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Enamel Thickness in 45,X Females' Permanent Teeth

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SUMMARY

Enamel thicknesses in 45,X females', their male and female relatives', and population control males' and females' permanent tooth crowns were determined from radiographs. The results showed that the enamel layer in both maxillary first incisors and canines of 45,X females is definitely thinner than that of control males or females. Enamel in control males' and females' teeth was about equal in size. The distance between mesial and distal dentino-enamel junctions or the thickness of "dentin" was similar in 45,X females' and in control females' teeth, but definitely smaller than in control males' teeth. These findings show that in the presence of the second sex-chromosome in the chromosome complement, whether X or Y, there is a definite and equal increase in the amount of enamel. On the other hand, in the presence of the Y chromosome in the chromosome complement, relative to the second X chromosome, there is a definite increase in the thickness of the dentin. The results of earlier studies have indicated a direct growth-promoting effect of the sex chromosomes on tooth growth, and that the effect of X and Y chromosomes is different. The present results suggest that the influence of the X- and Y-chromosome gene(s) on amelogenesis is the same in quantitative terms but different in relation to the determination of the distance between dentino-enamel junctions; the Y chromosome is more effective than the X chromosome in that respect. It is postulated that this size-increasing effect of the Y-chromosome gene(s) might result from its profound effect on cell proliferations.

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INTRODUCTION

The average difference in size between human males' and females' permanent tooth crowns has been attributed to several genetic and epigenetic factors, including hormonal influence beginning in early stages of development. However, there is increasing evidence in favor of a direct promoting effect of the sex-chromosome genes on tooth growth. The studies on permanent and/or deciduous tooth-crown sizes in normal male and female cousins and siblings [1] and in patients with 45,X- [2, 3], 47,XYY- [4, 5], 47,XXY- [6], and 46,Xdel(q)(11)-chromosome constitution [7], in 46,XX males [8], and in 46,XY females [9] strongly indicate a direct effect of the X- and Y-chromosome gene(s) on dental determination. These results also suggest that the effect of the Y-chromosome gene(s) is different from that of the X-chromosome gene(s), and that the average size difference between normal males' and females' teeth may result from this different action of the sex-chromosome genes on growth. The results of a recent study [7] also suggest that the location of the growth-promoting gene(s) of the Y chromosome is in Yq11. In addition, there is evidence from other studies for the role of the X and Y chromosomes on the maturation and growth of bony structures [10–13].

An attempt is made here to further elucidate the nature of the influence of sex chromosomes on dental determination. Specifically, the possible change in the structure of the tooth crown due to the different sex-chromosome constitution will be examined.

MATERIALS AND METHODS

For the determination of enamel thickness, 49 Finnish females with 45,X-chromosome constitution (Turner syndrome) were examined. The controls were first-degree male and female relatives of the study subjects and population males and females including dental students and regular patients at the Institute of Dentistry, University of Turku. The determinations of enamel thickness were made on maxillary permanent central incisors and canines on both sides of the jaw. These teeth were selected for technical reasons, and also, in the case of the canines, for their developmental stability as suggested previously.

The following techniques were employed. A film, sized 2 × 3 cm, was attached to the palatal surface of the tooth crown, and a central X-ray was directed to the middle point of the labial surface perpendicular to the plane bisecting the angle between the film and the long axis of the tooth crown. An open-ended cylindrical metal cone limited the diameter of the radiation field to 28 mm, and gave a target-film distance of 32 cm. The time exposure was 0.5 second, and the other exposure factors were 55 kVp and 15 mA. The films were developed by the automatic X-ray processor, and a dental X-ray viewer (Realist) was used to magnify the radiographs 10-fold for measurements. Maximum mesiodistal diameter and the thickness of mesial and distal enamel layers of the tooth crowns were measured along to the line perpendicular to the long axis of the tooth crown. Figure 1 illustrates the measurements. The accuracy of the measurements (after magnification) was to the nearest 0.5 mm, and measurements were made with a plastic ruler. All measurements were done by the same investigator (E. T.).

To test the validity of the method, 50 individuals (controls) were radiographed the second time after an interval of a few days. No statistically significant differences ($P < .05$) were found between the means of the measurements. Measurements made on the right side of the jaw were used for this study. However, if the measurements were missing on the right side, the measurements of the antimere were used, whenever possible. For statistical testing of the results, the *t*-test was applied.

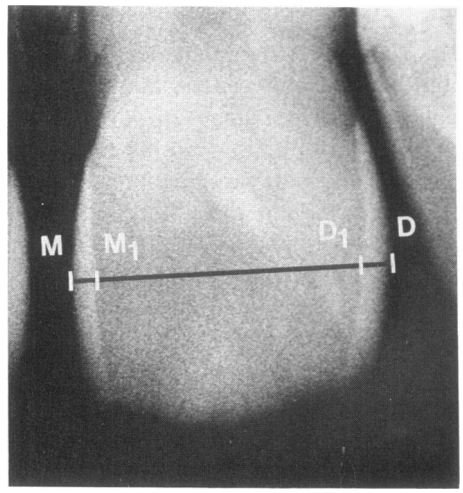

FIG. 1.—Measurements made on radiograph of permanent maxillary central incisor: M-D = maximum mesiodistal dimension of tooth crown; $M\text{-}M_1$ = mesial enamel layer; $D\text{-}D_1$ = distal enamel layer; ($M_1\text{-}D_1$ = distance between mesial and distal dentino-enamel junctions or thickness of "dentin").

Macroscopic inspection showed no gross systematic morphological abnormalities or defects in the central incisors or in the canines of the 45,X females, although a somewhat conical form of the incisor crowns was found in some instances.

