International Journal of Dentistry Research

Review Article

ISSN: 2581-3218
IJDR 2026; 11(2): 56-60
Received: 16-06-2026
Accepted: 02-08-2026
Published: 31-08-2026

www.dentistryscience.com
doi: 10.31254/dentistry.2026.11208

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Review of Factors Influencing the Duration of Traction of Maxillary Impacted Canines

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Abstract

Maxillary canine impaction is a common developmental anomaly that frequently necessitates combined surgical and orthodontic intervention. Orthodontic traction of impacted maxillary canine is often lengthy, technique-sensitive, and associated with biological and mechanical risks. Considerable variability exists in reported traction duration, reflecting differences in impaction characteristics, patient-related factors, diagnostic methods, and treatment strategies. This review synthesizes evidence from classic and contemporary literature to provide an in-depth analysis of the factors influencing traction duration of impacted maxillary canines. Emphasis is placed on epidemiology, etiology, radiographic predictors, surgical approaches, orthodontic biomechanics, biological considerations, complications, and recent advances in imaging and treatment modalities. Understanding these determinants is essential for accurate prognosis, optimized treatment planning, and improved clinical outcomes.

Keywords: Maxillary Impacted Canine , Orthodontic Traction Duration , Cone-Beam Computed Tomography (Cbct) , Radiographic Predictors , Corticotomy-Assisted Orthodontics.

INTRODUCTION

The maxillary canine plays a pivotal role in dental esthetics, arch integrity, functional occlusion, and guidance during mandibular movements, as emphasized by Bishara and Kokich in their classic reviews [1,2]. Owing to its long eruption path, late eruption timing, and reliance on adjacent teeth-particularly the lateral incisor, for eruption guidance, the maxillary canine is especially susceptible to eruption disturbances. Consequently, studies by Dachi *et al* and Bishara have reported that the maxillary canine is the second most commonly impacted tooth after third molars [1,3].

Impaction of maxillary canines often requires surgical exposure followed by orthodontic traction to guide the tooth into the dental arch [2,4].This phase of treatment may extend over several months or even years, contributing significantly to overall orthodontic treatment time. Investigations by Fleming *et al*. and Arriola-Guillén *et al* have demonstrated that traction time constitutes a major component of prolonged orthodontic therapy in such cases [5,6]. Prolonged traction is associated with increased risk of root resorption, periodontal compromise, patient discomfort, and reduced compliance [2,7,8]. Consequently, identifying factors that influence traction duration has been a major focus of orthodontic research [5,6,9].

Earlier reviews primarily focused on the prevalence, diagnosis, and treatment modalities of impacted maxillary canines. In contrast, more recent studies have shifted toward identifying predictive factors for treatment difficulty and duration, particularly through the use of advanced imaging modalities such as cone-beam computed tomography (CBCT). CBCT-based investigations by Yang *et al*, Goh *et al* and Vasović *et al* have provided three-dimensional insights into canine position and its relationship with traction duration [9-11]. Accordingly, the present review aims to comprehensively and descriptively analyze the factors influencing the duration of orthodontic traction of maxillary impacted canines, integrating evidence from epidemiological, radiographic, surgical, and orthodontic perspectives.

Epidemiology and Prevalence of Maxillary Impacted Canines

Epidemiological studies have consistently reported a prevalence of impacted maxillary canines ranging from approximately 1% to 3% in the general population [3,12-14]. Early radiographic surveys conducted by Dachi and Howell were among the first to identify impacted canines as a frequent incidental finding in routine dental radiographs, underscoring their clinical significance [3].

A female predilection has been widely documented, with ratios reported as high as 2:1 in some populations [12,15]. Although the exact etiology of this sex difference remains unclear, it has been hypothesized to relate to differences in craniofacial growth patterns or genetic susceptibility, as suggested by Peck *et al* [15]. Palatal impaction has been shown to occur more frequently than labial impaction in most epidemiological studies, although regional and ethnic variations have been reported by Lövgren *et al* and Al-Salmany *et al* (Table 1) [13,16].

More recent epidemiological investigations indicate that both the prevalence and severity of maxillary canine impaction may be influenced by early interceptive orthodontic practices. Studies by Ericson and Kurol, Baccetti *et al*, and Lövgren *et al* have demonstrated that populations subjected to routine radiographic screening and timely extraction of the primary canine exhibit lower rates of severe impactions and a reduced need for surgical exposure and prolonged orthodontic traction [13, 17, 18].

