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The Mandibular Angle as a Landmark for Identification of Cervical Spinal Level

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Study Design. Retrospective radiographic review.

Objective. To determine the utility of the mandibular angle as a landmark for identification of cervical spinal level.

Summary of Background Data. Improper localization of the skin incision during anterior cervical spine surgery may lead to increased technical difficulty of the surgery. Although the use of traditional palpable anterior neck landmarks (hyoid bone, cricoid cartilage, thyroid cartilage, and carotid tubercle) help identify appropriate spinal levels, their reliability has not been validated in actual surgeries. We hypothesize that the angle of the mandible (AM) is a consistently palpable landmark, and that the mandible can be used to accurately template the distance to subaxial cervical levels using preoperative radiographs.

Methods. As a pilot study, we prospectively evaluated 30 consecutive patients who underwent anterior cervical diskectomy and fusion to assess the interobserver accuracy of palpating the mandibular angle, hyoid, carotid tubercle, and thyroid and cricoid cartilages. In a second set of 26 consecutive patients undergoing anterior cervical diskectomy and fusion, we then retrospectively reviewed standing preoperative lateral plain radiographs of the cervical spine, in addition to supine lateral cervical spine radiographs taken at the time of surgery, to assess: (1) the position of the AM relative to the corresponding cervical spinal level, and (2) whether or not the position of the AM relative to the subaxial cervical levels is different on preoperative standing films and intraoperative supine films. In these same 26 patients, we also measured the vertical distance between the AM and the location of each subaxial intervertebral disc space. These measurements were repeated for the hyoid bone as a control for each patient.

Results. The interobserver accuracy was 100% between observers for identifying the AM, hyoid bone, thyroid cartilage, and cricothyroid membrane, and 93% for carotid tubercle. The frequency with which anterior neck landmarks were palpable by the surgeon and assisting senior residents was as follows: AM (100%), hyoid bone (83%), thyroid cartilage and cricothyroid membrane (93%), and carotid tubercle (Surgeon: 63%, Resident: 57%, $P = 0.79$). There was 100% correlation between the position of the mandibular angle in the preoperative standing lateral radiograph and the intraoperative supine lateral radiograph, compared with 65% with the hyoid bone. The distances between the AM or hyoid to each disc space did not vary significantly between preoperative and intraoperative radiographs ($P > 0.05$).

Conclusion. The mandibular angle was shown to be the most consistently palpable landmark. Further, the distance from the mandible, measured on preoperative plain lateral cervical spine radiographs, is an accurate template to determine cervical spine levels during anterior cervical spine surgery.

Key words: cervical, spine, mandible, mandibular angle, fusion, hyoid, landmark, intervertebral, disc. **Spine 2009;34:1006–1011**

Proper localization of the skin incision in anterior cervical spine surgery is critical to facilitate safe mobilization of the visceral and neurovascular structures of the neck, and to achieve adequate exposure for spinal decompression, arthrodesis, instrumentation, and arthroplasty. Failure to accurately place the incision over the intended spinal level may lead to increased technical difficulty during the procedure. Although lengthening an improperly placed incision may minimize further exposure-related difficulties, this may not be routinely performed at the risk of poor cosmesis. Consequently, the poorly-placed incision may lead to an increased risk of esophageal injury due to excessive or prolonged retraction, inadequate spinal decompression, difficulty with the placement of cervical plates or cervical disc replacements, or dysphagia.[1,2]

Several classic superficial anterior neck structures that have been used to identify approximate cervical spinal levels before skin incision include the hyoid bone (C3), thyroid cartilage (C4–C5), cricoid cartilage (C6), and the carotid tubercle (C6).[3] However, in patients with short and wide necks, muscular patients, or in obese patients with large body habitus, these landmarks are more difficult, and maybe impossible, to palpate.[4] The angle of the mandible (AM), which represents the confluence of the mandibular ramus and body, is a routinely palpable bony landmark even in patients with short, wide necks. Only anecdotal evidence exists which links the mandibular angle with a relative position to the cervical spine,[5,6] and no study, to the best of our knowledge, has correlated its position relative to the remainder of the subaxial cervical disc spaces.

