ORIGINAL ARTICLE

Location of the apex of the lower central incisor

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Clinicians have always had difficulty finding the apex of the lower central incisor on a lateral cephalometric radiograph. This study was undertaken to define the radiographic anatomy surrounding the true apex. Standard cephalograms were taken of 38 skulls with metallic markers in the socket apex of 1 lower central incisor. Similar cephalograms were taken with the lower central incisor apex positioned in the central ray of the x-ray source. The comparison of the marked apices in the complete skulls and their separate mandibles showed that there was no distortion. Measurements from the markers to the lingual and labial symphyseal borders located the apices labial of center. (Am J Orthod Dentofacial Orthop 2000;118:429-31)

Of the common lateral cephalometric landmarks, the apex of the lower central incisor is perhaps the most difficult to accurately locate. Baumrind and Frantz[1,2] studied a sample of 20 lateral headfilms traced by 5 judges and concluded that the lower incisor apex was clearly the least reliable of all of the landmarks identified. They said that the apex of the lower incisor was an example of a landmark for which the confounding "noise" from adjacent and superimposed structures leaves no direct physical evidence on the headfilm. The literature is replete with studies of the difficulty in the discovery and reproducibility of the location of the apex.

The inclination of the lower central incisor is an important part of many cephalometric analyses, including those of Downs, Riedel, Ricketts, Steiner, and Tweed, to name a few. Because the inclination of the lower central incisor can play a vital role in cephalometric diagnosis, and ultimately, the treatment of the patient's malocclusion, the correct location of the apex should be determined by cephalometric anatomic parameters.

Krogman[3] cited the positional analyses of Simon, de Coster, Moorrees, Sassouni, and Leroi-Gourhan as efforts to locate landmarks by reference to a presumed relationship to other anatomic structures.

In 1994, Tng et al[4] tried to validate the locations of a number of cephalometric landmarks, including the more prominent lower central incisor's apex. He sectioned 30 dry skulls sagittally, removed medullary bone immediately inferior to the apex, and widened the root-end enough to glue a 1-mm steel ball to the apical end of the tooth. A cephalogram was taken with the ball in place and another with the ball removed. X and Y coordinates were established. The difference between the "true landmark" and the estimated position of the apex was calculated. "The mean differences were statistically significant … Lower incisor apex was estimated backward of the true points, thereby tending to procline the teeth and increasing the lower incisor angulation." Again, it was a study on reproducibility but based on the actual landmark.

In 1996, Fuhrman[5] used 11 dissected cadaver mandibles and compared macroscopic measurements at the incisors' apical level with cephalograms and CT scans. He concluded that accurate cephalometric assessment of the apices was generally not possible in the cephalograms. In contrast, the correlation between his jaw specimens and the CT images was highly significant, and he found that the incisors' apices were located in the middle of the labiolingual dimension of the symphysis.

Graber[6] reported that William Golden of the Bolton Foundation at the First AAO Cephalometric Workshop assured his colleagues that whether they considered the area near the central ray or the peripheral regions, there was no variation in enlargement.

The purpose of this investigation was 2-fold: (1) to see if there was any distortion of the mandibular central incisor apex in the cephalogram by comparing it with a film of the same incisor's apex at the ear rod level of the cephalostat, and (2) to determine where the apex is most likely to be located using anatomic parameters.

MATERIAL AND METHODS

Thirty-eight complete skulls, independent of their occlusal classification, were obtained on loan from the Hamann-Todd Osteological Collection, which is housed at the Cleveland Museum of Natural History. The skulls ranged in age from 16 to 29 years (mean age was 22.8 years ± 3.3 SD). The sample was composed of 29 males and 9 females and included 6 white individuals and 32 African Americans.

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Fig 1. Ball at the apex of the lower central incisor.

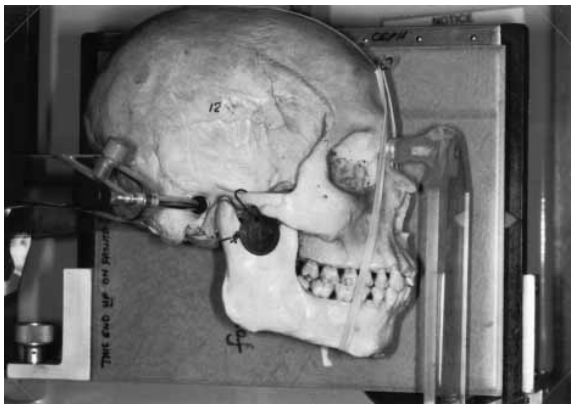

Fig 2. Skull in Broadbent-Bolton cephalometer.

