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RADIOGRAPHIC PREDICTORS AFFECTING ON THE DURATION OF TREATMENT FOR MAXILLARY IMPACTED CANINE

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The purpose of this study was to investigate radiographic predictors of impacted maxillary canine related to the duration of treatment time. A total of twenty-four maxillary impacted canines with surgical exposure and orthodontic treatment were collected. The average age of the patients was 13.7 years at the beginning of treatment and the study included 9 males and 14 females. There were sixteen impacted teeth on the buccal side and eight on the palatal side. Four panoramic radiographic predictors including canine angulation, mesiodistal position, vertical position and root formation related to the duration of orthodontic treatment were assessed. The duration of treatment was defined from beginning of orthodontic traction to alignment and leveling with .016" x .016" stainless steel archwires. In terms of statistics, a multiple regression analysis was used. The results showed that the mesiodistal position of the impacted canine was statistically significantly related to the duration of orthodontic treatment ($p=0.000$). However, there was no significant correlation between canine angulation, vertical position, or the root formation of the impacted canine and the duration of orthodontic treatment. It was concluded that the mesiodistal position of the impacted canine was a predominant predictor of the duration of orthodontic treatment. (*Taiwanese Journal of Orthodontics*, 29(2): 78-85, 2017)

Keywords: panoramic radiograph; treatment duration; maxillary impacted canine

INTRODUCTION

The impacted maxillary canine is the second location in which the occurrence of impacted teeth other than the third molar occurs. The incidence of a maxillary impacted canine is 1.0% to 2.8%.¹⁻³ The maxillary impacted canine occurs twice as often in females as compared to males

and is three times more likely to be located on the palatal side than the buccal side.^{2,3} A panoramic X-ray is a regular examination tool for orthodontic patients, so diagnosis and prediction of maxillary impacted canine using a panoramic radiograph has been described in several articles.⁴⁻⁶

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When an impacted maxillary canine is diagnosed, there are many treatment options. Autotransplantation, extraction or surgical exposure combined with orthodontic traction has been recommended for impacted teeth.² To preserve the impacted tooth, the use of surgical exposure and orthodontic traction is a conservative and common treatment option.

Since surgical exposure and orthodontic traction is a common treatment method, the duration of treatment is of concern to both patients and orthodontists. Therefore, the relationship between the severity of the impacted canine and orthodontic treatment duration have been investigated in several previous studies.⁷⁻¹² The aim of this research is to determine radiographic predictors of an impacted canine as it relates to the duration of treatment.

MATERIALS AND METHODS

Patients who had maxillary canine impaction treatment were obtained from March, 1989 to June, 2012 in this retrospective study. The research was approved by NCKUH IRB No. B-ER-101-324. The inclusion criteria included an impacted canine requiring surgical exposure,

successful orthodontic traction, and available pretreatment panoramic X-ray records. Patients with cleft lip/cleft palate or other craniofacial anomalies or incomplete records were excluded. A total of twenty-three patients were collected at National Cheng Kung University Hospital.

Four radiographic factors from a panoramic X-ray were used as predictors for the duration of orthodontic traction for a maxillary impacted canine. A pretreatment panoramic X-ray was used to measure canine angulation to the midline, the crown overlapping to the adjacent lateral incisor root, the crown vertical position to the central incisor and the root formation stage of canine by one operator (Dr. Jen-Bang Lo). For canine angulation to the midline (θ), the angle between the long axis of the canine and the midline between central incisors was measured (Figure 1). The long axis of the canine was described by a line drawn through the canine root apex and canine tip. The midline was defined by a line drawn through the following landmarks: the inter-maxillary suture, anterior nasal spine, nasal septum and the inter-nasal suture.

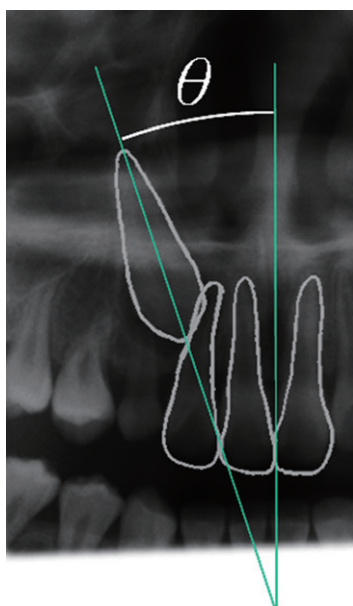


Figure 1. Canine angulation to the midline (θ): measurement of the angle between the long axis of the canine and the midline.