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The first objective of the current study was to examine the position of the AM relative to each cervical spinal level. Second, we evaluated whether or not the position of the mandible changed from preoperative standing films to intraoperative supine films. Finally, an assessment of the reliability with which the AM and each of the established anterior neck landmarks can be palpated intraoperatively before skin incision was made. We hypothesize that the mandible will be routinely palpable in all patients, will not change position from preoperative standing films to intraoperative supine films, and that the data provided herein will validate the mandibular angle as an additional superficial landmark to localize the skin incision in anterior cervical spine surgery.

■ Materials and Methods

Patient Selection

In the first (clinical) part of this study, we assessed whether or not common anterior neck landmarks were palpable in patients lying supine before skin incision. We prospectively evaluated 30 consecutive patients (12 women and 18 men, mean age of 50.4 years, range: 32–78 years) undergoing anterior cervical diskectomy and fusion (ACDF) for 1-level cervical spondylosis by a single surgeon between 2003 and 2005. Study exclusion criteria consisted of cervical kyphosis, revision surgery, multiple surgical levels, and the presence of any congenital spinal anomalies (*i.e.*, Klippel-Feil syndrome). The ability to palpate the AM, hyoid bone, thyroid cartilage, cricoid cartilage, and the carotid tubercle was assessed by both the senior author and by his PGY-3 assistant surgical resident after appropriate instruction. The frequency with which each structure was able to be palpated was recorded and compared.

For the second (radiographic) part of this study, a single observer, who was blinded to the results of the first part of the study, reviewed preoperative standing and intraoperative supine lateral cervical spine radiographs of a second set of 26 patients also undergoing ACDF for 1-level cervical spondylosis (11 women, 15 men, mean age 46 years, range: 21–65 years). Twenty-six patients had adequate lateral fluoroscopic images, which included visualization to the C6–C7 interspace (the C7–T1 interspace was unable to be routinely detected on the intraoperative supine fluoroscopic films so this level was not evaluated in the current study). Patients were excluded from the radiographic portion of this study if they had unavailable or poor-quality films. Because the temporomandibular joint is highly mobile, we analyzed the relative position of the mandible in both settings because it is possible that the resting position of the mandibular angle is different while standing compared with intraoperative supine positioning.

Patient Positioning During Intraoperative Supine Radiograph

All intraoperative supine films were taken once the patient was fully prepared and draped, and positioned as follows: the patient's head rested on a foam pad without application of rigid Gardner Wells or Mayfield tongs. The endotracheal tube was secured to the right side of the mouth with silk tape, away from the operative side (left) of the neck. After application of benzoin to the shoulders, 2-inch silk tape was applied to the shoulders to facilitate visualization of the lower cervical spine, and the arms were folded underneath blankets. An interscalene bump was placed underneath the patient, with variable height until the desired cervical lordosis was achieved. Care was taken not to overly lordose the neck, which may inadvertently place increased pressure on the visceral neck structures making mobilization more difficult.

Radiographic Measurements

Several measurements were made on the lateral cervical spine radiographs. The first was an assessment of the relative position of the mandible to the corresponding vertebral level or intervertebral disc space. The position of the mandibular angle on the preoperative standing film was called a "match" with its position on the intraoperative supine film if it was at the exact same vertebral or disc level, or was within 1 intervertebral disc space or vertebral body. For example, if on the preoperative standing film the AM was located at the C2–C3 disc space, and on the intraoperative supine film it was located at the level of either the C2 or C3 vertebral body, this was still called a match. If in the previous example the intraoperative radiograph revealed that the mandibular angle was at the level of the C3–C4 or caudal, however, this was not a match. Levels of significance (*P* values) were obtained using the Fisher exact test.

