Journal of Bacha Khan College of Dentistry (JBKCD) Open Access Journal

Received: August 03, 2025
Revised: November 01, 2025
Accepted: December 08, 2025
Online: December 30, 2025

ISSN (Print): 3104-3887
ISSN (Online): 3104-3895
Vol. 3, No. 2 (Fall 2025) | Pages: 18–25
DOI: 10.65293/jbkcd.v3i02.70

Radiographic Assessment of Impacted Canines in Orthodontic Patients

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ABSTRACT

Background: Impacted canines represent one of the most common eruption disturbances encountered in orthodontic practice, often leading to significant functional and aesthetic complications if left untreated. Therefore, this study aimed to determine the prevalence of impacted canines and to assess their association with demographic variables and occlusal risk factors.

Study Design: A Retrospective study.

Place and Duration of the Study: The study was conducted at the Department of Orthodontics, Rehman College of Dentistry, Peshawar, Khyber Pakhtunkhwa, Pakistan from January 2023 to December 2024.

Materials and Methods: A total of 170 orthodontic patients were included in this study. Panoramic radiographs were evaluated to identify impacted canines and to assess their position, angulation, depth, sector classification, and associated root resorption. Demographic data and Angle's classification of malocclusion were also recorded. Descriptive statistics and multivariate logistic regression analysis were performed to identify predictors of canine impaction. A p-value of <0.05 was considered statistically significant.

Results: Impacted canines were found in 15.3% (26/170) of patients, with a total of 30 impacted teeth identified. Most impactions occurred in the maxilla (93.3%), were unilateral (84.6%), and palatal in position (60%). Moderate angulation (30°–45°) and middle-third root depth were the most frequent radiographic findings. Root resorption of adjacent lateral incisors was observed in 20% of cases. Logistic regression analysis showed that Angle's Class II malocclusion was significantly associated with canine impaction (Adjusted OR = 2.31; 95% CI: 1.01–5.28; p = 0.047). Gender, age, and residence were not significant predictors.

Conclusion: Approximately one in six orthodontic patients had impacted canines, predominantly in the maxilla and palatal region. Class II malocclusion was identified as a significant risk factor. Early radiographic screening in orthodontic patients, particularly those with Class II malocclusion, is recommended for timely intervention and prevention of complications.

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Key Words
Impacted Canine, Prevalence, Orthodontic Patients, Panoramic Radiograph, Malocclusion, Logistic Regression

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How to Cite this Article
Saeed A, Iftikhar A, Nausheen A. Radiographic Assessment of Impacted Canines in Orthodontic Patients. Journal of Bacha Khan College of Dentistry. 2025 Jun 30;3(2):18–25.

INTRODUCTION

Tooth impaction is defined as the failure of a tooth to erupt into the dental arch within the expected chronological age due to physical obstruction, ectopic positioning, or developmental disturbances [1]. After third molars, maxillary canines are the second most frequently impacted teeth, with a reported prevalence ranging from 0.8% to 3.6% in the general population [2, 3]. In orthodontic populations, however, the prevalence may be considerably higher due to referral bias and the increased likelihood of eruption disturbances among patients seeking orthodontic care [4].

The permanent maxillary canine plays a critical role in dental esthetics, arch development, and functional occlusion. Its long eruption path and late eruption timing make it particularly susceptible to displacement and impaction [5]. Several etiological theories have been proposed to explain canine

impaction, including the guidance theory—suggesting that anomalies of the lateral incisor root affect canine eruption—and the genetic theory, which links canine impaction to inherited dental anomalies [6, 7]. Other contributing factors include arch length deficiency, prolonged retention of primary canines, supernumerary teeth, cysts, and trauma [8].

Impacted canines may result in various complications such as root resorption of adjacent teeth, cyst formation, infection, and esthetic concerns [9]. Early detection is therefore crucial for minimizing treatment complexity and improving prognosis. Panoramic radiography remains a widely used diagnostic tool for identifying impacted canines and assessing their angulation, vertical position, and relationship to adjacent structures [10]. Sector classification systems, such as that described by Ericson and Kurol, are commonly used to evaluate the severity and predict the likelihood of spontaneous eruption [11].

Several studies have investigated the association between impacted canines and demographic or occlusal characteristics, including gender differences and Angle's malocclusion classification [12]. However, findings remain inconsistent across populations, and regional variations have been reported. Furthermore, limited data are available regarding the detailed radiographic characteristics of impacted canines in specific orthodontic cohorts.

