



Investigating the Success Rate of Maxillary Impacted Canine Eruption Using Orthodontics According to Age, Gender and Type of Impaction in Shahrekord Dental Clinics in 2023

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Abstract

Background: Canine teeth have a significant impact on the order and proper function of other teeth. Canine impaction can have negative esthetic and functional effects. This study investigated the success rate of orthodontically-assisted eruption of maxillary canine teeth according to age, sex, and type of impaction in Shahrekord city, Iran.

Methods: In this retrospective study, panoramic radiographs of 112 patients who had initiated their orthodontic treatment at least 2 years earlier and had completed it by 2023 were evaluated. Cone-beam computed tomography scans were also used when necessary to assess the details. The type, depth, and angle of erupted and impacted canine teeth were determined. The data were analyzed by the Fisher's exact test and t-test.

Results: Impacted canines successfully erupted in 72 patients (64.3%). Palatal impaction was more common (71.4%) than buccal impaction (28.6%). Regarding the impaction depth, type C had the highest frequency (63.4%), followed by type B (30.4%), and type A (6.3%). There was no significant correlation between the gender of patients and success rate of assisted eruption ($P>0.05$), but age and type of impaction were correlated with the success rate ($P<0.05$). The erupted canine teeth had a significantly higher mean angle relative to the occlusal plane compared with non-erupted teeth ($P<0.05$).

Conclusion: The success rate of orthodontically-assisted eruption of impacted maxillary canine teeth was high, and patients in the age range of 15 to 18 years with grade II impaction showed the highest success rate of orthodontically-assisted eruption of impacted canine teeth.

Keywords: Tooth, Impacted, Canine, Orthodontics

Background

Tooth eruption is a continuous but complex process influenced by many local and systemic factors; however, some of these factors can cause difficulties in different stages of eruption and eruption pattern of teeth, and lead to delayed eruption of permanent or primary teeth (1).

Although dental impaction is a common phenomenon, it has high variations in terms of prevalence in different racial populations and in different areas of the jaws (2). Impacted teeth are associated with various problems ranging from simple (ectopic eruption, displacement, malformation, formation of odontogenic cysts, resorption of adjacent teeth, increased follicular



space) to complex (malignant changes in the lining of the cysts and transformation into squamous cell carcinoma) (1).

Canine teeth have a significant impact on the order and proper function of other teeth. Extraction or impaction of canine teeth can have a negative effect on the function of other teeth and can affect the smile attractiveness as well. Canine impaction is one of the most prevalent developmental problems worldwide (3). Canine impaction can cause major problems in the adjacent teeth as well as the jaws. Impacted teeth can have adverse effects on the general health, and necessitate some interventions or modification in treatment plans (4). Impaction is more common in the palatal side than the buccal side. Impaction of the canine tooth can lead to problems such as resorption of the adjacent teeth, external root resorption, infection, cyst formation, tooth displacement, and periodontal problems. Therefore, early diagnosis of canine impaction and its treatment are highly important (5). Since the treatment of canine impaction is a time-consuming task depending on the location of tooth, early diagnosis of impaction and its management have always been a concern for orthodontists and dentists (3). Factors such as crowding, space shortage in dental arch, space shortage due to early loss of primary teeth, ectopic position of tooth bud, presence of local physical barriers such as ankylosed primary teeth, over-retained primary teeth, supernumerary teeth, and pathological lesions may change the growth pattern of the teeth and lead to their impaction (4). Cleidocranial dysplasia, osteoporosis, Down's syndrome, hypothyroidism, and pituitary dysfunction are some of the systemic and genetic factors that affect tooth eruption. Mandibular third molars are the most commonly impacted teeth followed by maxillary canine teeth (6).

Impaction of canine teeth is a developmental disorder which is highly common (3). Tooth development and eruption are dynamic processes that include root completion, periodontium formation, and reaching functional occlusion (2). Tooth impaction is defined as intraosseous displacement of the tooth bud and its abnormal growth direction which results in delayed or no eruption of the tooth (3).

