DOI: 10.7860/JCDR/2018/36314.12241

Original Article

Dentistry Section

Early Radiographic Features of Maxillary Canine Impaction for Orthodontically Diagnosed Children Aged Between 8-14 Years Old

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ABSTRACT

Introduction: The early detection and diagnosis of maxillary canine impaction affect the planning of its treatment. Certain radiographic features may be used in order to diagnose such impaction.

Aim: To study the radiographic features for detection of the maxillary canine impaction in children and the changes associated with these features over time.

Materials and Methods: This was a retrospective cross-sectional study that included 37 children aged between 8-14-years-old. Each patient must be diagnosed orthodontically with canine impaction by the failure of its eruption clinically and by using Panoramic Radiographs (PRs). The patient must have at least two PR with at least a one-year interval (T1 and T2) between them both. The following radiographic features have been used to identify maxillary canine impaction: 1) the vertical canine crown height; 2) the degree of canine overlap in relation to any adjacent teeth; 3) the magnitude of canine to lateral incisor angle and 4) the magnitude of the canine to midline angle measurement. The null hypothesis for this study was that there is no difference in the radiographic features between impacted and non-impacted canines in children overtime.

Results: An assessment of the panoramic radiographs that were obtained at a later stage (T2) was carried out, which revealed that 56.76% of the canines were impacted whilst 43.24% had erupted normally. Impacted canines showed a significantly higher vertical crown height in relation to the adjacent teeth at T1 (p=0.01). Around 60% of the non-impacted canines were located in a normal position apical to the primary canine. However, the crown of impacted canine was around 75% placed either distal or mesial to the permanent lateral incisor (p<0.001). The mean values for both the canine-lateral incisor angle and the canine to midline angle were increased significantly (p<0.01) in the impacted canines. The canine to midline angle was decreased significantly (p=0.02) by an average of 5° over time in the non-impacted cases, whereas it did not change in the case of impacted canines.

Conclusion: The radiographic features can help to identify canine impaction at an early stage if it is: 1) located at a higher vertical position than the adjacent teeth; 2) overlapped with the lateral incisor 3) a canine-lateral incisor angle of more than 30° is present; and 4) the canine angulation in relation to the midline is more than 54.1°.

Keywords: Canine angulation, Canine position, Panoramic radiographs

INTRODUCTION

Tooth impaction can be defined as being the failure of a tooth to erupt after the completion of its root development [1]. The tooth can also be considered as being impacted when it fails to appear in the oral cavity while its corresponding tooth, on the other side of the arch, has been already erupted for at least six months [2]. The impacted tooth is usually embedded in the alveolus and it is locked in by bone, adjacent teeth, or any other obstacles [3]. The most frequently reported impacted tooth, after the third molar, is the maxillary canine. The incidence of this condition ranges from 1-3% [4]. Several studies have shown that the ratio of palatal to buccal maxillary impaction is 3:1 respectively with the possibility of this condition occurring twice as many times in females than in males [5]. The etiological factors for maxillary canine impaction are categorised into two main factors or theories, namely, guidance theory versus genetic theory [6]. Guidance theory states that the maxillary canine impaction results from a lack of its eruption due to the loss of guidance from the adjacent teeth [7]. Early loss of the maxillary lateral incisor can lead to the loss of such guidance. On the other hand, genetic theory refers to the existence of certain genetic factors that result in the failure of canine eruption [8]. Different dental anomalies are considered to be genetic factors in canine impaction. Such factors include the following: 1) congenitally missing maxillary lateral incisors; 2) peg-shaped maxillary lateral incisors; 3) enamel hypoplasia of adjacent teeth; 4) aplasia of second premolars; and 5) infra-occluded primary molars [4,9,10]. It was recently purported that the evidence supporting the guidance theory as being the cause of canine impaction has been diminished [11]. Alternatively, it is now believed that canine impaction can result from a combination of genetic, epigenetic and environmental influences.

