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TECHNICAL NOTE

ODONTOLOGY

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Cone-beam Computed Tomography for Analyzing Variations in Inferior Alveolar Canal Location in Adults in Relation to Age and Sex*

ABSTRACT: Previous studies have indicated that the relative position of the inferior alveolar canal and its mental and mandibular foramina in adults vary with age and show sexual dimorphism. Conceivably, these purported differences could be of forensic value for determining identity of human remains. This study was designed to determine the influence of age and sex on the relative position of inferior alveolar canal and its foramina in cone-beam computed tomography (CBCT) studies of adults. Existing CBCT studies of the maxillofacial region from dentate adult patients selected at random and ranging in age from 18 to 80 years (110 women and 55 men) were acquired, and the location of the inferior alveolar canal was assessed at three points: the mandibular foramen in axial view, the inferior alveolar canal in coronal view, and the mental foramen in coronal view. Measurements were also expressed for the mental foramen as the percentile position from the nearest superior bony crest to the inferior border; corresponding position of the mandibular foramen from the anterior to the posterior border of the mandibular ramus; and for the inferior alveolar canal at the level of first permanent molar from the nearest buccal bony surface to the lingual surface and from the superior alveolar crest to the inferior border. Regression analyses were performed on the variables with regard to the effects of age and sex. Most analyses resulted in no statistical significance ($p < 0.05$). A few of the sex-specific traits demonstrated near-statistically significant effects; however, these characterizations generally resulted in a 1% or less change per age decade. Overall, the results demonstrated that the relative location of the inferior alveolar canal and associated foramina in adults remain fairly constant without regard to age and sex.

KEYWORDS: forensic science, cone-beam computed tomography (CBCT), inferior alveolar canal, mental foramen, mandibular foramen, age, sex, adults

Computed tomography (CT), as a three-dimensional radiographic imaging technique, has been in use for several decades and has been demonstrated to be effective for head and neck imaging, both clinically (1) and for anthropologic/forensic studies (2). Cone-beam computed tomography (CBCT), a more recently introduced variation of CT, has shown several advantages over the conventional CT method, including improved data acquisition efficiency, spatial resolution, and spatial resolution uniformity, all of which have resulted in significantly improved three-dimensional imaging of osseous structures (3,4).

Previous studies using a variety of anatomic methods have indicated that the relative positions of the inferior alveolar canal and its mental and mandibular foramina in adults vary with age (5,6). Similarly, sexual dimorphism has been reported (7–9). Conceivably, these purported differences could be of forensic value for determining identity of human remains. This study was designed to determine the influences of age and sex on the relative position in adults of the inferior alveolar canal and its foramina in CBCT studies of the maxillofacial region.

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Materials and Methods

Existing CBCT studies of the maxillofacial region from dentate adult patients selected at random ranging in age from 18 to 80 years, 110 women and 55 men, and acquired by the CB MercuRay™ system (Hitachi Medical Systems America, Inc., Twinsburg, OH) were used. (The great majority of the CBCT studies in this report had originally been performed on patients from the Memphis, Tennessee locale who were being evaluated pending placement of metal dental implants. The fact that such patients are much more commonly female is reflected in the sex ratio in this study.) Length measurement ROI tool of OsiriX (http://www.osirix-viewer.com) was used to assess the location of inferior alveolar canal at three points: the mandibular foramen in axial view, the inferior alveolar canal in coronal view, and the mental foramen in the coronal view (Fig. 1). Measurements were also expressed for the mental foramen as the percentile position from the nearest superior bony crest to the inferior border; corresponding position of the mandibular foramen from the anterior to the posterior border of the mandibular ramus; and for the inferior alveolar canal at the level of first permanent molar from the nearest buccal bony surface to the lingual surface and from the superior alveolar crest to the inferior border. Statistical analyses were performed to verify the