Maxillary canine teeth play important roles in facial appearance and function, smile esthetics, dental arch development, and functional occlusion (2,4). Canine teeth are prone to ectopic eruption and impaction because of their deep position in the alveolar bone, their long eruption time, and long and complex eruption path. The etiology of this disorder is multifactorial, and environmental and

genetic factors may be implicated in its occurrence (3). An impacted tooth can cause periodontal disease, tooth caries, odontogenic cysts and tumors, pain without specific origin, jaw fracture, and root resorption of the adjacent teeth (6).

The overall prevalence of tooth impaction is between 2.94% and 18.8% (6) and the mean prevalence of canine impaction is between 1% and 3% (2). Except for third molars, maxillary canine teeth have the highest rate of impaction of 0.8% to 3% (7). Early clinical and radiographic examination can reveal the position of impacted teeth and aid in designing an appropriate intervention to guide the canine to its natural direction (3). In clinical examination, if the canine prominence is not palpable after the age of 10 years, permanent canine eruption is delayed after the age of 11 years, and the primary canine remains, one can suspect the impaction of permanent canine tooth. Panoramic radiography is commonly used for detection of tooth impaction due to its relatively low radiation dose and wide regional coverage (2,4).

High-quality panoramic radiographs may be used to determine the mesiodistal position and the impacted canine angle; moreover, it can be used to detect the buccal or palatal position of the tooth (4). Evaluation of the position of impacted canine tooth (buccal or palatal) depends on the relative radiopacity of two adjacent superimposed objects (4, 5). The film or the sensor on which the image is captured is placed in front of canine and incisor teeth. Following superimposition, an opacity showing the shape of a lateral incisor would mean that the lateral incisor is closer to the film, and therefore the canine is located more palatally (5). If this opacity is created by the contour of the canine tooth, it means that the canine tooth is closer to the film and is located more buccally (2, 5).

Maxillary canine teeth play an important role in esthetics and function, and treatment of patients with maxillary impacted canine teeth is more difficult than other orthodontic patients and requires more time (7). Many variables are involved in predicting the degree of difficulty of treatment of a maxillary impacted canine tooth and also the risk of treatment failure (8).

In a study conducted by Fleming et al, (9) the angle of canine, its vertical distance from the occlusal plane, the anteroposterior position of the apex of the canine root, and the degree of overlap of the adjacent incisors were correlated with the prognosis of ectopic canine teeth (9). Zuccati and colleagues (8) reported a strong relationship between increasing the number of orthodontic visits and age, vertical height, and mesial

displacement of the cusp tip. According to the findings of Pitt et al, (10) canine teeth with a more horizontal angle have a poorer prognosis for alignment, and the buccolingual position of the canine crown also affects its treatment. It has been reported that the higher the position of the canine in relation to the occlusal plane, the weaker the prognosis of its alignment would be (10). McSherry (7) described this finding as "the vertical rule of thirds".

Root resorption of the lateral incisor is the most common complication associated with impacted maxillary canine teeth (10). Management of impacted teeth in adults is more difficult than in children. A previous study reported the success rate of treatment in patients over 30 years of age to be 41%, while the success rate was 100% in patients between 20 and 30 years (8). To date, prediction of the success rate of treatment of impacted canine teeth has been mainly based on clinical experience, and most studies compared CBCT images and conventional radiographs, and did not estimate the degree of treatment difficulty and the success rate of assisted eruption. For this reason, developing a system to evaluate the difficulty of assisted-eruption of an impacted canine tooth and evaluate the success rate of assisted eruption can be highly valuable for both clinicians and patients. According to the special position of canine tooth in the dental arch and its effective role in facial esthetics, mastication, and movement and function of other teeth, and also due to the high prevalence rate of canine impaction, this study aimed to assess the success rate of orthodontically-assisted eruption of maxillary impacted canine teeth according to age, gender and type of impaction.

