Eruption process of upper permanent canine

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The purpose of this study was to investigate normal eruptive pattern of upper permanent canine. One hundred and fifty-one panoramic radiographs were used. Inclination of upper canine and lateral incisor, length and horizontal and vertical positions of cusp and root apex of the canine were evaluated. The canine erupted with increasing distal inclination and with no significant changes of the lateral incisor. Developmental changes of the canines relative to palatal plane and midline were shown by figures.
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INTRODUCTION

During eruption of the upper permanent canines, these teeth are in very close contact with the neighboring teeth. The upper permanent canine is frequently misplaced in relation to other teeth in the maxilla. Approximately 1.5% to 2% of the general population experiences impaction or ectopic eruption of the upper permanent canine.[1-3] These eruptive disorders of the upper permanent canines may lead to impaction or resorption of the neighboring permanent teeth.[3,4] Because of the risk of problems associated with eruption of the upper permanent canines, careful supervision and early diagnosis of disturbances in eruption have been considered important.[5-9] The early detection of eruptive anomalies of the upper permanent canines requires an understanding of its normal eruptive pattern. The purpose of the this study was to analyze the eruption process of the upper permanent canine, in terms of its inclination and positions on the basis of panoramic radiographic records.

MATERIAL AND METHODS

The materials were 151 panoramic radiographs, from full eruption of the upper four permanent incisors (Figure 1-A) to emergence of the upper permanent canine (Figure 1-B), collected by our department. Cases of trauma, agenesis, developmental disturbances, or supernumerary teeth in the study zone were not included in the materials. All panoramic radiographs had good quality.

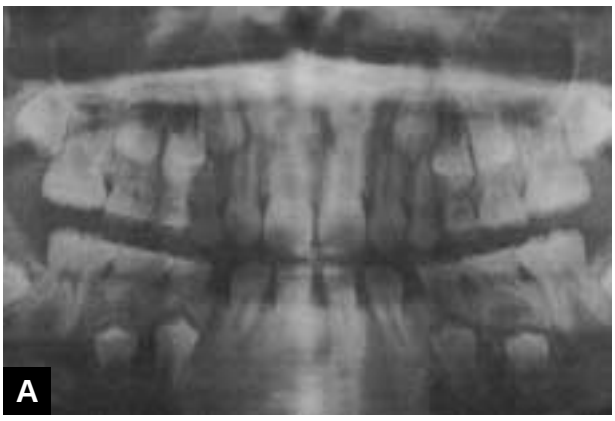

Figure 1. Panoramic radiographs.
A: Full eruption of the upper four permanent incisors
B: Emergence of the upper permanent canine (left side)

The developmental stages of the upper permanent canine were divided into three stages according to the length (distance between cusp and root apex): smaller than 14 mm (stage 1), between 14 and 20 mm (stage 2), and larger than 20 mm (stage 3). The number of the

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panoramic radiographs in each stage is given in Table 1. The radiographs were traced on overlying matte acetate paper (Figure 2). Eleven reference points on the tracing (Figure 3) were input to the personal computer with digitizer. The following seven measurements were calculated by using these points (Figure 4):

1. Inclination of the upper permanent canine.
2. Inclination of the upper permanent lateral incisor.
3. Length of the upper permanent canine.
4. Horizontal position of the upper permanent canine cusp (X coordinate value).
5. Vertical position of the upper permanent canine cusp (Y coordinate value).
6. Horizontal position of the upper permanent canine root apex (X coordinate value).
7. Vertical position of the upper permanent canine root apex (Y coordinate value).

Statistical analysis was done using SigmaStat software. Mean values and standard deviations of the seven measurements in each stage were calculated. The Student's 't' test was used to show whether or not statistically significant differences existed between right and left mean values. However, where the data was significantly skewed or where the intra-group variances differed significantly then the Mann Whitney 'U' test was used instead. Analysis of variance (ANOVA) was used for comparison of mean values for each measurement among three stages. Regression analysis was used to determine the correlation between inclination and length and between Y coordinate values and length of the upper permanent canine.

Table 1. Number of the panoramic radiographs.