Table 1: Prevalence of impacted canine in different population

Author (Year)	Population Studied	Prevalence (%)	Notable Findings
Dachi & Howell (1961) [3]	Dental radiographic survey	~1.8	Canines second most impacted tooth
Thilander & Myrberg (1973) [12]	Swedish schoolchildren	1–2	Higher prevalence in females
Lövgren *et al* (2019) [13]	Scandinavian population	1.3	Reduced severity with interceptive care
Rengalakshmi (2021) [14]	Chennai population	2.7	Palatal impaction predominant
Kumar *et al* (2024) [19]	Hyderabad population	2.1	Maxillary dominance
Al-Salmany *et al* (2025) [16]	Fallujah population	3.2	Association with arch length deficiency

Etiology and Pathogenesis

The etiology of maxillary canine impaction is multifactorial, involving a complex interaction between genetic, local, and environmental factors. Bishara and Peck *et al* emphasized that no single etiological factor is responsible for canine impaction [1, 15]. Rather, the underlying cause often determines the initial position of the canine, which subsequently influences the difficulty and duration of orthodontic traction, as demonstrated in CBCT-based studies by Arriola-Guillén *et al* [6].

Genetic Factors

Palatally displaced canines have been strongly associated with genetic predisposition. Peck *et al* demonstrated familial clustering of palatally impacted canines and their association with dental anomalies such as peg-shaped lateral incisors, congenitally missing teeth, and dental transpositions [15]. These findings support the concept that palatal impaction represents a genetically determined eruption disturbance rather than a purely space-related problem. This genetic theory has been further supported by Bishara and reinforced in recent comprehensive reviews by Almoammar [1,20].

Local Factors

Local etiological factors contributing to canine impaction include arch length deficiency, premature loss or prolonged retention of the primary canine, abnormal position or morphology of the lateral incisor, presence of supernumerary teeth or odontomas, and trauma. Kokich highlighted the role of mechanical obstruction and space deficiency, while Al-Salmany *et al* reported a strong association between arch length discrepancy and canine impaction in orthodontic populations [2,16] Labial impactions are more frequently associated with crowding, whereas palatal impactions are often observed in relatively well-aligned arches, as reported by Bishara and Peck *et al* [1,15].

Guidance Theory and Interceptive Treatment

The guidance theory, originally proposed and extensively investigated by Ericson and Kurol suggests that the eruption path of the maxillary canine is guided by the root of the lateral incisor [21]. Absence, hypoplasia, or abnormal morphology of the lateral incisor may result in loss of guidance and subsequent palatal displacement of the canine. They demonstrated that interceptive extraction of the primary canine during the mixed dentition period could redirect the eruption path of the permanent canine in a significant proportion of cases. These findings were later confirmed by Baccetti *et al*, who showed that early interceptive intervention reduces impaction severity and decreases the need for surgical exposure and prolonged orthodontic traction [18].

Diagnostic Imaging and Radiographic Assessment

Accurate radiographic assessment is fundamental for evaluating impacted maxillary canines and predicting traction duration. Kokich emphasized that precise localization of the impacted canine is essential for prognosis and treatment planning [2] Conventional two-dimensional imaging has largely been supplemented by three-dimensional cone-beam computed tomography (CBCT), which provides superior visualization of tooth position and surrounding anatomical structures, as demonstrated by Yang *et al* and Goh *et al* [10,11].

Two-Dimensional Imaging

Panoramic radiographs have historically been used to assess canine position, angulation, and sector location. Ericson and Kurol introduced panoramic indices to assess the severity of canine displacement and its relationship to adjacent teeth [21].

Fleming *et al* [14] later demonstrated that certain panoramic parameters correlate with orthodontic treatment duration. Key positional factors included the canine's mesiodistal location relative to adjacent teeth, vertical height from the occlusal plane, angulation to the midline, and buccopalatal position. Canines positioned more mesially, at a greater vertical height, and with increased angulation were associated with significantly longer treatment times. Palatal impactions generally required longer treatment than buccal ones. Among all variables, mesiodistal displacement and angulation were the strongest predictors of treatment duration, highlighting the importance of early radiographic assessment in treatment planning [5].

However, Yang *et al* and Goh *et al* reported that superimposition, magnification, and distortion limit the predictive accuracy of two-dimensional imaging [10,11].

Cone-Beam Computed Tomography

CBCT allows precise three-dimensional assessment of the buccopalatal position of the impacted canine, its proximity to adjacent roots, follicle size, and surrounding bone coverage. Yang *et al*. demonstrated stronger correlations between CBCT-derived variables and traction duration compared to panoramic indices [10]. Similar findings were reported by Arriola-Guillén *et al*, Goh *et al* and Vasović *et al* confirming CBCT as the most reliable imaging modality for prognostic evaluation [6,9,11].