The choice of treatment for impacted maxillary canines is affected by multiple factors. These include canine location, severity of impaction, and the age of the patient [4]. Early detection and diagnosis of maxillary canine impaction may affect the treatment modalities. Interceptive orthodontic treatment is often the first approach in growing persons for guiding the canine into a normal position and preventing tooth impaction [9]. It was suggested that the extraction of the primary canine could reduce the treatment complexity and cost [12,13]. Other treatment modalities include the creation of space in the dental arch by permanent teeth distalization, extraction of the maxillary deciduous first molar or by maxillary expansion. Surgical exposure of the impacted canine becomes necessary when interceptive treatment fails [14]. It requires a combination of surgical and orthodontic interventions in order to bring the canine into the dental arch [15-17].

Multiple radiographic features have been used in many studies to detect maxillary canine impaction [18-20]. These include the following features: 1) the canine to midline angle measurement; 2) the canine to lateral incisor angle measurement; 3) the vertical canine crown height and 4) the degree of canine overlap in relation to the adjacent teeth.

The aim of this study was to predict the changes in the radiographic features for maxillary canine impaction in children over time.

MATERIALS AND METHODS

This is a retrospective cross-sectional study that included the analysis of 3,000 children aged between 8-14-years-old, who visited the college of dentistry, King Saud University between the years of 2013 to 2016. The study protocol was reviewed and approved by the College of Dentistry Research Centre (CDRC) in King Saud University, Riyadh, Saudi Arabia (Reference IR 0193). The inclusion criteria were as follows:

- Healthy children with no abnormality detected,
- The children, taking part in this study, must be diagnosed orthodontically with canine maxillary impaction due to failure of its eruption,
- Each patient must have had at least two panoramic radiographs (PR) taken with at least a one-year interval between them and a maximum of two years between the two radiographs (T1 and T2),
- The patients must be aged between 9-14-year-old at the time of T2 so patients aged eight years old at T1 were included in the study.

The exclusion criteria included the following:

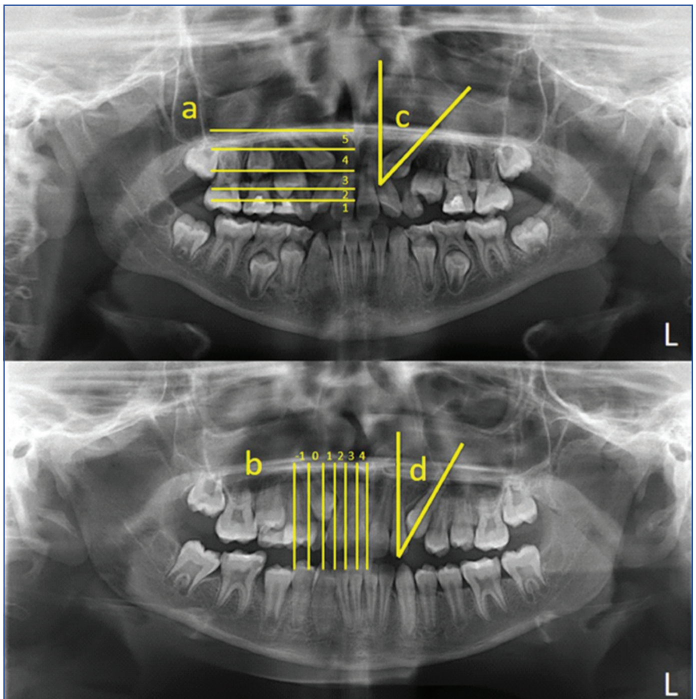
- Medically compromised children were not allowed to take part in the study,
- There should be no presence of craniofacial deformity in the study subjects,
- There should be no presence of dental pathology in the study subjects,
- Any dark or unfocused PR may not be used for analysis purposes.

All impacted maxillary canines were defined, based on their clinical data and on radiographic assessment, as being intraosseously located canines, which had failed to erupt at their appropriate site within the dental arch while complete eruption of the contralateral side was observed at T2 [21,22]. Bilateral canine impaction was identified based on a lack of space and from the patients' clinical data. Each canine was categorise as either demonstrating having maxillary canine impaction (thus identifying it as part of the impaction group) or normal canine eruption (in which case it was part of the control group) based on the T2 PR.