Methods

This descriptive-analytical retrospective study was conducted on eligible patients with maxillary impacted canine teeth referred to a private orthodontist office in Shahrekord, whose treatment had started at least 2 years earlier, and completed before the end of 2023. The success rate

of orthodontically-assisted eruption of maxillary impacted canine teeth was investigated according to age, gender, type of impaction, depth of impaction, and angle of impaction of canine tooth. The adverse effects of impaction on the adjacent teeth were also evaluated.

Of all the panoramic radiographs archived in the orthodontic clinics and offices in Shahrekord city, patients with impacted canines who had the same treatment method, such as the same surgical approach and the same type of orthodontic treatment plan, were selected. The selected patients were between 12 and 25 years, and the patients had to have at least one impacted maxillary canine tooth. Patients with systemic diseases or genetic or developmental syndromes were excluded from the study. Also, the patients who were not visited regularly or discontinued the treatment were excluded. All patients were treated by one orthodontist with the same treatment plan, and the exposure surgery was performed by one single periodontist. To reduce the confounding variables, all panoramic radiographs were collected from the same oral and maxillofacial radiography center and other radiographs from other centers were excluded. Due to the long process of treatment, patients under treatment who had started their treatment in the past two years and were in the final stages of treatment were selected. According to the power analysis for the sample size, in order to gain 0.8 power, the sample size had to be 110 patients; thus, 112 patients were evaluated.

After data collection, the selected patients who underwent treatment and their impacted canines successfully erupted, as well as patients with unsuccessful treatments were examined by another orthodontist, and the success rate of treatments that led to tooth eruption and its conditions were determined. The relationship of the factors that contributed to a successful treatment with age, gender, type of impaction, depth of impaction, and angle of impaction was determined. The classification system by Yamamoto et al. (11) was used to determine the type of impaction (Fig. 1) as follows:

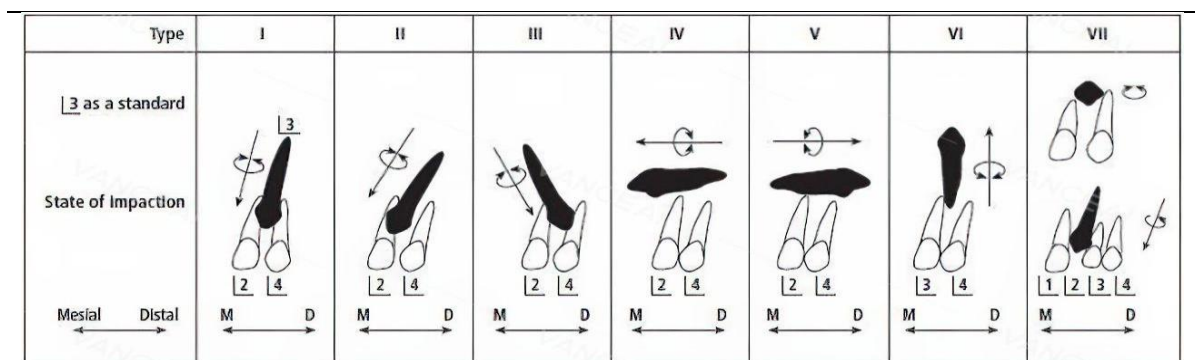


Figure 1. Classification of maxillary displaced canines by Yamamoto et al. (11)

Type I: vertically impacted canines with the tooth axis almost perpendicular to the occlusal plane, which is located between the lateral incisor and first premolar. A canine tooth which is close to lateral incisor is also placed in this class. In such cases, the root of the lateral incisor might have resorbed and there might not be enough space for the canine tooth to erupt; thus, eruption would be prevented in the future.

Type II: impacted canine teeth that have a mesial angulation relative to the occlusal plane.

Type III: impacted canine teeth that have a distal angulation relative to the occlusal plane.

Type IV: horizontally impacted canine teeth with mesially directed crowns.

Type V: horizontal canine teeth with distally directed crowns.

Type VI: the canine tooth crown is directed upward towards the orbital fossa.

Type VII: the longitudinal axis of the canine tooth has a horizontal direction with its crown placed buccally or involved with the adjacent teeth.

