

Investigating Altered Passive Eruption: Prevalence and Correlation with Crown Dimensions of Maxillary Anterior Teeth in Punjab

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ABSTRACT

Objective: This study aims to explore the prevalence of Altered Passive Eruption (APE) and its relationship with the width, length, and width-to-length (W/L) ratios of maxillary anterior teeth in the Punjab population. **Study Design:** Cross-sectional study. **Settings:** Institute of Dentistry, CMH Lahore Medical College, Lahore Pakistan. **Duration:** June 1, 2023 to December 30, 2023. **Methods:** This study after the approval of the Institutional Review Board of the Institute of Dentistry, CMH Medical College, on a sample of 128 participants using a consecutive sampling technique. Inclusion criteria required participants to be over 20 years old, non-smokers, and have intact maxillary front teeth. Exclusion criteria included recent orthodontic treatment, systemic conditions, and medications affecting gingival health. Clinical assessments were performed to measure tooth dimensions, and data was analyzed using SPSS v24. **Results:** The study found a 30.47% prevalence of APE in the sample population. Significant gender differences were observed, with males exhibiting larger maxillary anterior teeth dimensions than females. However, age and height did not show significant associations with tooth dimensions. The W/L ratio of central incisors and other dimensional differences between genders were statistically significant ($p < 0.001$). **Conclusion:** The prevalence of APE is notably high, emphasizing the need for awareness among clinicians. Gender-specific differences in tooth dimensions should be considered in dental assessments and treatments. Future research should explore the genetic and environmental factors influencing APE and employ advanced measurement techniques to enhance diagnostic and treatment strategies.

Keywords: Altered passive eruption, Dental aesthetics, Maxillary anterior teeth, Tooth dimensions.

INTRODUCTION

The aesthetics of a smile are heavily influenced by the appearance of the maxillary anterior teeth, which play a pivotal role in determining facial harmony and attractiveness.¹ Among the factors that contribute to dental aesthetics, the proportion of the maxillary anterior is critical.² "Altered Passive Eruption" (APE), where the gingival margin fails to recede apically to the cemento-enamel junction (CEJ), resulting in a gummy smile or the appearance of short clinical crowns.^{3,4}

APE can lead to excessive gingival display and short clinical crowns, which can impact the dentition's

aesthetics and function, leading to dissatisfaction among patients seeking aesthetic dental treatments.⁵ Previous studies have highlighted the significance of APE in dental aesthetics. Garber and Salama *et al* emphasized the role of the gingival margin in creating an aesthetically pleasing smile. They noted that the ideal smile line follows the curvature of the upper lip, with minimal gingival display. APE can disrupt this harmony, leading to patient dissatisfaction.⁶ Recent studies have shown that APE is prevalent in approximately 12% to 35% of the population, with variations based on age, gender, and ethnicity.⁷

The width and length of the maxillary anterior teeth are crucial determinants of dental aesthetics. The golden

proportion, a mathematical ratio of approximately 1.618:1, has been proposed as an ideal standard for dental aesthetics.⁸ However, studies have shown that individual variations often deviate from this ideal. For instance, Ali *et al* found significant differences in the dental proportions of different ethnic groups, emphasizing the need for personalized aesthetic treatments.⁹ Moreover, teeth' "width-to-length ratio" is a key factor in aesthetic evaluations. A 75% to 80% width-to-length ratio is ideal for maxillary central incisors.¹⁰ Deviations from this ratio, such as in cases of APE, can lead to aesthetic concerns and impact treatment outcomes.¹¹

Limited research has been conducted on the prevalence of APE in the Punjab, especially Lahore population. However, studies in similar urban populations have reported varying prevalence rates.

Understanding the prevalence of APE in specific populations and its relationship with dental dimensions can aid in developing targeted treatment strategies.⁵ Lahore, a metropolitan city in Punjab with a diverse population, provides a unique demographic for studying APE prevalence. This study will contribute to the existing literature by providing insights into the prevalence of APE in Lahore and its correlation with dental proportions, which can inform clinical practices and improve patient satisfaction.¹²

This study aims to investigate the prevalence of APE in patients in Lahore, Punjab, and how it relates to the "width, length, and width-to-length ratios" of the maxillary anterior crowns.

