

Comparison of Angulation of Unerupted Maxillary Canines in Unilateral and Bilateral Cleft Lip and Palate Patients

Abdul Ahad, Abdullah Jan, Kashif Iqbal, Noor Javed, Maryam Naseem*, Kinza Nisar

Department of Orthodontics, Armed Forces Institute of Dentistry/National University of Medical Sciences (NUMS), Rawalpindi Pakistan,

*Department of Operative Dentistry, Foundation University, Islamabad Pakistan

ABSTRACT

Objective: To compare the angulation of unerupted maxillary canines in patients with unilateral cleft lip and palate (UCLP) and bilateral cleft lip and palate (BCLP).

Study Design: Comparative cross-sectional study.

Place and Duration of Study: Armed Forces Institute of Dentistry, Rawalpindi Pakistan, from Dec 2025 to Mar 2026.

Methodology: A total of 60 subjects aged 12–18 years with either UCLP or BCLP and unerupted maxillary canines were included through non-probability consecutive sampling. Panoramic radiographs were used to measure the angle between the long axis of unerupted canines and the intercondylar line. Angulation was categorized as mild (0–15°), moderate (15–30°), or severe (>30°). Independent t-test was applied for comparison of mean values, while Chi-square test was used for categorical variables.

Results: The two groups did not differ significantly with respect to age ($p=0.28$) or gender ($p=0.79$). Canine angulation differed significantly, with higher mean angulation in BCLP group ($30.97^\circ \pm 8.05$) compared with UCLP group ($17.03^\circ \pm 6.18$) ($p<0.001$). Severe angulation was more common in BCLP patients ($n=15$, 50%) than UCLP patients ($n=1$, 3.3%), while mild angulation was more frequent in UCLP ($n=14$, 46.7%) than BCLP ($n=1$, 3.3%) ($p<0.001$). Moderate angulation was noted in similar proportion in both groups (BCLP: 46.7%; UCLP: 50%).

Conclusion: Patients with bilateral cleft lip and palate showed significantly greater angulation of unerupted maxillary canines compared with unilateral cleft cases.

Keywords: Cleft Lip Palate, Maxillary Canine, Panoramic Radiograph, Tooth Angulation, Unerupted Canine.

How to Cite This Article: Ahad A, Jan A, Iqbal K, Javed N, Naseem M, Nisar K. Comparison of Angulation of Unerupted Maxillary Canines in Unilateral and Bilateral Cleft Lip and Palate Patients. Pak Armed Forces Med J 2026; 76(Suppl-9): S1575-S1579.

DOI: <https://doi.org/10.51253/pafmj.v76iSUPPL-9.14433>

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INTRODUCTION

Cleft lip and palate (CLP) is among the most common congenital craniofacial disorders.¹ Its prevalence is 1 in 500 live births.² Similarly, cleft pathology also causes maxillary arch development and tooth eruption impairment in these individuals.³ The dentition of the affected individuals with CLP exhibits a significantly increased vulnerability to eruption abnormalities, including delayed eruption, impaction, and aberrant angulation.⁴ Maxillary canine angulation is important for eruption prognosis and treatment planning. In CLP, abnormal eruption may be caused by alveolar deformities, surgical scarring, and limited arch space.⁵ Panoramic radiographs and CBCT are useful for assessing canine angulation and position.⁶ Assessing canine angulation with reference lines helps predict eruption problems, guide surgery, and avoid damage to nearby teeth.⁷ In Pakistan, local data regarding comparative canine angulation in cleft

patients remains limited. Canine angulation differs by cleft type. UCLP usually shows asymmetrical dental arch development, while BCLP shows a more symmetrical but severely disrupted maxillary arch with loss of alveolar continuity.⁸

Previous studies have shown that the rate of canine impaction is higher in people with CLP compared to non-cleft groups and impacted canines often have severe mesioangular or palatal deviations.^{9,10} Korde *et al.*,⁷ found that angulation of maxillary canines which were not erupted was found in 19% of unilateral cleft lip and palate (UCLP) cases and 75% of bilateral cleft lip and palate (BCLP) cases.