Therefore, the present study aimed to determine the prevalence of impacted canines among orthodontic patients using radiographic evaluation and to analyze their distribution, radiographic features, and associated demographic and occlusal factors through multivariate regression analysis.

MATERIALS AND METHODS

Study Design and Setting

A retrospective study was conducted in the Department of Orthodontics, Rehman College of Dentistry, Peshawar. Data collection spanned a two-year period from January 2023 to December 2024. All panoramic radiographs were obtained as part of routine orthodontic diagnostic assessment.

Sample Size and Sampling Technique

The required sample size was estimated using the formula for prevalence studies:

$$n = Z^2 \times P\,(1-P) / d^2$$

where Z = 1.96 for a 95% confidence level, P = expected prevalence of impacted canines (13%) based on previous literature, and d = margin of error (5%). The minimum calculated sample size was 174 participants. However, due to strict inclusion criteria and availability of complete radiographic records within the study duration, 170 patients were included in the final analysis, which was considered adequate for prevalence estimation and regression analysis.

Inclusion Criteria

- Patients aged 12–30 years
- Availability of high-quality panoramic radiographs
- Complete clinical and orthodontic records
- Patients who had not undergone prior orthodontic treatment

Exclusion Criteria

- History of extraction of permanent canines
- Presence of craniofacial syndromes or cleft lip and palate
- History of maxillofacial trauma affecting the canine region
- Poor-quality or distorted radiographs

Data Collection Procedure

Ethical approval was obtained from the Institutional Review Board, Rehman College of Dentistry (RCD), Peshawar prior to commencement of the study (Letter No: 6571/RCD, dated: 29/11/2023). As this study involved retrospective evaluation of radiographic records, patient confidentiality was strictly maintained by anonymizing all data. No personal identifiers were included at any stage of data collection or analysis.

Demographic variables including age, gender, and residence (urban/rural) were recorded from patient files. Occlusal characteristics were assessed using Angle's classification (Class I, Class II, and Class III) based on clinical records.

Panoramic radiographs (orthopantomograms) were evaluated to determine the presence or absence of impacted canines. A canine was considered impacted if it failed to erupt into the dental arch beyond the expected eruption age and showed radiographic evidence of obstruction or ectopic positioning.

Radiographic Assessment

Radiographic evaluation was performed to record the following characteristics of impacted canines:

- Jaw involvement (maxillary or mandibular)
- Laterality (unilateral or bilateral)
- Side of impaction (right or left)
- Position of impaction (palatal, labial/buccal, mid-alveolar)

- Angulation to the midline (<30°, 30°–45°, >45°)
- Vertical depth of impaction (coronal, middle, or apical third relative to adjacent lateral incisor root)
- Sector classification according to Ericson and Kurol
- Presence of root resorption of adjacent lateral incisors

All radiographs were assessed under standardized viewing conditions. To minimize observer bias, radiographic evaluation was performed by a trained orthodontist. A subset of radiographs (10%) was re-evaluated after two weeks to assess intra-examiner reliability.

To assess intra-examiner reliability, 10% of the panoramic radiographs were randomly selected and re-evaluated by the same examiner after a two-week interval. Agreement between the two assessments was calculated using Cohen's Kappa statistics, which demonstrated excellent reliability ($\kappa = 0.86$).

Outcome Variable

The primary outcome variable was the presence of impacted canine(s) (Yes/No). Secondary outcomes included the radiographic characteristics and distribution patterns of impacted canines.

Statistical Analysis

Data were entered and analyzed using statistical software (SPSS version 27). Descriptive statistics were calculated in the form of frequencies, percentages, means, and standard deviations.The prevalence of impacted canines was determined as a proportion of the total sample. Associations between impacted canines and categorical variables (gender, age group, residence, and Angle's classification) were assessed using the Chi-square.Variables showing potential association were further analyzed using multivariate logistic regression to identify independent predictors of canine impaction. Adjusted odds ratios (OR) with 95% confidence intervals (CI) were calculated. A p-value of less than 0.05 was considered statistically significant.The goodness-of-fit of the logistic regression model was assessed using the Hosmer–Lemeshow test, and multicollinearity among predictor variables was evaluated using the Variance Inflation Factor (VIF). A non-significant Hosmer–Lemeshow test indicated an acceptable model fit.

