12-30-2020

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Recommended Citation

Köse, E., & Canger, E. M. Evaluation of Maxillary Impacted Teeth and Their Relationship with Adjacent Teeth and Anatomic Structures with Cone Beam Computed Tomography. J Dent Indones. 2020;27(3): 131-138

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ORIGINAL ARTICLE

Evaluation of Maxillary Impacted Teeth and Their Relationship with Adjacent Teeth and Anatomic Structures with Cone Beam Computed Tomography

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ABSTRACT

Objective: This study aimed to examine the cone beam computed tomography (CBCT) images of impacted maxillary canines and mesiodentes. **Methods:** This retrospective radiographic study was performed on 177 patients with 200 impacted maxillary canines and 12 mesiodentes. Using CBCT images, the unilateral/bilateral occurrence, presence of root dilaceration, mesio-distal and buccopalatal location, impaction condition, contact region of adjacent teeth, presence and degree of root resorption of adjacent teeth, dental follicle width, closest distance to the nasal cavity, nasopalatal canal, and maxillary sinus were assessed. For mesiodentes, the types, follicle width, direction, and relationship with anatomical structures were evaluated. **Results:** No statistical relationship was found between (buccopalatal and mesio-distal) position of canine and root resorption of adjacent teeth ($p = 0.171$). A negative correlation was observed between age and follicle width ($r = -0.145$, $p = 0.048$). No mesiodentes with enlarged follicle and root resorption of adjacent teeth was found. **Conclusion:** Given the negative correlation between age and follicle width, older patients with impacted teeth can be followed up by two-dimensional radiographs unless periradicular radiolucencies are absent. Otherwise, CBCT evaluation is required for early detection of pathologies and prevention of possible surgical complications.

Key words: cone beam computed tomography, impacted canine, impacted teeth, mesiodentes

How to cite this article: Köse E, Canger EM. Evaluation of maxillary impacted teeth and their relationship with adjacent teeth and anatomic structures with cone beam computed tomography. J Dent Indones. 2020;27(3):131-138

INTRODUCTION

Teeth that cannot complete their eruption process in a timely manner are defined as impacted teeth.¹ Impaction is a common condition in maxilla and occurs more commonly in women.² Its overall prevalence is about 0.8%–2.8%. Maxillary canines are the second most commonly impacted teeth, after the third molars. Two thirds of impacted canines are located at the palatal side and one third at the buccal side.³ Untreated impacted teeth cause esthetic and functional problems and lead to cystic formation, migration, root resorption in adjusting teeth, and shortening of the arch length; therefore, these teeth must be identified as soon as possible.⁴ Mesiodentes are also included in impacted

teeth. The prevalence of mesiodentes range between 0.5%–1.9%, and they occur frequently during the permanent dentition period. Mesiodentes are twice more common in women than in men.⁵

Periapical, occlusal, panoramic, and cephalometric radiographs can be used to determine the location of impacted teeth and their associations with neighboring structures. However, panoramic radiographs may be insufficient in cases of superpositions caused by distant locations of impacted teeth.⁶ Cone beam computed tomography (CBCT) is preferred because of its capability to allow examination of teeth at three planes without superpositions and to provide a clear visualization of the changes in nearby structures.^{7,8}

Important conditions to determine proper treatment options include the associations with nearby structures of impacted teeth, follicle widths, and the presence of ongoing resorption.¹

Resorption due to canine impaction is most commonly observed in the roots of central and lateral incisors and premolars.⁹ Lateral incisors are particularly susceptible to resorption because of their oval roots and close proximity to canine teeth. Incisor resorption is observed in half of the impacted maxillary canine cases¹⁰, but its etiology is not fully understood.^{11,12} The risk of resorption for lateral incisors is high for canine teeth approaching the midline; thus, root resorption must be determined as soon as possible. Although periapical radiographs are considered the primary option, the resorption area cannot be observed properly due to superpositions. Therefore, the use of CBCT greatly increases the resorption diagnosis.¹³

The present study aimed to evaluate the positions, associations with nearby teeth, and anatomical structures of impacted maxillary anterior teeth using CBCT.

