Factors Affecting Self-Eruption of Displaced Permanent Maxillary Canines

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Key words: *displaced canine; interceptive treatment.*

Summary. *The aim of this study was to examine the possibility of the spontaneous eruption of displaced unerupted maxillary canines after the extraction of the deciduous canine and dental arch expansion and to determine the impact of initial canine position on treatment success rate.*

Materials and Methods. The study sample included 50 patients (mean age, 13.5 years [SD, 2.2]) with unilaterally displaced unerupted maxillary canines. Deciduous canines were extracted, and the space for displaced canine was created at the beginning of the study. The follow-up period for the spontaneous eruption was 12 months. The initial vertical, horizontal, labio-palatal position and angle of inclination to the midline of the displaced canine were assessed on panoramic radiographs.

Results. Only 42% of displaced canines erupted spontaneously within one-year period (52.9% of labially displaced canines and 36.4% of palatally displaced canines). A significant difference of inclination was determined between spontaneously erupted and unerupted teeth in the labially displaced canine group ($P<0.01$), with no difference in the palatally displaced canine group. The receiver operating characteristic curve analysis showed that the critical angle of inclination for the spontaneous eruption of the retained canine was 20° (sensitivity 0.759; specificity 0.571; $P<0.05$). The majority of unerupted canines (75.9%) were inclined more than 20°. The initial height of canine was crucial for spontaneous eruption (sensitivity 0.966; specificity 0.81; $P<0.001$). This was true for both palatal and labial cases.

Conclusions. The initial vertical position of the labially and palatally displaced canines and the inclination of the labially displaced canines were the most important predictors for spontaneous eruption of the cuspid.

Introduction

Ectopic eruption of the permanent maxillary canines is a frequent anomaly in the development of dentition. Displaced canines diverge from the normal eruptive path to palatal or labial direction. The displacement of developing maxillary canines can cause tooth impaction requiring surgical and orthodontic treatment. There is no clear definition between impaction and displacement leading to the delayed eruption of maxillary canines. Lindauer et al. (1) defined a canine as being impacted if it was unerupted after complete root development or if the contralateral tooth was erupted for at least 6 months with complete root formation. Thilander and Jakobsson (2) defined an impacted tooth as one "whose eruption is considerably delayed, and for which there is clinical or radiographic evidence that further eruption may not take place." Baccetti et al. defined that beyond the stage CS5 of cervical vertebral maturation, which occurs on average 1 year after the end of the adolescent growth spurt, displaced canines can be defined as impacted canines (3). The differentiation between maxillary canine impaction and delayed eruption is critical for the treatment strategy.

The etiological causes of maxillary canine impaction include heredity, prolonged retention of the deciduous canine, trauma, rotation of tooth buds, disturbances in tooth eruption sequence, lack of space, premature root closure, canine eruption into cleft areas, and localized pathological lesions, such as dentigerous cysts and odontomas (4–9). It has been reported that labial displacement of the upper permanent canine is most frequently associated with crowding, but palatally impacted canines have sufficient space to erupt (4, 8, 10–12). A lack of space was diagnosed in 60%–90% of patients with impacted upper canines (2, 13). Subjects with maxillary canine impactions also may have a transverse maxillary deficiency (6, 14).

The most common treatment procedure is surgical exposure of the retained canine followed by orthodontic treatment, but this is related to the pro-