Cleft morphology may have a pronounced impact on dental development and therefore a comparative evaluation is needed for maxillary canine angulation in patients with unilateral and bilateral cleft lip and palate. The clarification of these differences makes a difference in clinical decision making, maximizes the orthodontic treatment outcomes, and facilitates the establishment of tailored therapeutic plans. This study aimed at comparing the

Correspondence: Dr Abdul Ahad, Department of Orthodontics, Armed Forces Institute of Dentistry, Rawalpindi Pakistan

Received: 03 Apr 2026; revision received: 29 Sep 2026; accepted: 30 Sep 2026

angulation of unerupted maxillary canines in groups of patients with unilateral cleft lip and palate and bilateral cleft lip and palate.

METHODOLOGY

The cross-sectional comparative study took place in the Department of Orthodontics in the Armed Forces Institute of Dentistry in Rawalpindi Pakistan by utilizing a non-probability consecutive sampling technique between 19 December 2025 and 10 March 2026. Ethical consent for the current study was granted by the Institutional Review Board of the Armed Forces Institute of Dentistry, Rawalpindi (Approval Ser. No: 1321, dated: Feb/2023). This study was carried out in full compliance with the principles of the Declaration of Helsinki, ensuring the safety, rights, and welfare of all participants. Each participant signed the informed consent; in the case of participants under 18 years old, informed consent was also signed by their parents or legal guardians. The participants were provided with detailed information about the study objectives, procedures, and expected risks and benefits, and were clearly advised that they could withdraw at any time without affecting the treatment they received. All data gathered were handled with strict confidentiality, and the information was used solely for research purposes.

Inclusion Criteria: Subjects of both sexes, aged 12–18 years, with either unilateral or bilateral cleft lip and palate and with unerupted or impacted maxillary permanent canines, having panoramic radiographs with clearly visualized condyles and canine region along with at least two-thirds root formation of the canine were included.

Exclusion Criteria: Those with syndromic clefts, previous orthodontics, maxillary trauma, or surgery in the canine area, low-quality radiographs, or absent lateral incisors were excluded.

Two proportions test was conducted to determine the required sample size. An earlier study by Korde *et al.*,⁷ reported that 19% of unilateral cleft lip and palate (UCLP) patients and 75% of bilateral cleft lip and palate (BCLP) patients exhibited angulation of unerupted maxillary canines. Using these proportions, the sample size was calculated at a 95% confidence level and 80% statistical power using OpenEpi software for comparing two independent proportions, which yielded a minimum requirement of 15 participants per group. To further increase the power of the study, a total of 60 participants (30 per group) were included.

The Department of Orthodontics had a radiographic database of eligible subjects, which was used to retrieve orthopantomograms of patients at the Armed Forces Institute of Dentistry in Rawalpindi. Age and sex of the participants were obtained from hospital records and recorded in full years at the time of imaging, as male or female. All the images were analyzed manually using acetate tracing paper and a fine pencil. The two highest points of the mandibular condyles were identified as anatomical landmarks, and a horizontal reference line linking these two points, called the intercondylar line, was drawn to serve as a stable reference. The long axis of the unerupted maxillary canine was traced from the cusp tip, and the angle between the long axis of the unerupted maxillary canine and the intercondylar line was measured in degrees. The canine angulation was further categorized into three groups: mild (0–15 degrees), moderate (15–30 degrees), and severe (>30 degrees). Each measurement was taken by the same examiner to reduce variability, and a portion of the images was re-evaluated after two weeks to ensure consistency. The type of cleft was considered the independent variable of the study, classified as either unilateral cleft lip and palate (UCLP) or bilateral cleft lip and palate (BCLP), while the angulation of the unerupted maxillary canine was the dependent variable. For the purposes of this study, an unerupted maxillary canine was defined as a tooth that had not penetrated into the oral cavity at the time of imaging. All information and data were securely stored and treated with a high level of confidentiality (Figure).

