INDONESIAN JOURNAL OF DENTISTRY
Faculty of Dentistry Universitas Muhammadiyah Semarang

Indonesian Journal of Dentistry
Volume 6 No. 1 (2026): February
DOI: http://dx.doi.org/10.26714/ijd.v6i1.19835

ORIGINAL ARTICLE

Investigating the Factors Related to the Success of Forced Eruption Treatment of Impacted Maxillary Canine Teeth

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ARTICLE INFO

Keywords:
Canine, Forced Eruption Technique, Impacted Tooth

Article History:

Received : 20/11/2025
Revision : 27/02/2026
Accepted : 27/02/2026
Published : 28/02/2026

ISSN: 2775-0159

ABSTRACT

Background: The maxillary canine is often more difficult to manage orthodontically compared to other teeth.
Objective: This study aims to evaluate additional factors affecting the success of Forced Eruption treatment for impacted maxillary canines, emphasizing the importance of timely and appropriate therapeutic strategies.
Method: This descriptive-analytical study evaluated the records of 52 patients diagnosed with maxillary canine impaction. Data sources included Cone Beam Computed Tomography (CBCT) images and initial and final panoramic radiographs available in the patients' files. The collected data were analyzed using SPSS software.
Outcome: The study revealed a significant relationship between the depth of impaction and the success of Forced Eruption treatment for maxillary impacted canines ($p < 0.05$). However, no significant associations were found between the success of the treatment and variables such as age, gender, position of impaction, or the available space in the maxillary arch. These findings suggest that depth of impaction is a critical factor influencing treatment outcomes, while other demographic and positional factors may not significantly affect success rates.
Conclusion: Patients with a lower depth of maxillary canine impaction experience better outcomes with Forced Eruption treatment.

Citation (Vancouver style):
Namadkolahi R, Maratebi M, Vajari SF, Ghaderi P, Deravi N, Pourkhamaneh S, Sigari P. Anti-inflammatory effects of pineapple core extract on macrophages in gingivitis-induced Wistar rats. Indones J Dent. 2026;6(1): 85-97.

INTRODUCTION

Growing individuals need to develop their teeth properly. It is essential for preventing malocclusion, ensuring that teeth line up correctly to prevent biting problems, and improving the appearance of the face. When a tooth does not erupt into the oral cavity at the anticipated time and instead remains embedded in the alveolar bone, it is referred to as dental impaction. If left untreated, this can result in a number of dental issues.[1, 2]

Depending on the population under study, impaction of the maxillary canine (IMC) is the most common type of impaction, second only to that of the third molars.[3] When forced eruption and subsequent alignment place the tooth correctly within the dental arch, managing an impacted canine is considered successful. However, in certain situations, additional surgical procedures may be necessary to remove obstacles obstructing the eruption path. The complexity and duration of therapy are determined by variations in the buccopalatal, vertical, and anteroposterior positions of impaction. [5 ,4]

Due to their proximity to nearby structures or their suboptimal placement within the alveolar bone, maxillary canines may become impacted, preventing natural eruption during the normal eruption sequence. Because of either limited surgical access or a clinically unfavorable and protracted eruption trajectory, canines that are positioned high or horizontally are considered difficult to manage.[6, 7] A mesial position, elevated α-Angle (the angle formed between the impacted canine's long axis and the inter-incisor median line; normal range = 20–53°), and significant vertical localization have all been associated with longer treatment durations, according to the literature.[8] The presence of ankylosis, odontoma, or root dilaceration complicates the treatment strategy and excludes simple orthodontically assisted eruption (Fig. 1). Orthodontic traction and surgical exposure may not be effective for some impacted canines.[7] The increased need for patient compliance throughout extended treatment is one possible complicating factor for canine impaction.[9-11]

The existence, position, and pathophysiology of impacted canines are evaluated using a variety of radiographic techniques. These include Computed Tomography (CT), intraoral periapical radiographs, occlusal radiographs, panoramic radiographs, and cone-beam computed tomography (CBCT).[12] A three-dimensional imaging approach called CBCT offers a precise way to identify the affected canine.[13, 14] However, it may expose the patient to more radiation, may not be available in all treatment centers, and is not appropriate for early evaluation. Because it provides a thorough two-dimensional view of the impacted teeth, including their position, angulation, and orientation in relation to adjacent teeth, panoramic radiography (OPG) is considered one of the most reliable imaging techniques.[15, 16]