According to the mesiodistal (MD) position of canine and the canine crown overlap to the adjacent lateral incisor root, four scales were defined as described in Figure 2. MD1 was defined as the canine crown distal to the lateral incisor with no crown overlap of the adjacent lateral incisor root. MD2 was defined as the canine crown overlapping the distal part of the root of the adjacent lateral incisor. MD3 was defined as the canine crown overlapping the mesial part of the root of the adjacent lateral incisor. MD4 was defined as the canine crown overlapping the root of the adjacent lateral incisor and across to the mesial side of adjacent lateral incisor. Two levels of the canine crown vertical (V) position to the middle of the central incisor root are shown in Figure 3.

Vc was recorded as when the canine crown tip was at the coronal half of the root of the central incisor. Va was recorded as when the canine crown tip was at the apical half of the root of the central incisor. According to the canine root formation, it was divided into incomplete root formation (Ri) and complete root formation (Rc) subgroups.

These patients received a fixed appliance with a .018" standard edgewise system. After initial alignment of full mouth teeth and space regained for the impacted tooth, surgical exposure was arranged. The surgical exposure procedures included local anesthesia, surgical exposure, and attachment bonding. Surgical exposure was performed using either open or close methods according

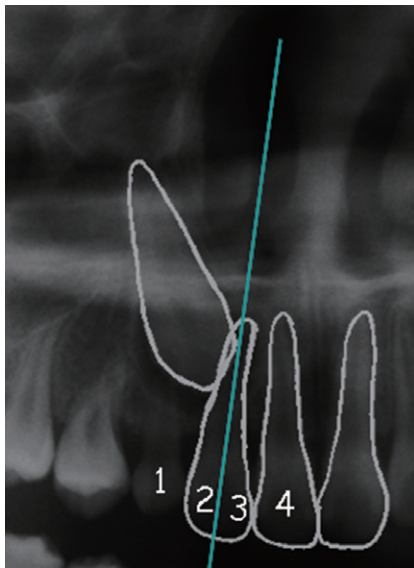


Figure 2. Mesiodistal (MD) position of canine: Canine crown overlapping the adjacent lateral incisor root, for which four scales are defined. MD1: no overlapping of canine crown and lateral incisor root, MD2: canine crown overlapping less than half of the root width of the lateral incisor, MD3: canine crown overlapping more than half of the root width of the lateral incisor, MD4: canine crown completely overlapping of the root of the lateral incisor and across it.

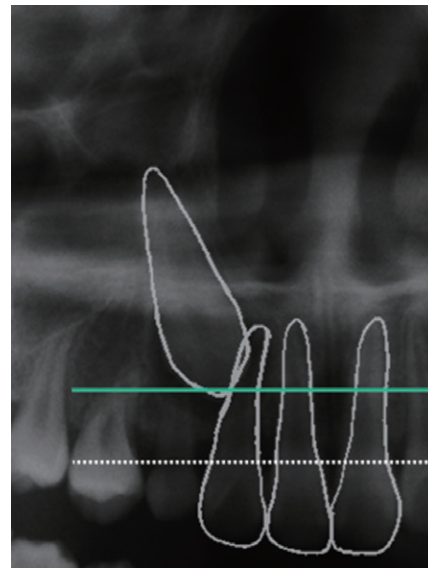


Figure 3. Canine crown vertical position related to the central incisor, for which two levels are defined. The green line is the middle of the root of the central incisor, and the dotted line is the cemento-enamel junction of the central incisor.

to whether the impacted position was shallow or deep. The open window method was used on a palatal impacted tooth and the apical positioned flap method was used on a buccal impacted tooth, respectively, for the shallow position. Both the open window and the apical positioned flap methods are defined as open methods. A closed method was applied to a deeply impacted tooth. When the flap was opened, the attachment was bonded to the tooth surface, and the flap was sutured back and covered the attachment, which is called the closed method technique. After surgical exposure of the impacted tooth, orthodontic traction with elastic thread was performed. After the impacted tooth was erupting into the oral cavity, it was aligned and leveled using light wire to the .016" x .016" stainless steel archwires.

The duration of treatment was assigned as the beginning of orthodontic traction after surgical exposure of the impacted tooth to alignment and leveling with .016" x .016" stainless steel archwires. All four predictors

related to the duration of treatment were statistically analyzed using a multiple regression method. The level of significance was set at $p < 0.05$. The correlation of each parameter with the duration of treatment was also analyzed. Statistical analyses were performed with the SPSS statistical package (SPSS statistics 17.0; SPSS, Chicago III).

RESULTS

A total of twenty-three patients (9 males and 14 females) were collected with an average age of 13 years 8 months (ranging from 9 years 8 months to 20 years 4 months) at the beginning of treatment. Only one patient had bilateral impacted canines. The sites of the impacted canines among the unilateral cases revealed that 6 occurred on the right side and 16 occurred on the left side. Sixteen teeth were located on the buccal side, and eight teeth were on the palatal side (Table 1).

Table 1. Descriptive categorical variables.