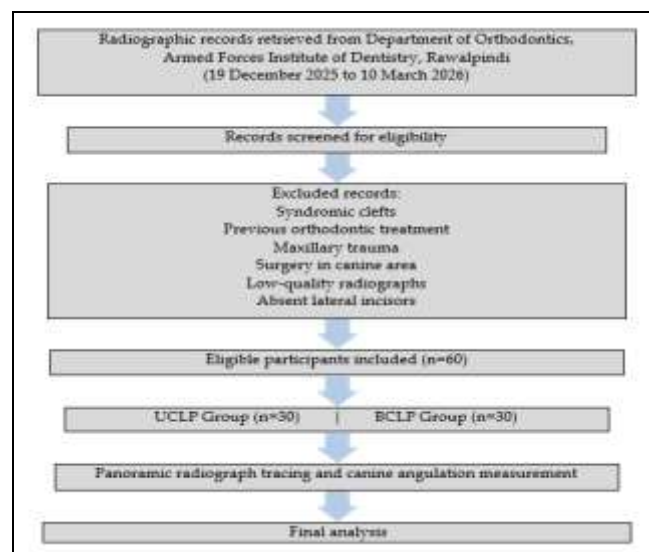


Figure: Patient Flow Diagram (n=60)

The analysis of the data was conducted in R software version 4.3.2. The Shapiro-Wilk test was used to test the normality of the data on the canine angulation. The mean and standard deviation of the values of canine angulation were calculated. An independent t-test was run to compare the mean angulation in both groups, whereas the Chi-square test was adopted to determine the differences in the distribution of angulation categories. The significance level was set at $p \leq 0.05$.

RESULTS

The study included 60 patients with 30 in the BCLP group and 30 in the UCLP group. The mean age was 15.23 ± 2.03 years in the BCLP group and 14.67 ± 2.02 years in the UCLP group ($p=0.28$). Eighteen (60%) were male and 12(40%) female in the BCLP group while 16(53.3%) male and 14(46.7%) female in the UCLP group ($p=0.782$). Age and gender were not different between the two groups statistically (Table-I).

Table-I: Demographic characteristics between Patients with Bilateral and Unilateral Cleft Lip and Palate (n=60)

Variables	Statistics	BCLP (n=30)	UCLP (n=30)	p-value
Age (years)	Mean $\pm$ SD	15.23 $\pm$ 2.03	14.67 $\pm$ 2.02	0.271*
Gender	Female, n(%)	12(40.0%)	14(46.7%)	0.782**
	Male, n(%)	18(60.0%)	16(53.3%)	

BCLP, bilateral cleft lip and palate; UCLP, unilateral cleft lip and palate ; *Independent samples t test; **Fisher exact test, *Independent samples t test; **Chi-square test

Canine angulation varied significantly between the two groups. The mean angulation was higher in the BCLP group (30.97 ± 8.05) than UCLP group (17.03 ± 6.18) and was very highly significant ($p < 0.001$). Severe angulation was more common in patients with BCLP (n=15, 50%) than in those with UCLP (n=1, 3.3%) whereas mild angulation was more frequent in UCLP (n=14, 46.7%) compared with BCLP (n=1, 3.3%) ($p < 0.001$). Moderate angulation was observed in a similar proportion of patients in both groups (BCLP: n=14, 46.7%; UCLP: n=15, 50%) (Table-II).