Seventy patients were found to have maxillary canine impaction upon clinical and radiographical diagnosis. Out of these, 48 patients had two digital PRs with a minimal interval of one year between the two radiographs. Eleven records were excluded from the study as they had either dark or unfocused PRs or the patients had a craniofacial deformity. A total of 37 patients (51% males and 49% females) were included in this study. The age of patients fell within the range of 8.3 to 13.2 years at T1 with a mean age of 9.6 years (SD 1.26). On the other hand, the average age of patients at T2 fell within the range of 9.6 to 14.4 years with a mean age of 11 years (SD 1.35).

Several radiographic features were observed from each PR by three independent examiners. Additionally, both inter and intra-examiner reliability tests were performed on 10% of the samples twice, with the tests being two weeks apart. In each radiograph, the bilateral maxillary canines were assessed. The presence or absence of canine impaction was recorded. Different radiographic features were also obtained from the digital PRs, such as: 1) the location of the canine impaction, as being either on the right side or the left side or bilaterally positioned; 2) the type of canine impaction involved, i.e., if the canine was vertically or horizontally impacted; 3) the state of the maxillary primary canine, such as whether it was exfoliated, displayed root resorption or if it was sound without any resorption; 4) the state of the permanent canine apex, such as if it was open, closed, or dilacerated; 5) The presence of permanent canine magnification; 6) the status of root development for permanent canines, as if they were completely developed, or if only three quarters of the root was developed, or half of the root was developed, or if only one quarter of the root was developed.

The vertical canine crown height in relation to the adjacent teeth was also obtained. This ranged from the crown being placed above the level of the apical third of the roots of adjacent teeth until if it is aligned with the occlusal plan [Table/Fig-1a]. The degree of canine overlap with the adjacent teeth was also recorded in scores. This represents the horizontal location of the canine. It includes six different positions: a) the canine placed distal to the normal position in the premolar region; b) the canine placed in normal position apical to the primary canine; c) the canine placed distal to the permanent lateral incisor; d) the canine placed mesial to the lateral incisor; e) the canine placed distal to the central incisor; and f) the canine placed mesial to the central incisor [Table/Fig-1b]. Additionally, both the degree of canine angulation in relation to the midline [Table/Fig-1c] and the canine-lateral incisor angle were measured [Table/Fig-1d]. All radiographic features and data were obtained using Planmeca Romexis dental imaging software (Planmeca OY, Finland). The non-impacted canines from each PR were used as a control.



[Table/Fig-1]: The features and angles obtained from each PR were recorded in the manner outlined below: a) Firstly, the vertical canine crown tip height in relation to the adjacent teeth was examined in each of the following positions: 1=in occlusion, 2=in the cervical third of the roots, 3=in the middle third of the roots, 4=in the apical third of the roots, and 5=above the apical third; b) Secondly, the degree of canine overlap on the adjacent teeth was examined in each of the following positions: -1=the canine tip placed distal to the normal position in the premolar region, 0=the canine tip placed in normal position apical to the primary canine, 1=the canine tip placed distal to the permanent lateral incisor, 2=the canine tip placed mesial to the lateral incisor, 3=the canine tip placed distal to the central incisor, and 4=the canine tip placed mesial to the central incisor; c)Thirdly, the magnitude of the canine-midline angle was determined; and d) Lastly, the magnitude of the canine-lateral incisor angle was established.

STATISTICAL ANALYSIS

Pearson's chi-squared statistical test was used to detect the significant differences between impacted and non-impacted canines for each feature with the significance (α) value set at 0.05. For the canine-lateral incisor angle and the degree of canine angulation in relation to the midline, a two-sample t-test was used in order to make the comparison between the two groups. The change over time was calculated by detecting changes in each radiographic features score between the earlier (T1) and later (T2) PRs. Two-sample t-test was used to compare this change between the impacted and non-impacted canines. The sample power calculation was calculated at a significance level (α)=0.05, estimated (SD)=5, maximum difference=1 and power=90%. The sample size in each of the impacted canines and non-impacted groups should be at a magnitude of at least 30 for the canine-lateral incisor angle and the canine angulation to midline assessment. A total of 37 patients were used in this study.