Parameter	Variables	N (%)
Age	9-12 Y/O	14 (60.9)
	13-16 Y/O	6 (26.1)
	17-20 Y/O	3 (13.0)
Gender	Male	9 (39.1)
	Female	14 (60.9)
Site of impaction	Right	6 (26.1)
	Left	16 (69.6)
	Bilateral	1 (4.3)
Location of impaction	Buccal	16 (66.7)
	Palatal	8 (33.3)

Patient Number: 23, Tooth Number: 24.

The average angulation between the canine and the midline was 29.58 ± 14.58 degrees, ranging from 5 to 54 degrees. The distributions of canine angulation, canine crown mesiodistal position, canine crown tip vertical position and canine root formation condition related to the duration of treatment are shown in Table 2.

After using a multiple regression method to analyze the relationships among the four predictors and the duration of treatment, we found that the correlation between the mesiodistal position of the impacted canine

and the duration of treatment achieved a statistical significance (Figure 4). However, there were no statistically significant relationships among the canine angulation, vertical position, or root formation with the duration of treatment (Table 3). Therefore, the mesiodistal position of the canine was considered a predominant predictor of the duration of treatment in the current study. According to the regression model, we obtained a regression equation as below:

$$\text{Tx duration} = 3.109 + 4.703 (\text{MD position})$$

Table 2. The distributions of four predictors and duration of treatment.

Variable	Number	Percentage (%)	Tx duration \pm SD (Month)
θ : 0~15°	5	20.83	11.31 \pm 8.66
θ : 16~30°	7	29.17	20.87 \pm 8.66
θ : >30°	12	50.00	15.75 \pm 6.34
MD1	5	20.83	7.87 \pm 2.70
MD2	5	20.83	13.62 \pm 6.35
MD3	5	20.83	15.84 \pm 4.43
MD4	9	37.50	22.77 \pm 8.61
Vc	18	75	16.36 \pm 8.79
Va	6	25	16.19 \pm 7.97
Ri	17	70.83%	15.70 \pm 6.29
Rc	7	29.17%	17.82 \pm 8.42

SD: standard deviation. **θ :** canine crown angulation. **MD1:** no overlapping of canine crown and lateral incisor root, **MD2:** canine crown overlapping less than half of the root width of the lateral incisor, **MD3:** canine crown overlapping more than half of the root width of the lateral incisor, **MD4:** canine crown completely overlapping of the root of the lateral incisor and across it. **Vc:** canine crown tip at coronal half of root of the central incisor, **Va:** canine crown tip at the apical half of root of the central incisor. **Ri:** incomplete root formation, **Rc:** complete root formation.

Table 3. The correlation of four predictors and the duration of treatment

Variable	coefficient	t-ratio	p value
θ	-0.034	-0.321	0.752
MD	5.401	4.232	0.000
V	2.667	0.816	0.425
R	5.272	1.679	0.110

θ : crown angulation, **MD:** mesiodistal position, **V:** vertical position, **R:** root formation condition.

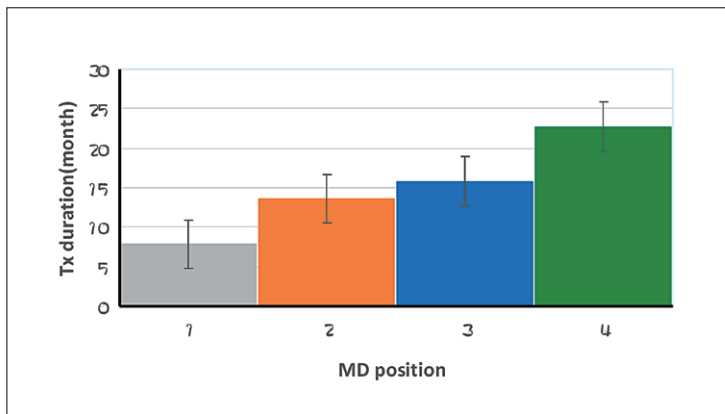


Figure 4. Graph of the relationship between the mesiodistal (MD) position of the canine and the duration of treatment, $p=0.000$.

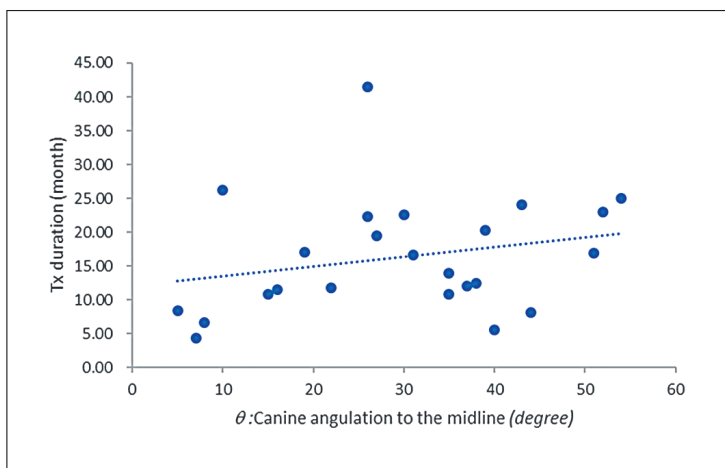


Figure 5. Linear regression of the relationship between canine angulation (θ) and the duration of treatment, $p>0.05$.

