

Incisor Root Resorption Associated with Impacted Maxillary Canines in Kerala: An Institutional-Based Retrospective CBCT Study

Ayisha Nizmiya K¹ Pradeep Philip George² Gopikrishnan Santhakumar³ Rahul Thalanany⁴

¹PG Student, Department of Orthodontics and Dentofacial Orthopaedics, Annoor Dental College and Hospital, Muvattupuzha, Kerala, India,

²Professor, Department of Orthodontics and Dentofacial Orthopaedics, Annoor Dental College and Hospital, Muvattupuzha, Kerala, India.

³Professor & Head, Department of Orthodontics and Dentofacial Orthopaedics, Annoor Dental College and Hospital, Muvattupuzha, Kerala, India.

⁴Reader, Department of Orthodontics and Dentofacial Orthopaedics, Annoor Dental College and Hospital, Muvattupuzha, Kerala, India,

ABSTRACT

Background: This study assessed root resorption in incisors associated with maxillary canine impactions and its relationship with eruption favorability in a Kerala Dental College.

Materials and Methods: CBCT scans of 24 patients (mean age 17.47 ± 3.38) were analyzed. Participants were categorized into Group A (favorable prognosis, α angle $< 31^\circ$) and Group B (unfavorable prognosis, α angle $> 31^\circ$). Key parameters included β angles (between the impacted canine and adjacent incisors), number and severity of resorbed incisors, resorption rate, and location. Statistical analyses involved independent t-tests and Pearson Chi-square tests.

Results: Group B had significantly more resorbed incisors than Group A ($p = 0.008$). Lateral incisors were more frequently affected, with resorptions mostly mild. There was no significant correlation between buccopalatal position and root resorption ($p = 0.886$).

Conclusion: An α angle $> 31^\circ$ is associated with a higher risk of incisor root resorption. Lateral incisors are most vulnerable, with resorption predominantly occurring in the apical third of the root.

Keywords: CBCT, Impacted maxillary canine, Incisor root resorption, Ericson and Kurol classification.

INTRODUCTION

Impaction of teeth is the "Failure or retardation of eruption of the tooth at its appropriate location within its normal growth period".^{1,2} Most frequently impacted teeth are third molars, followed by maxillary canine and mandibular second premolar.³ According to Lindauer et al., a canine is considered impacted if it remains unerupted after its root has fully developed, or if the canine on the contralateral side has erupted for at least six months with its root completely formed.⁴ Eruption Disturbances of permanent maxillary canines are frequently

observed due to their extended developmental period, location in the most anterior superior part of the mouth, and consequently, the most challenging eruption path compared to all other tooth in the oral cavity.⁵

The prevalence rate of maxillary canine impaction range from 1% to 3% and is more frequent in females than in males.^{6,7,8} Localization of impacted canines varies in reports from different authors, with many studies noting that the canines are predominantly positioned palatally (41% to

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*Correspondence Dr. Ayisha Nizmiya K.

Department of Orthodontics and Dentofacial Orthopaedics, Annoor Dental College and Hospital, Muvattupuzha, Kerala, India.

Email: Not Disclosed

90%).³ The occurrence of palatal canine impaction in Caucasian population and in African-Americans is approximately 2% and 1.2% respectively.^{9,10} In Asian populations, canine impactions are most often located buccally. Previous studies on impacted canines indicate that unilateral impaction is more prevalent than bilateral impaction. Additionally, maxillary canine impactions seem to occur more frequently than mandibular impactions.¹¹

The etiology of impacted maxillary canines remains controversial, potentially due to a multifactorial predisposition. Genetic and local predisposing factors like supernumerary teeth, odontomas, congenitally missing lateral incisors and other conditions can interfere with the eruption path of the canine.¹²

Untreated or mismanaged impacted or partially erupted canines can lead to various complications including canine ankylosis, shortening of the dental arch, recurrent infections, displacement and loss of vitality of the adjacent incisors, pain, formation of follicular cysts, internal resorption and external resorption of the canine and the adjacent teeth.⁸ The most common consequence of impacted canines is the external root resorption of the adjacent incisors, which can lead to tooth loss.¹⁰ Therefore, early diagnosis and treatment of canine impaction are crucial, particularly for maxillary canines impaction associated with root resorption of adjacent lateral incisor.