	Boys	Girls	Sum
Stage 1	11	22	33
Stage 2	46	54	100
Stage 3	8	10	18
Sum	65	86	151

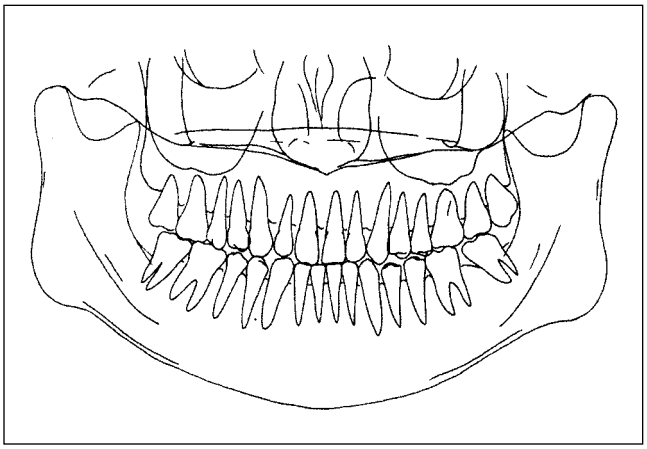

Figure 2. Panoramic tracing.

RESULTS

Results are given in Table 2. Because no significant differences were noted between right and left mean values for both sexes, the results of the comparison are not shown in the Table.

The upper permanent canine changed its inclination during eruption. It was inclined mesially at stage 1, however, it was inclined distally at stage 3. The amounts of the changes from stage 2 to 3 were larger than that from stage 1 to 2 for both sexes.

There was no significant difference in inclination of the upper permanent lateral incisor during eruption of the upper permanent canine.

There were little changes in horizontal positions of cusp and root apex of the upper permanent canine during observation. However, there were significant differences in vertical positions of cusp and root apex of the upper permanent canine from stage 1 to 3.

Figures 5 and 6 are graphs where the actual measurements of inclination and Y coordinate values are plotted against length of the canine. From the data points, best fit straight lines are drawn and least regression equations of the form $Y = B(X) + A$ are determined. Girls had high coefficient of determination (r^2) values for all the correlation analysis.

In order to make a summary of the results, cusp and root apex of the upper permanent lateral incisor and canine for each stage were connected by different color lines. The superimposition and positions relative to palatal plane and midline are shown in Figure 7.

DISCUSSION

Different studies have confirmed the reliability of angular measurements and vertical dimensions in the radiographs.[10-13] Because panoramic radiographs more commonly show overlapping of the upper permanent canine and lateral incisor when the latter is not yet fully developed, the investigations in this study were restricted to those of cases between the phases of full eruption of four incisors and emergence of the canine.

Before commencing to erupt, the dental follicle of the upper permanent canine is positioned above the follicle of the first premolar,[14] because it is limited mesially by the piriform aperture. Once eruption has started, and as a result of maxillary growth, a certain mesial displacement must occur to eventually reach a correct position within the arch. Broadbent[14] established that the upper permanent canine move downward, forward and laterally away from the root end of the lateral incisor. Moyers[15] reported that at age 3 years, the upper permanent canine is positioned high within the maxilla, with the crown directed mesially. It dis-

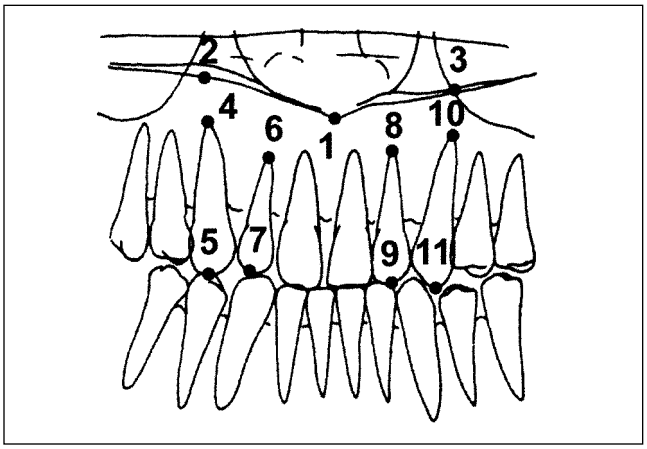

Figure 3. Reference points.
1: anterior nasal spine
2: palatal point at upper right permanent canine region
3: palatal point at upper left permanent canine region
4: upper right permanent canine root apex
5: upper right permanent canine cusp
6: upper right permanent lateral incisor root apex
7: upper right permanent lateral incisor edge
8: upper left permanent lateral incisor root apex
9: upper left permanent lateral incisor edge
10: upper left permanent canine root apex
11: upper left permanent canine cusp

