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Original Article

A Radiological Analysis of the Pulp Cavity in the Molars of 45,X Females

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Abstract

Turner's Syndrome is a representative sex chromosome abnormality in women (designated as 45,X females). These women have a fundamental karyotype of 44 autosomes and a single X chromosome. The purpose of this study was to perform a morphometric analysis of the pulp chambers of the upper and lower molars in 45,X females using orthopantomograms. We examined 40 Finnish 45,X females and 24 of their sisters. The mean age of the 45,X females was 15.6 years and that of their female relatives was 15.3 years. We measured six parameters of the pulp chamber, including the root canals, and calculated six indices using these items. The results of these measurements and indices showed that thepulp height, root length, crown size, and cervical width in the molars of 45,X females were shorter than those in their sisters Conversely, the pulp width in the teeth of 45,X females was expanded in the mesiodistal direction. The upper and lower molars of 45,X females had low and wide pulp chambers.

Introduction

Turner's Syndrome (sometimes called Ullrich-Turner Syndrome) is a representative sex chromosome abnormality in women (designated as 45,X females). The birth prevalence of Turner's Syndrome has been estimated to be 1/2000 female live births worldwide. The fundamental karyotype of these females is 44 autosomes and a single X chromosome. Their physical features include a webbed neck, short stature, cubitus valgus, a shield-like chest, reduction of metacarpal bones, circulation disorders, kidney problems such as horseshoe-shaped kidneys, and a lack of secondary sex characters (1). In 1938, Turner reported the cases of seven women who had diminished growth of sexual glands, webbed necks, short stature, and cubitus valgus (2). In the 1950s, with improvement in karyotype analysis, various structural anomalies and mosaicism in 45,X females were demonstrated (3). In recent years, a short-stature homeobox-containing gene (SHOX) was discovered in the end of the X-chromosome short arm ; this gene causes the short stature and other skeletal signs in 45,X females (4). On the other hand, a gene for the formation of the lymph channel was discovered in the proximal part of the X chromosome. Ogata reported that the lack of this gene is related to the abnormalities of visceral organs and soft tissue that appear in 45,X females (5). Absence of the short arm of the X chromosome is known to cause gonadal dysplasia, short stature, and skeletal anomalies (6). In dentistry, this genetic abnormality may be seen as micrognathia, high arched palate, occlusion anomalies, and shortening of dental arch length (Figs. 1 and 2) (7-10). We had the opportunity to study the data of the Kvantti collection housed in Oulu University in Finland. These data are the collective research of Professor Alvesalo conducted in Finland from the 1970s to the 1980s. Professor Alvesalo and the researchers of many countries, such as Canada and Israel, investigated this data and their results have been published periodically. In particular, they have studied the appearance of taurodontism, crown