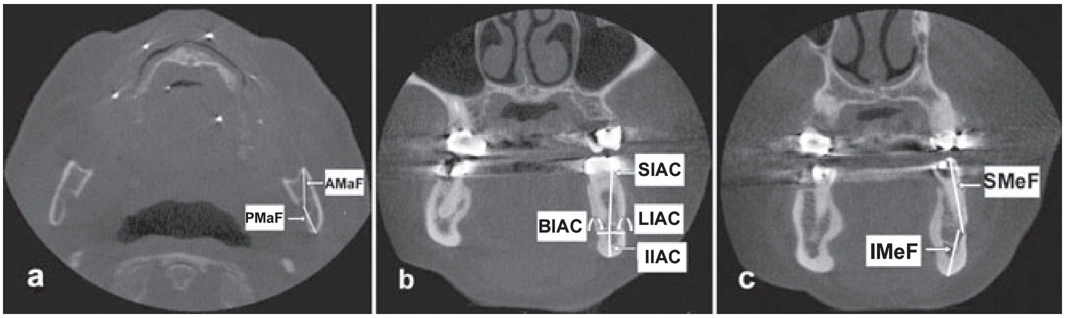

FIG. 1—*Three locations where measurements were taken for the position of inferior alveolar canal (IAC): (a) axial view with anterior and posterior measurements at the level of mandibular foramen; (b) coronal view with superior, inferior, buccal, and lingual measurements at the level of first molar; (c) coronal view with superior and inferior measurements at the level of mental foramen.*

significance of the findings. Regression analyses were performed on the variables considering the effect of age as the independent variable, and separate analyses were performed considering men and women.

Results

The sample consisted of 165 imaging studies with 110 women and 55 men. The measurements taken at each location were as follows: the anterior and posterior positions of the mandibular foramen in the axial view; the superior, inferior, buccal, and lingual positions of the inferior alveolar canal at the crest of the inter-radicular bone at the mandibular first molar in the coronal view; and the superior and inferior positions of the mental foramen in the coronal view. The measurements were analyzed using the variables defined in Table 1.

Regression analyses on the variables considering the effect of age as the independent variable, and separate analyses considering men and women are shown in Table 2. Most analyses resulted in no statistical significance ($p < 0.05$). A few of the sex-specific traits demonstrated near-statistically significant effects; however, the effect was small and difficult to functionally characterize.

Specifically, the data that approached statistical significance were the AMaF% for men ($p = 0.084$) (Fig. 2) showing a positive correlation ($r = 0.292$), the AMaF% for women ($p = 0.050$) (Fig. 3) showing a negative correlation ($r = -0.227$), and SIAC% for women ($p = 0.063$) (Fig. 4) showing a negative correlation ($r = -0.254$). For men, the AMaF% is expected to increase by about 1% in 9 years, while for women, the AMaF% is expected to decrease by about 1% in 12 years. Finally, for women, the SIAC% is expected to decrease by about 1% in 14 years. These characterizations generally resulted in a 1% or less change per age decade.

Thus, the results overall demonstrated that the relative location of the canal and associated foramina remain fairly constant with regard to age and sex.

TABLE 1—*Definitions of the variables used in analysis of the data.*

Definitions of Variables	
AMaF	Anterior Mandibular Foramen
PMaF	Posterior Mandibular Foramen
SIAC	Superior Inferior Alveolar Canal
IIAC	Inferior Inferior Alveolar Canal
LIAC	Lingual Inferior Alveolar Canal
BIAC	Buccal Inferior Alveolar Canal
SMeF	Superior Mental Foramen
IMeF	Inferior Mental Foramen
AMaF%	AMaF/(AMaF + PMaF) × 100
SIAC%	SIAC/(SIAC + IIAC) × 100
LIAC%	LIAC/(LIAC + BIAC) × 100
SMeF%	SMeF/(SMeF + IMeF) × 100

Discussion

Levine et al. (5) in a U.S. CT study reported that older patients and caucasoid patients on average have less distance between the buccal aspect of the inferior alveolar canal and the buccal mandibular border. Similarly, Taiwanese CT studies (7,8) have indicated that there are significant sex differences in positions of both the mandibular and mental foramina. Cutright et al. (9) in a U.S. study of cadaveric heads reported that the position of the mental foramen showed a small but significant difference in location between men and women as well as between races. And Thai studies (10,11) have shown sex differences in the relative position of the mental foramen in adult skulls and isolated mandibles.