Radiographic Predictors of Traction Duration

Radiographic characteristics are the most consistently reported determinants of orthodontic traction duration. Fleming *et al*. demonstrated that the three-dimensional position of the impacted canine is the dominant predictor of treatment length [5].

Buccopalatal Position

Bishara and Fleming *et al*. reported that palatally impacted canines generally require longer traction periods than labially impacted canines [1,5]. Yang *et al* attributed this to increased bone density, thicker palatal cortical bone, and longer eruption pathways [10] Vasovic *et al*. have demonstrated that buccally impacted canines may emerge into the oral cavity in approximately 6–7 months, whereas palatally impacted canines may require more than twice this duration before eruption is achieved [9]. Similarly, the time required to achieve ideal orthodontic alignment is also significantly longer in palatal impactions. Therefore, the buccopalatal position of the impacted canine is considered an important prognostic factor influencing overall treatment duration and orthodontic mechanics [9].

Angulation to the Midline

Fleming *et al* demonstrated that increased angulation of the impacted canine relative to the midline significantly prolongs orthodontic treatment (Figure 1) [5].

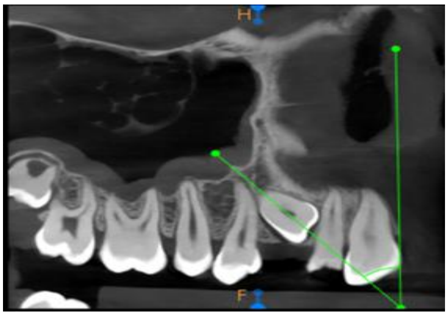

Figure 1: Angulation of the impacted canine relative to the midline

CBCT studies by Arriola-Guillén *et al* and Yang *et al* confirmed these findings [6,10]. while Kokich and Almoammar emphasized the biomechanical complexity associated with highly angulated canines [2,20].

Sector Location and Root Overlap

Lindauer classified the position of impacted canine into five sectors (Figure 2) [22]. Ericson and Kurol first reported that canines located in medial sectors and overlapping incisor roots are associated with increased treatment difficulty [21]. These findings were confirmed by Arriola-Guillén *et al* and Vasovic *et al* [6,9] With CBCT investigations by Yang *et al* and Goh *et al* highlighting root proximity as a critical determinant of prolonged traction[10,11].

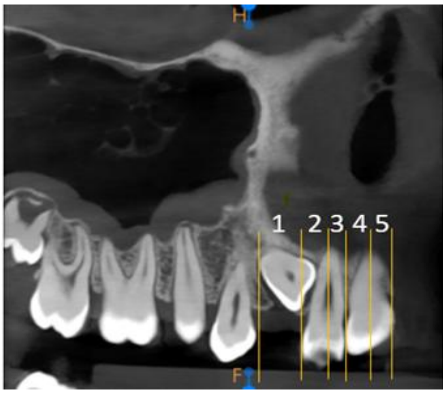

Figure 2: Lindauer's sector classification of impacted canine

Vertical Height from Occlusal Plane

Fleming *et al* [14] and Arriola-Guillén *et al* [19] demonstrated a strong positive correlation between vertical distance from the occlusal plane and traction duration (Figure 3) [5] Yang *et al* [22] explained that deeply positioned canines require extended movement through dense alveolar bone, increasing treatment time [10].

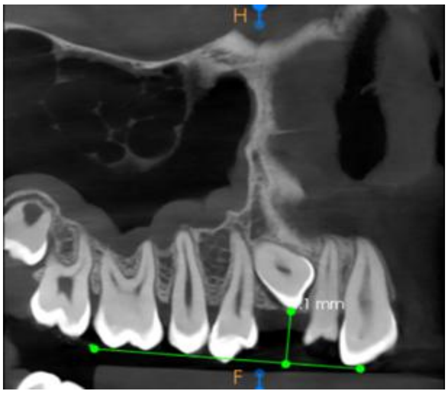

Figure 3: vertical distance of impacted canine from the occlusal plane

Surgical Factors Affecting Traction Duration

Surgical Exposure Techniques

Vermette *et al* [10] and Kokich [12] described the two principal surgical exposure techniques: open eruption and closed eruption [2,4]. Systematic reviews by Parkin *et al* and Sampaziotis *et al* , as well as clinical trials by Amjad Bari *et al*, demonstrated no consistent difference in traction duration between the two techniques [23,25]. However, periodontal outcomes, gingival aesthetics, and patient comfort may vary depending on the surgical approach [24].