Canine impaction presents a major issue for orthodontists in terms of origin, localization, and preventive treatments, according to the aforementioned facts.[17, 18] For the best outcomes, it is therefore essential to evaluate the probability of impaction and the timing of treatment influenced by canine impaction. In these situations, delaying orthodontic treatment until later in life increases the risk of ankylosis, which can negatively impact the roots of neighboring incisor teeth.[7, 19]

This article investigates the key factors associated with the success of forced eruption treatment for impacted maxillary canines, providing insights that can guide clinical decision-making and enhance the predictability of treatment results.[2] By examining these elements, we aim to contribute to a more comprehensive understanding of canine impaction management and its implications for orthodontic practice.[6, 17, 20]

RESEARCH METHODS

Study Design

This study is descriptive, analytical, and cross-sectional. All patients referred to various orthodontic clinics for eruption guidance operations in dental clinics connected to Ardabil University of Medical Sciences between July 2015 and July 2019 were included in the study population. The ethics committee of Ardabil University of Medical Sciences has granted ethical approval for the study.

Sampling Method

Complete enumeration sampling was used to collect the research population. All patient records were reviewed, and cases that met the pre-established inclusion and exclusion criteria were added. A minimum of 30 instances were needed for the sample size, which was determined using a 2% prevalence of impacted maxillary canines, a 0.05 margin of error, and 95% confidence.

Exclusion and Inclusion Criteria

The presence of impacted maxillary canines, maxillary lateral teeth on the impaction side, and first premolars on the impaction side were requirements for inclusion. Dilaceration of the impacted canine, substantial crowding within the dental arch, and the existence of systemic or metabolic disorders were the exclusion criteria. Fifty two instances were added to the study when the selection criteria were applied. The clinical files of the patients were used to report their age and gender.

Assessment of Treatment Success and **Impaction Characteristics**

Treatment success was defined as the complete eruption of the impacted canine into the dental arch, confirmed using final panoramic radiographs obtained from the same institution under standardized imaging protocols to ensure consistency in image quality and minimize observational bias. The depth of impaction was determined using initial CBCT and panoramic images,[21, 22] which were part of the patients' routine diagnostic records prior to inclusion in the study and were not obtained specifically for research purposes. Impactions were classified as Grade 1 (below the CEJ), Grade 2 (above the CEJ but below half of the root), Grade 3 (above half of the root but below the apex), or Grade 4 (above the apex) as shown in Figure 1.

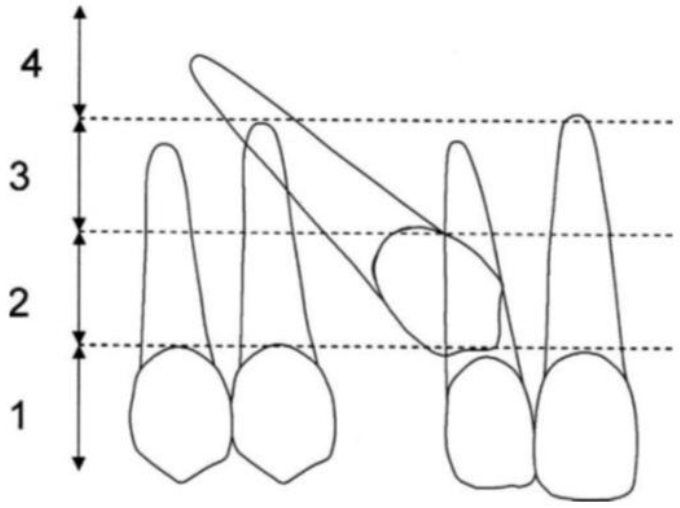

Figure 1. Classification of Impaction Depth

Notes:

1. Grade 1: Below the level of the Cementoenamel Junction (CEJ).
2. Grade 2: Above the CEJ and below half of the root.
3. Grade 3: Above half of the root and below the apex.
4. Grade 4: Above the apex.

The position of impaction was categorized as labial or palatal. Available arch space was assessed using the Pitt et al. classification,[23] measuring the space between the lateral incisor and first premolar as Grade 1 (>7 mm), Grade 2 (4–7 mm), Grade 3 (2–4 mm), or Grade 4 (0–2 mm). Figure 2 shows a representative CBCT image of an impacted canine, while Figure 3 illustrates a panoramic radiograph for treatment assessment.

