Original Article

Maxillary and Mandibular Dentoalveolar Heights of French-Canadians 10 to 15 Years of Age

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ABSTRACT

Objective: To establish reference data for anterior and posterior dentoalveolar heights of growing French-Canadians with untreated normal occlusions and malocclusions.

Materials and Methods: The mixed longitudinal sample includes 227 French-Canadians, 119 male and 108 female, with cephalograms taken annually between 10–15 years of age. Maxillary and mandibular dentoalveolar heights were measured as the perpendicular distances of the incisor tips and first molar mesial cusp tips to the palatal (ANS-PNS) and mandibular (Go-Me) planes.

Results: Male dentoalveolar heights were significantly ($P < .05$) greater than female heights at all ages. Dentoalveolar heights at 15 years of age were significantly larger ($P < .05$) than at 10 years of age, with differences ranging from 2.1–4.2 mm in male subjects and from 2.1–3.8 mm in female subjects. The greatest difference in dentoalveolar heights between the 10- and 15-year-old age groups was for the maxillary first molar; the maxillary central incisor height showed the smallest age effects. The coefficients of variation were greater for the maxillary than the mandibular dentoalveolar heights. Correlations of dentoalveolar heights within jaws ranged from 0.53 to 0.82; correlations between jaws ranged from 0.30 to 0.44. The mandibular heights showed the strongest associations.

Conclusions: French-Canadian adolescents require age- and sex-specific reference data for dentoalveolar heights.

KEY WORDS: Dentoalveolar height; Cephalometrics; French-Canadians; Reference data; Adolescents; Eruption

INTRODUCTION

Adolescents undergo dramatic changes in maxillary and mandibular dentoalveolar heights that hold important clinical implications.[1] Due to greater vertical growth potential, dentoalveolar heights of adolescents can be easily manipulated and corrected. For instance, open and deep bite malocclusions, as well as hyperdivergent or hypodivergent facial types are typically treated by inhibiting or stimulating dentoalveolar growth. Determining how much dentoalveolar modification might be necessary during treatment requires reference data (ie, growth standards) and an understanding of how the heights are interrelated. To be clinically applicable, reference data must be population-specific, unbiased, and, perhaps most importantly, precise enough to estimate extreme percentiles.

Existing reference data for dentoalveolar heights of White adolescents are limited. The majority of studies pertaining to dentoalveolar heights do not provide reference data for clinical application. They were designed to compare superimposition methods,[2] describe longitudinal changes,[3] illustrate dentofacial maturation,[4,5] and evaluate different facial patterns.[6] For Whites, only two sets of reference data are currently available. The Michigan survey describes the dentoalveolar heights of untreated male (n = 47) and female (n = 36) subjects followed from 10 to 15 years of age.[7] The King's College School of Medicine and Dentistry study, conducted in UK, describes dentoalveolar heights of 58 male and 63 female Whites.[8] Due to lim-

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Table 1. Sample Sizes (N) by Sex, Age, and Dentoalveolar Heights[a]

		Age, Years					
Tooth	Sex	10	11	12	13	14	15
U1	M	111	115	114	115	111	109
	F	102	107	106	107	104	79
U6	M	106	105	104	97	90	87
	F	97	97	91	88	82	68
L1	M	111	116	116	118	113	113
	F	101	107	106	107	100	81
L6	M	99	98	94	93	87	78
	F	83	77	67	65	51	40

[a] U1 indicates upper incisor tip; U6, upper first molar mesial cusp tip; L1, lower incisor tip; and L6, lower first molar mesial cusp tip.

ited sample sizes and sample differences in dentoalveolar heights, additional reference data are needed to determine population parameters, especially for other population groups.

The purpose of this study was to describe the anterior and posterior dentoalveolar heights of growing French-Canadian adolescents between 10 and 15 years of age and to evaluate their interrelationships. This study is uniquely based on a large number of subjects who are representative of the larger population.