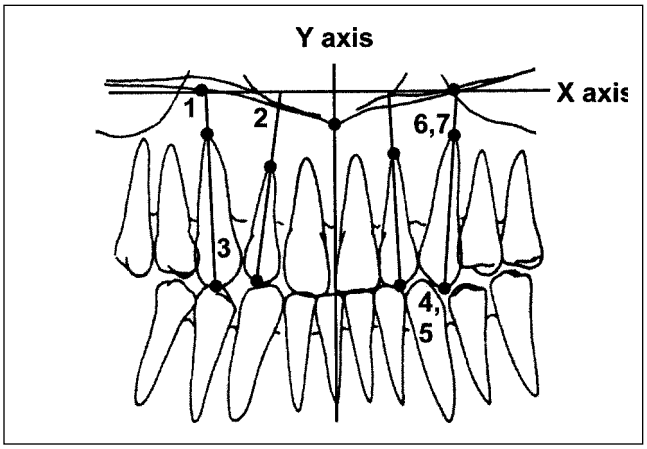

Figure 4. Measurements.
1: Inclination of the upper permanent canine (external angle formed by X axis and the straight line that passes the upper permanent canine cusp and root apex)
2: Inclination of the upper permanent lateral incisor (external angle formed by X axis and the straight line that passes the upper permanent lateral incisor edge and root apex)
3: Length of the upper permanent canine (distance between the upper permanent canine cusp and root apex)
4: X coordinate value of the upper permanent canine cusp
5: Y coordinate value of the upper permanent canine cusp
6: X coordinate value of the upper permanent canine root apex
7: Y coordinate value of the upper permanent canine root apex

X axis: the straight line that passes right and left palatal points at upper permanent canine region (palatal plane)
Y axis: perpendicular to the X axis and passes the anterior nasal spine (midline)

places toward the occlusal plane, straightening gradually until it appears to contact the distal aspect of the root of the lateral incisor, deviating toward a more vertical position. According to the results of this study, the upper permanent canine erupted with increasing distal inclination and with no significant changes in inclination of the upper lateral incisor.

Although there were little changes in horizontal positions of cusp and root apex of the upper permanent canine during observation, there were interesting findings in those changes. The horizontal position of the cusp changed gradual distally. In contrast, the horizontal position of the root apex initially changed distally, followed by mesially. As for the upper permanent canine changed inclination during eruption, it is suggested that it could be due to horizontal positional changes of the root apex especially from stage 2 to 3.

The vertical positions of cusp and root apex of the upper permanent canine changed downward with eruption. The changes in the cusp were larger when compared with that in the root apex. The root apex of the upper permanent canine was located at upside of the palatal plane at stage 1, it closed to the plane at stage 2, then changed toward the occlusal plane at stage 3.

The abnormal inclination or positions versus length of the upper permanent canine in panoramic radiographs when the four incisors has completed eruption may be a sign of eruptive disorders of the upper permanent canine, suggesting the adoption of preventive measures to avoid developmental disturbances.