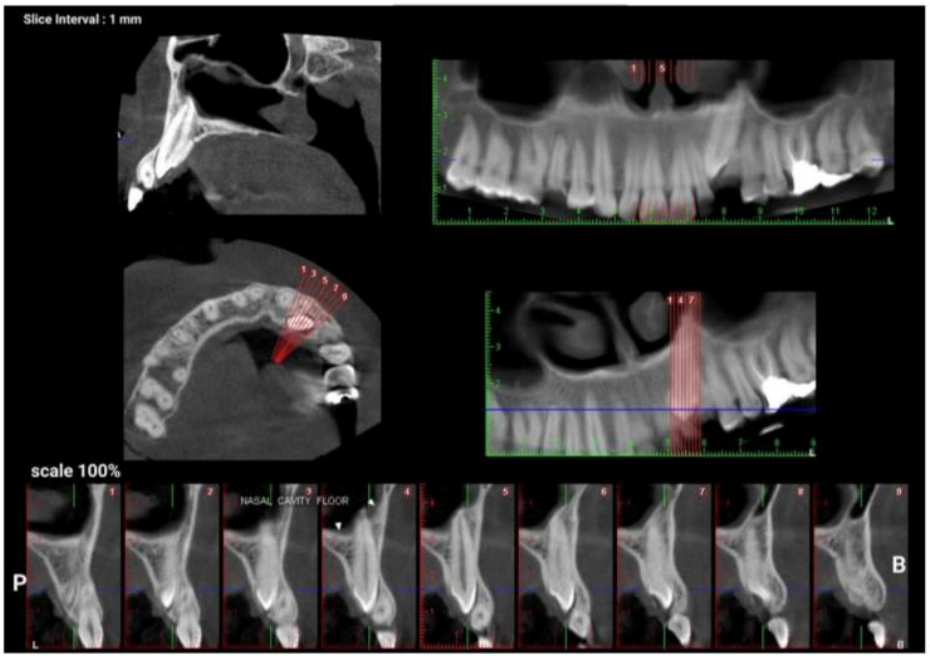

Figure 2. Representative CBCT Image of an Impacted Canine

Figure 3. Panoramic Radiograph for Treatment Assessment

Statistical Analysis

Statistical AnalysisData analyses were conducted utilizing SPSS software (Version 24). Kolmogorov-Smirnov tests determined the distribution of the data, Kruskal-Wallis tests evaluated age and treatment success, and Chi-square tests determined gender, impaction depth, and impaction position. A p-value < 0.05 determined levels of significance.

RESEARCH FINDINGS

Baseline characteristics

This research assessed the results of forced eruption therapy for impacted maxillary canines in 52 patients, reporting a success rate of 84.6% (44 of 52). The patient sample was 73.1% female, with 32.7% of patients aged 10-15 years and 23.1% over 30 years of age. There was no statistically significant effect of age ($p>0.05$) or gender ($p>0.05$) on treatment success. However, there were significant differences in treatment success based on clinical factors. There was a 92.3% success rate for shallow impactions (below CEJ), compared with a 66.7% success rate for deep impactions (above apex, $p<0.05$) and 94.1% success when there was adequate space (>7 mm) in the arch versus 71.4% success when there was minimal space (0-2 mm, $p<0.05$). Labial impactions had a higher success rate (88.9%) compared to palatal impactions (78.6%); however, there was no statistically significant difference ($p>0.05$). These findings suggest that, rather than age and gender, the primary factors affecting treatment outcomes are anatomical factors, such as impaction depth and space available in the arch.

Table 1. Base line characteristics of the Category

	Subgroup	Frequency	Percentage	Cumulative Percentage
Gender	Male	14	26.90%	26.90%
	Female	38	73.10%	100%
	Total	**52**	**100%**	
Age Group	Okt-15	17	32.70%	32.70%
	16-20	6	11.50%	44.20%
	21-25	8	15.40%	59.60%
	26-30	9	17.30%	76.90%
	Over 30	12	23.10%	100%
	Total	**52**	**100%**	

The normality of the data was assessed using the Kolmogorov-Smirnov test, as shown in Table 2-4. None of the examined variables demonstrated a normal distribution, as indicated by p-values less than 0.05.