Second, for each radiograph we measured the vertical distance between the AM (confluence of the ramus and body of the mandible) and each intervertebral disc space. This was accomplished as follows: first, the cervical sagittal vertical axis (SVA) was drawn, which is a line extending from the tip of the odontoid process to the center of the C7 vertebrae using established methods.[7] The vertebral body center was located at the intersection of diagonal lines drawn from the anterosuperior corner to the posteroinferior corner, and from the anteroinferior corner to the posterosuperior corner. Second, a line drawn inferiorly from the AM parallel to the cervical SVA was placed (mandibular line [ML]). Third, a horizontal line, drawn perpendicular to the cervical SVA, was placed from the middle of each subaxial intervertebral disc space to the ML. Finally, the vertical distance between the AM and each intervertebral disc space along the ML was measured (Figure 1). We chose to measure the vertical distance between the mandibular angle and a line drawn parallel to the cervical SVA because this vertical distance best approximates where the projected skin incision would be placed to access the corresponding intervertebral disc space. Student *t* test was used to assess measurement differences between preoperative standing lateral and intraoperative supine lateral distances from the mandible to the respective disc spaces.

We performed similar measurements and assessments of the hyoid bone for internal comparison. The hyoid was chosen because it was always present and visible on lateral cervical spine radiographs, whereas the other anterior neck landmarks were not always visible (*i.e.*, thyroid cartilage, cricoid cartilage, carotid tubercle). Using a line drawn from middle of the anterior aspect of the hyoid body parallel to the cervical SVA (hyoid line), the following measurements were performed: (1) position of the hyoid bone relative to the corresponding vertebral level or intervertebral disc space, and (2) vertical distance between the hyoid bone and each intervertebral disc space, using the technique described earlier (Figure 1). Negative values for vertical distance reflect that the disc space was located cranial to the hyoid or mandibular angle, whereas positive values indicated that the disc space was located caudad to the hyoid or mandibular angle. Any discrepancy between the size magnifi-

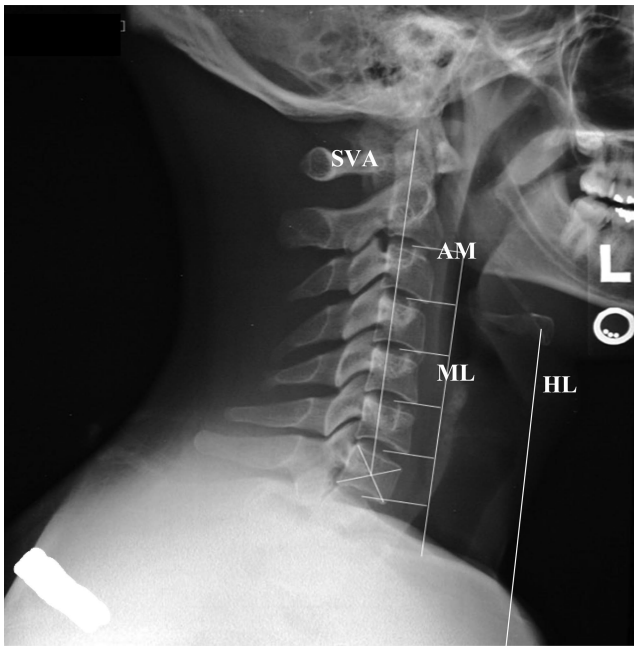

Figure 1. Preoperative standing lateral cervical spine radiograph. Measurement technique: (1) cervical SVA is drawn along a line from the tip of the odontoid to the midpoint of the C7 vertebral body; (2) ML is a vertical line drawn from AM parallel to the cervical SVA; (3) perpendicular line from middle of each disc space to the ML; and (4) measure the vertical distance between AM and each disc space along the ML. These steps were repeated for measurements of the hyoid bone relative to each disc space using the hyoid line. Notice the correlation of the AM to the C2–C3 disc space, and the hyoid bone to the C3–C4 disc space.

cation of the preoperative radiographs and the intraoperative fluoroscopic images were corrected before data analysis.