Several methods such as panoramic, occlusal and periapical projections, lateral or posteroanterior cephalometric radiographs and advanced techniques, like as CBCT and CT have been employed.¹³ CBCT addresses the limitations of 2D techniques and provides more accurate results. CBCT generates a 3D visualization of the dentition and surrounding anatomical structures, facilitating the study of their relationships easier. This allows for the precise positioning of impacted canines, assessment of the amount of bone covering them, and evaluation of the condition of adjacent anatomical structures.

Root resorption of maxillary incisors due to impacted canines is a frequent occurrence,

underscoring the importance of prior diagnosis, precise localization, and accurate categorization of impacted canines. This study aims to evaluate the extent resorption of incisor root associated with maxillary canines impaction and its correlation with the likelihood of successful eruption.

MATERIALS AND METHODS

This retrospective study utilized pre-treatment CBCT data from 24 patients at Annoor Dental College. The study was conducted with approval from the Institutional Human Ethics Committee (IHEC Ref No: 020-A/02). Included in the study were CBCT images of impacted maxillary canines in patients aged 15 to 25 years, with unilateral or bilateral impactions located palatally or buccally. Exclusions encompassed CBCT images from patients younger than 15 or older than 25 years, cases involving congenitally missing central or lateral incisors, trauma-related issues, root canal-treated maxillary incisors, presence of cysts or other maxillary incisor pathologies, and instances of multiple impacted teeth excluding canines.

Canine eruption favorability was assessed using the α angle criteria by Power and Short, where angles $<31^\circ$ indicated favorable prognosis (Group A, $n=12$), and angles $>31^\circ$ indicated unfavorable prognosis (Group B, $n=12$).¹⁴

CBCT scans were performed using a NewTom® machine with standardized settings (8x8 cm FOV, 110 kV, 20.49 mA, 5.4 seconds exposure). Images were anonymized, coded, and analyzed independently by three examiners using NNT Viewer® version 6.1 software from Verona, Italy. Impaction details, buccopalatal positions, and incisor root resorption were evaluated in axial, coronal, and sagittal views using multiplanar reformation (MPR) mode.

Parameters analyzed included:

- Angle between longitudinal axis of impacted canine and the adjacent lateral incisor. (Fig 1)
- Angle between longitudinal axis impacted canine and ipsilateral central incisor. (Fig 1)

- Total number of resorbed teeth.
- Location of the resorption in relation to the root level. (Fig 2)

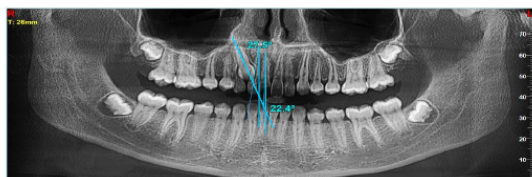


Fig 1: β angle -angle formed between long axis of impacted canine and incisors

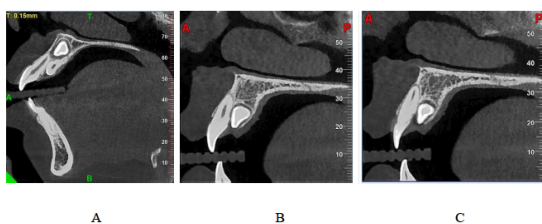


Fig 2: Resorptions at apical, middle and cervical third; 2A-resorption at apical third, 2B-resorption at middle third, 2C- resorption at cervical third

Resorption grading (Ericson and Kurol criteria) was used to assess root resorption of adjacent lateral and ipsilateral central incisors (Grade I- No resorption, Grade II- Mild, Grade III- Moderate, Grade IV-Severe).¹⁵

The investigator repeated measurements and assessed inter-examiner agreement to ensure reliability. Statistical analysis included independent t-tests for comparing β angles, Pearson's Chi-square tests for associations between teeth involved and resorption incidence, and correlations of resorption severity with study groups and teeth involved. Chi-square tests also explored associations between buccopalatal position and resorption.