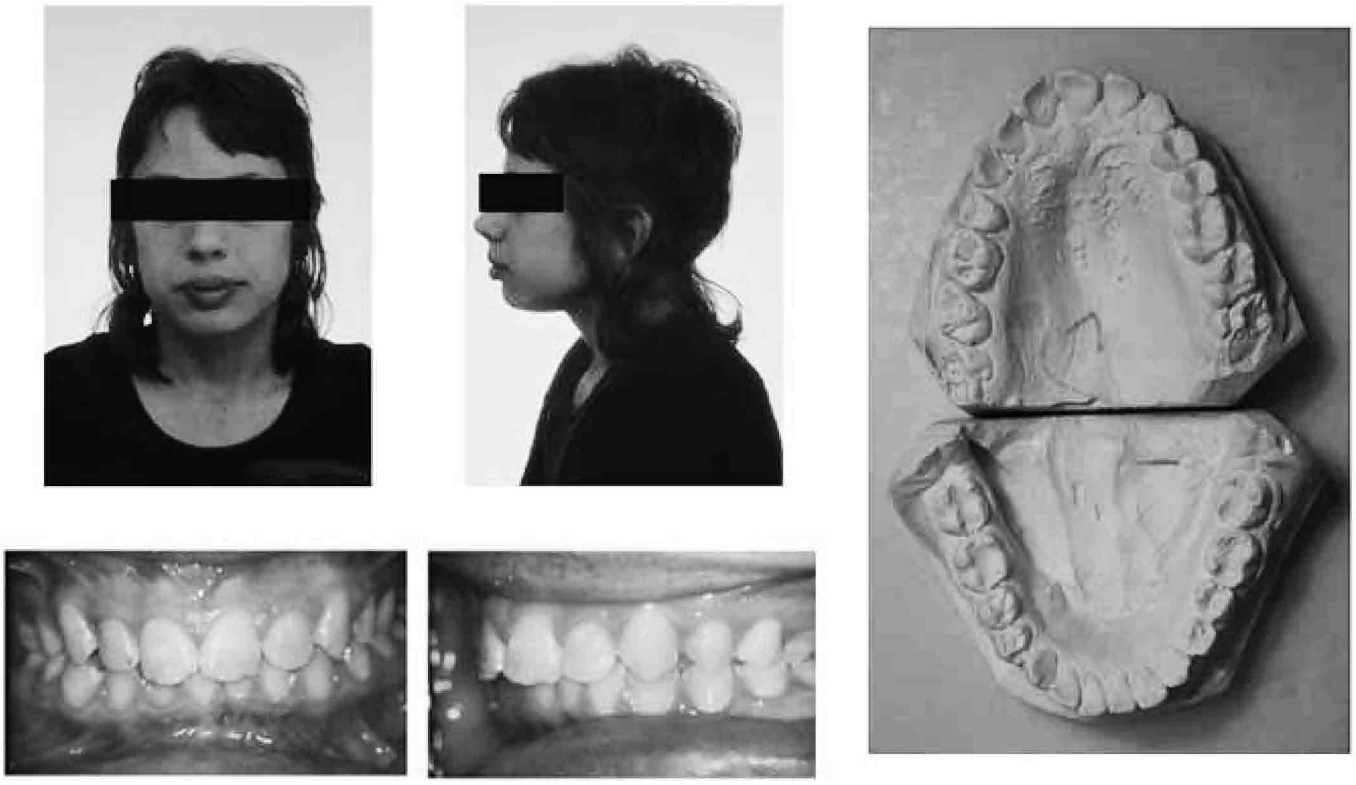

Fig. 1. An example of 45,X female : Profiles, bites and an oral impression model.