In addition, the variances of the distances from the mandibular angle and the hyoid bone at each disc space were calculated to assess the relative precision of these 2 landmarks using both preoperative and intraoperative radiographs. The levels of significance of any differences in precision were assessed by the *F* test for homogeneity of variance.

Results

Landmark Detection

The ability of the attending and the residents to palpate the anterior neck landmarks is depicted in Figure 2. The AM was reliably palpable to both the attending and resident in 100% of patients (30/30). The thyroid cartilage and cricothyroid membrane were palpable in 93% of patients (28/30) by both the attending and resident, whereas the hyoid bone was palpable in 83% of patients (25/30). The carotid tubercle was the only landmark in which the attending and resident differed; it was also the most difficult for each examiner to palpate. The attending surgeon was able to identify the carotid tubercle in 63% of patients (19/30), while the resident was able to palpate it in 57% of patients (17/30). This difference in sensitivity was not found to be statistically significant using the Fisher exact test ($P = 0.79$).

Mandibular Angle

The location of the mandibular angle on preoperative standing lateral cervical spine radiographs "matched" its location on intraoperative supine radiographs in 100% of patients (26/26), with 77% (20/26) being located at the exact same body or disc space on both preoperative and intraoperative radiographs. The AM was located at the C2–C3 disc space most commonly on both preoperative and intraoperative radiographs. It was found at the C2–C3 disc space in 69.2% (18/26) of preoperative films and 80.8% (21/26) of intraoperative films. The complete breakdown of the mandibular angle location on both preoperative and intraoperative radiographs is shown in Table 1.

In preoperative standing lateral radiographs, the mandibular angle was located an average distance of 0.53 ± 6.56 mm from the C2–C3 disc space. In intraoperative supine radiographs, the AM was located an average distance of 3.24 ± 6.31 mm from the C2–C3 disc space. The difference in distance from the mandibular angle to

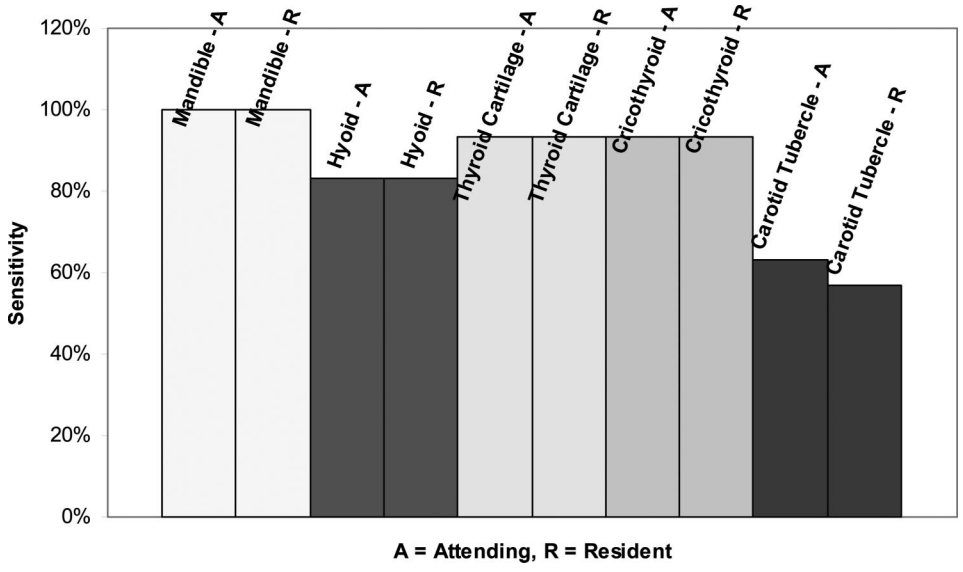

Figure 2. Frequency with which anterior neck landmarks were able to be palpated by both the senior attending (A) and a PGY-3 resident (R) in 30 consecutive patients undergoing ACDF.