RESULT

CBCT scan of 24 samples with 31 maxillary canine impactions were included in the study. A total of 62 maxillary incisors were assessed including 31 lateral incisors and 31 central incisors. Out of 62 incisors, 22 incisors (35.50%) presented with resorption whereas 40 incisors (64.50%) had no resorption. A significant difference was seen between the rate of

resorption of lateral incisors and central incisors, which showed that lateral incisors were mostly affected compared to central incisors. (Table :I)

Table I: Incidence of resorption and rate of resorption of lateral incisors and central incisors

Teeth Involved	Total number of teeth	No Resorption	Resorption	P value
Lateral	31	15 (48.40%)	16 (51.60%)	0.008
Central	31	25 (80.60%)	6 (19.40%)	
Total	62	40 (64.50%)	22 (35.50%)	

Results suggested that, a statistically significant difference exists between the 2 groups. Group B- unfavourable group presented with a greater number of resorbed incisors compared to Group A- favourable group. (Table :II)

Table II: Rate of resorption of Group A and Group B

Group	No resorption	Resorption	Total number of teeth assessed	P value
Group A	25 (78.1%)	7 (21.9%)	32	0.021
Group B	15 (50.0%)	15 (50.0%)	30	
Total	40 (64.50%)	22 (35.50%)	62	

Measurements of angulation of canine to incisors show a positive correlation between this angle and root resorption. The mean angle for resorbed incisors were 57.814° and the mean angle for non-resorbed incisors were 34.493° which shows a significant difference in angle between canine to resorbed incisors and canine to non-resorbed incisors. (Table :III)

Table III: Correlation between angle of impacted canine to incisors and resorption

Angle	Total Number	Mean	Std. Deviation	P value
Resorption	22	57.814	19.785	0.000
No Resorption	40	34.493	12.371	

It was observed that the apical third had the highest occurrence of root resorption, with the cervical third being the least commonly involved area. (Table :IV) Majority of the resorptions were mild, followed by moderate and severe resorptions respectively. (Table :V)

Table IV: Position of resorption at root level

Position at root level	No. of Resorption	Percent
Apical	14	63.6%
Cervical	3	13.6%
Middle	5	22.7%
Total	22	100.0%

Table V: Distribution of Grades of resorption between central incisors and lateral incisors

Teeth	Mild	Moderate	Severe	Total	P value
Lateral	6 (37.5%)	5 (31.3%)	5 (31.3%)	16	0.774
Central	3 (50.0%)	2 (33.3%)	1 (16.7%)	6	
Total	9 (40.9%)	7 (31.8%)	6 (27.3%)	22	

No statistically significant result was found between the severity of resorption among 2 groups and the severity of root resorption between central incisors and lateral incisors. (Table :VI) In addition, the correlation between buccopalatal position and root resorption showed no significant difference. (Table :VII)

Table VI: Distribution severity/ grades between Group A and

Group	Mild	Moderate	Severe	Total	P value
Group A	4 (57.10%)	2 (28.60%)	1 (14.30%)	7	0.514
Group B	5 (33.30%)	5 (33.30%)	5 (33.30%)	15	
Total	9 (40.90%)	7 (31.80%)	6 (27.30%)	22	

Table VII: Distribution of buccopalatal position and its correlation to resorption

Bucco-palatal position	No Resorption	Resorption	Total	P value
Buccal	6 (40.0%)	9 (60.0%)	15	0.886
Palatal	6 (37.5%)	10 (62.5%)	16	
Total	12	19	31	