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longed treatment, discomfort associated with surgical exposure, additional costs, and numerous complications (15–19). Although the etiology of palatal canine displacement has been linked to a genetic component, the eruption of the displaced canine can be affected by local/mechanical factors that have become the targets of "interceptive treatment" to allow the canine to erupt physiologically (20). Only several case reports (21–23) and few longitudinal studies (24–32) have demonstrated that simple interceptive procedures may favorably influence spontaneous eruption of the permanent canine. The most popular interceptive measure is removal of the deciduous canine (24, 25). The results of a study by Bruks and Lennartsson study showed that one-third of patients have a reasonably good chance of the spontaneous eruption of the canine if impaction was diagnosed and primary canine was extracted at an earlier age (26). In the study by Ericson and Kurol (24), after removal of the deciduous canines, 91% of impacted canines displaced no more than half of the lateral incisor root and 64% located more mesially erupted. The authors reported that the removal of primary teeth as a treatment measure was effective if there was enough space in the dental arch and only up to 11 years of age. However, in a study by Leonardi et al., the percentage of successful outcomes in the group that underwent the extraction of the deciduous canines did not differ significantly from those in the untreated control group (27).

The reliable prediction of interceptive treatment success could help decrease the patient's need for oral surgery and simplify orthodontic treatment. The mesiodistal location of the crown and the angulations of the unerupted canine are the most frequently used possible predictors of eventual treatment success (24, 25, 29).

The vast majority of the studies of interceptive treatment procedures were focused on palatally displaced canines with little data about labial displacements, but up to 30% of unerupted canines can be displaced labially (4, 8, 33). The dominating opinion is that labially displaced canines tend to erupt spontaneously. But when they are impacted, the treatment of labially displaced unerupted canines is difficult in managing the attached gingiva and is associated with complications such as gingival recession and root resorption of adjacent incisors (34, 35). At the moment, there are no clear indications for the differentiation between the labial impaction and labially displaced unerupted canine at the early stage (4).

The aim of this study was to examine the possibility of the spontaneous eruption of displaced unerupted maxillary canines after the extraction of the deciduous canine and dental arch expansion and to determine the impact of initial canine position on treatment success rate.

Material and Methods

The sample of this study included 50 patients (41 girls and 9 boys; mean age, 13.5 years [SD, 2.2]). The patients were selected according to the following criteria:

1. Adolescent nonsyndromic patients with permanent occlusion no older than 18 years presenting with unilaterally unerupted upper permanent canine.
2. No previous orthodontic treatment.
3. The conclusion about maxillary canine retention was based on panoramic radiograph (completed root formation of impacted tooth) and presence of erupted canine on the opposite side of the dental arch.
4. Complete records consisted of 3 panoramic radiographs (at the beginning, 6- and 12-month follow-up), occlusal radiographs, lateral cephalogram, photographs, and study casts. The date of the spontaneous eruption of displaced canines during the follow-up period had to be available as well as dates of the beginning and end of orthodontic treatment. All panoramic radiographs were taken by using the same x-ray procedure and machine.

The deciduous canines were extracted at the beginning of the study. Orthodontic treatment with fixed appliances was performed. Dental arches were aligned, and the adequate space for unerupted canine was created using an open coil spring on a 0.017×0.025-inch stainless steel arch wire. The follow-up period for the spontaneous eruption was 12 months. Control clinical check-ups were performed monthly. A successful outcome for an unerupted canine was defined as the eruption of the tooth, permitting bracket positioning for further arch alignment. Combined surgical and orthodontic treatment was applied, if displaced canines did not erupt within one year.

The initial labial (labially displaced canine, LDC) or palatal (palatally displaced canine, PDC) position of the unerupted canine was judged by clinical observation, palpation of the alveolar process, and radiographic examination. The round bulge found on any side of the alveolar process was considered as a positive feature of palpation of displaced canine, and smooth surface was judged as a negative feature. Radiographic localization included panoramic tomography and parallax technique with occlusal radiographs.