The null hypothesis is that there is no difference in each of these features and the angles between the impacted and non-impacted canines detected at either an early stage or at a late stage. In addition, there is no difference between the impacted and non-impacted canines in the changes of these features and angels overtime.

RESULTS

Among the 74 canines assessed at T2, 42 (56.76%) of the canines were impacted while 32 (43.24%) were erupted normally. Bilateral canine impaction was found in 19% of the cases. The right canine was impacted in 52% of the cases while left canine impaction was observed in the rest of the cases. Vertical canine impaction was found in 81% of the cases. A high degree of agreement was revealed between the readings obtained from the three examiners with a kappa value of 0.95. The intra-examiner reliability had a kappa value of 0.97, 0.94 and 0.96, respectively, for the three examiners.

The percentage of each score for different radiographic features for the non-impacted canines and impacted canines are summarised in [Table/Fig-2]. The scores that were obtained at both T1 and T2 are also shown also in [Table/Fig-2].

Although the maxillary primary canine showed no resorption in 45% of the cases with impacted canines at T1 [Table/Fig-2], the changes in the maxillary primary canine were deemed to be non-significant between the impacted and non-impacted canines. This was shown both in the T1 PR (p=0.37) and the T2 PR (p=0.88) and in the changes over time (p=0.75). Similarly, there was no significant difference between the impacted and non-impacted canines in terms of the permanent canine apex in either the T1 or T2 PR. The permanent canine magnification was noticed more at T1 when compared with the T2 PR. In addition, a statistically significant difference was found between the impacted (31%) and non-impacted canines (10%) at T1 (p=0.03). There was no difference between the two groups at T2 (p=0.06). In addition, no significant difference was found in the stage of root development for permanent canines in the T1 PR (p=0.36) and the T2 PR (p=0.98) and in the changes over time between the two groups.

Impacted canines showed a significantly higher vertical crown height in relation to the adjacent teeth in the T1 PR (p=0.01) and the T2 PR (p=0.02) [Table/Fig-2]. However, the vertical canine location of both groups was found to have changed over time with no statistical difference (p=0.63) being observed.

The majority of the non-impacted canines were located in a normal position apical to the primary canine at T1 (58%) and T2 (72%).

Radiographic feature	Score	Non-impacted canine		Impacted canine	
		T1 PR	T2 PR	T1 PR	T2 PR
Maxillary primary canine	Missing tooth	19%	41%	7%	36%
	Resorbed root	48%	44%	48%	45%
	No resorption	32%	16%	45%	19%
Permanent canine apex	Open	90%	84%	98%	83%
	Close	3%	16%	2%	14%
	Dilacerated	6%	0%	0%	2%
Permanent canine magnification	No	90%	97%	69%	83%
	Yes	10%	3%	31%	17%
Root development for permanent canine	1/4 of the root developed	13%	0%	21%	0%
	1/2 of the root developed	68%	56%	60%	57%
	3/4 of the root developed	10%	28%	16%	26%
	Complete development	10%	16%	2%	17%
Vertical canine crown height	0	0%	0%	0%	0%
	1	6%	16%	0%	0%
	2	32%	34%	7%	21%
	3	39%	44%	60%	64%
	4	23%	6%	33%	14%
	5	0%	0%	0%	0%
Permanent canine overlap on the adjacent teeth	-1	0%	0%	0%	0%
	0	58%	72%	21%	19%
	1	39%	28%	35%	48%
	2	3%	0%	42%	26%
	3	0%	0%	0%	5%
	4	0%	0%	2%	2%

[Table/Fig-2]: Shows the percentage of each score for different radiographic features for both non-impacted canines and impacted canines that were scored on both the T1 PR and the T2 PR.