DISCUSSION

In this study, 35.5% of the incisors examined experienced root resorption due to canine impaction. The result was somewhat comparable to that suggested by Lai et al that about 32.50% incisors were resorbed.¹ Although this represent a critical incidence of lateral root resorption, this finding shows lesser percentages compared to Rafflenbeul *et al.* where 67.5% of incisors were resorbed.¹⁶ However, this result showed higher percentage compared to Kalavritinos *et al.* where incidence of incisor resorption was 18.5%.⁸

Results suggested that a significant difference was observed between the rate of resorption of lateral incisors and central incisors, which showed that lateral incisors were more often affected than central incisors. This result supports the findings of previous other studies. According to Ericson *et al.*, 58 out of 152 maxillary lateral incisors (38%) and 14 out of 156 maxillary central incisors (9%) showed root

resorptions.¹⁵ Similar distributions was found by Rafflenbeul *et al.* where, 55.7 percent of the lateral incisors and 8.4 percent of the central incisors were resorbed.¹⁶ On the contrary to all these findings, Liu *et al.* identified similar rate of resorption between central incisors (23.4%) and lateral incisors (27.2%).¹⁷ Finding of Kalavritinos *et al.* added to the same conclusion that there was no relationship between lateral incisors or central incisors root resorption.⁸

The study shows a significant difference existing between 2 Groups. Group B presented with greater number of resorbed incisors compared to Group A, which shows that, as the angle between long axis of impacted canine (impacted angle) to midline increases, there is an increased chance for resorption. So, the impacted angle greater than 31° can be considered as one of the risk factors for resorption. There were limited number of studies available on favorability of eruption and root resorption of adjacent incisors. Here the favorability was assessed based on Power and Short criteria for assessing favorability of impacted canine using impacted canine angulation.²⁶

In available studies, most of them assessed the prognosis of impacted canine based on sector analysis. In one study by Guillen *et al.*, the influence of treatment complexity on root resorption (RR) of adjacent incisors were assessed. The complexity was evaluated based on sector analysis by Ericson and Kurol. He concluded that complexity was not a risk factor for increased root resorption of maxillary incisors adjacent to the impaction area.¹⁸ In contrast, Guarnieri *et al.* reported that the probability of resorption is very low (0.06%) when the canine is in Sector I of Lindauer classification and the β angle (angle between long axis of impacted canine and long axis of adjacent incisors) is less than 18°.¹⁹

The study concludes that as the angle between the longitudinal axis of the impacted canine and the adjacent lateral incisor increases, root resorption also increases. This result is in agreement with the findings of Wang *et al.* where he reported that relative angle (angle between impacted canine and incisor) greater

than 30° was one of the risk factors for incisor resorption.²⁰ In favor of findings by Wang *et al.*, Kalavritinos *et al.* reported that there was a positive correlation between the occurrence of resorption on the lateral incisor and the angle between the long axis of canine and the adjacent lateral incisor.⁸ Even though the results of the present study are supportive to above studies, it opposes the findings of Yan *et al.*, Ucar *et al.* and Alemam *et al.* where they reported that there was no correlation between angle of canine to incisor and resorption.^{10,21,22}

The site of resorption can be described based on the level and root surface affected. Many studies show that most of the lesions are found in the apical third of the root while the cervical third is the least commonly affected area.^{15,23} The results of the present study is in agreement with the site pattern suggested by Dogramaci *et al.*, Cernochova *et al.*, Yan *et al.* where they found that most of the resorptions were located at the apical third followed by middle and then by cervical area.^{10,23,24} Conversely, studies by Kojima *et al.* and Olsen *et al.* showed that, middle third was the most affected, followed by cervical and apical third was the least affected.^{25,26}