The initial vertical and horizontal position of the displaced canine was assessed on panoramic radiographs using the criteria proposed by Ericson and Kurol (33) (Figs. 1 and 2). All x-rays were studied under standardized conditions; negative films were traced onto acetate paper and analyzed. The tracings were done using a Staedtler Marsmicro 0.3-mm pencil (Staedtler Mars GmbH & Co. KG, Germany). The angles were measured with a goniometer to 1° and interval distances with a sliding caliper (Dentaurum, Germany) to 0.1 mm. The distance measurements on the panoramic radiograph tracings

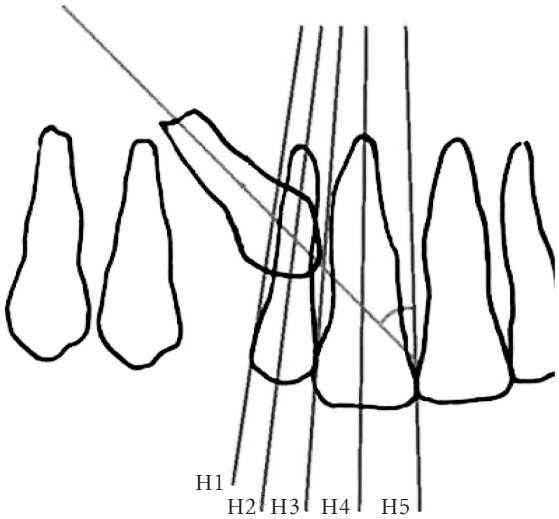

Fig. 1. The coordination mesh used to determine the horizontal localization and angle of inclination of the displaced unerupted canine

The horizontal localization of displaced unerupted canine was assessed in relation to the adjacent incisors. Horizontal sectors: H1, between first premolar and lateral incisor roots; H2, distal half of the lateral incisor root; H3, mesial half of the lateral incisor root; H4, distal half of the central incisor root; H5, mesial half of the central incisor root. The inclination was assessed by the angle between the long axis of impacted canine and vertical midline.

were adjusted considering magnification factors.

The space deficiency for the retained canine to erupt was assessed on plaster models. The distance between the distal contact point of the lateral incisor and medial contact point of the first premolar was measured and compared with the width of opposite side erupted canine.

All measurements were taken by one examiner only. The measurement errors were assessed using the paired-sample test. The angular and interval distances were measured twice for 10 patients. The mean limit of the error of the linear measurement between the repeated measurements was ±0.23 mm for plaster models and ±0.18 mm for radiograph tracings. The mean limit of the error of the angular measurements was 1°±0.7° ($P>0.05$), and sector designation did not differ between measurements.

All data were analyzed using the SPSS (version 14.0). The reliability of the differences between groups was performed by calculating the Student criterion and tested by the Mann-Whitney U test. Hypotheses of interrelations between characteristics were verified using the χ^2 criterion method, Spearman and Kendall tau correlation coefficients (r). If the number of cases in the observed groups was less than 5, exact Student t and χ^2 criteria were calculated. The most specific predictors of the spontaneous canine eruption were assessed using logistic regression analysis and receiver operating characteristic (ROC) curve analysis.

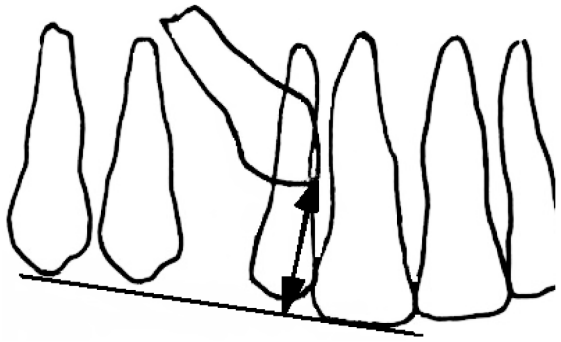

Fig. 2. The vertical position of the displaced unerupted canine was assessed by the perpendicular from the canine crown tip to the occlusal line

Results

The mean characteristics of displaced unerupted canines of the PDC and LDC groups are presented in Table 1.

The persisted primary canine in the area of retained permanent canine was found in 81.8% of PDC cases and 35.3% of LDC cases ($P<0.05$). The mean space deficiency among patients with the primary canine exfoliated was 5.94 mm (SD, 2.49), while with persisted only was 1.54 mm (SD, 1.18) ($P<0.05$). There were no differences in other parameters (patients' age, horizontal, vertical positions and angle of inclination of the retained permanent canine, palpation data) comparing patients with a persisted and exfoliated primary canine.