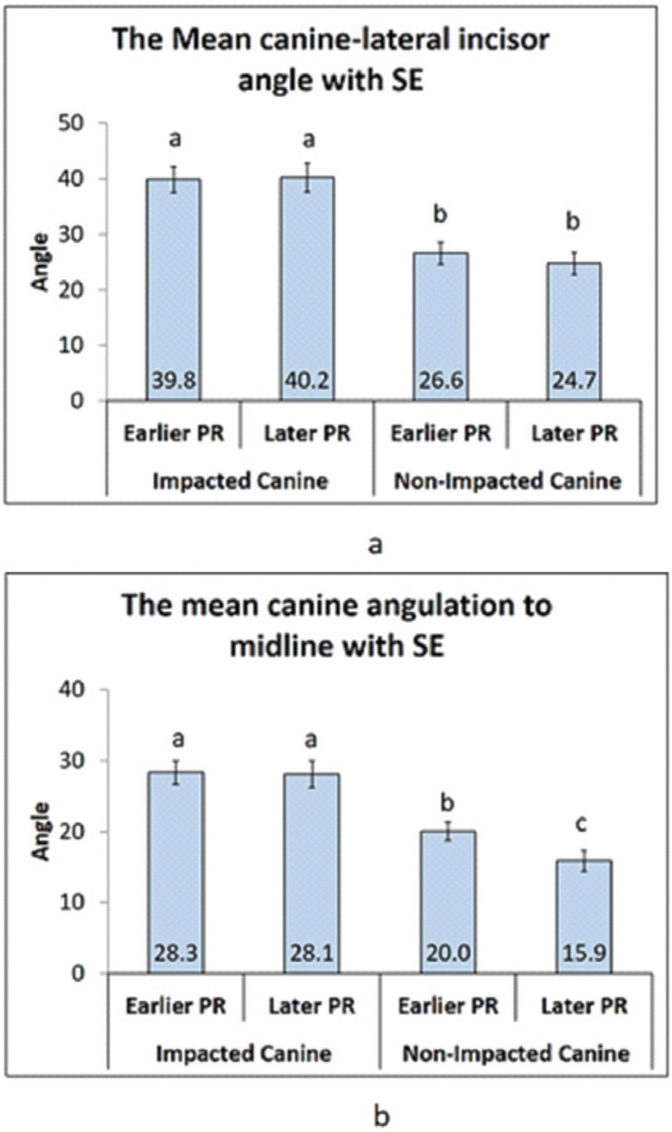
However, the crowns of the cases with impacted canines were placed either distal or mesial to the permanent lateral incisor in both the T1 and T2 PRs. Moreover, the difference between the two groups was deemed to be statistically significant (p<0.001).

The mean canine-lateral incisor angle was found to have increased significantly (p<0.01) in the impacted canines in both the T1 and T2 PRs when compared with the non-impacted canines [Table/Fig-3a]. Similarly, the degree of canine angulation in relation to the midline was also found to have increased significantly (p<0.01) in the impacted canine cases in both PRs [Table/Fig-3b]. The latter angle was decreased significantly (p=0.02) by an average of 5° over time in the non-impacted cases, whereas it did not change in the impacted canine cases.

The 95th percentile of the non-impacted canine-lateral incisor angle was 31.72°, whereas it was 57.02° for the impacted canine-lateral incisor angle. In addition, the 95th percentile of the non-impacted canine angulation in relation to the midline was 54.1°, whereas the degree of canine angulation in relation to midline was 70.43° in the case of impacted canines.

DISCUSSION

Several studies have previously looked before at the early prediction of the maxillary canine impaction [21,22]. This is because the treatment of such impaction can be complicated with a less favourable outcome if such treatment is delayed. Therefore, the aim of this study, was to find the specific radiographic features that any individual dentist can rely on in order to predict canine impaction.



[Table/Fig-3]: Shows the mean degree of canine-lateral incisor angle (Graph a) as well as the mean degree of canine angulation in relation to the midline (Graph b). The standard error for both of these mean results is included in the data. Both angles were found to be significantly increased in the case of impacted canines in both the T1 and theT2 PRs. The bars with different letters are statistically significant ($p<0.05$)

Thus, any the interceptive orthodontic treatment can be started at a suitable time.

Different radiographic techniques have been used to demonstrate the characteristics of canine impaction such as Cone-Beam CT (CBCT) scans and PRs [23,24]. The latter technique has been widely used as a primary route of investigation for many patients. Moreover, it has also been used in the identification of diagnostic features for maxillary canine impaction. It is also aimed to facilitate interceptive orthodontic treatment. It has been found, via mathematical calculations, that PRs provide are reliable method for obtaining geometric measurements in clinical practice [25,26].