METHODS

This cross-sectional study investigated the prevalence of Altered Passive Eruption (APE) and its association with the dimensions of maxillary anterior teeth. The research was conducted at the Outpatient Department (OPD) of the CMH Medical College Institute of Dentistry after approval from institutional ERC/ERB vide letter No. (Case#.686/ERC/CMH/LMC), over seven months, from June 1, 2023, to December 30, 2023. The setting provided a suitable environment for examining a diverse patient population, enhancing the study's relevance and applicability to real-world clinical scenarios.

The sample size of 128 participants was obtained based on a 95% confidence interval, a 9% margin of error, and an anticipated APE frequency of 35.8%.³ A consecutive sampling technique was used to recruit participants systematically. This approach allowed for the inclusion of patients who met the study's eligibility criteria as they presented to the OPD, ensuring a representative sample.

Inclusion criteria for the study required participants to be over 20 years old, presenting with various periodontal

complaints, and non-smokers to avoid the confounding effects of smoking on periodontal health. Additionally, participants needed to have all maxillary front teeth present, from canine to canine, with no signs of attachment loss, gingival overgrowth, hyperplasia, or inflammation, and no history of periodontal surgery. Pregnant or lactating women were excluded to avoid hormonal influences on gingival conditions. Furthermore, the Cementoenamel Junction (CEJ) had to be detectable using a periodontal probe, and the incisal edge needed to be intact, with no restorations, traumatic injury, or attrition. Exclusion criteria also included individuals taking medications known to cause gingival enlargement, such as Amlodipine or Nifedipine, those who had undergone orthodontic treatment after the age of 20 or were currently receiving orthodontic treatment, and individuals with a history of systemic conditions like diabetes or hypertension, verified through medical records.

Data collection commenced after receiving approval from the Institutional Review Board, and informed consent was obtained from each participant. A calibrated examiner conducted clinical assessments to ensure consistency and accuracy in measurements. APE was diagnosed if the distance from the gingival margin to the CEJ exceeded 2mm, measured using a periodontal probe to the nearest 0.5mm. For the clinical crown length and width, calipers were used on stone casts of the teeth, with measurements recorded to the nearest 0.1mm, capturing the widest apical-coronal and mesiodistal dimensions. All data were systematically documented in a structured proforma to maintain comprehensive and organized data collection.

IBM SPSS Statistics Version 24 was employed to conduct descriptive and inferential analyses for statistical analysis. Quantitative variables, such as age, height, tooth width, length, and width-to-length ratios, were expressed as mean and standard deviation (SD), while qualitative variables, including gender and presence of APE, were presented as frequencies and percentages. Data were stratified by age, gender, and height to control for potential confounding variables. Independent samples t-tests were conducted post-stratification to compare tooth width, length, and width-to-length ratios between groups, with a significance level equal to or less than 0.05.

RESULTS

The study included 128 participants, comprising 66 females (51.56%) and 62 males (48.44%). The mean age of participants was 27.39±6.94 years, while the average height was calculated at 162.15±13.12 cm. These demographic characteristics are tabulated in Table 1.

Table 1: The demographic characteristics of the participants (n=128)

Variable		n(%)
Gender	Female	66 (51.56)
	Male	62 (48.44)
Age group (years)	20-30	78 (60.94)
	31-40	50 (39.06)
Height group (cm)	171 & above	38 (29.69)
	Up to 170	90 (70.31)

Altered Passive Eruption (APE) was observed in 39 (30.47%) of the total sample. This significant prevalence rate underscores the commonality of APE within the studied population and highlights the importance of awareness and potential intervention in clinical practice to address this condition (Table 2).