The spontaneous eruption of displaced canines was registered in 21 patients (42%). The spontaneous eruption occurred in 52.9% and 36.4% of LDC and PDC cases, respectively ($P>0.05$). The mean eruption time for PDC was 7.67 months (SD, 3.92) and for LDC 7.44 months (SD, 4.5) ($P>0.05$).

The factors affecting spontaneous eruption of the displaced unerupted canines is shown in Table 2.

Significant differences in the initial vertical position between successful cases and unerupted canines were found ($P<0.01$). The critical initial vertical height of the displaced unerupted canine was determined using ROC curve analysis (Fig. 3). The initial height of 12 mm was crucial for spontaneous eruption (sensitivity, 0.966; specificity, 0.81; $P<0.001$). This was true for both palatal and labial

Table 1. Descriptive Data of Displaced Unerupted Maxillary Canines

Characteristic	PDC n=33	LDC n=17	*P* Value
Initial vertical position, mm	14.39 (3.40)	13.47 (4.60)	NS
Angle of inclination, °	35.00 (13.85)	15.41 (9.94)	0.05
Lack of space for the displaced canine to erupt, mm	2.55 (2.48)	3.99 (2.97)	0.05

Data are mean (SD). NS, not significant.

Table 2. The Factors Affecting Spontaneous Eruption of the Displaced Unerupted Canines

Factor	Labially Displaced Canines									Palatally Displaced Canines								
	Erupted n=9				Unerupted n=8				*P* value	Erupted n=12				Unerupted n=21				*P* value
	Mean	SD	Min	Max	Mean	SD	Min	Max		Mean	SD	Min	Max	Mean	SD	Min	Max	
Initial vertical height of the displaced canine above occlusal line, mm	10.44	2.4	6	14	16.88	4.87	12	23	0.01	11.67	3.06	6	18	15.95	2.52	13	21	0.01
Angle of inclination of the displaced canine, °	10.11	7.22	0	9	21.38	9.47	7	35	0.01	32.08	14.76	0	50	36.67	13.34	18	73	NS
Lack of space for the displaced canine to erupt, mm	3.42	2.3	0.6	6.8	4.63	3.64	0	8	NS	2.14	2.38	0	8.3	2.78	2.56	0	8.5	NS

NS, not significant.

cases. All PDCs and 88.9% of LDCs located below 12 mm erupted spontaneously, while only about 10% of PDCs and LDCs displaced above this critical limit emerged within one year.

Significant differences in the inclination were determined between spontaneously erupted and unerupted teeth in the LDC group ($P<0.01$) with no difference in the PDC group. The ROC curve analysis (Fig. 4) disclosed that the critical angle of inclination for the spontaneous eruption of the displaced canine was 20° (sensitivity, 0.759; specificity, 0.571; $P<0.05$). The majority of unerupted canines (75.9%) were inclined more than 20°.

The initial horizontal localization of the displaced canine had no significant impact on spontaneous eruption (Table 3, $P>0.05$). The correlation between initial horizontal localization and spontaneous eruption was not significant (Kendall tau test, $r=0.03$, $P=0.9$ for PDC; and $r=0.4$, $P=0.1$ for LDC).

A multinomial logistic regression model was developed to disclose the variables predicting the spontaneous eruption of displaced canines (Table 4). The analysis revealed that canine inclination of more than 20° and every millimeter of its vertical displacement reduced the odds of spontaneous eruption by 4.861 (95% CI, 1.194–19.796) and 6.758 (95% CI, 1.853–24.651), respectively.