Table 1. Location of the Mandibular Angle and the Hyoid Bone Relative to the Cervical Spine

	Mandibular Angle		Hyoid Bone	
	Preoperative	Intraoperative	Preoperative	Intraoperative
C2 body	11.6% (3/26)	11.6% (3/26)	0%	0%
C2/C3	69.2% (18/26)	80.8% (21/26)	3.8% (1/26)	3.8% (1/26)
C3 body	19.2% (5/26)	3.8% (1/26)	11.6% (3/26)	15.4% (4/26)
C3/C4	0%	3.8% (1/26)	38.4% (10/26)	46.2% (12/26)
C4 body	0%	0%	23.0% (6/26)	15.4% (4/26)
C4/C5	0%	0%	11.6% (3/26)	15.4% (4/26)
C5 body	0%	0%	0%	3.8% (1/26)
Unavailable (poor quality radiograph)	0%	0%	11.6% (3/26)	0%

each disc space from C2–C7 was not statistically significant between the preoperative and intraoperative radiographs (P value = 0.14–0.98). The vertical distances from the mandibular angle to the remaining subaxial cervical intervertebral disc spaces is shown in Table 2.

Hyoid Bone

The location of the hyoid bone on preoperative standing lateral cervical spine radiographs matched its location on intraoperative supine radiographs in 65% of patients (17/26), with only 27% (7/26) being located at the exact same body or interspace. The hyoid bone was located at the C3–C4 disc space most commonly on both preoperative and intraoperative radiographs. It was found at the C3–C4 disc space in 38.4% (10/26) of preoperative radiographs and 46.2% (12/26) of intraoperative radiographs. The complete breakdown of the hyoid bone location relative to the cervical spine is shown in Table 1.

In preoperative standing lateral radiographs, the hyoid bone was located an average distance of −3.53 ± 10.29 mm from the C3–C4 disc space. In intraoperative supine radiographs, the hyoid bone was located an average distance −3.60 ± 11.70 mm from the C3–C4 disc space. The difference in distance from the hyoid bone to each disc space from C2–C7 was not statistically significant between the preoperative and intraoperative radiographs (P value = 0.48–0.98). The distances from the hyoid bone to the remaining cervical disc spaces is shown in Table 3.

Table 2. Position of the Mandibular Angle Relative to Cervical Spine Intervertebral Disc Spaces*

	Preoperative Radiographs		Intraoperative Radiographs		
Level	Distance (mm)	Range	Distance (mm)	Range	P†
C2–C3	0.53 ± 6.56	−10.00 to 13.60	3.24 ± 6.31	−15.70 to 12.30	0.14
C3–C4	21.33 ± 7.71	7.00–34.50	24.22 ± 7.60	0.00–34.43	0.19
C4–C5	41.68 ± 9.10	25.00–58.00	44.10 ± 9.82	14.29–58.62	0.37
C5–C6	61.11 ± 11.03	41.00–77.00	63.02 ± 12.77	30.08–86.21	0.57
C6–C7	80.39 ± 11.71	59.00–103.00	80.26 ± 15.01	45.86–108.42	0.98

*Plus-minus values are means ± SD.
†P calculated by the student t test.

Table 3. Position of the Hyoid Bone Relative to Cervical Spine Intervertebral Disc Spaces*

	Preoperative Radiographs		Intraoperative Radiographs		
Level	Distance (mm)	Range	Distance (mm)	Range	P†
C2–C3	−22.35 ± 11.41	−49.00 to −3.00	−22.86 ± 10.41	−38.95 to −1.94	0.88
C3–C4	−3.53 ± 10.29	−25.00 to 16.00	−3.60 ± 11.70	−25.30 to 16.50	0.98
C4–C5	16.36 ± 10.11	−1.00 to 34.50	17.67 ± 11.83	0.00–42.37	0.69
C5–C6	36.32 ± 11.66	16.00–65.00	36.64 ± 14.79	10.53–70.76	0.94
C6–C7	55.81 ± 12.52	34.00–85.00	52.73 ± 14.82	26.32–90.68	0.48

*Plus-minus values are means ± SD.
†P calculated by the student t test.