The majority of the resorptions were mild, followed by moderate and severe resorptions. No statistically significant result was found between the severity of resorption among 2 groups and severity of resorption between central incisors and lateral incisors. This pattern of distribution of severity was concomitant with distribution in previous studies. Study by Rafflenbeul *et al.* demonstrated that majority of resorption were mild resorption which constitutes 71.7% ,14.9 % moderate and 13.4 % severe.¹⁶ An additional correlation was carried out for determining the association between resorption and buccopalatal position of 15 buccally placed and 16 palatally placed canines the correlation between buccopalatal position and root resorption which showed no significant difference. Since this retrospective study was carried out with 24 samples presented with 31 impacted maxillary canines, an increased sample size and variations among different ethnic groups may also be considered for

further studies to strengthen the evidence obtained.

CONCLUSION

The present study assessed the association of incisor root resorption with impacted maxillary canines and compared the rates between favorably and unfavorably impacted canines to explore correlations. The findings suggest a positive correlation existing between the incidence of resorption and the favorability of eruption or prognosis of impacted maxillary canines, with unfavorably impacted canines demonstrating a greater incidence of adjacent

incisor resorption. An impacted canine angle $>31^\circ$ emerged as a significant risk factor for root resorption of adjacent incisors. As the angle between the impacted canine's axis and the midline increases, the likelihood of resorption also increases. Additionally, a positive correlation was observed between incisor root resorption and the angle between the impacted canine's axis and adjacent incisors. Lateral incisors were predominantly affected by root resorption. Most cases exhibited mild resorption, followed by moderate and severe categories. Apical third was the most commonly affected area, while the cervical third being least affected. Analysis of buccopalatal position showed no significant association with resorption.

REFERENCES

1. Lai CS, Bornstein MM, Mock L, Heuberger BM, Dietrich T, Katsaros C. Impacted maxillary canines and root resorptions of neighbouring teeth: a radiographic analysis using cone-beam computed tomography. *Eur J Orthod*. 2013 Aug 1;35(4):529-38.
2. Abron A, Mendro R, Kaplan S. Impacted permanent maxillary canines. *N Y State Dent J*. 2005 Jan;70(9):24-28.
3. Walker L, Enciso R, Mah J. Three-dimensional localization of maxillary canines with cone-beam computed tomography. *Am J Orthod Dentofac Orthop*. 2005 Oct 1;128(4):418-23.
4. Lindauer S J , Rubenstein L K, Hang W M, Andersen W C, Isaacson R J. Canine impaction identified early with panoramic radiographs. *J Am Dent Assoc*. 1992 Mar;123(3):91-2, 95-7.
5. Dewel BE. The upper cuspid: Its development and impaction. *Angle Orthod*. 1949 Apr 1;19(2):79-90.
6. Bishara SE, D. Ortho. Impacted maxillary canines: a review. *Am J Orthod Dentofac Orthop*. 1992 Feb 1;101(2):159-71.
7. Thilander B, Myrberg N. The prevalence of malocclusion in Swedish schoolchildren. *Scand J Dent Res* 1973 Feb;81(1):12-21.
8. Kalavritinos M, Benetou V, Bitsanis E, Sanoudos M, Alexiou K, Tsiklakis K, et al. Incidence of incisor root resorption associated with the position of the impacted maxillary canines: A cone-beam computed tomographic study. *Am J Orthod Dentofac Orthop*. 2020 Jan 1;157(1):73-9.
9. Oliver RG, Mannion JE, Robinson JM. Morphology of the maxillary lateral incisor in cases of unilateral impaction of the maxillary canine. *Br J Orthod*. 1989 Feb;16(1):9-16.
10. Yan B, Sun Z, Fields H, Wang L. Maxillary canine impaction increases root resorption risk of adjacent teeth: a problem of physical proximity. *Am J Orthod Dentofac Orthop*. 2012 Dec 1;142(6):750-7.
11. Bedoya MM, Park JH. A review of the diagnosis and management of impacted maxillary canines. *J Am Dent Associ*. 2009 Dec 1;140(12):1485-93.
12. Brin I, Becker A, Shalhav M. Position of the maxillary permanent canine in relation to anomalous or missing lateral incisors: a population study. *Eur J Orthod*. 1986 Feb 1;8(1):12- 6.
13. Becker A, Zilberman Y, Tsur B. Root length of lateral incisors adjacent to palatally-displaced maxillary cuspids. *Angle Orthod*. 1984 Jul;54(3):218-25.