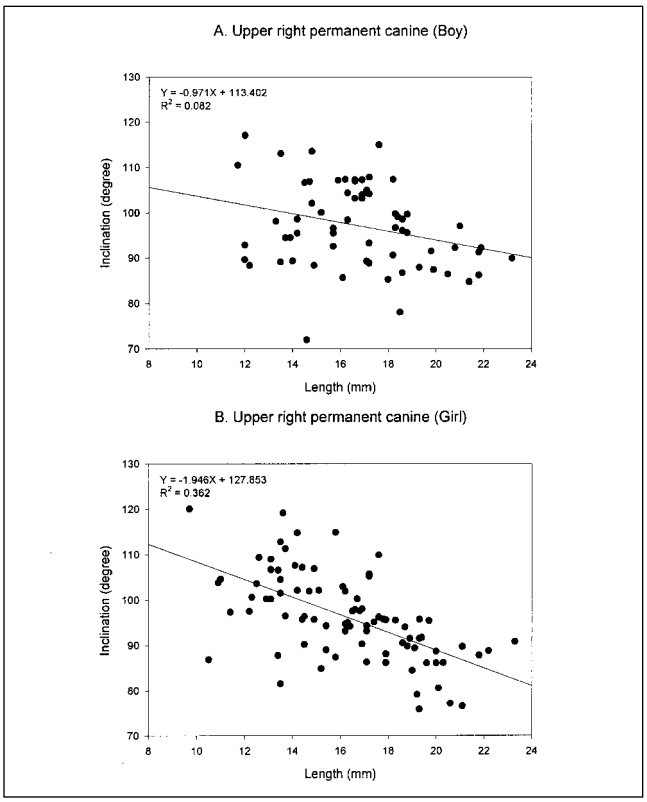

Figure 5. Actual measurements of inclination versus length of the upper permanent canine.
(**A:** boy, **B:** girl).

Table 2. Mean values and standard deviations of measurements and statistical comparison among three stages.

Measurements		Boy							Girl						
		Stage 1 (N=11)		*Stage 2 (N=46)*		*Stage 3 (N=8)*		One way anova	*Stage 1 (N=22)*		*Stage 2 (N=54)*		*Stage 3 (N=10)*		One way anova
		mean	s.d.	mean	s.d.	mean	s.d.		mean	s.d.	mean	s.d.	mean	s.d.	
Inclination of canine (degree)	*Right*	97.945	10.545	98.100	9.107	90.075	4.064	n.s.	102.805	9.525	95.491	7.958	85.250	5.212	***
	Left	95.827	10.338	96.389	8.343	86.700	12.261	*	99.191	6.969	94.524	9.376	85.510	5.616	***
Inclination of lateral incisor (degree)	*Right*	89.064	6.538	85.091	6.059	86.487	6.511	n.s.	86.573	8.614	82.991	6.009	85.310	4.519	n.s.
	Left	90.627	4.988	87.283	7.212	85.238	9.698	n.s.	87.309	8.567	84.122	6.454	85.610	10.281	n.s.
Length of canine (mm)	*Right*	12.891	0.899	16.920	1.542	21.550	0.842	***	12.595	1.170	16.894	1.680	21.050	1.097	***
	Left	13.509	1.130	17.067	1.876	20.900	1.837	***	12.800	1.831	17.241	2.255	20.470	2.468	***
X coordinate value of canine cusp	*Right*	-15.145	3.155	-16.735	3.364	-17.238	5.770	n.s.	-13.909	2.558	-15.328	3.137	-16.550	3.321	n.s.
	Left	15.055	2.857	16.917	3.503	17.325	3.807	n.s.	13.718	2.722	15.557	3.344	16.130	3.547	n.s.
Y coordinate value of canine cusp	*Right*	-8.300	2.427	-15.074	5.087	-24.488	2.158	***	-9.277	3.180	-16.406	5.107	-25.170	2.366	***
	Left	-8.709	2.061	-14.865	5.321	-21.925	3.659	***	-9.314	3.072	-16.196	5.497	-23.670	2.433	***
X coordinate value of canine root apex	*Right*	-16.827	4.219	-19.026	4.516	-17.212	6.645	n.s.	-16.627	3.291	-16.811	3.239	-14.940	3.347	n.s.
	Left	16.436	4.696	18.743	4.278	16.163	5.922	n.s.	15.736	3.197	16.759	3.905	14.540	2.977	n.s.
Y coordinate value of canine root apex	*Right*	4.291	1.596	1.483	4.047	-3.000	2.282	***	2.845	2.690	0.254	3.935	-4.280	2.225	***
	Left	4.527	2.482	1.928	4.150	-1.487	3.273	**	3.250	1.885	0.802	3.873	-3.330	3.051	***