The positive palpation of the unerupted canine

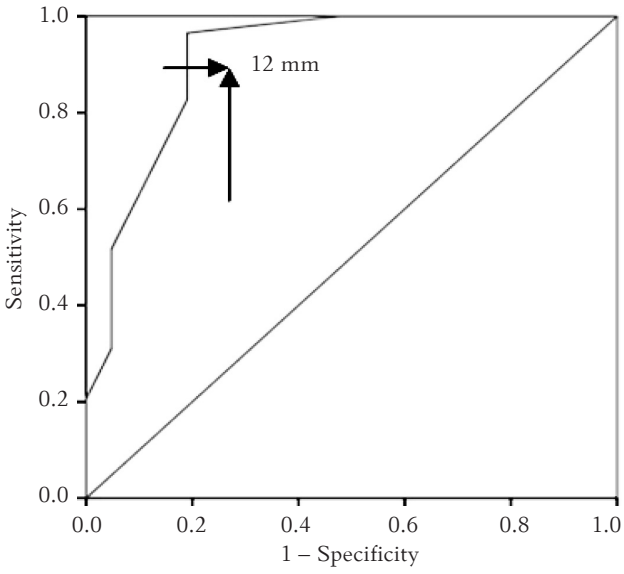

Fig. 3. Receiver operating characteristic curve analysis for prediction of the critical initial vertical height of the displaced unerupted canine

Area under the receiver operating characteristic curve, 91.3%.

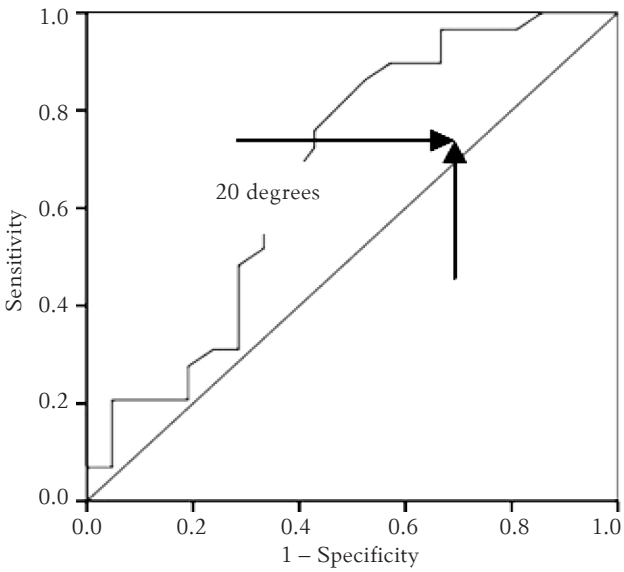

Fig. 4. Receiver operating characteristic curve analysis for prediction of the critical initial angle of inclinations of the displaced unerupted canine

Area under the receiver operating characteristic curve, 67.7%.

Table 3. The Initial Horizontal Position of Displaced Unerupted Canines

Initial horizontal position of the displaced canine (sectors)	n	Labially Displaced Canines					Palatally Displaced Canines				
		Erupted		Unerupted		Total	Erupted		Unerupted		Total
		n	%	n	%		n	%	n	%	
H1	17	9	100	5	62.5	14	1	8.3	2	9.5	3
H2	11	0	0	3	37.5	3	3	25.0	5	23.8	8
H3	16	–	–	–	–	–	6	50.0	10	47.6	16
H4	4	–	–	–	–	–	2	16.7	2	9.5	4
H5	2	–	–	–	–	–	0	0	2	9.5	2
Total	50	9		8		17	12		21		33

Table 4. Results of Logistic Regression

Criteria	*β*	*df*	OR	95% CI	Sig.
Initial angle of inclination of the displaced unerupted tooth >20°	1.581	1	4.861	1.194 to 19.796	0.027
Initial vertical position of the displaced unerupted tooth Increase by 1 mm	1.911	1	6.758	1.853 to 24.651	0.04
Constant	–3.569	1	0.028		0.003

β, beta; *df*, degrees of freedom; Sig., statistical significance; OR, odds ratio; CI, confidence interval.

was a good predictor of the spontaneous eruption. More than half (58.3%) of displaced canines in the PDC group and 77.8% in the LDC group erupted within one year in case of positive palpation ($P<0.05$).