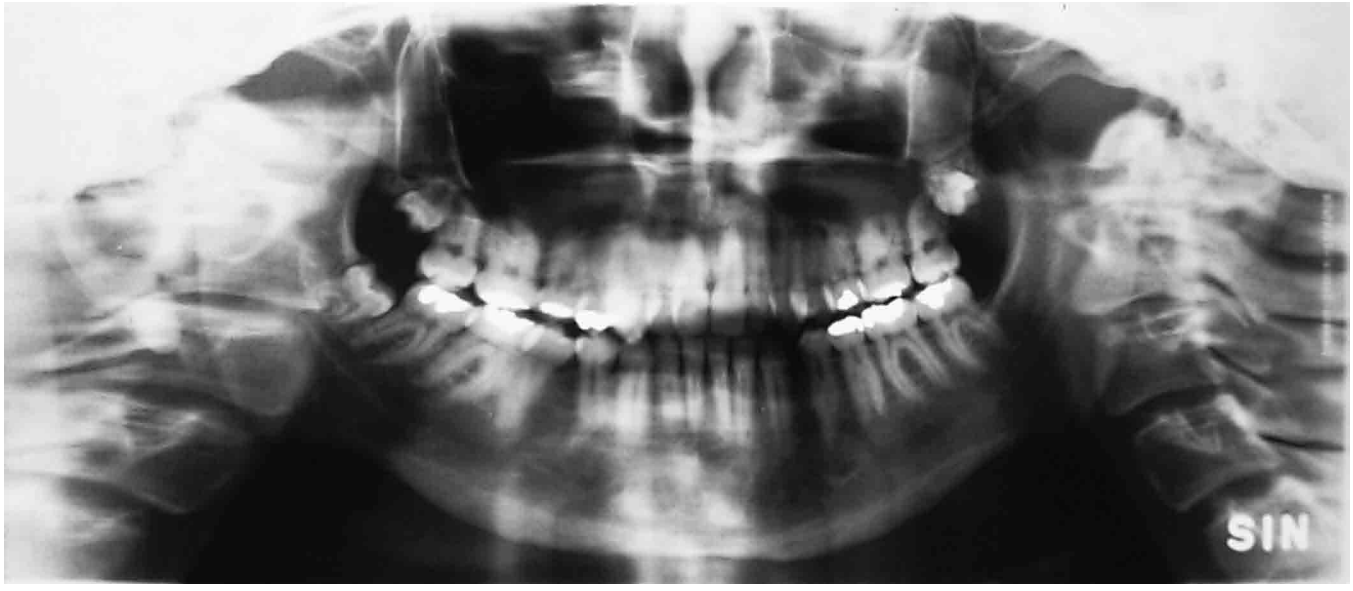

Fig. 2. An example of orthopantomogram in 45,X female.

components, torus mandibularis, somatometry, dental morphology, oral and craniofacial morphology, and crown size of teeth in 45,X females (11-17). The purpose of this study was to compare the dental pulp cavity in the upper and lower molars in 45,X females with that in normal women using orthopantomograms.

Table 1. Average age and number of subject.

	45,X female		Control		
	n	Mean age and SD	n	Mean age and SD	t-test
・Upper molars					
M1	30	13.99±4.45	18	14.39±2.07	NS
M2	20	16.27±3.84	17	15.67±3.79	NS
・Lower molars					
M1	36	13.86±4.47	22	15.22±3.48	NS
M2	27	16.09±3.79	18	15.44±3.69	NS

NS: Not significant

Materials and Methods

Forty Finnish females with 45,X chromosome constitution and 24 of their sisters with normal chromosome constitution housed at the University of Oulu in Finland were examined. The karyotypes of the 45,X females were confirmed by cytogenetic tests of skin fibroblasts. Table 1 shows the characteristics of each case. The measurements were taken from the right side of the orthopantomogram, but if right side molars were missing, those from the left side were used. We measured six parameters: pulp chamber height (PH), height from the roof of the pulp chamber to the mesial root apex (PRH), height from the roof of the pulp chamber to the position of root bifurcation (PBH), maximum crown width (CRW), minimum cervical width (CEW), and minimum width of the pulp chamber (PW), using a digital caliper (Mitsutoyo, Japan). Four indices were calculated using these values: the ratio of the pulp height to the height from the roof of the pulp chamber to the mesial root apex (PH/PRH), the ratio of the pulp height to the height from the roof of the pulp chamber to the position of root bifurcation (PH/PBH), the ratio of the minimum width of the pulp chamber to the maximum crown width (PW/CRW), and the ratio of the minimum width of the pulp chamber to the minimum cervical width (PW/CEW) (Fig. 3). The F-test and t-test were used to compare variances and mean values between 45,X females and their sisters. A statistical software package, S-PLUS 2000 (Mathematical Systems, Inc. Tokyo), was used for data analysis.

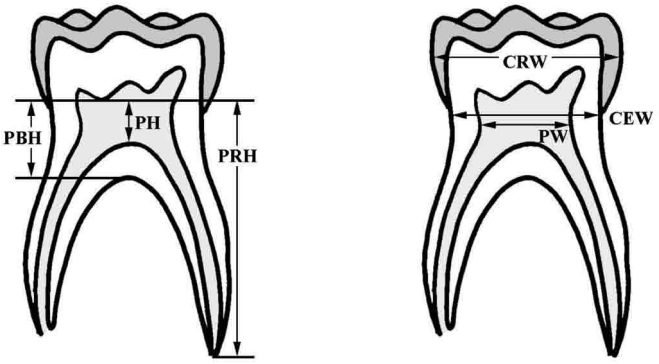

Fig. 3. The measurement items for pulp chamber in molars.
PH: The pulp chamber height
PRH: The height from roof of pulp chamber to mesial root apex
PBH: The height from roof of pulp chamber to the position of root bifurcation
CRW: The maximum crown width
CEW: The minimum cervical width
PW: The minimum width of the pulp chamber

PH/PRH: The ratio of PH to PRH (PH/PRH×100), PH/PBH: The ratio of PH to PBH (PH/PBH×100)
PW/CRW: The ratio of PW to CRW (PW/CRW×100), PW/CEW: The ratio of PW to CEW (PW/CEW×100)

Results

The mean values and standard deviation of the upper and lower molar measurements for 45,X females (Table 2) and their sisters (Table 3) were calculated. All of the measurements except the minimum width of the pulp chamber (PW) were smaller in 45,X females than in their sisters. The differences between 45,X females and their sisters in four parameters of the maxillary (upper) first molars were found statistically significant at $p<0.001$: PRH, PBH, CRW, and CEW. The maxillary second molars showed significant differences in all items except the minimum width of the pulp chamber (PW).