The Pell & Gregory and Winter's classifications were used to classify the depth and angle of impaction. In the Pell & Gregory classification, the depth of third molar impaction is divided into types A, B and C (12). In the Winter's classification (13), the impaction type is divided into mesial, horizontal, vertical, distal and transverse types based on the longitudinal axis of the tooth and the angle of impaction.

In the present study, panoramic radiographs were generally used for assessment of canine impaction; however, in cases where the information acquired from the panoramic radiographs was unclear or obscured, or when it was necessary to know the exact location of the impacted canine tooth or its adverse effects on the adjacent teeth, cone-beam computed tomography scans of the patients were evaluated. Finally, factors involved in treatments that led to eruption

of impacted canine in a shorter period of time were identified.

Statistical analysis:

Data were reported as mean and standard deviation values, and analyzed using the Fisher's exact test and t-test by SPSS version 26 (SPSS Inc., Chicago, USA). Additionally, a 95% confidence interval was considered when analyzing the data and a significance level of 0.05 was set.

Results

Of 112 patients evaluated in this study, impacted canines successfully erupted in 72 patients (64.3%) and did not erupt in 40 patients (35.7%). Of the non-erupted group, 10 patients (25%) decided to discontinue treatment while others terminated the treatment without successful eruption. Most canine impactions were palatal (71.4%), and buccal impaction was noted in 28.6% of the patients. Regarding the impaction depth, the highest frequency was related to type C (63.4%), followed by type B (30.4%), and the lowest frequency was related to type A (6.3%). Women had a higher frequency of unerupted teeth than men, but the success rate of orthodontically-assisted maxillary impacted canine eruption was the same in males and females, and Fisher's exact test revealed no significant difference between males and females in the success rate of impacted canine eruption ($P=0.077$, Table 1).

Regarding the age of the patients, the success rate of orthodontically-assisted eruption of impacted maxillary canine teeth in patients aged 15 to 18 years was significantly higher than that in other age groups, and based on the Fisher's exact test, there was a significant correlation between age and success rate of orthodontically-assisted eruption of impacted maxillary canines ($P=0.001$, Table 1).

Regarding the type of canine impaction, the highest frequency was related to grade II, and a significant correlation was observed between the impaction type and the success rate of orthodontically-assisted eruption of impacted maxillary canines. In other words, patients with type II impaction had a significantly higher success rate of orthodontically-assisted eruption of impacted maxillary canines than other patients (P=0.001, Table 1).

Regarding the angle of impacted canines relative to the occlusal plane, it was determined

that the erupted canines had a significantly higher mean angle than the non-erupted canine teeth (P<0.05, Table 2), which means that the erupted canines were more vertically oriented than the non-erupted group.

According to Table 3, the most common complication caused by the impacted canines was root resorption of lateral incisor. Also, no significant difference was observed between the effects of erupted and non-erupted impacted canines on the adjacent teeth according to the Fisher's exact test (P=0.10, Table 3).

Table 1. Comparison of the demographic characteristics of the two groups with erupted and non-erupted maxillary canine teeth

| Variable | Category | Non-erupted | | Erupted | | P-value |
|----------------|----------------|-------------|------------|---------|------------|---------|
| | | Number | Percentage | Number | Percentage | |
| Sex | female | 31 | 36.5 | 54 | 63.5 | 0.77 |
| | male | 9 | 33.3 | 18 | 66.7 | |
| Age | 15 to 18 years | 4 | 9.1 | 40 | 90.9 | 0.001* |
| | 18 to 20 years | 13 | 40.6 | 19 | 59.4 | |
| | Above 21 years | 23 | 63.9 | 13 | 36.1 | |
| Impaction Type | Grade II | 19 | 22.4 | 66 | 77.6 | 0.001* |
| | Grade III | 10 | 66.7 | 5 | 33.3 | |
| | Grade IV | 11 | 91.7 | 1 | 8.3 | |

A significant difference between groups is indicated by a * sign. (P<0.05).

A 95% confidence interval of the mean was estimated in the analysis.