METHODS

Cone beam computed tomography images of a Turkish population from Middle Anatolian Region who were referred to our clinic for several reasons were examined in this retrospective study. This study was approved by the local ethical committee.

Inclusion criteria were:

1. Patients who are 15 years or older;
2. Images with adequate resolution;
3. Images showing complete impacted tooth, nasal cavity, and the lower borders of maxillary sinus.

Exclusion criteria were:

1. Images showing an incomplete examination area;
2. Images with artifacts due to patient movement;
3. Images of patients who had undergone orthodontic treatment or orthognathic surgery or had pathology or jaw fractures in the maxillary anterior area.

The CBCT images of 177 patients were examined. The images were analyzed in a dark room using a Dell Precision T5400 workstation. The contrast and brightness of the images were adjusted using the image processing tool provided by the software to ensure optimal visualization. The CBCT images, sagittal, coronal, and axial sections, and multiplanar images that

showed all three sections were examined. All CBCT images were evaluated by the same radiologist, who has prior experience in assessing CBCT volumetric data (E.K.).

Evaluated parameters for canine teeth

Impaction: In accordance with the work of Lai et al.¹, the impacted teeth were divided into the following groups: teeth surrounded by bone and soft tissue (Figure. 1a), teeth surrounded by complete bone tissue (Figure. 1b), and teeth surrounded by soft tissue only. The persistency of primary canines and microdontism in lateral incisors were evaluated as present or absent. **Follicle width:** Following the work of Lai et al.¹, follicle width was measured as the distance between the crown and the most distant point of the follicle (Fig. 1c); enlarged follicles comprised those that were larger than 3 mm. **Buccopalatal location:** Teeth were evaluated based on their location, namely, in the buccal region, in the line of arc, and in the palatal region¹² (Figures. 1d, 1e, and 1f, respectively). **Horizontal position:** The distance between the normal location of canines and the midline was divided into five parts. The horizontal position was determined based on the location of the cusp of crown and enumerated as 1, 2, 3, 4, and 5 (Figure. 2a).¹³

The position was accepted as a dilaceration when the angle between the long axis of the tooth and root was 20° or greater (Figures. 2b and 2c).¹⁴ For the tooth contact with canines, the distance between the cemento-enamel junction and the apex of related tooth was divided into three equal parts and grouped as apical, middle, and coronal from the apex to the crown (Figures. 2d, 2e, and 2f, respectively).¹⁵ Resorption status was grouped as undisturbed continuity of the lamina dura, minimal resorption with disruption of the lamina dura, significant resorption without pulp exposure, and excessive resorption exposed the pulp (Figure. 3).¹⁵ Additionally, the closest distances between the impacted canines and nasopalatine canal, nasal cavity, and maxillary sinus were measured in the CBCT images.

Parameters evaluated in mesiodentes

Mesiodentes were classified as supplemental, conical, or tuberculate based on their morphology.¹⁶ Measurements included their impaction status, resorption status of the adjacent teeth, and closest distance to the nasopalatine canal.¹⁷ Mesiodentes were further grouped as inverted, horizontal, and normal based on their positions (Figure. 4).¹⁸

Figure 1. a. Impacted canine covered with soft and bone tissue (axial section). b. Impacted canine covered with bone tissue only (sagittal section). c. Follicle width measurement (axial section). d. Buccal impaction (sagittal section). e. Impaction in the arch (sagittal section). f. Palatal impaction (axial section).

Figure 2. a. Horizontal positions (panoramic reconstruction image). b. Dilacerated canine in sagittal section. c. Dilacerated canine in coronal section.

Figure 3. Root resorption of lateral incisors in axial and sagittal CBCT sections (a. minimal, b. pronounced, and c. excessive).

Figure 4. Positions of mesiodentes in sagittal and axial CBCT sections (a. inverted, b. horizontal, and c. normal).

