Evaluation of altered passive eruption in maxillary anterior teeth

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Abstract

Background: Altered passive eruption (APE) is a condition in which the g does not move in the direction of the apex during teething, making the crown appear shorter and square, changing width/length ratio of clinical crown and the shape of gingival margin. The study evaluated morphological characteristics of maxillary anterior teeth with APE. **Materials and Methods:** A cross-sectional study was conducted with 30 patients, involving 141 maxillary anterior teeth diagnosed with APE. **Results:** The widths of crown are: 7.98 mm, 6.43 mm, and 7.48 mm; the lengths of clinical crown are: 7.98 mm, 6.43 mm, and 7.48 mm, and the lengths of anatomical crown are: 10.09 mm, 8.72 mm, and 9.42 mm in the central incisors, lateral incisors, and canines, respectively. The widths of free gingiva recorded in the central incisors: 3.9 mm, lateral incisors: 3.57 mm, and canines: 3.76 mm. The width of keratinized gingiva in the central incisors, lateral incisors, and canines are 7.53 mm, 7.45 mm, and 7.32 mm, respectively. **Conclusion:** These morphological features assist clinicians in obtaining a broad understanding of the anatomy related to APE, while also aiding in the precise diagnosis and treatment of individual patients.

Keywords: *Altered passive eruption, width of crown, length of anatomical crown, length of clinical crown, free gingiva, keratinized gingiva.*

1. INTRODUCTION

The process of tooth eruption consists of 2 stages: active tooth eruption is determined by the upward movement of the tooth out of the alveolar bone until it occludes with its antagonistic tooth. This movement causes the gum to shift along with the tooth structure. Besides, passive tooth eruption is a normal physiological process in which the gum moves towards the apex until the dentogingival unit is at the cemento-enamel junction (CEJ). This process comprises 4 stages:

Stage 1: When the tooth contacts the occlusal plane, the junctional epithelium adheres entirely to the tooth enamel surface.

Stage 2: Junctional epithelium partly adhering to the enamel surface and partly to the cementum towards the apex compared to CEJ, the base of the gingival crevice remains on the enamel surface.

Stage 3: All junctional epithelium adheres to the cementum, and the base of the gingival crevice is now positioned at the level of the CEJ line.

Stage 4: The final stage when junctional epithelium adheres entirely to the cementum, the base of the gingival crevice is on the cementum, and part of the tooth root may be exposed due to inflammatory processes causing junctional epithelium adhesion to move towards the apex.

Stages 1 to 3 represent physiological progression, while stage 4 is pathological [1]. Unlike active eruption, passive eruption continues throughout life even after the tooth contacts the opposing one on the dental arch. If passive eruption fails to progress beyond stages 1 or 2, it may lead to altered passive eruption. In this case, the gum does not move towards the apex during tooth eruption, resulting in more gingiva coverage over the crown, causing part of the tooth to be submerged in the gum, clinically shortening. Amsterdam introduced a distinction between altered active eruption (AAE) and APE, where AAE occurs when the alveolar bone and dentogingival unit cannot move towards the apex, causing the alveolar bone to be closer to CEJ than usual, with the bone crest (BC) close to the junctional epithelium, hindering gingival movement towards the apex during passive tooth eruption [2].

Coslet classified APE into two types 1 and 2 based on the relationship between the mucogingival junction (MGJ) and BC, and two subtypes A and B based on the relationship between BC and CEJ. For APE type 1, besides excessive gingival display on the tooth surface, keratinized gingiva width is significant, with MGJ located more apically than the bone crest position. In contrast, for APE type 2, keratinized gingiva width is narrow, and MGJ is at the same level

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as CEJ. Both types are further classified into subtypes A and B. In subtype A, the distance between the BC and CEJ is 1.5 - 2mm (allowing normal connective tissue and junctional epithelium attachment to the cementum surface), while in subgroup B, the bone crest is close to or even at the same level of CEJ. Subgroup B is commonly found in children and adolescents still in the active eruption stage [3].