Table 2: Length, width, and width-to-length ratio for central incisor, lateral incisor, and canine on the left and right side in the upper arch

Tooth	Length	Width	W/L Ratio
Left Central Incisor	9.78±0.64	8.22 ± 0.62	0.84 ± 0.06
Left Lateral Incisor	7.80 ± 0.68	6.51 ± 0.61	0.84 ± 0.05
Left Canine	10.56 ± 0.61	7.93 ± 0.66	0.75 ± 0.03
Right Central Incisor	10.23 ± 0.62	8.35 ± 0.63	0.82 ± 0.02
Right Lateral Incisor	8.13 ± 0.62	6.51 ± 0.62	0.80 ± 0.02
Right Canine	10.57 ± 0.61	7.98 ± 0.64	0.75 ± 0.02

The study found significant gender differences in tooth dimensions, particularly in the W/L ratio of the central incisors. A significant gender difference was noted in the “width-to-length ratio” of the left central incisor ($p < 0.001$). A significant gender difference was observed in the length of the left lateral incisor ($p < 0.001$) and the “width-to-length ratio” of the left lateral incisor ($p < 0.001$).

Although other measurements between genders, such as the length and left canine’s width, showed variations, these differences did not reach statistical significance ($p > 0.05$). Similar patterns were observed on the right side, where no significant gender differences were found in most measurements, as exhibited in Table 3.

Table 3: Comparison of length, width and width-to-length ratio for central incisor, lateral incisor, and canine on the left and right side in upper arch among genders

Tooth Measurements	Female (n=66)	Male (n=62)	p-Value*
Left CI width	8.14 ± 0.63	8.30 ± 0.61	0.16
L/W ratio of left CI	0.86 ± 0.08	0.81 ± 0.01	<0.001
Left LI length	7.51 ± 0.62	8.10 ± 0.61	<0.001
Left LI width	6.54 ± 0.62	6.48 ± 0.61	0.57
W/L ratio of Left LI	0.87 ± 0.04	0.80 ± 0.02	<0.001
Left Canine length	10.59 ± 0.62	10.54 ± 0.60	0.65
Left Canine width	8.00 ± 0.65	7.86 ± 0.67	0.24
W/L ratio of Left Canine	0.75 ± 0.03	0.74 ± 0.03	0.064
Right CI length	10.26 ± 0.64	10.20 ± 0.61	0.57
Right CI width	8.39 ± 0.64	8.31 ± 0.61	0.45
W/L ratio of Right CI	0.82 ± 0.03	0.81 ± 0.01	0.33
Right LI length	8.16 ± 0.63	8.10 ± 0.61	0.58
Right LI width	6.54 ± 0.62	6.48 ± 0.61	0.54
W/L ratio of Right LI	0.80 ± 0.02	0.80 ± 0.02	0.56
Right Canine length	10.60 ± 0.62	10.54 ± 0.61	0.57
Right Canine width	8.02 ± 0.65	7.94 ± 0.64	0.53
W/L ratio of Right Canine	0.76 ± 0.02	0.75 ± 0.02	0.58

*independent samples t-test

The analysis also included stratification by age and height. The comparison of tooth dimensions across age groups (20-30 years vs. 31-40 years) revealed no significant differences in width, length, or width-to-length ratios for the central incisor, lateral incisor, and canine, with p-values exceeding 0.05 (Table 4). Similarly, height stratification showed no significant differences in tooth dimensions between individuals with heights up to 170 cm and those 171 cm and above, except for a few measurements that exhibited borderline significance (Table 5).

Table 4: Comparison of length, width and width-to-length ratio for central incisor, lateral incisor, and canine on the left and right side in upper arch among age groups