Statistical analysis

Statistical analyses were conducted using the IBM SPSS Statistics software package (IBM Corp., Armonk, New York, USA). Shapiro–Wilk test was used to determine the normal distribution of numerical variables. Categorical data were compared using the exact method of Chi-square test. A total of 20% of the images were recorded again after 1 month to evaluate the consistency of measurements. Kappa coefficient and intraclass correlation coefficient (ICC) were used for observer reliability. The significance level was accepted as $p < 0.05$.

RESULTS

The CBCT images of 177 patients were evaluated. Exactly 200 impacted canines in 165 patients and 12 impacted mesiodentes in 12 patients were detected. Table 1 presents the distribution of impacted teeth based on genders. The mean age of the 177 patients was 29.6 ± 8.7 years. Bilateral and unilateral impacted canines were identified in 35 and 130 patients, respectively. Persistent primary canine teeth were detected in 85 (51.5%) of the impacted canine cases. A total of 120 (60%) canines were covered with bone and soft tissue, and 80 (40%) were assessed with full bone impaction. Microdontism in lateral incisors was followed up in

26 (13.6%) of the remaining 190 impacted canine cases, and the absence of lateral incisor teeth was detected in 13 (6.8%) of these 26 microdontism cases. Persistent primary canines were detected in 43 (36.4%) of the 118 cases with impacted canines in the palatal region, whereas the absence of lateral incisor teeth was detected in 12 (10.1%) cases. Microdontism of lateral incisor teeth was detected in 24 cases (20.3%).

The mean value of follicle width was 2.2 ± 0.5 mm. Enlarged follicle width (>3 mm) was detected in 14 teeth (7%). The largest follicle width measured 13.3 mm. Enlarged follicle was more common in males than females ($p < 0.05$). A statistically significant relation was found between the follicle width and root resorption of the adjacent teeth ($p < 0.05$). Notably, root resorption was often detected with enlarged follicle widths. A low negative correlation was found between the follicle width and age ($r = -0.145$, $p = 0.048$). With the increase in age, a decrease in follicle width was detected.

Table 2 presents the buccopalatal conditions of impacted canines. Female patients showed palatal impacted canines (73/62.2%) and impacted canines at the midline (42/63.9%). No statistically significant relation was found between the buccopalatal location of impacted canines and root resorption of the adjacent

Table 1. Distribution of impacted teeth based on genders

Impacted teeth	Female		Male		Total
	n	%	n	%	
Canine	101	61.2	64	38.8	165
Mesiodens	6	50.0	6	50.0	12

Table 2. Distribution of parameters of impacted canines based on gender

	Female (n)	Male (n)	Total N(%)
Region of impacted canine			
Buccal	8	8	16 (8)
Palatinal	73	45	118 (59)
Midline	42	24	66 (33)
Number of subject with teeth resorption	46	22	68
Distribution of adjacent tooth resorption			
Central incisor	6	4	10 (14.7)
Lateral incisors	32	28	50 (73.5)
First premolar	4	4	8 (11.8)
Horizontal position			
1	7	5	12 (6)
2	10	10	20 (10)
3	17	14	31 (15.5)
4	32	36	68 (34)
5	38	31	69 (34.5)
Interaction of canines with adjacent tooth			
Apex	36	42	78 (39)
Middle	40	37	77 (38.5)
Coronal	20	25	45 (22.5)

teeth ($p > 0.05$). Table 2 shows the horizontal positions of impacted canines. A total of 31(15.5%) canines had root dilacerations. Table 2 also presents the root resorption of adjacent teeth.

Table 2 lists the contact regions of impacted canine and adjacent teeth. No statistically significant relation was found between gender and root resorption ($p > 0.05$). Tooth root resorption was detected five times more frequently in lateral incisors than central incisors. CBCT examination revealed excessive resorption with pulpal

exposure in 14 teeth. A total of 79 (39.5%), 53 (26.5%), and 56 (28%) impacted canines were in direct contact with the nasal cavity, maxillary sinus, and nasopalatine canal, respectively. Twelve teeth (6%) were not in contact with any anatomical structure.