Table-II: Comparison of canine angulation between patients with bilateral and unilateral cleft lip and palate (n=60)

Variable	Statistics	BCLP (n=30)	UCLP (n=30)	p-value
Canine angulation (°)	Mean $\pm$ SD	30.97 $\pm$ 8.05	17.03 $\pm$ 6.18	<0.001*
Angulation category	Mild, n(%)	1(3.3%)	14(46.7%)	<0.001**
	Moderate, n(%)	14(46.7%)	15(50.0%)	
	Severe, n(%)	15(50.0%)	1(3.3%)	

BCLP, bilateral cleft lip and palate; UCLP, unilateral cleft lip and palate ; *Independent samples t test; **Fisher exact test

Canine angulation was higher in the BCLP group compared with the UCLP group in both males and females. In males the mean angulation was 30.00° (SD 7.28) in BCLP and 17.06° (SD 6.55) in UCLP ($p < 0.001$). Severe angulation was more common in BCLP (n=9,

50%) compared with UCLP (n=1, 6%) while mild angulation was seen more in UCLP (n=7, 44%) than BCLP (n=1, 6%) ($p < 0.001$). In females the mean angulation was 32.42° (SD 9.24) in BCLP and 17.00° (SD 5.99) in UCLP ($p < 0.001$). Severe angulation was present in BCLP (n=6, 50%) and not observed in UCLP (n=0, 0%), while mild angulation was seen only in UCLP (n=7, 50%) ($p < 0.001$) (Table-III).

Table-III: Comparison of Canine Angulation between patients with Bilateral and Unilateral Cleft Lip and Palate by gender (n=60)

Gender	Variables	Statistics	BCLP (n=30)	UCLP (n=30)	p-value
Male	Canine angulation (°)	Mean $\pm$ SD	30.00 $\pm$ 7.28	17.06 $\pm$ 6.55	<0.001*
	Angulation category	Mild, n(%)	1(6.0%)	7(44.0%)	<0.001**
		Moderate, n(%)	8(44.0%)	8(50.0%)	
Female	Angulation category	Severe, n(%)	9(50.0%)	1(6.0%)	<0.001**
		Mean $\pm$ SD	32.42 $\pm$ 9.24	17.00 $\pm$ 5.9	
		Mild, n(%)	0(0.0%)	7(50.0%)	
	Angulation category	Moderate, n(%)	6(50.0%)	7(50.0%)	<0.001**
		Severe, n(%)	6(50.0%)	0(0.0%)	

BCLP, bilateral cleft lip and palate; UCLP, unilateral cleft lip and palate ; *Independent samples t test; **Fisher exact test, *Independent samples t test; **Fisher exact test

DISCUSSION

Our findings shows that the patients having bilateral cleft lip and palate (BCLP) in the current research were more angulated with unerupted maxillary canines than the patients with unilateral cleft lip and palate (UCLP). Angulation was also significantly more severe in BCLP cases compared to the cases of UCLP. The trend was similar in both male and female subgroups meaning that the extent of cleft morphology is highly correlated with further divergent eruption dynamics of maxillary canines. These findings are clinically important because more angulation is usually associated with delayed eruption, impaction risk, and more complex orthodontic-surgical management.¹¹

These results support previous research that has indicated a greater rate and degree of canine impaction and abnormal angulation in the CLP patients than in the non-cleft. Our results also indicate that not only the presence of a cleft, but also the extent of cleft involvement (bilateral versus unilateral), has a measurable effect on canine angulation. Russell and McLeod found cleft sites to be very high in risk of canine impaction compared to non-cleft sides because the pre alveolar bone grafting (ABG) operations change the position and eruption path of the canine prior to and after the operations. In their study, they have proved that modified lateral and vertical eruption positions, which are closely linked with greater angulation, are strongly connected with cleft

morphology and timing of surgical interventions in both unilateral and bilateral cleft patients.¹²

The radiographic evidence of earlier cohort studies suggests that affected canines of cleft lip and palate (CLP) patients tend to have larger pre-eruptive inclination angles when compared to their counterparts that erupt (34.40 versus 15.40), and that higher angulation is a significant predictor of risk of impaction ($p < 0.05$). The mean angulations observed in the present study, particularly among BCLP patients, are consistent with these reports and support the concept that increasing angular deviation may serve as an early radiographic predictor of eruption failure. These data support your observation of high mean angulations in bilateral cleft lip and palate (BCLP) cases, which suggests that the extent of deviation of normative values could be used as a predictive factor of clinical impaction and increased complexity of treatment.⁸