Relative Precision of Mandibular Angle and Hyoid Bone

In the comparison of preoperative standing lateral radiographs, the mandibular angle showed significantly less variability with respect to distance from the C2–C3 disc space than did the hyoid bone (variance: 41.66 *vs.* 129.11, $P = 0.004$), and there was also a trend toward less variance with respect to the distance from the C3–C4 disc space ($P = 0.09$). Other disc spaces showed nonsignificant differences in variance of distance from either landmark in the preoperative series. Intraoperative radiographs showed only nonsignificant differences with respect to variance of distance from either the mandibular angle or the hyoid bone. The results of both the preoperative and intraoperative comparisons are summarized in Table 4.

■ Discussion

The ability to safely mobilize the visceral and neurovascular structures of the neck, thereby facilitating adequate spinal exposure for decompression, instrumentation, arthrodesis, or arthroplasty, are essential steps for successful anterior cervical spine surgery. Improper localization of the skin incision may portend difficulty during the surgery, which may lead to increased pressure and duration of soft tissue retraction. Although the development of postoperative dypshagia remains poorly understood, it has been linked with longer surgery, obesity, tissue damage from esophageal retraction against an inflated endotracheal tube, esophageal impingement, and the development of prevertebral swelling, and nerve damage.[8–15] Proper placement of the skin incision can maximize the mobile working window and minimize the risk of developing these pressure-related phenomena in the neck.

The use of traditional superficial anterior neck landmarks help identify vertebral levels about the anterior aspect of the neck. The hyoid bone typically overlies C3, whereas the thyroid cartilage spans the C4 body, the C4–C5 interspace, and the C5 body.[3,5,6] The cricoid cartilage is usually at the level of the C6 vertebral body, which can be confirmed by palpation of the carotid tubercle, the anterior tubercle of the C6 transverse process.[3,5] These landmarks, when palpable, can significantly help the surgeon localize the incision for anterior approaches to the cervical spine. However, in obese or muscular patients or those with short and wide necks,

Table 4. Relative Precision of Cervical Spinal Landmarks: Mandibular Angle *Versus* Hyoid Bone

	Preoperative Radiographs					Intraoperative Radiographs				
	AM		Hyoid Bone			AM		Hyoid Bone		
Level	Distance (mm)	Variance	Distance (mm)	Variance	*P**	Distance (mm)	Variance	Distance (mm)	Variance	*P**
C2–C3	0.53	41.66	−22.35	129.11	0.004	3.24	92.47	−22.86	104.03	0.39
C3–C4	21.33	58.41	−3.53	101.86	0.09	24.22	300.80	−3.6	200.59	0.16
C4–C5	41.68	85.62	16.36	97.95	0.37	44.1	584.09	17.67	357.61	0.11
C5–C6	61.11	138.75	36.32	130.97	0.45	63.02	815.12	36.64	534.95	0.15
C6–C7	80.39	174.91	55.81	156.78	0.40	80.26	1569.63	52.73	1027.47	0.19

*P calculated by the F test.

the surgeon may find that these landmarks are not reliably palpable.[4] In this situation, it may be necessary to localize the skin region over the appropriate vertebral level with a preoperative fluoroscopic image. Alternatively, we propose that the mandibular angle may be useful as an additional landmark to aid the surgeon during localization of the skin incision in anterior cervical spine surgery.

The mandible is highly mobile and may be active during mastication, speech, and swallowing. We have previously shown that significant upper cervical spinal motion results from mastication while immobilized in a hard cervical collar, likely the result of mandibular action being restricted against the collar which causes the head to compensate and tilt backwards.[16] Without a collar, there is no detectable cervical spine motion due to unrestricted mandibular action. Because of this potential for positional variability, it is likely that the mandible has been neglected as a potentially useful landmark for cervical spine level localization. Previously, the AM has been described only anecdotally to correspond to both the C1–C2 and C2–C3 interspaces.[5,6] However, in our review of the literature, we were unable to find any rigorous studies that specifically evaluated the relative position of the AM in relation to the cervical spine.