Half of mesiodentes (50%) were in inverted position, whereas the number of normal and horizontally positioned mesiodentes were 4 (33.3%) and 2 (16.7%), respectively. Six (50%) mesiodentes were located in the midline, five (41.7%) at the left maxilla, and one at the right maxilla (8.3%). A total of 10 (83.3%) and 2 (16.7%) conical shaped and supplemental mesiodentes were observed. No tuberculate mesiodens was observed. Nine (75%) mesiodentes were totally impacted, and three (25%) were partially impacted. No follicle enlargement nor adjacent tooth resorption was detected.

Kappa coefficients for impaction, buccopalatal location, horizontal position, presence of dilacerations, presence and degree of resorption, types, and positions of mesiodentes were $\kappa=0.99$, $\kappa=0.96$, $\kappa=0.94$, $\kappa=0.96$, $\kappa=0.93$, $\kappa=0.94$, $\kappa=0.96$, and $\kappa=0.99$, respectively, (with $p<0.001$ for all values). The ICCs for the measurements between tooth and nasopalatine canal, maxillary sinus, and nasal cavity were ICC=0.943, ICC=0.996, and ICC=0.996, respectively, (with $p<0.001$ for all ICC values).

DISCUSSION

Impacted canines are more common in the female population¹⁴⁻¹⁷. We also observed that the number of female patients with impacted canines was twice that of male patients. We assumed that genetic factors, gender differences in growth processes, and more frequent consultation of female patients with dentists compared with male patients could have influenced the results. As also indicated by our findings, studies on the buccopalatal location of impacted canines have shown that these teeth are most likely located in the buccal region.^{16,18} Although Asian people have a predominant buccal impaction, canine impaction coincides mostly in the palatal region in European and North American communities.^{16,18,19}

Canines are often observed as unilaterally impacted.^{16,20} Delli et al. observed a prevalence of 7% for bilaterally impacted canines.²¹ Our recorded data also show that most of the impacted canines were unilateral, and the rate of bilateral impaction was 21%.

The follicle width of impacted teeth decreases with age due to the decrease in growth hormone, as long as no pathology develops.^{11,22-24} We similarly noted a decrease in the follicle width with age ($r = -0.145$). Identification of the relationship between the follicle width of impacted teeth and root resorptions of the

adjacent teeth is important.^{24,25} The relation between the thickness and shape of follicles and the resorption of central and lateral incisor teeth has not been reported in most studies.^{11,25-27} Lai et al. stated that the frequency of adjacent tooth root resorption increases in the presence of totally impacted canines in the buccal region of the bone and when the crown is located along the long axis of adjacent teeth.¹ They also indicated that the incidence of root resorption increases in the presence of impacted canines with an enlarged follicle width. Our study also demonstrated the absence of relationship between totally impacted canines and root resorptions of the neighboring teeth. Nevertheless, the resorption rate is higher when compared with that of canines impacted in bone and soft tissue. Similar to other studies, the enlarged follicle width was not followed up in most patients of our study.^{7,28} However, a statistically significant relation and positive correlation was found between follicle width and root resorption ($p = 0.035$).

Ericson et al. and Liu et al. determined that impacted canines have the greatest effect on the lateral incisor teeth and cause root resorption.^{7,10} Central incisor teeth are the second most affected teeth, followed by lateral incisor teeth. Lai et al. also stated that the first and second premolar teeth follow the lateral incisor teeth in the terms of effects.¹ In general, studies that evaluated resorptions with CBCT indicated root resorption rates of 9%–23% for the central incisor teeth and 27%–65% for the lateral incisor teeth.^{10,29,30} Oberoi et al. detected slight, significant, and excessive root resorption in 35.7%, 14.2%, and 4% of the lateral incisor teeth, respectively.³¹ In our study, root resorptions were followed up in 35.4% of the lateral incisor teeth, 12% of the central incisor teeth, and 32% of the first premolar teeth. We also observed minimal and excessive resorption rates of 74% and 16%, respectively. A resorption rate of 10% was considered significant, similar to the conclusions of Ericson et al.²⁹ The old age of patient population, which has a rising resorption risk, is thought to be one of the reasons for the high resorption rates observed in our study. An et al. reported that resorptions in central incisor teeth can occur because of impacted canines in the buccal region, but we did not follow up any such case in our study.³ No statistically significant difference was also identified between central and lateral incisor tooth root resorption, gender, and age.^{29,30}