MATERIALS AND METHODS

The sample included untreated growing adolescents between 10 and 15 years of age with four French-Canadian grandparents. The records were collected by the Human Growth and Research Center, University of Montreal, Montreal, Canada. The sample was drawn from three randomly selected school districts representing the socioeconomic background of the larger population.[9] Within each district, the individuals were chosen at random from 107 randomly selected schools. This mixed-longitudinal sample includes 227 individuals (119 male and 108 female) with untreated normal occlusions and malocclusions (Table 1). The number of subjects decreased over time due to drop-outs, loss of teeth during the course of the study, and elimination of teeth with major restorations.

Calculation of Dentoalveolar Height

The cephalograms were traced and eight landmarks were identified and digitized (Figure 1). All lateral cephalograms were traced by the same technician, with an overall reliability ranging between 0.947 and 0.996. PNS and the lower molar mesial cusp tip showed the lowest and highest reliabilities, respectively. Maxillary dentoalveolar heights were defined as the perpendicular distances of the incisor tip and first molar mesial cusp tip to the palatal plane (ANS-PNS). The mandibular dentoalveolar heights were calculated based on the perpendicular distances of the lower incisor tip and lower first molar mesial cusp tip to the mandibular plane (Go-Me). The four dentoalveolar heights were corrected for radiographic enlargement.

Based on skewness and kurtosis, all of the dentoalveolar height measures were normally distributed. The mean, standard deviation, and coefficient of variation were calculated using SPSS (Version 12.0.1, SPSS Inc, Chicago, Ill). Student's *t*-tests were used to compare the growth changes between male and female subjects at each age based on a significance level of $P < .05$. Associations between dentoalveolar heights were quantified using Pearson product-moment correlations.

RESULTS

Statistical comparisons (*t*-test) showed that all but three of the dentoalveolar heights were significantly ($P < .05$) greater in male than female subjects (Table 2). The exceptions included maxillary first molar heights at the age of 13 years and mandibular first molar heights at the ages of 12 and 13 years. Mandibular incisor heights at age 15 years showed the largest sex difference.

All four dentoalveolar heights increased significantly with age (Table 2; Figures 2 and 3). Dentoalveolar heights at 15 years of age were 2.1–4.2 mm (7.6%–23.0%) greater than the heights at 10 years of age. Maxillary incisor dentoalveolar height showed, on average, the smallest changes between 10 and 15 years of age (8.4% for male; 8.8% for female subjects), followed by mandibular incisor (11.0% for male; 7.6% for female subjects), mandibular molar (13.6% for male; 12.1% for female subjects), and maxillary molar height (23.0% for male; 21.5% for female subjects), respectively.

Within each jaw the absolute variation, as represented by the standard deviation, was consistently greater for incisor dentoalveolar heights than for the molar heights. The coefficients of variation, representing relative variation, were approximately 2%–3% greater for the maxillary than for the mandibular dentoalveolar heights. The coefficients of variation showed no clear pattern of differences within the jaws (Table 2).

The correlations between the dentoalveolar heights (Table 3) within the mandible were larger (0.70–0.82) than the correlations within the maxilla (0.55–0.69). Incisor dentoalveolar heights show higher associations between arches (0.53–0.58) than molar heights (0.08–0.34). The correlations between dentoalveolar heights at the incisors of one arch and the dentoalveolar

Table 2. Maxillary and Mandibular Dentoalveolar Heights of Untreated French-Canadians 10 to 15 Years of Age (mm), Measured as the Perpendicular Distance of the Upper Dentition to the Palatal Plane (ANS-PNS) and for Lower Dentition to the Mandibular Plane (Go-Me)[a]

		10		11		12	
Tooth	Sex	Mean ± SD	CV	Mean ± SD	CV	Mean ± SD	CV
U1	M	25.0 ± 2.2*	8.8%	25.2 ± 2.3*	9.1%	25.6 ± 2.4*	9.4%
	F	23.9 ± 2.4	10.0%	24.4 ± 2.4	9.8%	24.7 ± 2.5	10.1%
U6	M	18.3 ± 1.8*	9.8%	19.2 ± 1.7*	8.9%	19.7 ± 1.7*	8.6%
	F	17.7 ± 1.8	10.2%	18.5 ± 2.1	11.4%	19.1 ± 2.0	10.5%
L1	M	35.4 ± 2.2*	6.2%	35.8 ± 2.3*	6.4%	36.3 ± 2.5*	6.9%
	F	34.1 ± 2.1	6.2%	34.7 ± 2.2	6.3%	35.3 ± 2.3	6.5%
L6	M	26.4 ± 1.8*	6.8%	26.7 ± 1.9*	7.1%	27.2 ± 2.1	7.7%
	F	25.6 ± 1.6	6.3%	26.1 ± 1.8	6.9%	26.7 ± 2.0	7.5%