The incidence of maxillary canine impaction ranges from 1-3% [4]. This explains the difficulty of predicting such cases in a prospective study. This study was designed to look at cases that had already been diagnosed cases with maxillary canine impaction in order to reveal the radiographic features which will lead to early detection of the condition. Data were collected from children aged between 9-14-year-old at the time of T2. It was reported that a highly statistically significant difference was found between the location of the impacted and non-impacted canines beyond the age of nine-year-old [21]. In addition, no change in the significance level was found beyond the age of 14. In each case, the non-impacted canine was used as a control. However, in cases of bilateral canine impaction, the data were compared with the values obtained from the non-impacted canines in other cases. This explains to a certain degree the higher number of cases of impacted canines.

Four radiographic features were assessed in this study. These included the following: 1) the vertical canine crown height in relation to adjacent teeth; 2) the degree of canine overlap in relation to the adjacent teeth; 3) the magnitude of the canine-lateral incisor angle, and (4) the degree of canine angulation in relation to the midline. Although, several studies have looked at the same features [20-23], this was the first study to evaluate such features in the Saudi population.

It was found that there were no changes in the maxillary primary canine as well as the state of the permanent canine apex between the impacted and non-impacted canines. This finding has also been demonstrated by Sajnani AK and King NM [21]. Permanent canine magnification was noted in the T1 PR with no differences showing between impacted and non-impacted cases. This may possibly be explained by the relative size difference between the canine and adjacent tissues. In addition, the buccolingual position of the canine at the earlier stage (T1) can provide such magnification.

The vertical crown height in relation to the adjacent teeth demonstrated an important and early feature of eventual canine impaction in the T1 PR. This is in agreement with other studies [21,22]. In addition, the constant difference in the vertical height between the impacted and non-impacted canines over time makes this a reliable predictor of the condition.

The horizontal overlap of the canine on the lateral incisor showed an increased probability of canine impaction. This is considered to be a major predictor of canine impaction according to many studies [20,21]. The presence of the permanent canine apical to the primary canine at an early stage is considered to be within sector zero. The impacted canine is usually located within sector 1 or 2 according to the literature, however.

The mean angulation formed by the long axis of the impacted canine and the lateral incisor was around 40° in both the T1 and T2 PRs. On the other hand, the degree of angulation between the non-impacted canine with the midline was around 25°. Similar results were reported by Alqerban A et al., [22]. The 95th percentile of the non-impacted canine-lateral incisor angle revealed that the maximum value should be around 30°. Any increase in such angle can increase the chances of the canine being impacted.

In addition, the degree of canine angulation in relation to the midline was around 28° for the impacted canine, whereas it was 17° for the non-impacted ones. Sajnani A and King NM, reported that the mean angulation formed by the long axis of the impacted canine with the midline was 28.4° at nine years of age [21]. The same angle was reported to be 29.5° for impacted canine cases in another study [22]. The data showed that the degree of canine angulation in relation to the midline could be up to 54.1° before it can be considered to be impacted. It was also shown that this angle would decrease overtime, which is in agreement with the literature [21].

LIMITATION

The limitation of this study is that only a few patients had undergone an earlier PR before they were diagnosed with canine impaction. It is very important that each child undergoes regular follow-up visits where frequent PRs are taken in order to early predict canine impaction at an early stage. Further investigations should continue in order to find the best radiographic factors that general dental practitioners, as well as paediatric dentists, can use in order to diagnose canine impaction at an early stage.

CONCLUSION

If any canine is located at a higher vertical position than the adjacent teeth and is overlapped by the lateral incisor it has a higher chance of being impacted. The magnitude of the canine-lateral incisor angle and the magnitude of the canine to midline angulation should be less than 30º and 54°, respectively, in order to avoid canine impaction from occurring.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude towards the College of Dentistry Research Center as well as the Deanship of Scientific Research at King Saud University, Saudi Arabia, for their support in conduction this research.

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FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Mar 13, 2018**
Date of Peer Review: **May 23, 2018**
Date of Acceptance: **Aug 29, 2018**
Date of Publishing: **Nov 01, 2018**