Outcome analysis

The study evaluated treatment outcomes for impacted maxillary canines in 52 patients undergoing forced eruption, demonstrating an overall success rate of 84.6% (44/52 cases). Analysis revealed that the depth of impaction significantly influenced treatment success ($p = 0.042$), with Grade 2 impactions showing 95.8% success (23/24) compared to 75% (21/28) for Grade 3 impactions. While age distribution showed a non-significant trend ($p = 0.083$), with younger patients (10-15 years) achieving 94.1% success (16/17) versus 66.7% (8/12) in patients

over 30, neither gender (p=0.894) nor impaction position (p = 0.192) significantly affected outcomes. Labial impactions showed 100% success (12/12) compared to 80% (32/40) for palatal impactions, though this difference was not statistically significant. Available arch space demonstrated a non-significant association with success (p = 0.317), with Score 1 cases achieving 100% success (9/9) versus 77.8% (7/9) for Score 4 cases. Overall, the findings reported relevant outcomes of maxillary canines impacted using forced eruption. Anatomical factors do have strong predictive values for successful treatment, while demographic characteristics did not show strong predictive values regarding forced eruption outcomes.

Table 2. Outcomes assessment of the study

Variable	Category	Successful	Unsuccessful	Total	p-value
Age Group	10-15	16	1	17	0.083
	16-20	5	1	6	
	21-25	7	1	8	
	26-30	8	1	9	
	Over 30	8	4	12	
Gender	Male	12	2	14	0.894
	Female	32	6	38	
Impaction Position	Labial	12	0	12	0.192
	Palatal	32	8	40	
Depth of Impaction	Grade 2	23	1	24	0.042*
	Grade 3	21	7	28	
Available Space	Score 1	9	0	9	0.317
	Score 2	19	2	21	
	Score 3	17	4	21	
	Score 4	7	2	9	

*Statistically significant ($p < 0.05$)

DISCUSSION

The previously mentioned maxillary canines play a significant role in both the aesthetic and functional aspects of dental systems. The treatment of affected canines is essential because their impaction might result in a number of issues. The results of a study looking at the variables influencing the success of eruption are examined in this discussion, specifically the forced method of treating impacted maxillary canines.[19, 24]

The study unexpectedly discovered no meaningful relationship between the patients' age and gender and the effectiveness of their treatment. The results of this study reveal that age alone may not be a crucial factor, despite previous studies suggesting that younger patients may have better outcomes due to more favorable anatomical characteristics. In line with earlier

research findings, the absence of a significant correlation with gender implies that male and female patients respond to the treatment in a similar way.

According to Darab Gholami Boroujeni and colleagues, the success rate of orthodontically aided eruption of impacted canines is not substantially influenced by gender ($P>0.05$). This study emphasizes the need for additional research to examine the underlying biological mechanisms that may influence canine eruption beyond demographic considerations, despite widespread beliefs regarding gender differences in dental development.[25] According to Mirasmaeili et al. (2015), gender has no discernible effect on how difficult orthodontic treatment is for maxillary impacted canines.[26] This conclusion supports the idea that gender may have little effect on treatment outcomes in this situation and is in line with the current study's findings.

During 2009, Schubert assessed whether it was possible to estimate the length of treatment based on the distance traveled by the canine's cusp tip during the forced eruption of impacted maxillary canines. In contrast to the results of the current study, he discovered that age was a key factor influencing treatment success in patients under the age of eighteen who had at least one canine. The fact that Schubert's study only looked at patients under the age of 18, whereas the current study did not have this restriction, may be one of the primary causes of the two studies' disparate findings.[27]

Koenraad Grisar and colleagues' 2021 study examined 17 consecutive autotransplanted maxillary canines in 17 patients and found no significant correlations between treatment outcomes and baseline parameters. The majority of patients were receiving active orthodontic treatment, and the mean age at surgery was eighteen. The majority of canines demonstrated satisfactory post-operative healing despite some early problems, such as soft tissue abnormalities and injury to the root surface; nevertheless, one instance showed evidence of inflammatory root resorption after six weeks.[28] This leads to the conclusion that age cannot be regarded as a factor associated with the efficacy of forced eruption treatment because the current study did not find a statistically significant link between patients' ages and treatment success at a significance level of 0.05.

Investigating the connection between the success rate of forced eruption treatment and the depth of impaction was the main goal of this investigation. In terms of depth of impaction, the majority of research participants fell into Grade 3, with none falling into Grades 1 or 4. The Grade 3 group had a far higher rate of treatment failure than the Grade 2 group. Additionally, statistical research verified a strong correlation between the effectiveness of forced eruption treatment and the depth of impaction.