[a] SD indicates standard deviation; CV, coefficient of variation; Change, mean changes from 10 to 15 years of age (mm); U1, upper incisor tip; U6, upper first molar mesial cusp tip; L1, lower incisor tip; and L6, lower first molar mesial cusp tip.

* Indicates significant sex difference ($P < .05$).

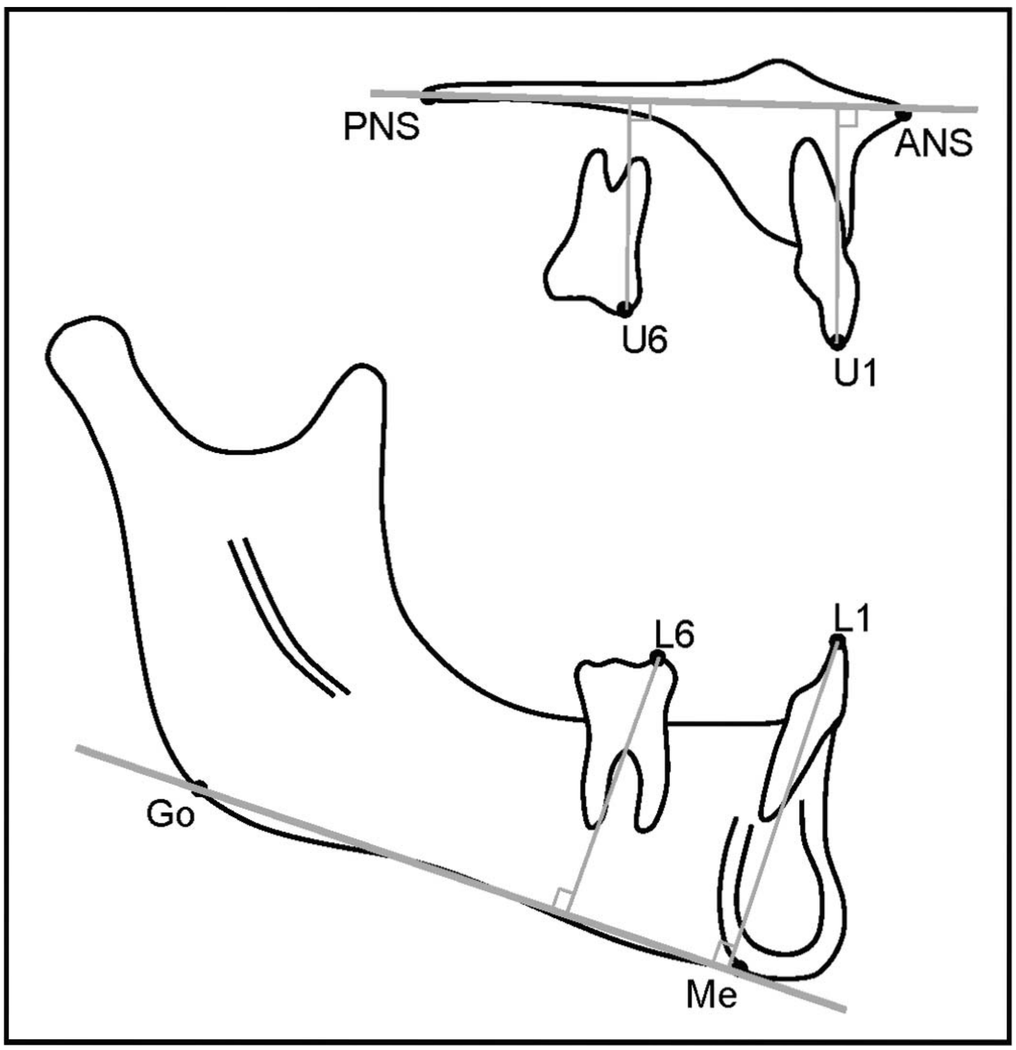

Figure 1. Digitized landmarks and dentoalveolar height measurements used in the maxilla and mandible. PNS indicates posterior nasal spine; ANS, anterior nasal spine; U1, upper incisor tip; U6, upper first molar mesial cusp tip; Go, gonion; Me, menton; L1, lower incisor tip; and L6, lower first molar mesial cusp tip.