Tooth measurements	16-30 years, n=78	31-40 years, n=50	p-value
Left CI width	8.22 ± 0.66	8.22 ± 0.55	0.99
L/W ratio of left CI	0.84 ± 0.06	0.84 ± 0.06	0.74
Left LI length	7.82 ± 0.68	7.75 ± 0.69	0.56
Left LI width	6.56 ± 0.64	6.43 ± 0.56	0.22
W/L ratio of Left LI	0.84 ± 0.05	0.83 ± 0.05	0.31
Left Canine length	10.62 ± 0.63	10.47 ± 0.56	0.14
Left Canine width	8.00 ± 0.69	7.82 ± 0.61	0.13
W/L ratio of Left Canine	0.75 ± 0.03	0.75 ± 0.03	0.26
Right CI length	10.28 ± 0.66	10.15 ± 0.56	0.23
Right CI width	8.41 ± 0.66	8.26 ± 0.57	0.19
W/L ratio of Right CI	0.82 ± 0.03	0.81 ± 0.02	0.25
Right LI length	8.19 ± 0.64	8.04 ± 0.57	0.17
Right LI width	6.56 ± 0.65	6.43 ± 0.56	0.24
W/L ratio of Right LI	0.80 ± 0.02	0.80 ± 0.02	0.81
Right Canine length	10.62 ± 0.64	10.49 ± 0.56	0.22
Right Canine width	8.05 ± 0.65	7.88 ± 0.61	0.14
W/L ratio of Right Canine	0.76 ± 0.02	0.75 ± 0.03	0.12

*Independent samples t-test

Table 5: Comparison of length, width, and width-to-length ratio for central incisor, lateral incisor, and canine on the left and right side in upper arch among height

Tooth measurements	171 & above (cm), n=38	Upto 170 (cm), n=90	p-value*
Left CI width	8.05 ± 0.64	8.29 ± 0.60	0.047
L/W ratio of left CI	0.85 ± 0.08	0.83 ± 0.05	0.15
Left LI length	7.43 ± 0.62	7.95 ± 0.65	<0.001
Left LI width	6.48 ± 0.62	6.52 ± 0.61	0.73
W/L ratio of Left LI	0.87 ± 0.05	0.82 ± 0.04	<0.001
Left Canine length	10.51 ± 0.62	10.58 ± 0.61	0.57
Left Canine width	7.97 ± 0.64	7.91 ± 0.67	0.69
W/L ratio of Left Canine	0.76 ± 0.03	0.75 ± 0.03	0.14
Right CI length	10.20 ± 0.65	10.24 ± 0.61	0.74
Right CI width	8.32 ± 0.63	8.36 ± 0.63	0.73
W/L ratio of Right CI	0.82 ± 0.03	0.82 ± 0.02	0.82
Right LI length	8.10 ± 0.62	8.14 ± 0.62	0.72
Right LI width	6.48 ± 0.62	6.52 ± 0.62	0.74
W/L ratio of Right LI	0.80 ± 0.02	0.80 ± 0.02	0.9
Right Canine length	10.54 ± 0.62	10.58 ± 0.61	0.73
Right Canine width	7.95 ± 0.65	7.99 ± 0.64	0.76
W/L ratio of Right Canine	0.75 ± 0.02	0.75 ± 0.02	0.92

*independent samples t test

The findings from this study indicate that the dimensions of anterior maxillary teeth are generally larger in males compared to females. However, age and height do not

significantly associate with the width of anterior teeth. These results emphasize the importance of considering gender-specific differences in dental assessments and treatments, providing valuable insights into the prevalence and anatomical implications of altered passive eruption among the study population.

DISCUSSION

This study examines the relationship between APE and the dimensions of maxillary anterior, focusing on how factors such as age, gender, and height influence these variables. The present study's findings align with existing literature, emphasizing the complex interplay between anatomical and physiological factors that govern dental morphology.⁸

The current research indicates that the length of teeth is influenced by aging, whereas the width remains relatively stable over time. This observation is consistent with previous studies that have proposed formulas like $L=W/\text{Tooth proportion}$, where the tooth proportion ratio typically falls within 72% to 81%.¹³ These findings challenge the assumption that average tooth dimensions are universally applicable, as our data revealed that only a minority of patients fell within these conventional metrics. Specifically, 34% of participants had average widths of 8.5 mm for central incisors, around 6.5 mm for lateral incisors, and 7.5 mm for canines.¹⁴ The study by Alpiste-Illueca *et al* emphasized that APE is characterized by a significant gingival overlap and increased gingival width and is associated with a thick bone crest and connective tissue attachment, suggesting specific morphological patterns of APE.¹⁵ A study conducted by J. Nart *et al* reported a higher prevalence of APE in patients who underwent orthodontic treatment (42.1%) compared to untreated patients (29.5%), although the difference was not statistically significant. APE was more common in individuals with a thick-flat gingival biotype.¹⁶