The results of this research are consistent with other research, such as that done by Fleming et al. (2009), which investigated the effect of impacted canines' radiographic location on the length of orthodontic treatment. According to their research, the mesiodistal position of canines may be a predictor of therapy duration and results. Nevertheless, they discovered no relationship between treatment results and the canine's initial angle, depth of impaction, or apex position. This disparity could be explained by variations in the research populations and the small sample sizes used.[21]

Pitt et al. also sought to develop an index for the difficulty of treating maxillary impacted canines (TDI) and found that buccopalatal location, age, vertical height, and horizontal position were important factors in the treatment of these canines. This result is in line with our research, supporting the notion that a number of positional parameters, such as depth of impaction, are critical to treatment results.[23]

Furthermore, Zuccati et al. showed that factors like depth of impaction could offer a more precise estimate of the number of sessions needed to finish the forced eruption phase, thereby affecting treatment success. This validates our results and emphasizes how crucial it is to take impaction depth into account when developing treatment plans.[29]

The success of forced eruption treatment is significantly influenced by the depth of impaction, as our study highlights. These results imply that precise evaluation of impaction depth is crucial for maximizing treatment results and customizing strategies to meet the needs of specific patients. The association between impaction position and the effectiveness of forced eruption treatment was another conclusion of the current investigation. Our findings showed that the effectiveness of forced eruption treatment was not significantly correlated with impaction position. Similarly, impaction position was not found to be a significant influencing factor in the Fleming et al. investigation.[21]

On the other hand, Yusuke Hamada et al. found that the treatment strategy for impacted maxillary canines is greatly influenced by the site of impaction. The study suggests that although the position is important for choosing the intervention strategy, there may not be a direct relationship between it and the treatment's overall success rates.[11] In contrast to our findings, Pitt et al. suggested that age, depth, and impaction position are three important determinants in the outcome of forced eruption treatment.[23] Pitt's study limitations, which assessed eight variables in just thirty samples, could be one explanation for these disparities. The robustness of their findings may have been impacted by this limited sample size, which could also explain the discrepancies between our investigations.

Examining the connection between the efficacy of forced eruption treatment and the amount of space between the lateral incisor and the first maxillary premolar was another goal of this investigation. At the 0.05 level, there was no discernible correlation between the distance between the teeth in question and the effectiveness of forced eruption therapy. Similar to our findings, Pitt et al.'s investigation discovered no correlation between treatment outcomes and the variable of space between the lateral incisor and the first premolar on the side of impaction.[23]

In 2009, Schubert evaluated the correlation between the duration of treatment and the distance traveled by the canine tip during the forced eruption of impacted maxillary canines. He showed that the impacted canine's location in relation to neighboring teeth had a substantial impact on the length of treatment.[27] This conclusion is at odds with the current study's findings, which can be mostly explained by variations in sample size, study location, and time.

The effectiveness of forced eruption treatment for impacted maxillary canines was examined by Chawla et al. in a 2011 study. They found that impacted canines were more common in the maxillary region on the palatal side and that forced eruption was an effective treatment option for these patients, depending on a number of variables, including the amount of space between the teeth.[30] This discovery, however, contradicts our study's findings. Variations in the inclusion and exclusion criteria among the studies could be the cause of the disparities in the results.

The results of this study highlight how important the depth of impaction is in deciding whether forced eruption treatment for impacted maxillary canines is successful. It is crucial for doctors to perform comprehensive assessments of impaction depth before starting treatment, given the strong correlation seen between impaction depth and treatment outcomes. More individualized treatment strategies that can improve patient outcomes will be possible with this approach. In order to reduce consequences related to impacted canines, such as root resorption and periodontal problems, clinicians should give priority to early management techniques.

Given the limitations of this study, the limited sample size of 52 individuals may not offer enough statistical power or generalizability to larger populations. It identifies a number of areas for future research to better improve the understanding and management of impacted maxillary canines. Such as: investigation of biological mechanisms, longitudinal research, wider sample comparative studies that measure the efficacy of various treatment modalities for affected canines in relation to forced eruption procedures. Thes should be beneficial for populations and future study.

CONCLUSION

In the present study, the success rate of forced eruption treatment was estimated to be 84.6%. This success demonstrated a significant relationship with the depth of impaction. However, variables such as age, gender of the patients, impaction position, and the space available between the lateral incisor and the first maxillary premolar were not found to be associated with the success of the treatment. These findings emphasize the importance of considering the depth of impaction when predicting treatment outcomes for forced eruption while also suggesting that other commonly considered factors may not play a significant role in determining success.

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