods

From June 2015 to January 2016, patients who were admitted to Kwong Wah Hospital in Hong Kong and who underwent computed tomography (CT) scans of their cervical spines were recruited to participate. Axial CT images with 2.5-mm slice thickness were obtained for included patients using a GE LightSpeed VCT scanner (GE Healthcare, Milwaukee, WI, USA). The images were then used for sagittal reconstruction. To standardize the posture of the neck and to mimic the positional alignment standard in the anterior approach to the cervical spine, patient craniums were aligned in the Frankfurt plane (Fig. 1), wherein the inferior margin of the left orbit was aligned to the upper margin of the external auditory meatus, using a metal-free carbon fiber axial head holder (GE Healthcare). Patients with cervical spine fracture, cervical segmentation anomalies, history of cervical fusion operation, and severe thoracic kyphosis who could not lie flat on the head holder were excluded. Pediatric patients, defined as less than 17 years old, were also excluded. In



**Fig. 1.** Craniums of recruited patients aligned in the Frankfurt plane using the GE metal-free carbon fiber head holder (GE Healthcare, Milwaukee, WI, USA).

total, the CT images of 78 adult patients were included, of whom 45 patients were male. The mean age of the patients was 60.6 years (range, 17–94 years; standard deviation=17.7 years). Surface landmarks investigated include the center of the body of the hyoid bone, the upper limit of the lamina of the thyroid cartilage, and the lower limit of the cricoid cartilage. The vertebral levels, considered as either a vertebral body or an intervertebral disc, were assigned to correspond with the aforementioned landmarks using the axial plane of the CT images. Cervical lordosis was measured as the angle made in the lower border of C2 vertebrae and the upper border of C7 vertebrae. The images of the recruited patients were divided into half and assessed by two orthopedic surgeons.

Data were analyzed with SPSS ver. 10.0 (SPSS Inc., Chicago, IL, USA). Anatomical landmarks and their measured vertebral levels were recorded. The most frequent result represented the mode of the dataset. Factors potentially affecting vertebral level, including gender and the degree of cervical lordosis, were analyzed using the chi-square test or *t*-test.

## Results

The center of the body of the hyoid bone most frequently corresponded with the C4 vertebra (47.5%), followed by the C4/5 intervertebral disc (15.4%), and C3/4 intervertebral disc (12.8%). The upper limit of the lamina of the thyroid cartilage most frequently corresponded with the

**Table 1.** Percentage of the most commonly corresponded vertebral level of various anatomical landmarks

Variable	%
Center of the body of hyoid bone	
C4 vertebral body	47.5
C4/5 intervertebral disc	15.4
C3/4 intervertebral disc	12.8
Upper limit of laminae of the thyroid cartilage	
C5 vertebral body	35.9
C4 vertebral body	23.1
C6 vertebral body	20.5
Lower limit of the cricoid cartilage	
C7 vertebral body	42.3
C6 vertebral body	24.4
C6/7 intervertebral disc	17.9

C5 vertebra (35.9%), followed by the C4 vertebra (23.1%), and the C6 vertebra (20.5%). The lower limit of the cricoid cartilage most frequently corresponded with the C7 vertebra (42.3%), followed by the C6 vertebra (24.4%), and the C6/7 intervertebral disc (17.9%) (Table 1). Patient gender contributed to significant differences between the corresponding vertebral levels of the thyroid cartilage and the cricoid cartilage (Table 2). The thyroid cartilage lamina in male patients most commonly corresponded with the C5 vertebral body (35.6%), whereas in female patients, it corresponded with the C4 vertebral body (42.4%,  $p=0.01$ ). Additionally, the cricoid cartilage in male patients frequently corresponded with the C7 vertebral body (55.5%), and in female patients, with the C6 vertebral body (42.4%,  $p<0.01$ ). Gender did not affect the vertebral levels corresponding with the hyoid bone ( $p=0.30$ ). Moreover, cervical lordosis was determined to have no significant impact on the deviation of anatomical landmarks from their classically described corresponding vertebral levels (Table 3).