Gender differences were evident in tooth dimensions, with male subjects exhibiting larger mean widths and lengths. Meanwhile, the width-to-length ratios for central and lateral incisors did not significantly differ between genders.¹⁷ The current study identified positive correlations in the proportional dimensions within gender groups. A previous study specific to the Indian Punjab population by Indrani Jatana *et al* investigated the mesiodistal dimensions of anterior teeth and found "sexual dimorphism" in certain teeth, indicating potential ethnic and regional differences in dental morphology.¹⁸ In another study by Tripathi *et al*, males showed greater mesiodistal dimensions in maxillary canines and incisors than females, highlighting significant sexual dimorphism in anterior tooth dimensions.¹⁹ Moreover, a study focusing on the Punjab population found that mesiodistal

dimensions of teeth 13 and 23 exhibited sexual dimorphism, aiding gender determination in forensic contexts.¹⁸

Prevalence data underscores the importance of APE awareness in clinical practice. The current study identified APE in 30.47% of the sample population, contrasting with the 12.1% prevalence reported by Volchansky and Cleaton-Jones.¹⁶ This discrepancy may stem from differences in sample demographics, highlighting the need for targeted studies across various populations to better understand the prevalence and implications of APE. Moreover, in a study focusing on the dimensions of maxillary anterior teeth in different populations, Naseer Ahmed *et al* reported significant differences in crown width-to-height ratios, indicating variability across populations.²⁰ This suggests that standardized ratios might not be applicable universally.¹⁹

The implications of APE extend to orthodontic and restorative dentistry. Excess gingival tissue can complicate orthodontic procedures, affecting bracket placement and oral hygiene. Surgical intervention, such as gingivectomy or apically positioned flap surgery, is often required to correct these issues.²¹ However, the timing of these procedures is debated, with some experts advocating for periodontal surgery before orthodontic treatment to ensure optimal outcomes.²² A case series by F. Cairo *et al* demonstrated that “periodontal plastic surgery” exhibited predictable outcomes in treating APE, especially if it involves osseous resection. A significant improvement in crown length was observed, with high patient satisfaction post-surgery.²³ Furthermore, aesthetic crown lengthening surgery was further evaluated in a study by Cléverson O Silva *et al*, which reported higher patient satisfaction and significant improvements in gingival display and tooth dimensions post-procedure.²⁴

CONCLUSION

There was a significant prevalence of APE at 30.47%, highlighting the need for increased awareness among clinicians. While tooth length appears to change with age, width remains stable, with males exhibiting larger dimensions than females. The study underscores the importance of individualized dental treatment plans, considering patient-specific factors. Limitations include the study's cross-sectional design, single-institution setting, and lack of consideration for genetic and environmental variables. Future research should focus on exploring the underlying mechanisms of APE and its impact on oral health, employing diverse populations and advanced measurement techniques. By enhancing our understanding of APE, we can improve diagnostic accuracy and treatment strategies, ultimately contributing to better dental care outcomes.

LIMITATIONS

The cross-sectional study design is one of the limitations that restricts the ability to establish causal relationships between APE and the various demographic and anatomical variables examined. Longitudinal studies are necessary to explore how these factors interact over time and contribute to the development or progression of APE. Moreover, the present study has limited settings, which may limit the generalizability of the findings to broader populations.

SUGGESTIONS / RECOMMENDATIONS

Future studies should aim to include a more diverse sample and longitudinal design to better understand and capture variations in APE prevalence and tooth dimensions across different populations. Incorporating digital imaging techniques and three-dimensional analysis could enhance measurement accuracy and provide more comprehensive data on tooth dimensions and gingival relationships. Moreover, understanding the genetic, molecular, and environmental factors involved in APE could offer deeper insights into its etiology and guide more effective treatment strategies.

CONFLICT OF INTEREST / DISCLOSURE

The authors declare no conflict of interest.

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