RESULTS

The study sample consisted of 170 orthodontic patients with a mean age of 17.8 ± 4.2 years (range: 12–30 years), indicating that the population was predominantly adolescent. The largest proportion of participants fell within the 16–19-year age group (36.5%), followed closely by those aged 12–15 years (34.1%), while fewer patients were in the 20–24 years (20.0%) and 25–30 years (9.4%) categories. Females constituted a slightly higher proportion of the sample (57.6%) compared to males (42.4%), suggesting greater female attendance for orthodontic treatment. Most participants were from urban areas (65.9%), reflecting higher access to orthodontic services in urban settings. Regarding occlusal characteristics, Angle's Class I malocclusion was the most common (43.5%), followed by Class II (40.0%), while Class III malocclusion was the least prevalent (16.5%). Overall, the sample primarily comprised urban adolescent females with Class I or Class II malocclusion.

Table 1: Demographic and Baseline Characteristics of the Study Sample (N = 170)

Variable	Category	n	%
Age (years)	Mean ± SD (Range)	17.8 ± 4.2 (12–30)	—
	12–15	58	34.1
	16–19	62	36.5
	20–24	34	20.0
	25–30	16	9.4
Gender	Male	72	42.4
	Female	98	57.6
Residence	Urban	112	65.9
	Rural	58	34.1
Angle's classification	Class I	74	43.5
	Class II	68	40.0
	Class III	28	16.5

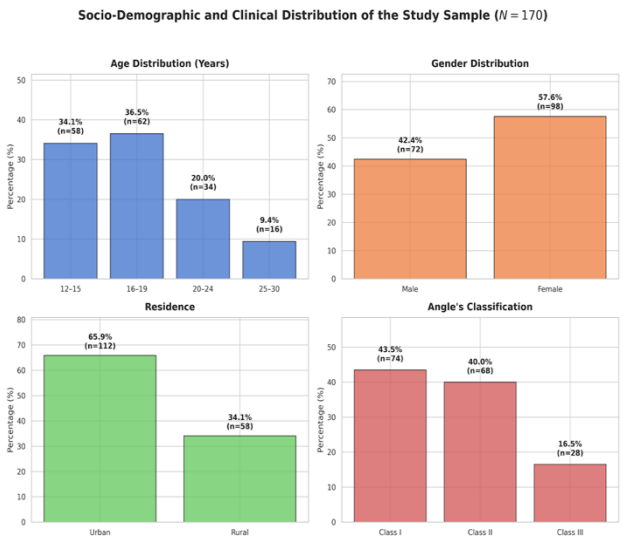

Figure 1: Demographics

Out of 170 orthodontic patients, 26 individuals (15.3%) were diagnosed with impacted canines, while the majority (84.7%) showed normal eruption. Among the affected patients, most cases were unilateral (84.6%), with only 15.4% presenting bilateral impaction. A total of 30 impacted canines were identified, reflecting the presence of bilateral cases. The vast majority of impacted teeth were located in the maxilla (93.3%), with mandibular impaction being rare (6.7%). Regarding side distribution, impactions were nearly evenly distributed, with a slight predominance on the left side (53.3%) compared to the right (46.7%). In terms of position, palatal impaction was the most common (60.0%), followed by labial/buccal impaction (30.0%), while mid-alveolar impaction was the least frequent (10.0%). Overall, impacted canines in this sample were predominantly unilateral, maxillary, and palatally positioned.

Table 2: Distribution and Radiographic Characteristics of Impacted Canines

Variable	Category	n	%
Patients with impacted canine(s) (N=170)	Yes	26	15.3
	No	144	84.7
Laterality (n = 26)	Unilateral	22	84.6
	Bilateral	4	15.4
Total impacted canines	Teeth count	30	—
Jaw involved (n = 30)	Maxillary	28	93.3
	Mandibular	2	6.7
Side (n = 30)	Right	14	46.7
	Left	16	53.3
Position of impaction	Palatal	18	60.0
	Labial/Buccal	9	30.0
	Mid-alveolar	3	10.0
Angulation to midline	<30°	8	26.7
	30–45°	12	40.0
	>45°	10	33.3
Vertical position	Coronal third	7	23.3
	Middle third	15	50.0
	Apical third	8	26.7
Sector classification	Sector I	4	13.3
	Sector II	6	20.0
	Sector III	9	30.0
	Sector IV	7	23.3
	Sector V	4	13.3
Root resorption	Absent	24	80.0
	Present	6	20.0