Table 2. Extended

13		14		15		10–15
Mean ± SD	CV	Mean ± SD	CV	Mean ± SD	CV	Change ± SD
26.0 ± 2.4*	9.2%	26.6 ± 2.6*	9.8%	27.1 ± 2.6*	9.6%	2.1 ± 1.4
25.3 ± 2.5	9.9%	25.8 ± 2.7	10.5%	26.2 ± 2.7	10.3%	2.1 ± 1.0
20.3 ± 1.8	8.9%	21.6 ± 1.8*	8.3%	22.5 ± 1.8*	8.0%	4.2 ± 1.2
20.1 ± 2.1	10.5%	20.8 ± 2.1	10.1%	21.4 ± 2.3	10.8%	3.8 ± 1.2
37.3 ± 2.6*	7.0%	38.3 ± 2.8*	7.3%	39.5 ± 2.7*	6.8%	3.9 ± 1.2
35.9 ± 2.3	6.4%	36.4 ± 2.2	6.0%	36.7 ± 2.4	6.6%	2.6 ± 1.0
28.0 ± 2.2	7.9%	29.2 ± 2.3*	7.9%	30.5 ± 2.5*	8.2%	3.6 ± 1.3
27.6 ± 2.0	7.3%	28.3 ± 2.1	7.4%	28.7 ± 2.2	7.7%	3.1 ± 1.6