The review of literature has indicated that eruption of maxillary canines in cases with cleft lip and palate (CLP) is regulated by the anatomical variables, which includes discontinuity of the alveolar ridge, lateral incisors abnormalities, and spatial constraints that can be attributed to the severity of the cleft. Because bilateral clefts usually involve both sides of the alveolus and a wider defect, the erupting canine may encounter more resistance and less guidance, resulting in increased mesial inclination and positional deviation compared with unilateral clefts. In a systematic review by Algerban *et al.*, it was found that mesial or palatal eruption patterns are commonly noted in CLP patients and that any deviation in the positioning of the canines is mostly due to the change in maxillary architecture and the lack of sufficient eruptive guidance information. Therefore, this increased canine deviations propensity could be predisposed by the anatomical disruption that is more marked in bilateral cleft lip and palate (BCLP), as a consequence.¹³

An increased angulation of unerupted canines among patients, who present with bilateral cleft lip and palate has numerous clinical sequelae. First of all, it increases the risk of eruption failure, resorption of the neighboring tooth roots, and requires an early intervention plan. Mesioangular and palatal deviations are severe anomalies requiring careful radiographic evaluation which may be supplemented by surgical disclosure or orthodontic traction; these procedures should be precisely timed with proper

alveolar bone grafting to prevent the side effects and maximize the functional results. In turn, it is recommended to implement the use of early cone-beam computed tomography that would improve the visual representation of three-dimensional angulation and spatial associations, which would help to make individualized treatment plans.¹⁴

In relation to orthodontic management, the more angulation, the more prolonged treatment duration, which need careful planning of the space and frequent observation of the maturation of the lateral incisors.¹⁵ Since lateral incisor anomalies are common among cleft lip and palate patients and a positive correlation with canine impaction has been identified, clinicians must consider the information regarding the surrounding dentition when planning their treatment.^{9,16}

From the Surgical stand point, the identified differences in bilateral cleft lip and palate (BCLP) and unilateral cleft lip and palate (UCLP) in angulation are important to highlight the need to perform early alveolar bone grafting at a period of development when the canine root has grown about 2/3 of the size in order to support more normal eruption angles and reduce the magnitude of angular deviation. As much as the alveolar bone grafting (ABG) does not ensure that the eruption curve is normalized, the technique has the ability of reducing the vertical positional differences and enhancing periodontal health of the erupting canine. However, if canine angulation is already severe before grafting, spontaneous correction may be less predictable thereby stressing the need for earlier diagnosis and coordinated treatment planning between orthodontists and cleft surgeons.^{17,18}

Having a age-matched comparison and the usage of standardized measurement protocol based on panoramic tracings can be considered a strengths of the current investigation. However, the panoramic imaging has an intrinsic disadvantage of not being able to correctly visualize the bucco-lingual positions and can also give an underestimation of the deviations in three dimensions compared to cone-beam computed tomography (CBCT). Future studies that use CBCT with volumetric evaluation should provide more comprehensive assessment of spatial angulation and its relationship with the severity of the cleft. Further, despite the differences in unilateral and bilateral presentations as explained in the current study, longitudinal cohorts would be useful in studying how angulation changes with time

particularly during the stages before and after secondary alveolar bone grafting surgery. The study designs that can be used as prospective could help to identify the modifiable predictors of pronounced angulation, which would guide the aspects of the best timing and methodological approach to implement interventions.

CONCLUSION

Within the limitations of this study it can be conclude that patients with bilateral cleft lip and palate exhibited significantly greater angulation of unerupted maxillary canines compared with unilateral cleft cases, highlighting the influence of cleft severity on canine eruption trajectory.

Conflict of Interest: None.

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

AA & AJ: Data acquisition, data analysis, critical review, approval of the final version to be published.

KI & NJ: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

MN & KN: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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