Table 2. Mean impaction angle (degrees) of the teeth

| Group | Number | Mean | Standard deviation | P-value |
|-------------|--------|-------|--------------------|---------|
| Non-erupted | 40 | 22.95 | 10.43 | 0.001* |
| Erupted | 72 | 56.97 | 15.696 | |

A significant difference between the groups is indicated by a * sign. (p < 0.05).

A 95% confidence interval of the mean was estimated in the analysis.

Table 3. Effects of the erupting canine teeth on the adjacent teeth

| Effect | Non-erupted | | Erupted | | P-value |
|--|-------------|------------|---------|------------|---------|
| | Number | Percentage | Number | Percentage | |
| No effect | 12 | 30.0 | 20 | 27.8 | 0.10 |
| Premolar caries | 0 | 0.0 | 1 | 1.4 | |
| Lateral incisor caries | 10 | 25.0 | 18 | 25.0 | |
| Root resorption of premolar teeth | 1 | 2.5 | 2 | 2.8 | |
| Root resorption of lateral incisors | 7 | 17.5 | 26 | 36.1 | |
| Lateral incisor and premolar root resorption | 4 | 10.0 | 2 | 2.8 | |
| Central and lateral incisor root resorption | 6 | 15.0 | 3 | 4.2 | |

A 95% confidence interval of the mean was estimated in the analysis.

Discussion

Canine teeth are considered as the pillars of the dental arch and play an important role in terms of esthetics and function. An accurate diagnosis and treatment approach along with adequate knowledge about the treatment prognosis are essential for appropriate treatment planning for an impacted canine tooth. In such cases, surgical exposure combined with orthodontic traction is often required for treatment. Impaction of a maxillary canine leads to problems such as resorption of the adjacent teeth, external root resorption, infection, cyst formation, tooth displacement, and periodontal problems. Early clinical and radiographic evaluation to investigate the position of such teeth and appropriate intervention can lead the canine towards its natural path of eruption and prevent the problems and risks caused by its impaction (3).

Considering the importance of eruption of impacted canine teeth and high prevalence of impaction, this study was conducted to assess the success rate of orthodontically-assisted eruption of impacted maxillary canine teeth according to age, gender and type of impaction in dental centers in Shahrekord city, Iran.

According to the results of the present study, the frequency of non-erupted canine teeth was higher in women than in men; however, gender was not an effective factor in increasing the rate of maxillary canine tooth eruption; in other words, the success rate of orthodontically-assisted impacted canine tooth eruption was the same in males and females. Ebrahimi et al, (2) and Shirinbak et al. (14) stated that the frequency of canine impaction was higher in women than men, but this difference was not statistically significant; which was in line with the results of the present study. In contrast to the present results, Motamedi et al. (15) assessed impacted canine tooth surgery, the success rate of fixed orthodontic treatment following palatal exposure, and radiographic factors affecting it. They stated that canine tooth eruption after orthodontic treatment in women was more successful than in men. The difference between the results of the present study and the study by Motamedi et al. (15) may be due to the difference in sample size and the study populations. Therefore, it appears that gender cannot be confidently introduced as an effective factor on impaction or eruption of canine teeth. Also, some studies (16, 17), in contrast to the present study, demonstrated that tooth impaction in females was significantly more common than in males, which can be due to the difference in facial dimensions of

females and males and the smaller size of dental arch in females. In addition, the sequence of tooth eruption can also have a significant effect on the degree of impaction in some males and females. Furthermore, racial differences and their effect on dental arch length, variations in tooth size and morphology, and differences in sample size can be the possible causes of differences observed in the results of different studies.