RESULTS

Table 1 indicates the measurements of enamel thickness in the maxillary central incisors and canines of the study subjects and population and relative controls. In addition to the enamel thickness (mesial enamel layer plus distal enamel layer), table 1 indicates maximum mesiodistal dimension of the crowns measured from the radiographs as described, and the distance between mesial and distal dentino-enamel junctions or the thickness of "dentin" (maximum mesiodistal dimension minus enamel layers).

The results show that with regard to maximum mesiodistal measurements of the tooth crowns, 45,X females' central incisors and canines are clearly smaller than those of population controls, and control males have larger teeth than do females. The finding of generally small teeth in 45,X females is parallel with the previous findings [2, 5]. Enamel in 45,X females' incisors and canines is definitely thinner than that of the control males' or females' teeth. Statistically the differences are highly significant. Control males' and females' enamel is about equal in thickness, although females show a tendency toward higher values.

Dentin is also significantly thinner in 45,X females' teeth than in control males' teeth, but close to the values found in normal females' teeth. The results of comparing 45,X females and their male and female relatives are parallel with the results described above.

TABLE 1

MEAN MESIODISTAL TOOTH-CROWN SIZES AND ENAMEL AND "DENTIN" THICKNESSES OF THE CROWNS OF MAXILLARY CENTRAL INCISORS AND CANINES IN 45,X FEMALES AND IN POPULATION AND RELATIVE CONTROL MALES AND FEMALES MEASURED FROM THE RADIOGRAPHS

				POPULATION CONTROLS						RELATIVE CONTROLS					
	45,X FEMALES			MALES			FEMALES			MALES			FEMALES		
TOOTH	M (mm)	SD	No.	M (mm)	SD	No.	M (mm)	SD	No.	M (mm)	SD	No.	M (mm)	SD	No.
I1*															
Mesiodistal†	8.56	0.50	49	‡9.43	0.57	85	‡9.00	0.50	93	‡9.20	0.41	9	§8.92	0.58	26
Enamel†	1.41	0.19	49	‡1.69	0.21	85	‡1.74	0.22	93	‡1.77	0.20	9	‡1.79	0.26	26
Dentin†	7.15	0.48	49	‡7.74	0.55	85	7.26	0.47	93	7.43	0.31	9	7.13	0.46	26
C‖															
Mesiodistal	8.16	0.47	47	‡8.78	0.50	84	#8.35	0.47	94	#8.62	0.47	6	8.36	0.46	20
Enamel	2.10	0.25	47	‡2.31	0.25	84	‡2.40	0.29	94	#2.37	0.21	6	‡2.44	0.26	20
Dentin	6.06	0.36	47	‡6.47	0.44	84	5.95	0.40	94	6.25	0.30	6	5.93	0.40	20

* I1 = maxillary central incisor.

† Mesiodistal = maximum mesiodistal dimension of tooth crown; enamel = enamel thickness (mesial enamel layer plus distal enamel layer); dentin = distance between mesial and distal dentio-enamel junction or thickness of "dentin" (maximum mesiodistal dimension minus enamel layers).

‡ $P < .001$
§ $P < .01$
# $P < .005$
} 45,X females vs. controls.

‖C = maxillary canine.

DISCUSSION

The observations on enamel thickness in 45,X females' and control males' and females' teeth indicate that in the presence of the second sex chromosome in the chromosome complement, whether X or Y, there is a definite increase in the amount of enamel. It is known [cf. 14] that one hypoplasia type of *amelogenesis imperfekta* is due to the gene(s) on the X chromosome. Therefore, the increase of enamel in the presence of the two X chromosomes observed here is not totally unexpected. The observed increase of enamel in the presence of the Y chromosome suggests that there is also a gene (or genes) on the human Y chromosome that influences enamel formation, and in that respect, X and Y chromosomes might then possess homologous loci. The results also indicate that the effect of the X and Y chromosomes on amelogenesis is quantitatively the same. Permanent tooth crowns reach their final shape and size at an early stage of development; for example, the first upper incisors have completed their crown growth by the age of 3–3½ years. Although there are minor maturational changes of the enamel after this time, the results indicate that the final enamel size increase in normal males and females related to 45,X females has occurred early and within a short period of time.

The findings on the distance between mesial and distal dentino-enamel junctions in 45,X females and control males and females indicate that in the presence of the two X chromosomes in the chromosome complement there is either a minor increase or none at all in that distance compared with the one X-chromosome situation, but in the presence of the Y chromosome there is a definite increase. The average size difference between normal males' and females' teeth might then be due to the different action of X and Y chromosomes on tooth growth. Amelogenesis is influenced in a similar way, but the effect on the increase of distance between dentino-enamel junctions is different: the gene(s) on the Y chromosome is more effective than the gene(s) on the X chromosome in this respect. It is known that the distance between dentino-enamel junctions is determined at an early stage of tooth-crown development, at the time when amelogenesis occurs, and there are good reasons to believe that mitotic activity of the cells of the inner enamel epithelium is the decisive factor in the determination of that distance [cf. 15]. It is therefore possible that the size-increasing effect of the Y-chromosome gene(s), compared to the X-chromosome gene(s), results from its profound effect on cell proliferations. Whether this size-increasing effect might be due to the specific growth-promoting genes on the human Y chromosome compared to the X chromosome, due to the inactivation of the gene(s) on the X chromosome, or due to some other relative "nonspecific" effect should be further studied. However, in regard to the total inactivation of the second X chromosome in normal females, the present results clearly suggest that the second X chromosome in the chromosome complement is of decisive importance for the completion of amelogenesis in quantitative terms.

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