n.s. not significant *** P<0.001 ** P<0.005 * P<0.05

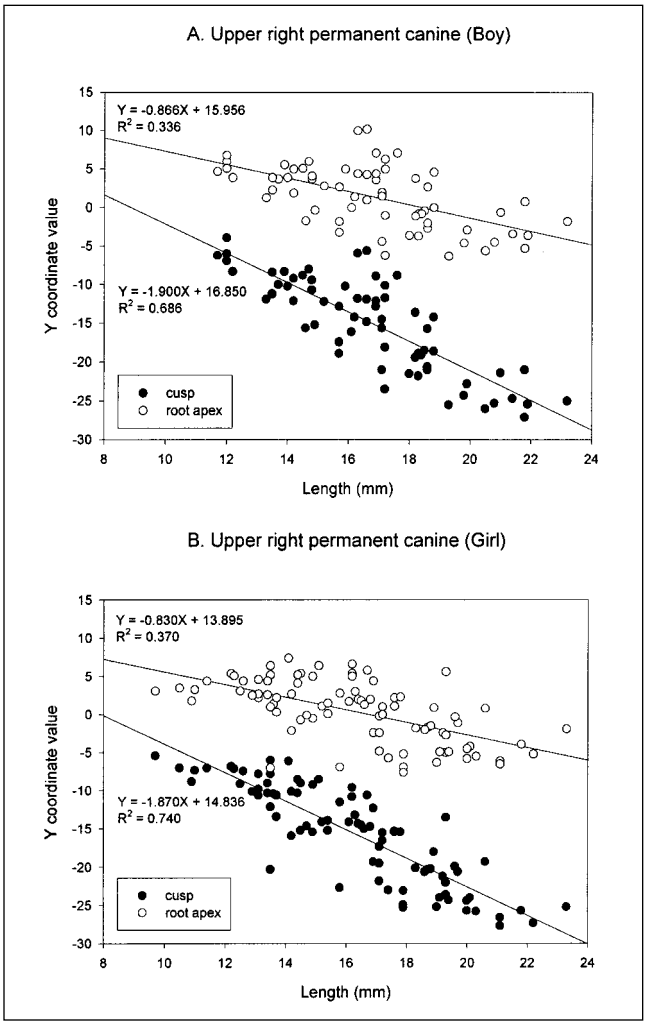

Figure 6. Actual measurements of Y coordinate values of the cusp and root apex versus length of the upper permanent canine (**A:** boy, **B:** girl).

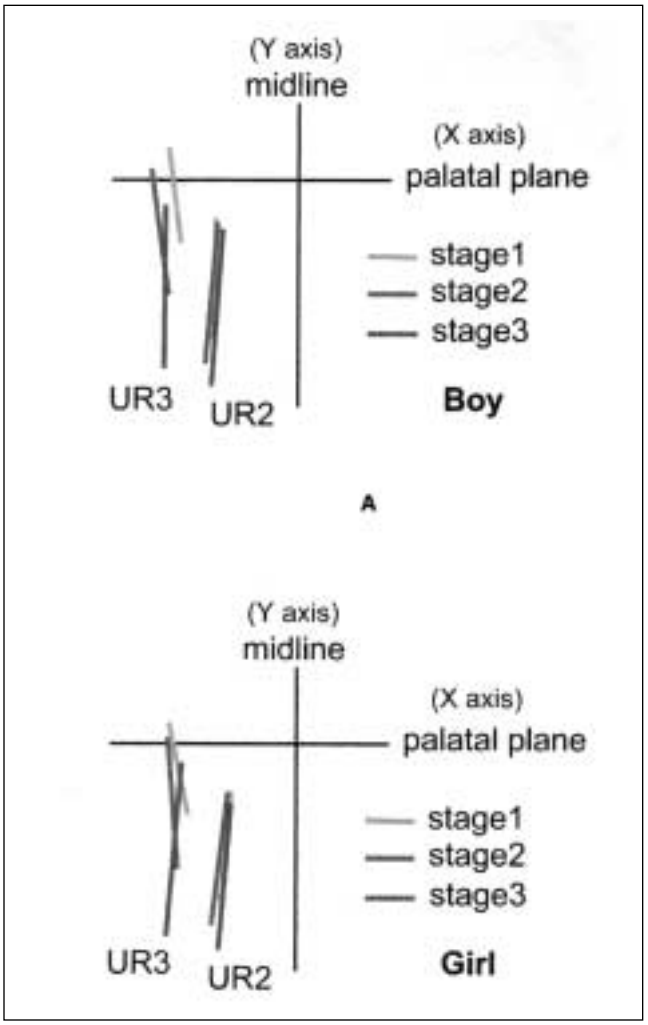

Figure 7. The developmental changes of the upper permanent canine through stage 1 to 3
(**A:** boy, **B:** girl).
UR3: upper right permanent canine
UR2: upper right permanent lateral incisor

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