The prevalence of impacted canines did not differ significantly according to gender, age group, or residence ($p > 0.05$). Although females showed a slightly higher prevalence (17.3%) compared to males (12.5%), the difference was not statistically significant ($p = 0.38$). Similarly, impacted canines were somewhat more frequent in older age groups (16–19 years: 17.7%; 20–24 years: 17.6%; 25–30 years: 18.8%) compared to the 12–15-year group (10.3%), but this variation was not statistically significant ($p = 0.55$). Urban residents exhibited a higher prevalence (17.0%) than rural residents (12.1%); however, this difference was also not significant ($p = 0.42$). In contrast, a statistically significant association was observed between impacted canines and Angle's classification ($p = 0.04$). Patients with Class II malocclusion demonstrated the highest prevalence (22.1%), which was approximately double that observed in Class I (10.8%) and Class III (10.7%) patients. These findings suggest that while demographic factors were not significantly associated with canine impaction, occlusal classification—particularly Class II malocclusion—may be an important contributing factor.

Table 3: Prevalence of Impacted Canines by Demographic and Occlusal Characteristics (N = 170)

Variable	Category	Impacted n/N	Prevalence %	p-value†
Gender	Male	9/72	12.5	0.38
	Female	17/98	17.3	
Age group (years)	12–15	6/58	10.3	0.55
	16–19	11/62	17.7	
	20–24	6/34	17.6	
	25–30	3/16	18.8	
Residence	Urban	19/112	17.0	0.42
	Rural	7/58	12.1	
Angle's classification	Class I	8/74	10.8	0.04
	Class II	15/68	22.1	
	Class III	3/28	10.7	

Radiographic evaluation of the 30 impacted canines revealed that moderate angulation to the midline (30°–45°) was the most common finding (40.0%), followed by severe angulation greater than 45° (33.3%), while mild angulation less than 30° accounted for 26.7% of cases. Regarding vertical depth, half of the impacted canines (50.0%) were positioned at the middle third of the adjacent lateral incisor root, whereas 26.7% were located at the apical third and 23.3% at the coronal third, indicating that most impactions were moderately deep. According to the Ericson and Kurol sector classification, Sector III was the most frequently observed (30.0%), followed by Sector IV (23.3%) and Sector II (20.0%), while Sectors I and V were less common (13.3% each), suggesting a tendency toward more medially positioned impactions. Assessment of overlap with the lateral incisor root showed that mild overlap was most prevalent (36.7%), followed by moderate overlap (30.0%) and severe overlap (13.3%), while 20.0% demonstrated no overlap. Root resorption of the adjacent lateral incisor was detected in 20.0% of cases, whereas 80.0% showed no evidence of resorption. Overall, the radiographic findings indicate that most impacted canines exhibited moderate angulation, mid-root vertical positioning, and varying degrees of overlap, with a clinically relevant proportion associated with root resorption.

Multivariate logistic regression analysis demonstrated that, after adjusting for other variables, most demographic factors were not significantly associated with impacted canines. Females had 1.42 times higher odds of impaction compared to males; however, this association was not statistically significant (95% CI: 0.62–3.24; p = 0.40). Similarly, older age groups (16–19, 20–24, and 25–30 years) showed slightly increased odds compared to the 12–15-year reference group, but none of these associations reached statistical significance (p > 0.05), and the wide confidence intervals suggest variability in the estimates. Urban residence was associated with 1.48 times higher odds of impaction compared to rural residence, though this finding was also not significant (95% CI: 0.60–3.67; p = 0.39). In contrast, Angle's Class II malocclusion was significantly associated with impacted canines, with patients demonstrating 2.31 times greater odds compared to those with Class I malocclusion (95% CI: 1.01–5.28; p = 0.047). Class III malocclusion showed no significant association (OR = 0.99; p = 0.99). These results indicate that, among the variables analyzed, Class II malocclusion emerged as the only independent predictor of canine impaction in this study population.