Conventional imaging may yield incorrect results when identifying locations of impaction.^{32,33} As a supporting result for this statement, Ericson and Kurol estimated the inaccuracy rate of 8% for conventional imaging for the detection of localization of impaction.¹⁰ Additionally, An et al. marked the accuracy rates between the panoramic and CBCT examinations at 68% for buccal cases and 69.5% for palatal cases.³ Mason et al. stated that 90% and 10% of the palatal and buccal cases, respectively, can be determined correctly using two-dimensional imaging.³³ Similarly,

for the determination of root resorption, they expressed a discordance rate of 36% between the two-dimensional and three-dimensional imaging methods. Bjerklin and Ericson used computed tomography to re-evaluate patients and reported that root resorptions were identified in almost half of the adjacent teeth, and they were overlooked in previous radiographic examinations carried out with conventional methods.³⁴ Conventional images only give information about apical and lateral resorptions, because they cannot scan the resorptions occurring in the buccopalatal direction.¹⁴ In addition, minimal resorptions in the mesio-distal direction cannot be detected with panoramic radiographs.^{8,14,25,35,36} By contrast, CBCT can detect incipient and minimal resorptions and is thus recommended for proper treatment planning.¹

Knowledge of the relationship between teeth and structures, such as the maxillary sinus, nasopalatine canal, nasal cavity, mandibular canal, and adjacent teeth, is important in cases requiring the extraction of impacted or supernumerary teeth.³⁷ Most of the impacted teeth in our study were in contact with or adjacent to the nasopalatine canal, maxillary sinus, and nasal cavity.

Although mesiodens occurs predominantly in male populations, the results of our study revealed equal gender distribution.^{5,38} In addition, in our study, most of mesiodentes were impacted. They may be placed predominantly in inverted position but are also present in the normal direction or horizontally inclined.^{5,39} Tuna et al. observed a 60% rate for the inverted position.⁶ Liu et al. showed a rate of 50%, and Asaumi et al.⁵ detected a rate of 67%.^{5,7} Mesiodentes were also predominantly inverted. Delays in the eruption of permanent teeth, displacement of adjacent teeth, crowding, diastema, periodontal problems, and cystic formation are several of the complications of mesiodentes.³⁸ A total of 5% of dentigerous cysts are caused by supernumerary teeth, in which the majority is compromised by mesiodentes. Von Arx et al. reported a 2.7% development rate of dentigerous cysts in mesiodens cases.³⁹ Lustmann et al. reported a rate range of 5%–6%, and Asaumi et al. arrived at a value of 11%.^{5,40} Additionally, according to studies, mesiodens rarely causes root resorption of the adjacent teeth.^{41,42} The average age of our patient population was higher compared with the cohorts examined in previous studies, but neither cyst formation nor root resorption was observed in the adjacent teeth. In previous studies, most of mesiodentes had conical morphology, similar to our results.^{43,44}

Impacted maxillary canines and mesiodentes related with enlarged follicle and contacted with adjacent teeth should be evaluated by CBCT for early diagnosis of pathologies. Additionally, given the negative correlation between age and follicle width, older patients with impacted teeth can be followed up by using

two-dimensional radiographs unless periradicular radiolucencies are absent.

CONCLUSION

Given the negative correlation between age and follicle width, older patients with impacted teeth can be followed up by two-dimensional radiographs unless periradicular radiolucencies are absent. Otherwise, CBCT evaluation is required for early detection of pathologies and prevention of possible surgical complications.

CONFLICT OF INTEREST

The authors declare no conflict of interest in this study.

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(Received March 26, 2020; Accepted November 1, 2020)