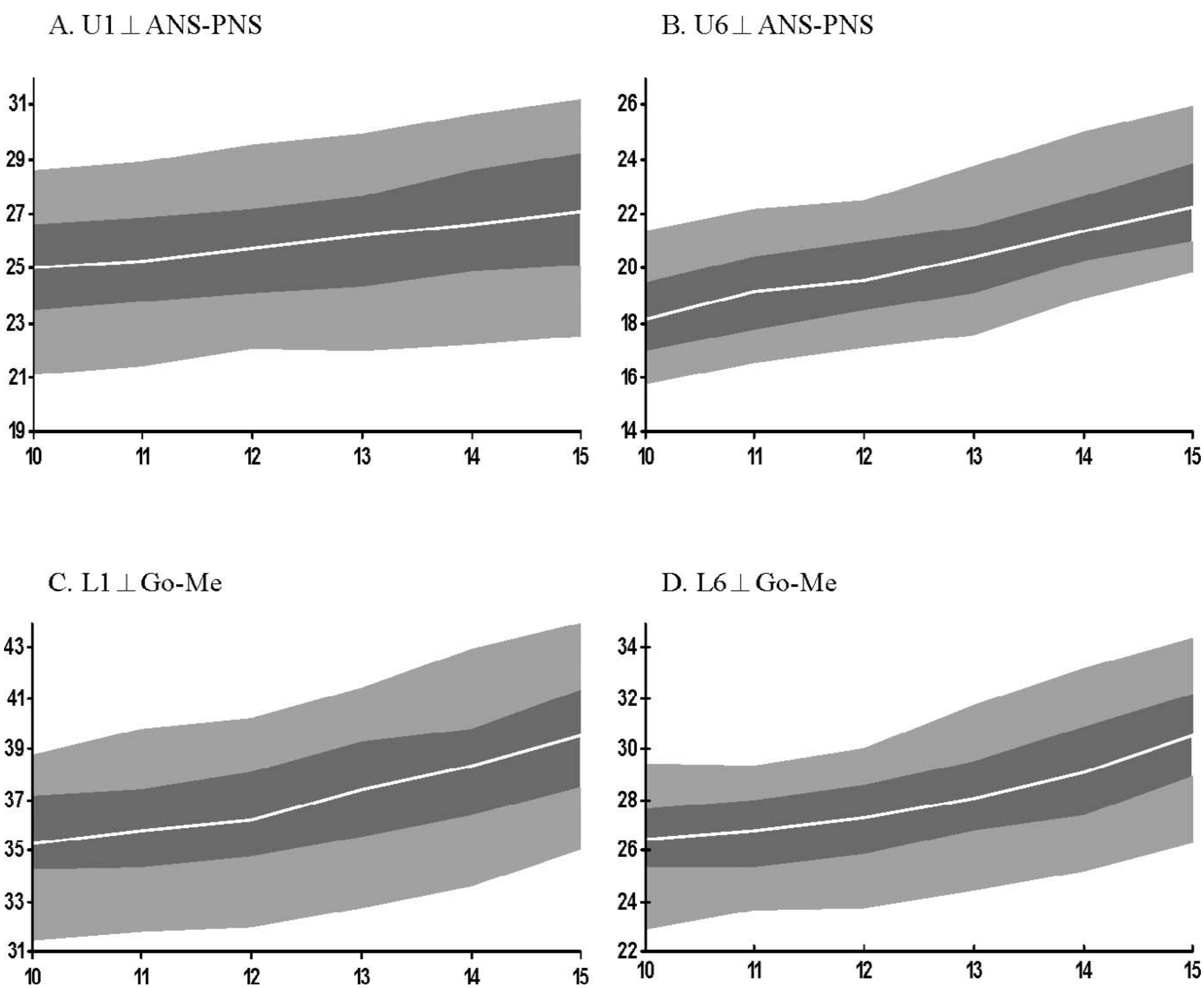

Figure 2. Maxillary and mandibular dentoalveolar heights (mm) for untreated male French-Canadian children 10 to 15 years of age. ■, 25th to 75th percentile band. ■, 25th to 50th and 75th to 95th percentile bands.