Discussion

In this study, the probability of the spontaneous eruption of maxillary displaced unerupted canines after the dental arch expansion and deciduous canine extraction was evaluated, and the factors predicting successful outcome were analyzed. We found that only 42% of unerupted teeth erupted spontaneously. The success rate in our study was found to be considerably lower than that in other studies (Table 5).

The lower rate of spontaneous eruption in our study also can be explained by older age of the study group. The older age usually means higher probability of impactions. The older age of our patients was also the main reason to reduce follow-up period to 12 months.

Labial displacement in the present study was much less frequent than palatal, and we found no study in the literature comparing subjects with diagnosed LDC and PDC who underwent both interceptive deciduous canine extraction and arch expansion. It is interesting to note that, on contrary to opinion that labially impacted canines tend to erupt if sufficient space is created, no statistical difference was recorded in number of successful patients between those groups in our study.

The initial mesiodistal and vertical location of the crown of the retained canine has been shown to be the most popular predictors of the successful canine eruption after interceptive treatment (24, 25, 29). However, the results of this study showed no significant correlation between the initial horizontal localization of the retained canine and possibility of spontaneous eruption. This could be explained by the fact that the majority of PDCs were located in the sector H3 (i.e., closer to the mesial half of the lateral incisor root) and LDCs in the sector H1 (i.e., between the first premolar and lateral incisor roots). The small number of the cases in other sectors did not create adequate power for statistical assumptions. On the other hand, a strong correlation between the mesiodistal location and inclination of the retained tooth was observed ($P<0.01$).

Angulation was one of the decisive factors predicting the spontaneous eruption of the retained canine in this study. The retained teeth inclined more than 20° reduced the chances for spontaneous eruption. Our results are in agreement with the results of other studies. Power and Short (25) examined the angulation as a predictor and reported that if the tooth was angled more than 31° to the midline, its chances of eruption after deciduous extraction were decreased.

The distance from the crown tip of the displaced canine to its final position in the dental arch showed the strongest impact on the spontaneous eruption. The distance of 12 mm was a borderline between successful and unsuccessful outcome in this study. It is not possible to assess three-dimensional "depth" of impaction on the conventional orthopantomograms. The use of orthopantomograms appears to be reliable especially in angular measurements, whereas calibration is problematic in linear measurements. Nevertheless, in the present study, the vertical position of the retained canine was assessed with the mean error of only 0.18 mm. The results showed that canine inclination of more than 20º and every millimeter of its vertical displacement reduced the odds of spontaneous eruption by nearly 4.9 and 6.8, respectively. This is in agreement with the study by Stewart et al. (36).

The palpation was used in our study to assess the

Table 5. The Findings of Different Studies on Spontaneous Eruption of Displaced Unerupted Canines

Study	Treatment	Rate of Spontaneous Eruption	Follow up Period	The Mean Age of the Study Group	Factors Used to Predict Spontaneous Eruption
Present study	Primary canine extraction and dental arch expansion	42%	1 year	13.5 years	Initial vertical position of the tooth The inclination angle of the impacted tooth
Ericson and Kurol 1988	Primary canine extraction	78%	Radiographically, up to 18 months; clinically, to the end of treatment	11.5 years	The initial horizontal position The initial vertical position of the tooth The distance of the tooth from the dental arch
Power and Short, 1993	Primary canine extraction	62%	2 years	11.2 years	The horizontal position of the impacted tooth degree of dental crowding The inclination angle of the impacted tooth
Olive, 2002	Primary canine extraction and dental arch expansion	75%	27 months	13.5 years	The initial horizontal position
Leonardi et al., 2004	Primary canine extraction and cervical-pull headgear	50% 80%	The average time for complete eruption – 1 year 8 months	11.6 years	Not evaluated
Baccetti et al., 2008	Primary canine extraction	65.2%	18 months	11.7 years	Not evaluated
	Primary canine extraction + Cervical-pull headgear	87.5%	18 months + 3 months	11.9 years	Not evaluated
Baccetti et al., 2009	RME	65.7%	4.11 years	8.4 years	Not evaluated

position of retained canine regardless its subjectivity. The positive palpation of the retained canine was a good predictor of the spontaneous eruption of PDC.