By contrast, Afsar et al. (12) in Canada found in a panoramic and cephalometric radiograph study that the relative position of the

TABLE 2—*Data from near-statistically significant regression analyses (with relevant information in bold type).*

	Age with AMaF%			Age with SIAC%			Age with LIAC%			Age with SMeF%		
	Sample	Men	Women	Sample	Men	Women	Sample	Men	Women	Sample	Men	Women
r	−0.077	**0.292**	**−0.227**	0.169	0.012	**−0.254**	0.073	−0.023	0.107	0.07	−0.034	0.13
p	0.42	**0.084**	**0.05**	0.147	0.961	**0.063**	0.534	0.925	0.440	0.503	0.857	0.307
a*	51.36	**44.322**	**54.084**	76.028	73.57	**76.818**	37.436	39.65	36.593	57.714	59.127	56.913
b†	−0.029	**0.109**	**−0.086**	−0.05	0.004	**−0.071**	0.051	−0.013	0.08	0.019	−0.009	0.036
	(0.036)	**(0.061)**	**(0.043)**	(0.034)	(0.081)	**(0.038)**	(0.082)	(0.134)	(0.103)	(0.028)	(0.051)	(0.035)
n	112	**36**	**75**	75	20	**54**	75	20	54	95	30	64

Numbers in parentheses beneath the regression coefficient, b, are the ‘‘standard error’’ of the estimates.
r = correlation coefficient; *regression constant; †regression coefficient; *n* = sample size.