## Discussion

Despite minor differences, classical texts usually share a consensus on surface landmarks and their corresponding vertebral levels. As described in textbooks, the hyoid bone, the upper limit of the thyroid cartilage, and the inferior border of the cricoid cartilage correspond with the C3, C4, and C6 vertebrae, respectively. Hale et al. [5] also found that the hyoid bone corresponds to the C3 verte-

bral level and the cricoid cartilage corresponds to the C6 vertebral level. However, the consensus for most modern textbooks was based on the anatomical study of Caucasian or non-Asian cadavers. This study demonstrated different findings for the Southern Chinese population. Indeed, each surface landmark could be up to one vertebral level more caudal than that described in the textbooks. Moreover, <50% of the patients demonstrated the same vertebral level for each anatomical landmark, except the lower limit of the cricoid cartilage in male patients. Gender likely contributed to the different vertebral levels observed to be corresponded with the thyroid and cricoid cartilage: male patients frequently demonstrated a vertebral level more caudal than that demonstrated by female patients for both. In 2012, Mirjalili et al. [6] also demonstrated these findings in neck CT scan images of 52 patients with a standardized head position.

Apart from the above findings, deviations between anatomical landmarks and their classically described vertebral levels can be attributed to a few other factors, such as neck length, body mass, and height. These factors could not be assessed by the CT scan images of this study but should be taken into consideration during clinical practice. Importantly, the incision and dissection angles from the skin down to the vertebrae also have a significant influence on the accessible vertebra. However, since the incision for single-level anterior cervical discectomy and fusion normally follows Langer's lines to create a better cosmetic effect, adjustments of the dissection angle or incision length after the act are limited. Inaccurate surface landmarks pose a potential risk to the anterior approach.

## Conclusions

Because there was no unified finding for anatomical landmarks and their corresponding vertebral levels in this study, we conclude that using surface landmarks for the

**Table 2.** Percentage of the most commonly corresponded vertebral level of various anatomical landmarks in different genders

Variable	Hyoid	Thyroid	Cricoid
Male	C4 (47.4%)	C5 (35.6%)	C7 (55.5%)
Female	C4 (42.4%)	C4 (42.4%)	C6 (42.4%)
Chi-square test	$p=0.30$	$p=0.01$	$p<0.01$

**Table 3.** Mean cervical lordosis of the patients with their anatomical landmarks matched with and deviated from the classical descriptions

Variable	Hyoid (C3)	Thyroid (C4)	Cricoid (C6)
Mean cervical lordosis of the patients with their anatomical landmark matches with the classical description (°)	9.8±16.4	5.0±14.9	5.1±14.3
Mean cervical lordosis of the patients with their anatomical landmark deviates from the classical description (°)	7.0±14.0	8.0±14.0	8.0±14.2
<i>t</i> -test	$p=0.61$	$p=0.43$	$p=0.44$

Values are presented as mean±standard deviation.

anterior approach to the cervical spine is an antiquated practice. Data from this study indicate that the accuracy of locating even the most frequently encountered vertebral level using surface landmarks is <50%. There are also significant gender differences regarding the vertebral levels corresponding with the lamina of the thyroid cartilage and the cricoid cartilage. In clinical procedures utilizing the anterior approach to the cervical spine, it is not advisable to use surface landmarks alone to locate the cervical vertebrae. The marking of the vertebral levels and the planned site of incision should be determined by fluoroscopy to avoid the risk of inaccurate incisions.

### Conflict of Interest

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

### References

1. Standring S, Gray H. Gray's anatomy: the anatomical basis of clinical practice. 40th ed. Edinburgh: Churchill Livingstone; 2008.
2. Sinnatamby CS. Last's anatomy: regional and applied. 12th ed. Edinburgh: Churchill Livingstone, Elsevier; 2011.
3. Moore KL, Dalley AF, Agur AMR. Clinically oriented anatomy. 6th ed. Philadelphia (PA): Lippincott Williams & Wilkins; 2010.
4. Ellis H, Mahadevan V. Clinical anatomy: a revision and applied anatomy for clinical students. 11th ed. Oxford: Blackwell Publishing; 2006.
5. Hale SJ, Mirjalili SA, Stringer MD. Inconsistencies in surface anatomy: the need for an evidence-based reappraisal. *Clin Anat* 2010;23:922-30.
6. Mirjalili SA, McFadden SL, Buckenham T, Stringer MD. Vertebral levels of key landmarks in the neck. *Clin Anat* 2012;25:851-7.