Minimally Invasive and Accelerated Techniques

Fischer *et al* investigated corticotomy-assisted exposure of palatally impacted canines and reported a 28–33% reduction in orthodontic treatment time compared with conventional surgical exposure, with no significant differences in final periodontal outcomes [26].

Expanding on these findings, Ferguson *et al*. evaluated forced-eruption times in a large cohort using an ostectomy-decortication approach [27]. Canines treated with accelerated surgery erupted significantly faster than conventionally treated canines (6.6 vs 21.0 months), representing a 3.2-fold reduction in traction duration, despite variations in initial canine position.

More recently, Mousa *et al* conducted a randomized controlled trial demonstrating that minimally invasive corticotomy-assisted traction significantly increased traction velocity and reduced both traction and overall treatment duration by up to 36% [28] CBCT analysis confirmed comparable bone support and root resorption between accelerated and conventional techniques.

Collectively, these studies support accelerated surgical adjuncts as effective methods for reducing traction duration in palatally impacted canines. Further studies are required to explore the effectiveness of other minimally invasive and non-invasive acceleration techniques in the management of impacted canines. While corticotomy-assisted approaches have demonstrated promising reductions in traction duration, evidence regarding alternative modalities such as micro-osteoperforations (MOPs), piezocision, low-level laser therapy, and vibration-based stimulation remains limited and inconsistent for impacted teeth. Future randomized controlled trials with adequate sample sizes should evaluate these techniques specifically in palatally and buccally impacted canines, using standardized outcome measures such as traction velocity, total eruption time, root resorption, and periodontal response assessed with CBCT.

Canine traction using temporary anchorage devices

The use of temporary anchorage devices (TADs) for impacted canine traction offers significant biomechanical and clinical benefits, as reported by Heravi *et al* [8]. TADs provide a stable, non-dental anchorage source, allowing controlled force application without causing undesirable movement of adjacent teeth. This results in improved precision during canine eruption and better preservation of arch form. Early canine disimpaction using TADs can shorten overall treatment duration and enhance treatment efficiency, while reducing reliance on patient compliance and minimizing anchorage loss.

Biological and Patient-Related Factors

Ericson and Kurol demonstrated that younger patients show faster orthodontic tooth movement due to higher bone turnover [17] Yang *et al* also supported this [10] Lövgren *et al* emphasized that delayed diagnosis results in deeper impactions and longer traction duration [13].

Complications Associated with Prolonged Traction

Prolonged orthodontic traction increases the risk of root resorption, periodontal attachment loss, gingival recession, and patient fatigue [4,8]. CBCT studies by Yang *et al* and Goh *et al*. highlighted a high prevalence of incisor root resorption in severely displaced canines [10,11].

CONCLUSION

Maxillary impacted canines continue to represent a significant clinical challenge due to their complex etiology, variable anatomical presentation, and the prolonged orthodontic traction often required for successful alignment. This review demonstrates that traction duration is not governed by a single determinant but by an interplay of multiple factors, among which radiographic characteristics remain the most influential.

Future research should emphasize prospective CBCT-based studies and standardized treatment protocols to refine predictive models and establish evidence-based guidelines for minimizing traction duration while preserving periodontal and dental health.

Authors Contributions

SV and RKR conceptualized and designed the study. SV and VD conducted data collection and analysis and drafted the manuscript. RKR supervised the study, critically reviewed the analysis, and revised the manuscript. SV, KG, and AD developed the methodology, provided overall supervision, edited the manuscript, and managed journal correspondence as the corresponding author. KG, AD, and VD co-supervised data collection, assisted with data collection, and reviewed the manuscript. All authors reviewed and approved the final version of the manuscript.

Data Availability Statement

The data that support the findings of this study are available and will be made available upon request.

Use of AI in Drafting of Manuscript

The authors declare that they have not used any generative AI/AI-assisted technologies in the writing of this manuscript.

Conflicts of Interest

The authors declared no conflict of interest.

Financial Support

None declared.

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HOW TO CITE THIS ARTICLE-
Shafna V, Goel K, Dubey A, Dogra V, Ratre RK. Review of Factors Influencing the Duration of Traction of Maxillary Impacted Canines. Int J Dent Res 2026; 11(2):56-60. doi: 10.31254/dentistry.2026.11208