Fig 3. Incisor apex in ear rod location

Either the left or the right lower central incisor, depending on its ease of removal, was taken from its socket in each of the 38 mandibles. The assumption was made that at the apical level, based on Fuhrman's CT-scan study of lower central incisor facial and lingual bone plates, there was no difference in labiolingual location of left or right central incisors. A straight orthodontic ball (.028-inch diameter) clasp was inserted into the socket to its maximum depth to mark the apex (Fig 1). Only the position of the ball had any significance; the inclination of the wire was of no importance.

Table I. Paired samples statistics

Variables	*Mandible x-ray ± SD*	*Cephalometric x-ray ± SD*	*P value*
SW	6.43 ± 1.44	6.49 ± 1.37	.419
LiB	3.99 ± 1.01	4.02 ± 1.00	.629
%LiB	62.63 ± 11.34	62.43 ± 11.47	.763
LaB	2.44 ± 1.06	2.47 ± 1.02	.531
%LaB	37.39 ± 11.36	37.57 ± 11.47	.779

SW, Symphysis width; *LiB,* lingual bone; *LaB,* labial bone. Measurements in millimeters.

Each skull, with its mandible in occlusion and the apex of the lower central incisor marked, was placed in a Broadbent-Bolton cephalometer with the ear rods in the external auditory meati and the skull oriented according to the Frankfort horizontal plane (Fig 2). The distance of the film cassette to the midsagittal plane of each skull was recorded. Each individual mandible was also mounted on a tripod and positioned between the ear rods so that the central x-ray beam passed through the symphysis apical level. The same cassette-to-midsagittal-plane distance was used as in the corresponding conventional cephalogram (Fig 3).

Exposure in all cases was 3 pulses at 90 kV and 15 mA. Collimation (15 × 19 mm) and filtration were identical in all exposures, which were performed with the same Kodak X-Omatic 8 × 10-inch cassette, Lanex Fast screen, and Kodak TML/RA-1 8 × 10-inch film. Anode-to-midsagittal-plane distance was fixed at 5 feet. Development of all film was consistent throughout the study.

The lower incisor apical area of each skull x-ray and separate mandible x-ray was illuminated through a half-inch square opening in black construction paper overlaying a light box. A digital caliper (Mitutoyo Digimatic) was used to measure the shortest distance from the center of the marker ball to the external lingual contour of the symphysis (LiB) and to the external outline of the labial cortical plate (LaB). For each skull with mandible occluded and the mandible separate, the measurements were added together to determine the symphysis width (SW) at the apical level. Subsequently, the percentage of lingual bone (%LiB) and labial bone (%LaB) for the 2 samples was calculated.

A paired *t* test was computed to determine the difference in means between the skull and mandible in the conventional cephalostat position and the separate

mandible in the ear rod location. Significance was assessed at $P < .05$.

RESULTS

The paired *t* test revealed no significant difference between the cephalogram and the x-ray of the separate mandible for any of the variables measured (Table I).

The true location of the lower central incisor apex was most often found in an approximate 60:40 ratio from the external lingual parameter to the external labial outline of the symphysis at the apical level.

DISCUSSION

We found the lower central incisor apices to be more anterior than Fuhrman determined from CT scans. Of the 9 skulls with the marker ball lingual to the center of the symphysis, the average deviation was .28 mm.

The discrepancy between Fuhrman's location of the lower central incisor apices in the CT scans and ours may be explained by differences in the description and size of the samples. We used skulls of young adults unclaimed by relatives. It was assumed that the persons had never had orthodontic treatment. A majority of the skulls were male and African American. Fuhrman did not identify the sex, race, or age of his sample.

Tng et al used a 1-mm steel ball to designate the lower central incisor apex, and our .028-inch ball was equivalent to a 0.7-mm ball; thus, the location of the apex was more finite than Tng's marker.

Trigonometry demonstrates that the apex of a 22-mm lower central incisor, mislocated buccally or lingually by 3 mm, would make an error of 8° in the inclination of the tooth. There should be concern, then, about the validity of any cephalometric analysis that uses the inclination of the lower central incisor in formulating the patient's diagnosis and treatment plan, particularly when the apex is estimated lingual to the middle of the symphysis at the apical level.

CONCLUSIONS

The oriented cephalometric headfilm, as commonly used in orthodontic diagnosis, is as accurate as its similarly oriented mandible with its apical area exposed to the central x-ray beam. Therefore, the cephalogram can be used with confidence that its lower central incisor apical area is not distorted, even though the location is distant from the central x-ray beam.

Because our study showed statistically where the apex of the lower central incisor is in the sample, locating it slightly forward of halfway from the lingual to the labial surface of the symphysis at the apical level would seem to be a valid estimate of its location in a cephalometric radiograph.

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