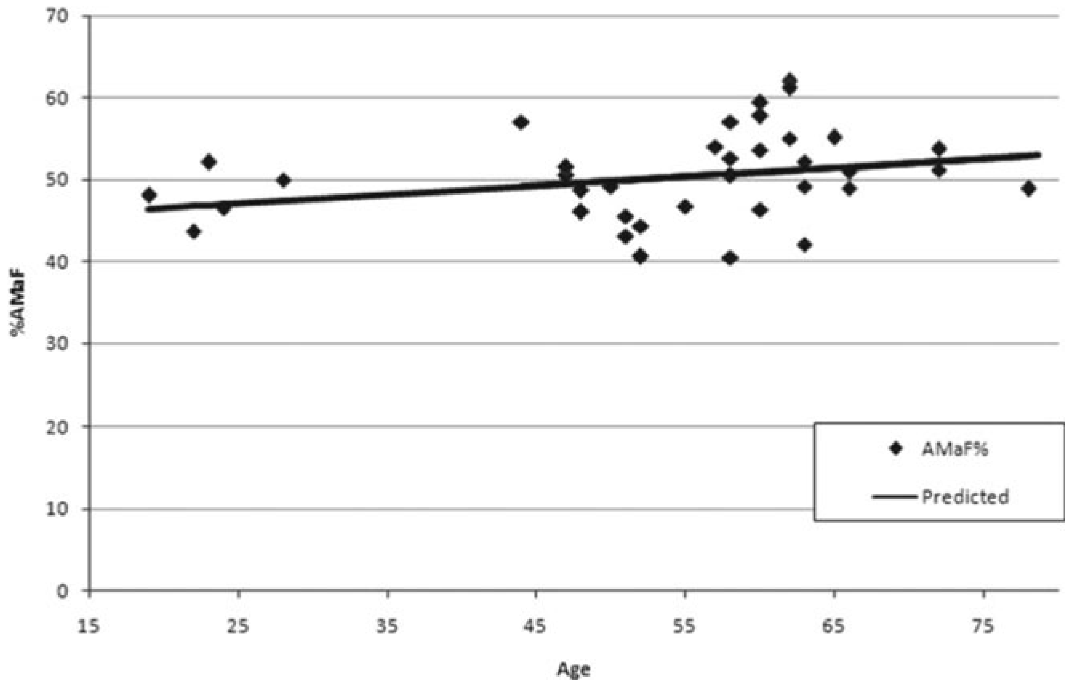

FIG. 2—*AMaF% compared to age in males.*

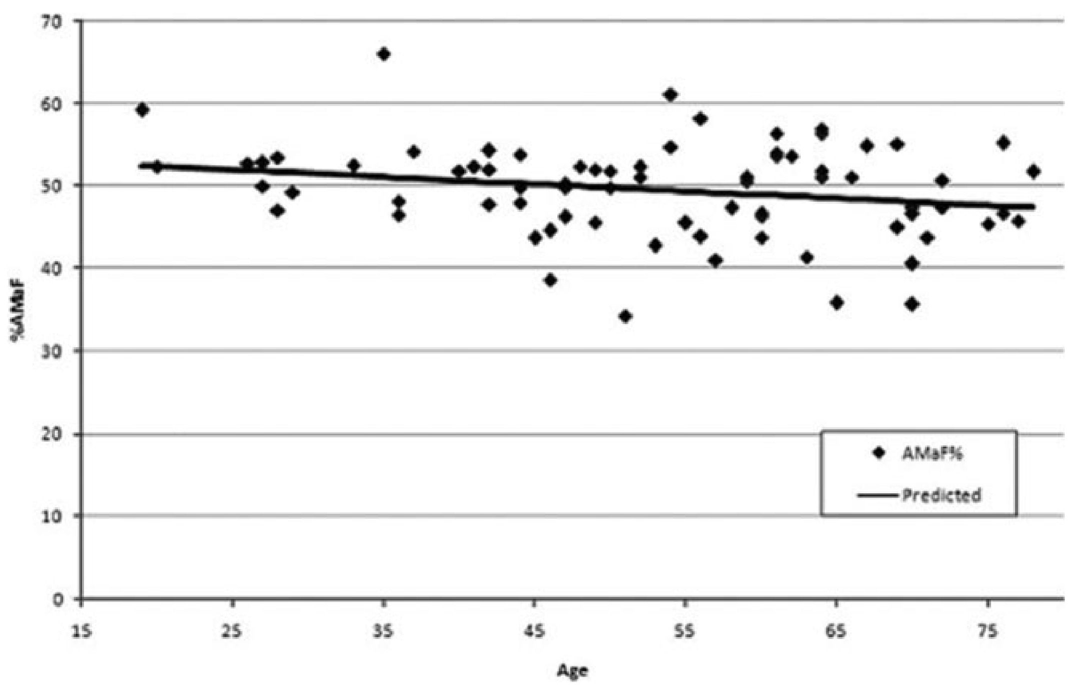

FIG. 3—*AMaF% compared to age in females.*

mandibular foramen is highly variable and without age or sex correlations. And Kieser et al. (13) in a microdissection study of edentulous cadavers in New Zealand found no significant differences between the sexes or with age in height and distribution of the inferior alveolar nerve.

In the present study, we also found minimal differences in the location of the inferior alveolar canal at the levels of the mandibular foramen, first permanent molar and mental foramen with respect to age and sex. Although three relative position values, the AMaF% for both men and women and the SIAC% for women, demonstrated a small correlation with increasing age, the correlation was so small that its characterization likely would be of limited value in determining age of a subject in forensic investigations. Overall, our results demonstrated that the relative locations of the canal and associated foramina remain fairly constant with increasing age and sex.