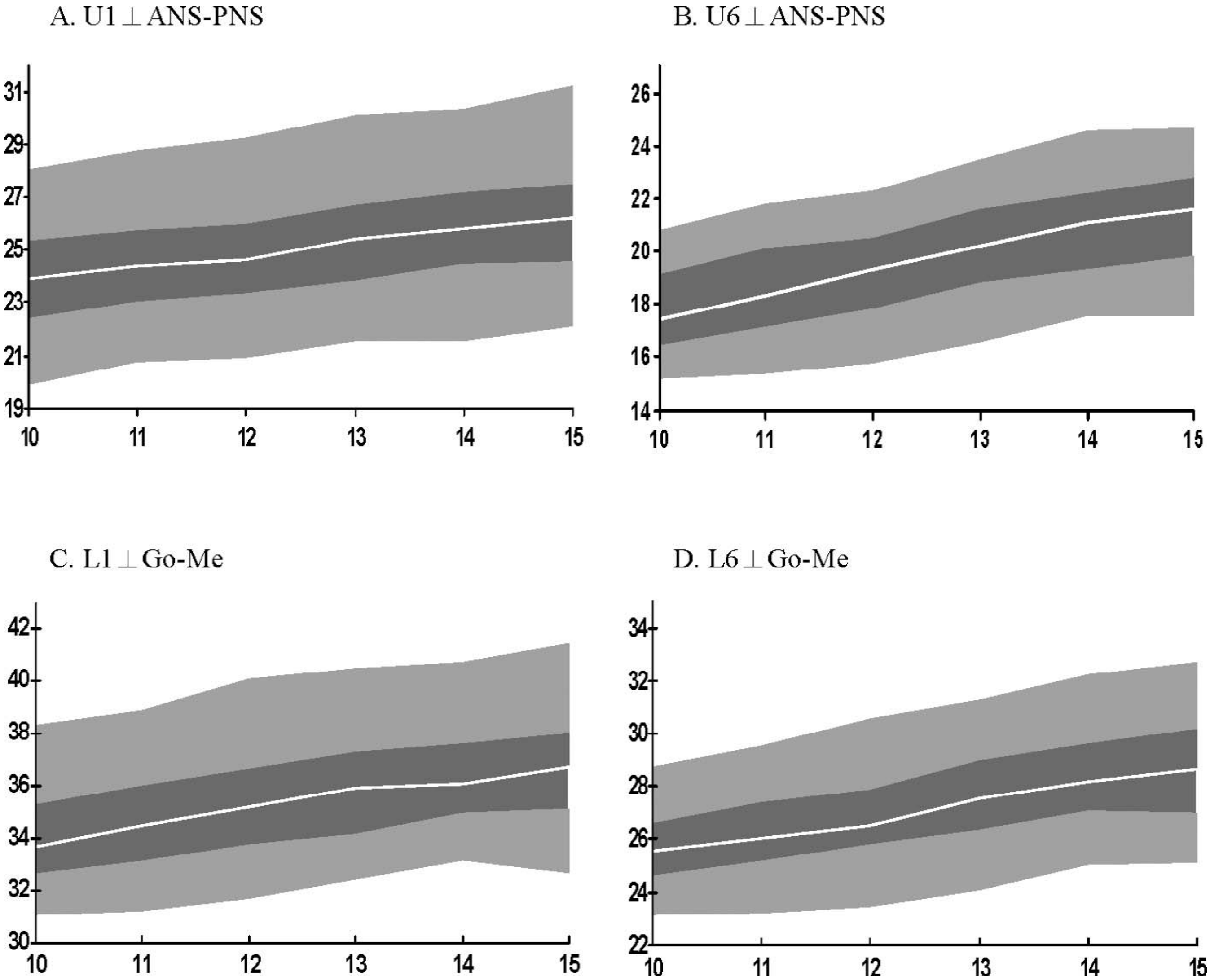

Figure 3. Maxillary and mandibular dentoalveolar heights (mm) for untreated female French-Canadian children 10 to 15 years of age. ■, 25th to 75th percentile band. ■, 25th to 50th and 75th to 95th percentile bands.

Table 3. Correlation Coefficients Relating the Dentoalveolar Heights Within and Between Arches[a]

	Dentoalveolar Heights					
	Within Arches			Between Arches		
Age, Years	U1 & U6	L1 & L6	U1 & L1	U6 & L6	U1 & L6	U6 & L1
10	0.60	0.70	0.58	0.17*	0.39	0.36
11	0.55	0.74	0.53	0.08*	0.35	0.30
12	0.56	0.71	0.57	0.09*	0.39	0.30
13	0.62	0.79	0.54	0.22*	0.41	0.35
14	0.68	0.78	0.54	0.34	0.42	0.42
15	0.69	0.82	0.53	0.31	0.44	0.41

[a] U1 indicates upper incisor tip; U6, upper first molar mesial cusp tip; L1, lower incisor tip; and L6, lower first molar mesial cusp tip.
* Indicates nonsignificant ($P > .05$).

heights at the molars of the opposite arch ranged between 0.30 and 0.44.

DISCUSSION

Dentoalveolar heights increased an average of 7.6%–23.0% between 10 and 15 years of age, depending more on tooth position than arch. The increases (2.1–4.2 mm) were similar to those reported by Bhatia and Leighton[8] (1.8–4.1 mm) and Riolo and coworkers[7] (1.8–4.6 mm). With the exception of the maxillary incisor dentoalveolar height, the mean values observed at the various ages compare closely with those of Bhatia and Leighton.[8] The difference in anterior maxillary dentoalveolar development implies an enhanced susceptibility to extrinsic factors. In general, dentoalveolar heights (after correcting for enlargement) reported by Riolo and coworkers[7] were slightly larger than ours, as well as those reported by Bhatia and Leighton.[8] Because similar landmarks and measurements were used in all three studies, the small differences that exist were probably due to sample bias, population differences in body size, facial morphology, or tooth size.[10] Nevertheless, the marked similarity of means across samples indicates that the data herein reported may be applicable beyond the French-Canadian population.