14. Power SM, Short MB. An investigation into the response of palatally displaced canines to the removal of deciduous canines and an assessment of factors contributing to favourable eruption. *Br J Orthod.* 1993 Aug;20(3):215-23.
15. Ericson S, Kurol J. Resorption of incisors after ectopic eruption of maxillary canines. A CT study. *Angle Orthod.* 2000. Dec;70(6):415-23.
16. Rafflenbeul F, Gros CI, Lefebvre F, Bahi-Gross S, Maizeray R, Bolender Y. Prevalence and risk factors of root resorption of adjacent teeth in maxillary canine impaction, among untreated children and adolescents. *Eur J Orthod.* 2018 Sep 21;41(5):447-53.
17. Liu DG, Zhang WL, Zhang ZY, Wu YT, Ma XC. Localization of impacted maxillary canines and observation of adjacent incisor resorption with cone-beam computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2008 Jan 1;105(1):91-8.
18. Arriola-Guillen LE, Ruíz-Mora GA, Rodriguez-Cardenas YA, Aliaga-Del Castillo A, Boessio-Vizzotto M, et al. Influence of impacted maxillary canine orthodontic traction complexity on root resorption of incisors: A retrospective longitudinal study. *Am J Orthod Dentofac Orthop.* 2019 Jan 1;155(1):28-39.
19. Guarnieri R, Cavallini C, Vernucci R, Vichi M, Leonardi R, Barbato E. Impacted maxillary canines and root resorption of adjacent teeth: A retrospective observational study. *Med Oral Patol Oral Cir Bucal.* 2016 Nov 1;21(6):e743-e750
20. Wang H, Li T, Lv C, Huang L, Zhang C, Tao G, et al. Risk factors for maxillary impacted canine-linked severe lateral incisor root resorption: A cone-beam computed tomography study. *Am J Orthod Dentofac Orthop.* 2020 Sep 1;158(3):410-9.
21. Ucar FI, Celebi AA, Tan E, Topcuoglu T, Sekerci AE. Effects of impacted maxillary canines on root resorption of lateral incisors. *J Orofac Orthop.* 2017 May;78(3):233-40.
22. Alemam AA, Alhaija ES, Mortaja K, AlTawachi A. Incisor root resorption associated with palatally displaced maxillary canines: analysis and prediction using discriminant function analysis. *Am J Orthod Dentofac Orthop.* 2020 Jan 1;157(1):80-90.
23. Cernochova P, Krupa P, Izakovicova-Holla L. Root resorption associated with ectopically erupting maxillary permanent canines: a computed tomography study. *Eur J Orthod.* 2010 Oct 1;33(5):483-91.
24. Dogramaci EJ, Sherriff M, Rossi-Fedele G, McDonald F. Location and severity of root resorption related to impacted maxillary canines: a cone beam computed tomography (CBCT) evaluation. *Aust Orthod J.* 2015 May;31(1):49.
25. Kojima R, Taguchi Y, Kobayashi H, Noda T. External root resorption of the maxillary permanent incisors caused by ectopically erupting canines. *J Clin Pediatr Dent.* 2003 Jan 1;26(2):193-7.
26. Hadler-Olsen S, Pirttiniemi P, Kerosuo H, Bolstad Limchaichana N, Pesonen P, Kallio-Pulkkinen S, Lähdesmäki R. Root resorptions related to ectopic and normal eruption of maxillary canine teeth-A 3D study. *Acta Odontologica Scandinavica.* 2015 Nov 17;73(8):609-15.