Table 4: Multivariate Logistic Regression Analysis for Predictors of Impacted Canines (N = 170)

Variable	Category (Reference)	Adjusted OR	95% CI	p-value
Gender	Female (Ref: Male)	1.42	0.62 – 3.24	0.40
Age group (years)	16–19 (Ref: 12–15)	1.58	0.52 – 4.76	0.42
	20–24	1.54	0.41 – 5.71	0.52
	25–30	1.71	0.35 – 8.21	0.51
Residence	Urban (Ref: Rural)	1.48	0.60 – 3.67	0.39
Angle's classification	Class II (Ref: Class I)	2.31	1.01 – 5.28	0.047
	Class III	0.99	0.25 – 3.89	0.99

DISCUSSION

The present cross-sectional radiographic study evaluated the prevalence and characteristics of impacted canines among orthodontic patients and explored associated demographic and occlusal risk factors. The overall prevalence of impacted canines in this study was 15.3%, which is notably higher than the prevalence reported in general population studies [13, 14]. This finding is consistent with previous research indicating that orthodontic populations exhibit a greater frequency of impacted canines due to referral bias and the higher incidence of malocclusion among such patients [15].

In agreement with earlier studies, the majority of impacted canines in the present study were located in the maxilla (93.3%), with mandibular impaction being relatively rare [16, 17]. The predominance of maxillary impactions has been attributed to the longer and more complex eruption path of the maxillary canine, as well as its late eruption timing [18]. The anatomical position and developmental pattern of the maxillary canine increase its susceptibility to displacement and impaction compared to other teeth [19].

With respect to laterality, most impactions were unilateral (84.6%), which aligns with findings from previous investigations reporting unilateral impaction as more common than bilateral cases [20]. Bilateral impactions, although less frequent, may suggest a stronger genetic or developmental component [21].

The present study also demonstrated a higher frequency of palatal impaction (60%) compared to labial impaction. This observation is consistent with several studies conducted in European and Asian populations, where palatal displacement has been reported as the predominant pattern [22, 23]. The guidance theory proposes that anomalies or absence of the lateral incisor root may influence palatal displacement of the canine [14]. Additionally, genetic factors have been implicated in palatal impaction, particularly when associated with other dental anomalies such as peg-shaped lateral incisors or tooth agenesis [24].

Radiographically, moderate angulation (30°–45°) and middle-third vertical positioning were the most common findings. These characteristics are clinically significant, as increased angulation and deeper impaction levels have been associated with prolonged treatment duration and increased surgical complexity [25]. Root resorption of adjacent lateral incisors was observed in 20% of cases, which is comparable to rates reported in previous radiographic studies [21]. Early detection through panoramic screening is therefore essential to minimize such complications and optimize interceptive management.

Multivariate logistic regression analysis revealed that Angle's Class II malocclusion was significantly associated with impacted canines. Patients with Class II malocclusion demonstrated more than twice the odds of canine impaction compared to Class I patients. This association may be explained by maxillary arch discrepancies and altered eruption guidance patterns commonly observed in Class II malocclusion [23, 26]. In contrast, gender and age were not statistically significant predictors, which is consistent with some previous studies [14, 20], although other investigations have reported a female predominance [23]. Such discrepancies may reflect ethnic, genetic, or sample-size variations across different populations.

The present study has several limitations. First, its cross-sectional design does not allow causal inferences. Second, the sample was derived from orthodontic patients, limiting generalizability to the broader population. Third, panoramic radiographs, although widely used, may have limitations in accurately assessing three-dimensional relationships compared to cone-beam computed tomography (CBCT). Future studies incorporating CBCT imaging and larger multicenter samples may provide more precise evaluation of impaction severity and associated risk factors.

Study Limitations

Despite these limitations, this study provides valuable insight into the prevalence and radiographic characteristics of impacted canines in an orthodontic cohort. The findings emphasize the importance of early radiographic assessment, particularly in patients presenting with Class II malocclusion, to facilitate timely interceptive or surgical-orthodontic management and reduce potential complications.

CONCLUSION

The prevalence of impacted canines was 15.3%, mostly maxillary, unilateral, and palatal. Common features included moderate angulation and middle-third depth, with notable lateral incisor root resorption. Class II malocclusion was a significant predictor, while age, gender, and residence were not. Routine radiographic screening is essential for early detection and management.

Acknowledgement: We sincerely thank the hospital administration and all those who contributed to the successful completion of this study.
Disclaimer: Nil
Conflict of Interest: The authors declare that there is no conflict of interest regarding the publication of this study
Funding Disclosure: This study was not funding by any organization

AUTHORS CONTRIBUTION

Concept & Design of Study: Dr. Anum Saeed,
Drafting: Dr. Ayesha Iftikhar
Data Analysis: Dr. Aneela Nausheen
Critical Review: Dr. Anum Saeed,
Final Approval of Version: Dr. Anum Saeed, All authors have reviewed and approved the final manuscript.

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