The results of this study demonstrate that the initial vertical position of LDCs and PDCs and the inclination of LDCs are the most important predictors for the spontaneous eruption of the cuspid. The relatively older age at the beginning of treatment may explain the low frequency of the spontaneous eruption of the permanent canines.

Conclusions

Only 42% of displaced maxillary canines erupted spontaneously within one-year period after removal of the primary canine and expansion of the dental arch. One of the major factors affecting spontaneous eruption of the retained canine was the displacement distance of the crown tip to the occlusal line. The second major factor affecting the eruption was the inclination of the cuspid in the group of labially displaced canines. In the group of palatally displaced canines, the angulation of the cuspid was not associated with the eruption.

Statement of Conflict of Interest

The authors state no conflict of interest.

Viršutinių retinuotų iltinių dantų savaiminį išdygimą lemiantys veiksniai

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Raktažodžiai: retinuoti iltiniai dantys, ortodontinis gydymas.

Santrauka. *Tyrimo tikslas.* Įvertinti retinuotų viršutinių pastoviųjų iltinių dantų savaiminio išdygimo tikimybę išplėtus dantų lanką ir pašalinus pieninius iltinius dantis bei nustatyti retinuotų pastoviųjų iltinių dantų pradinės padėties įtaką savaiminiam dygimui.

Medžiaga ir metodai. Tyrimo imtį sudarė 50 pacientų (amžiaus vidurkis – 13,5 metų, standartinis nuokrypis – 2,2 metų), kuriems diagnozuotas vienos pusės neišdygęs retinuotas viršutinis pastovusis iltinis dantis. Gydymo pradžioje buvo pašalinti pieniniai iltiniai dantys ir padaryta vieta retinuotam iltiniam dančiui dantų lanke. Savaiminio dygimo stebėsenos trukmė – 12 mėn. Panoraminėse rentgenogramose

įvertinta retinuoto pastoviojo iltinio danties pradinė vertikali, horizontali, lūpinė-gomurinė padėtis bei danties pasvirimo į centro liniją kampas.

Rezultatai. Per vienerius stebėsenos metus išdygo tik 42 proc. retinuotų iltinių dantų (52,9 proc. – lūpine kryptimi, 36,4 proc. – gomurine kryptimi dislokuotų dantų). Lūpine kryptimi dislokuotų dantų grupėje nustatytas reikšmingas skirtumas tarp savaime išdygusių ir neišdygusių dantų pasvirimo į centro liniją kampo reikšmių ($p<0,01$). ROC kreivių analizė parodė, kad savaiminiam dislokuoto danties išdygimui kritinė pasvirimo kampo reikšmė yra 20° (jautrumas – 0,759; specifiškumas – 0,571; $p<0,05$). Dauguma neišdygusių iltinių dantų (75,9 proc.) buvo palinkę daugiau kaip 20°. Pradinė vertikali danties padėtis turėjo įtakos savaiminiam išdygimui (jautrumas – 0,966; specifiškumas – 0,81; $p<0,001$) tiek lūpine, tiek gomurine kryptimi dislokuotų dantų grupėse.

Išvada. Savaiminio dislokuotų iltinių dantų išdygimo svarbiausi prognostikos veiksniai yra pradinė vertikali neišdygusio danties padėtis ir pasvirimo į centro liniją kampas.

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Received 23 March 2011, accepted 27 May 2011
Straipsnis gautas 2011 03 23, priimtas 2011 05 27