DISCUSSION

The occurrence of a maxillary impacted canine has been reported to be more frequent in females than in males, which was also noted in our study. Previous reports have shown that the location of the maxillary impacted canine is three times more common on the palatal side than on the buccal side,^{2,3} but on the contrary, we found that the buccal side location was two times higher than the palatal side location. The difference might be due to a racial difference, e.g. Caucasians have more palatally impacted canines; whereas Orientals have more buccally impacted canines. An impacted maxillary canine can be

diagnosed after ten years of age.^{4,13} In this study, patients at the beginning of treatment ranged in age from 9 years to 20 years old. There was no significant difference between age and treatment duration in this study. One previous paper found longer treatment duration for younger patients due to deeply impacted teeth.⁷ However, other papers have indicated that being more than 20 or 25 years old at the time of treatment results in longer treatment time.^{8,11}

Because a panoramic X-ray is a routine examination tool for orthodontic patients, radiographic predictors of maxillary impacted canine have been investigated by many previous studies.⁵⁻¹² Factors including in crown angulation, vertical position and mesiodistal position

of the impacted canine in regard to their effects on the duration of treatment were assessed in most of these papers.⁷⁻¹² In one paper, crown angulation, vertical position and mesiodistal position all affected the duration of treatment, and crown angulation was pointed out to be the determinant factor.¹¹ However, there was no statistical significance found between the duration of treatment and crown angulation in this study (Figure 5). The overlap to the lateral incisor in the mesiodistal position of the impacted canine has been found to be significantly related to duration of treatment in many previous studies.⁸⁻¹⁰ The mesiodistal position of the impacted canine might be a predominant factor for treatment duration, which was concurrent with our results. According to the regression equation: Tx duration = 3.109 + 4.703(MD position), the treatment duration could be predicted by the mesiodistal position of the canine crown. If the scale of the MD position is one, the treatment duration is predicted to be 7.912 months. If the scale of the MD position is four, the treatment duration is predicted to be 21.921 months.

In most impacted canines, the angulation of the crown increases and the crown overlapping to the lateral incisor increases too. Due to different sample sizes and statistical methods, it is hard to distinguish between the two factors. If the angulation of the impacted canine is higher than 45 degrees, the canine is more likely to be unresponsive to orthodontic treatment, and extraction is recommended.⁹

A significant correlation between the vertical position of the impacted canine and the duration of treatment has been presented.^{7,8} If the crown tip is higher 14 mm than the occlusal plane, it requires a longer treatment time.⁷ One additional visit is required if the distance increased by 0.63 mm.⁸ In the current study, the levels of the canine crown vertical position using the middle of the central incisor root as reference because the central incisor root formation was almost complete at this moment. Unfortunately, there was no positive relationship ($p>.05$)

found between the vertical position of the impacted canine and the duration of treatment. Other factors, including root formation and the root position of the impacted canine, have been reported to bear no relationship to the duration of orthodontic treatment.^{9,10} In the present study, no correlation was found between the root formation status of the impacted canine and treatment duration.

The average duration of treatment in this study was 13.6 months, ranging from 3.22 to 26.58 months. The definition of duration of treatment has varied in different studies. One study counted the time period from the date of surgical exposure to correct alignment in the arch with a 0.019 x .025 inch stainless steel wire, where the average duration of treatment was 26.3 months.¹⁰ Another study defined it from surgical exposure to leveling with .018" stainless steel wire or debonding time for which their results were 19.3 months or 28.8 months of treatment time respectively.¹⁴ The average time of traction (crown tip to intraoral position) and that of total treatment (debonding) were 8 months and 22 months, respectively, in another study.¹¹ Therefore, it was hard to compare the treatment duration because of the differences in the definition for the different studies.

One limitation of this study was the small sample size. There were only 24 cases in this study. If we could collect more cases in the future, we might divide the samples into more subgroups, and more information could be obtained. According to the results of the present study, we may simply predict that a longer the treatment duration will result from more mesiodistal overlapping area between the canine crown and the lateral incisor root.

CONCLUSIONS

1. The mesiodistal position of the canine had a statistically significant relation with the duration of treatment.
2. There was no statistically significant correlation between canine angulation, crown vertical position, or root formation and the duration of treatment.

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