Dentoalveolar heights of male subjects were larger than the corresponding heights of female subjects. Sex differences, which ranged from 3.1%–4.4% at 10 years and from 3.5%–7.6% at 15 years, compare well with those reported by Bhatia and Leighton[8] and are somewhat smaller than those reported by Riolo and coworkers.[7] Dentoalveolar heights were probably greater in male adolescents because they undergo more vertical growth and have larger teeth than female adolescents.[9,11,12] Interestingly, there was a reduction or lack of a sex difference around 12 and 13 years of age, as previously reported.[8,13] The reduction in sex differences at these ages may be due to the females initiating their adolescent growth spurt earlier than males.[14,15]

Variability of dentoalveolar height increased with age, depending upon the jaw and tooth position. The coefficients of variation for maxillary dentoalveolar heights were between 2%–3% larger than those of the mandibular arch. Bhatia and Leighton,[8] as well as Riolo and coworkers,[7] also showed greater relative variation for maxillary than for mandibular dentoalveolar heights. Correlations between dentoalveolar heights within the maxilla were also weaker than associations within the mandible. Weaker maxillary correlations might be associated with the greater angular changes that have been reported for the maxillary molars.[16] The increased variability observed suggests that the maxillary dentoalveolar region has greater adaptive capacity than the mandibular dentoalveolar region, perhaps due to differences in the amounts of eruption that occur or to differences in bone quality.[17]

The utility of reference data depends largely on how precise and representative they are. Because our sample sizes were usually two or three times larger than existing reference data,[7,8] the estimates might be expected to be more precise. Precision is important because it allows orthodontists to make a better assessment at the extreme percentiles, where patients with serious problems are often found. The results are also representative of the larger population because the subjects were randomly selected; they comprise a nonorthodontic sample with normal occlusions and malocclusions. Moreover, the mean values compared well with other Whites, particularly with those reported by Bhatia and Leighton.[8] For all of these reasons, the present results provide some of the best reference data available for making clinical decisions about dentoalveolar height.

Importantly, the results of this study do not represent the actual longitudinal changes of dentoalveolar heights that occur during adolescence. As shown by the classic implant studies of Björk and Skieller,[16] the actual changes are often camouflaged by the bone remodeling that occurs on the surfaces of the maxilla and mandible. For example, maxillary dentoalveolar heights are likely to be underestimated during growth because the nasal floor is resorptive. Similarly, the anterior aspect of the lower mandibular border tends to be appositional, which causes longitudinal estimates of dentoalveolar based on the mandibular plane to be overestimated. These reference data were developed to evaluate dentoalveolar heights cross-sectionally. The charts and tables serve as diagnostic tools used to determine the extent of problems based on a single observation.

Since orthodontists regularly alter dentoalveolar heights, it is important to be able to assess the individual's needs during diagnosis and treatment planning. After determining the appropriate vertical position of the maxillary incisor relative to the upper lip, the dentoalveolar height of the maxillary incisor should be measured (Figure 1) and compared to the age and sex specific norms provided (Table 2; Figures 2 and 3). This roughly estimates the patient's appropriate percentile ranking, particularly if it corresponds to the patient's body size percentiles. Based on the observed relationships between the dentoalveolar heights (Table 3), the upper incisor percentile provides the basis for estimating the appropriate percentiles of the upper molar, the lower incisor, and the lower molar. Due to the limited strength of the associations, the percentile rankings should be used as adjustable guidelines rather than as rigid goals. The forgoing approach makes it possible to identify areas of discrepancy for the patient and to determine the best treatment approach. By using these standards in conjunction with facial esthetics and proportions, treatment mechanics can be better planned and controlled to produce more efficient treatments and better outcomes.

CONCLUSIONS

- French-Canadian adolescents require age- and sex-specific reference data for dentoalveolar heights because
  —Dentoalveolar heights increase from 10–15 years of age, with the anterior and posterior heights showing the smallest and greatest changes, respectively.
  —Male adolescents have larger dentoalveolar heights than female adolescents.
- Relative variability is 2% to 3% greater in the maxillary dentition than in the mandibular dentition; absolute variability was consistently greater for the incisors than the molar heights in both jaws.
- Correlations between dentoalveolar heights ranged from moderate to low, with mandibular heights showing the strongest associations.

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