Our results suggest that the mandible is consistently located at the C2–C3 disc space. The 100% correlation between the position of the mandible in preoperative standing films and in intraoperative supine films further demonstrates that the preoperative film can serve as a template for localization of the skin incision at the time of surgery, and that the mandible does not "shift" its relative position to the spine in going from standing to supine. This study demonstrates that when the neck is prepared and positioned in a predictable fashion, the mandible may also be used to approximate cervical spinal level. The data provided herein may prove that the mandibular angle is useful not only as an adjunct for localizing incisions at the C2–C3 level, but also for more caudad levels, as depicted in Table 2.

Our evaluation of the relative position of the hyoid bone to the cervical spine revealed that it was most commonly located at the level of the C3–C4 interspace, which is slightly caudad to its previous descriptions at the C3 vertebral body, although potential variations in measurement technique cannot be ignored.[3,5,6] The hyoid bone was also more variable in position when compared with that of the mandibular angle, with the hyoid being located at the C3–C4 interspace in 38.4% and 46.2% of patients from preoperative standing to intraoperative supine radiographs, respectively. In contrast, the mandibular angle was located consistently at the C2–C3 interspace in 69.2% and 80.8% of preoperative and intraoperative radiographs, respectively. Our analysis of measurement variance using the 2 landmarks revealed that the mandibular angle had more precision in predicting the location of the C2–C3 disc space, and that there was a trend toward improved precision in predicting the location of the C3–C4 disc space, as well. These findings suggest that, despite being a classic anterior neck landmark, the hyoid bone may have more individual positional variability regarding its relative location to the cervical spine disc spaces than previously thought.

One limitation of the current study was the inability to include the C7–T1 interspace in the analysis, usually the result of poor-quality intraoperative fluoroscopic radiographs that failed to adequately visualize the C7–T1 disc space. Another potential study limitation was that the current study was not performed in obese patients or those with short, wide necks, the population in whom this additional neck landmark may prove to be the most useful. Our goal in this study was to describe the relationship, if any, of the mandibular angle to the cervical spine levels in all patients. Future study will evaluate the efficacy of this landmark in the subset of patients with short, wide necks. A final study limitation was the inability to include the thyroid or cricoid cartilage in the comparative analysis; however, this is the subject of ongoing research within our group. In a prospective study, we are currently comparing the efficacy of the various skin landmarks described earlier in their ability to correctly predict spinal level.

In conclusion, although the mandible is a component of the highly mobile temporomandibular joint, the AM is a highly consistent bony landmark that is routinely located at the C2–C3 intervertebral disc space. Additionally, the mandibular angle is located a predictable vertical distance away from more caudad cervical spinal levels, with a precision that is equivalent or superior to

that of the hyoid bone. We submit that the mandibular angle is an additional superficial anatomic anterior neck landmark that can help localize the skin incision before anterior cervical spine surgery.

■ Key Points

- The frequency with which anterior neck landmarks were palpable by the surgeon and assisting senior residents was as follows: AM (100%), hyoid bone (83%), thyroid cartilage and cricothyroid membrane (93%), and carotid tubercle (Surgeon: 63%, Resident: 57%, $P = 0.79$).
- Although the mandible is a component of the highly mobile temporomandibular joint, the AM is a highly consistent bony landmark that is routinely located at the C2–C3 intervertebral disc space.
- There was 100% correlation between the position of the mandibular angle in the preoperative standing lateral radiograph and the intraoperative supine lateral radiograph.
- The distances between the AM or hyoid to each disc space did not vary significantly between preoperative and intraoperative radiographs ($P > 0.05$).
- The mandibular angle was shown to be the most consistently palpable landmark. Further, the distance from the mandible, measured on preoperative plain lateral cervical spine radiographs, is an accurate template to determine cervical spine levels during anterior cervical spine surgery.

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