Table 2. The results of measurements in upper molars.

(mm)

		45,X female		Control		
		mean	SD	mean	SD	t-test
Upper first molars	PH	2.2	0.9	2.3	0.8	NS
	PRH	14.6	2.4	17.1	1.5	***
	PBH	5.1	0.8	5.9	0.9	***
	CRW	13.3	1.2	15.4	1.0	***
	CEW	10.2	0.7	11.3	1.0	***
	PW	3.4	0.6	3.3	0.6	NS
Upper second molars	PH	2.6	0.7	3.7	1.0	***
	PRH	14.5	2.1	15.6	2.3	*
	PBH	5.1	0.9	6.0	1.0	**
	CRW	12.8	1.0	14.0	0.9	***
	CEW	9.4	2.0	10.7	0.9	**
	PW	3.0	0.6	3.1	0.5	NS

NS: Not Significant, *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

Table 3. The results of measurements in lower molars.

(mm)

		45,X female		Control		
		mean	SD	mean	SD	t-test
Lower first molars	PH	1.1	0.6	1.5	0.8	**
	PRH	15.8	1.6	18.5	1.8	***
	PBH	3.7	0.7	4.6	0.8	***
	CRW	14.5	1.1	16.4	1.4	***
	CEW	11.9	0.9	12.8	1.1	***
	PW	5.2	0.8	5.1	0.9	NS
Lower second molars	PH	1.3	0.5	2.3	1.0	***
	PRH	15.6	1.9	16.7	1.8	*
	PBH	3.9	0.8	5.0	1.1	***
	CRW	14.4	1.1	15.9	1.3	***
	CEW	11.7	0.9	12.8	1.0	***
	PW	5.3	0.8	5.3	0.9	NS

NS: Not Significant, *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

The mandibular (lower) first and second molars showed significant differences in all items except the minimum width of the pulp chamber (PW). We then calculated the mean values and standard deviation of the upper and lower molar indices for 45,X females (Table 4) and their sisters (Table 5). No significant differences in all molar indices were found between 45,X females and their sisters. The differences in PH/PRH and PH/PBH in the maxillary second molars between 45,X females and their sisters were statistically significant at $p<0.01$. The differences in PH/PRH and PH/PBH in the mandibular second molars between 45,X females and their sisters were statistically significant at $p<0.001$. However, all width indices showed no significant differences in upper and lower molars.

Table 4. The results of indices in upper molars.

		45,X female		Control		
		mean	SD	mean	SD	
Upper first molars	PH/PRH	15.20	6.22	13.41	3.97	NS
	PH/PBH	43.01	15.04	39.19	11.83	NS
	PW/CRW	25.40	4.48	21.05	3.28	NS
	PW/CEW	33.18	5.61	28.82	4.78	NS
Upper second molars	PH/PRH	17.48	2.37	24.54	9.34	**
	PH/PBH	49.46	5.02	60.8	13.07	**
	PW/CRW	23.54	3.33	22.3	2.62	NS
	PW/CEW	37.69	30.21	29.21	3.59	NS

NS: Not Significant, *: $p<0.05$, **: $p<0.01$

Table 5. The results of indices in lower molars.