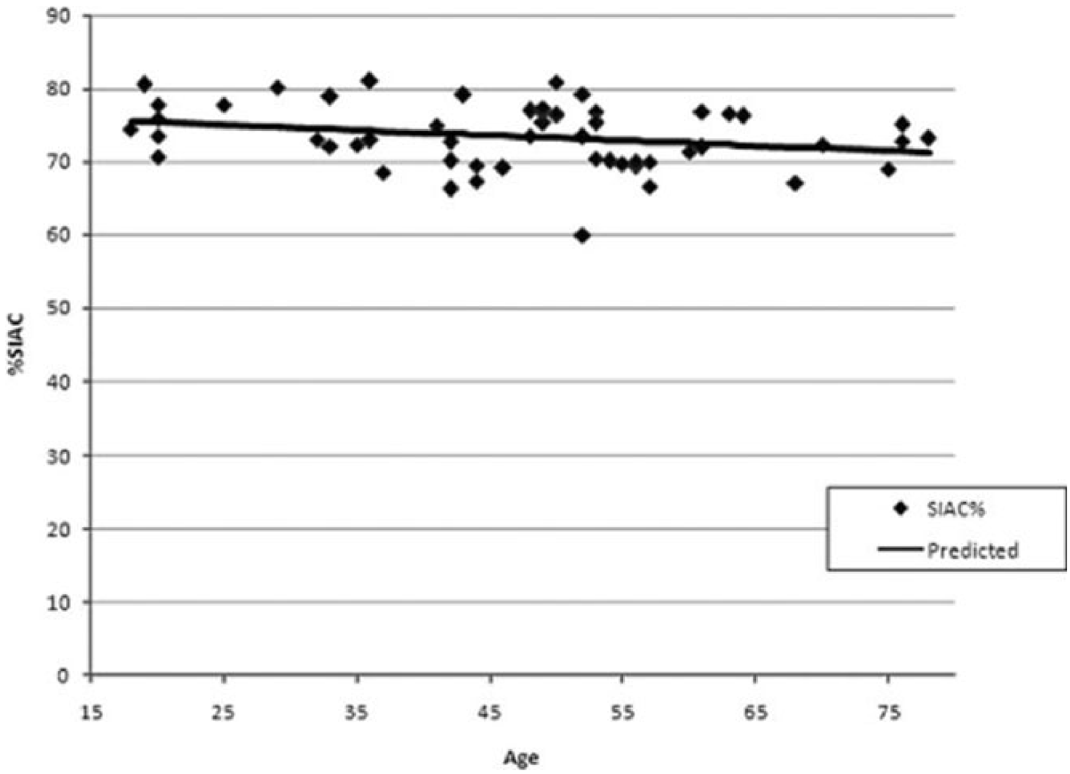

FIG. 4—*SIAC% compared to age in females.*

Thus, although the use of these values as forensic determinants of age or sex is unlikely, with future characterization of the canal location, a relatively consistent landmark potentially could be defined for use by clinical practitioners, such as dentists and surgeons.

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References

1. White SC, Pharoah MJ. The evolution and application of dental maxillofacial imaging modalities. Dent Clin North Am 2008;52(4):689–705.
2. Tyrrell AJ, Evison MP, Chamberlain AT, Green MA. Forensic three-dimensional facial reconstruction: historical review and contemporary developments. J Forensic Sci 1997;42(4):653–61.
3. Scarfe WC, Farman AG. What is cone-beam CT and how does it work? Dent Clin North Am 2008;52(4):707–30.
4. De Greef S, Willems G. Three-dimensional cranio-facial reconstruction in forensic identification: latest progress and new tendencies in the 21st century. J Forensic Sci 2005;50(1):12–7.
5. Levine MH, Goddard AL, Dodson TB. Inferior alveolar nerve canal position: a clinical and radiographic study. J Oral Maxillofac Surg 2007;65(3):470–4.
6. Gershenson A, Nathan H, Luchansky E. Mental foramen and mental nerve: changes with age. Acta Anat (Basel) 1986;126(1):21–8.
7. Kane AA, Lo LJ, Chen YR, Hsu KH, Noordhoff MS. The course of the inferior alveolar nerve in the normal human mandibular ramus and in patients presenting for cosmetic reduction of the mandibular angles. Plast Reconstr Surg 2000;106(5):1162–74.
8. Lo LJ, Wong FH, Chen YR. The position of the inferior alveolar nerve at the mandibular angle: an anatomic consideration for aesthetic mandibular angle reduction. Ann Plast Surg 2004;53(1):50–5.
9. Cutright B, Quillopa N, Schubert W. An anthropometric analysis of the key foramina for maxillofacial surgery. J Oral Maxillofac Surg 2003;61(3):354–7.
10. Agthong S, Huanmanop T, Chentanez V. Anatomical variations of the supraorbital, infraorbital, and mental foramina related to gender and side. J Oral Maxillofac Surg 2005;63(6):800–4.
11. Apinhasmit W, Methathrathip D, Chompoopong S, Sangvichien S. Mental foramen in Thais: an anatomical variation related to gender and side. Surg Radiol Anat 2006;28(5):529–33.
12. Afsar A, Haas DA, Rossouw PE, Wood RE. Radiographic localization of mandibular anesthesia landmarks. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;86(2):234–41.
13. Kieser J, Kieser D, Hauman T. The course and distribution of the inferior alveolar nerve in the edentulous mandible. J Craniofac Surg 2005;16(1):6–9.

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