In the present study, age was an effective factor on orthodontically-assisted eruption of impacted maxillary canine teeth since the eruption rate of canine teeth in patients between 15 to 18 years was significantly higher than other age groups. Becker and Chaushu (16) stated that canine eruption was not successful in adults older than 30 years; thus, considering the positive correlation between age and lack of success in erupting impacted canine teeth, the result obtained in the present study was in line with the study by Becker and Chaushu (16). Also, in a study by Ebrahimi et al, (2) the rate of successful eruption of impacted canines in younger patients in the age range of 16 to 20 years was higher than in older age groups, which was in line with the results of the present study. However, other studies (17, 18) evaluated limited age range of patients, and the age of patients was not reported as an influential factor on the success rate of assisted eruption of impacted canine teeth; therefore, evaluation of the demographic variables of age and gender and their effect on the success rate of eruption of impacted canine teeth was a strength of the present study.

Grade II was the most common type of canine impaction in the present study. Also, the highest eruption rate of impacted canine teeth was observed in grade II cases, indicating a significant correlation between the type of impaction and success rate of orthodontically-assisted impacted maxillary canine eruption. In other words, orthodontic treatment was significantly more effective in eruption of impacted canine in patients with type II impaction than other types (III and IV). In the study by Ebrahimi et al, (2), type II was the most common type of impaction, which was in line with the results of the present study. Alassiry et al. (5) used the Yamamoto's classification (11) of impacted canines in a Saudi Arabian population (500 panoramic radiographs) and reported that the highest frequency was related to type I impaction, followed by types II and VI, and no case of type IV was observed. This difference in prevalence rates between the two studies was expected due to the difference in sample size between their study and the present study. Although tooth impaction is a common phenomenon, it has a high variation in

terms of prevalence and incidence in different racial populations and in different areas of the jaw (19).

Previous studies indicated that with an increase in the angle of tooth compared to the midline, the chance of tooth eruption decreased (20,21), which was in line with the current results; thus, the lower the angle of the canine tooth relative to the occlusal plane, the lower the chance of its successful eruption and treatment would be.

Alqerban et al. (22) showed that three factors namely the angle formed between the canine and first premolar teeth, distance from the cusp tip of the canine tooth to the midline, and distance from the cusp tip of the canine tooth to the occlusal plane of the maxilla can be helpful in investigating maxillary canine impaction. Uribe et al. (23) showed that among the factors affecting canine impaction, examining the canine position on panoramic radiographs had a direct relationship with the possibility of canine impaction.

Guarnieri et al. (24) showed that among all the investigated variables, the angle of the impacted canine relative to the axial inclination of the adjacent lateral incisor had the highest diagnostic value in predicting root resorption of the adjacent tooth. Motamedi et al, (14) also stated a reduction in success rate of orthodontically and surgically assisted eruption of palatally-impacted canine teeth with the increase in the angle of the palatally impacted canine relative to the midline, presence of abnormality in the palatally impacted canine root, and presence or increase of the overlap of the exposed canine tooth on the root of the adjacent lateral incisor tooth.

In the current study, eruption or no eruption of the impacted canine tooth had the greatest effect on root resorption of lateral incisor. In a study by Akkuc et al, (25), it was shown that 33% of the impacted canines caused root resorption in the adjacent lateral incisors, which was in line with the results obtained in the present study.

Hosseini et al. (6) stated that the most common type of impaction was mesial impaction, the most common level of impaction was buccal, and the most common type of pathology was adjacent root resorption. Alshawy and Kolarkodi (26) also reported that impacted canine teeth affected the adjacent incisor teeth and led to caries development in the adjacent teeth.

The relatively high prevalence of impacted maxillary canine teeth can be due to the fact that this tooth occupies a sensitive position in the arch and serves as a connector between the anterior and posterior teeth. Its long development time and its complex eruption path are also among the main

causes of the high prevalence of canine tooth impaction. Due to the important role of this tooth in occlusion, forming the shape of the arch and creating a beautiful smile, ectopic eruption and impaction of this tooth is an important clinical problem faced by patients and orthodontists, and therefore treatment of such teeth requires a multidisciplinary approach to design a comprehensive treatment plan (24).

Conclusion

Based on the results of the present study, it may be stated that orthodontic treatment of maxillary impacted canine teeth is an effective method to aid their eruption, and patients in the age range of 15 to 18 years with grade II impaction had the highest success rate of orthodontically-assisted eruption of impacted maxillary canine teeth.

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