		45,X female		Control		
		mean	SD	mean	SD	
Upper first molars	PH/PRH	7.02	4.02	8.11	3.89	NS
	PH/PBH	29.09	12.81	31.57	11.99	NS
	PW/CRW	36.09	4.81	31.25	3.91	NS
	PW/CEW	44.17	5.87	39.92	6.16	NS
Upper second molars	PH/PRH	8.64	3.17	13.76	5.18	***
	PH/PBH	33.55	8.62	45.22	14.08	***
	PW/CRW	37.08	5.55	33.14	3.81	NS
	PW/CEW	45.46	5.55	41.41	5.13	NS

NS: Not Significant, *: $p<0.05$, **: $p<0.01$

Discussion

Before we discuss the pulp cavity of 45,X females, we must consider our methods. The pulp cavity is a lacuna that is surrounded by hard dental tissue in the center of the tooth and the dental pulp exists inside of it. Generally, the pulp cavity is divided into a pulp chamber and root canals. Coronal pulp exists in the pulp chamber and is affected by crown form; radicular pulp exists in the root canals from the neck of the tooth to the apical foramen (18). In this research, we measured six parameters including the root canals. A root is practically fully developed from 9 to 10 years old in first molars and from 14 to 16 years in second molars (19). We referred to Moorrees's stage of tooth formation for the development of permanent mandibular molars. The materials in the present study used the stages of half closure of the root apex (A1/2) and complete closure of the root apex (Ac). If the root apex was closed in the lower first molar, we could measure the upper and lower first molars (20, 21). Table 1 shows the average age of the upper and lower molars and the measurements taken. No significant differences in the average age of each molar were found between 45,X females and their sisters. However, the average ages of the upper and lower first molars were younger in the 45,X females than in their sisters. Tooth eruption is affected by the growth of the root and the alveolar bone, as well as the vascular organization around the root (7). In 45,X females, teeth may erupt prematurely; for example, the first permanent molars may appear between 1.5 and 4 years of age. In

the Kvantti collection, Kari and Alvesalo evaluated both the development and the eruption of permanent teeth and found that both in 45,X females were clearly earlier than in normal control girls (22).

Orthopantomograms showed indistinct tooth outlines and deformation of the teeth. From the Kvannti collection, our coauthors (R.L and L.A) published the results of measuring root lengths in 47,XYY males using orthopantomograms (23). We also used orthopantomograms under the three conditions selected suitable for measurements by an orthodontist (R.L) in the previous study. We excluded molars that had received dental treatment for their crowns and root canals. We also excluded molars that had crowns worn by friction or abrasion. In molars that had worn crowns or previous dental treatment, the pulp cavity had become narrow and small. In addition to comparing measurement values, we also compared index values to minimize the influence of amplification on the orthopantomograms.

Humans normally have 22 matched pairs of autosomes and one matched pair of sex chromosomes that are present in every cell of the body. The autosomes are the same in males and females ; however, the X and Y sex chromosomes are not shaped similarly and the pair of sex chromosomes is responsible for differences in development between males and females. The Y chromosome contains the genes responsible for testis development. The presence of an X chromosome paired with a Y chromosome determines male development. On the other hand, two X chromosome are required for normal ovarian development in females (1). Dental development is affected by genes on both the X and Y chromosomes (24). A gene for enamel formation has been located on the X chromosome, but very little if any influence on the growth of dentin has been found there. The Y chromosome generally promotes the growth of enamel and dentin (25-29). The 45,X females have the same number of autosomes as normal females ; however, they are missing a single X chromosome. Almost all 45,X females and their mosaics have short stature and loss of ovarian function, but the severity of these problems varies considerably among individuals (30). In dentistry, the palate is highly arched in approximately 35% of 45,X females and cleft palate may occur at a somewhat higher than normal frequency. Their premolars look increasingly like molars (31). The cusp height and the crown size were reduced (8, 32). The cranial base of a 45,X female is short, so her face is retrognathic. The mandible is short but the maxilla is of normal length (33). Our measurements showed that the pulp height, root length, crown size, and cervical width of upper and lower molars in 45,X females were shorter than those of their sisters. However, there was no significant difference in the measurements and indices of pulp width between 45,X females and their sisters, although their pulp width was expanded in the mesiodistal direction relative to that of their sisters. The upper and lower molars of 45,X females had low and wide pulp chambers.

Conclusions

1. The measurements and indices of teeth in 45,X females showed that their pulp height, root length, crown size, and cervical width were shorter than those in their sisters.
2. The pulp width in the teeth of 45,X females was expanded in the mesiodistal direction relative to that in the teeth of their sisters.
3. The upper and lower molars of 45,X females had low and wide pulp chambers.

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