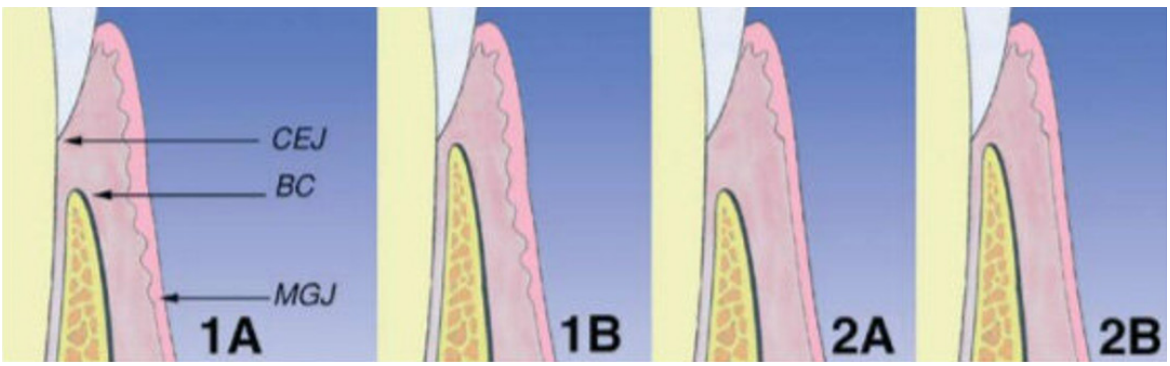

Figure 1. Classification of APE according to Coslet [3]

In cases where APE occurs in the upper anterior teeth, it affects the aesthetics of the patient's smile. It can be one of the causes of excessive gingival display, as well as posing potential risks for periodontal disease. A study by Volchansky in 1976 reported an APE prevalence of 12.1% among 1025 patients with an average age of 24.2 ± 6.2 years, and the author also noted the correlation between APE and periodontal inflammation in these patients [4]. Recently, Nart reported a higher current prevalence of APE at 35.8% (29.5% in the control group and 42.1% in the orthodontic treatment group) [5].

With the advancement of society, the demand for functional and aesthetic treatments in these patients is increasing. However, the anatomical and morphological characteristics related to APE have not been adequately addressed. Therefore, this study was conducted to investigate the prevalence of altered passive eruption in the upper anterior teeth, to analyze the morphological characteristics, and to find related solutions to provide a perfect smile for patients and prevent periodontal diseases.

2. MATERIALS AND METHODS

The study was conducted on 141 upper anterior teeth diagnosed with APE, involving a total of 30 patients who visited the Odonto-Stomatology Clinic at Hue University Hospital. The sample selection criteria ensured the following: the upper anterior teeth from tooth 13 to tooth 23 were complete, free from gingivitis, gingival hyperplasia or hereditary gingival fibromatosis, no subgingival tooth decay was noted, no history of orthodontic treatment or prosthodontic rehabilitation of the upper anterior teeth, and patient consent was obtained for participation in the study.

The criteria for altered passive tooth eruption included the following:

Table 1. Diagnostic criteria according to Silberberg [6]

Criteria	Central Incisor	Lateral Incisor	Canie
Width/length of clinical crown ratio	> 80%	> 72%	> 75%
Free gingival width/anatomical crown length ratio	> 19%	> 19%	> 19%
CEJ to gingival margin distance	> 1mm	> 1mm	> 1mm

Research tools included:

- Examination instruments: trays, mirrors, forceps, dental probes, gloves.
- William's periodontal probe marked at 1mm, 2mm, 3mm, 5mm, 7mm, 8mm, 9mm, and 10mm.
- Feng Liang digital caliper: manufactured by Feng Liang, China, measuring range 0 - 150mm, accuracy 0.02mm.

To assess the condition of altered passive eruption in patients, direct measurements were taken from the patients:

Table 2. Statistical table of variables measured directly on the patient

Variable	Measurement Method	Unit	Tool
Crown width	Maximum dimension from mesial to distal aspect perpendicular to the long axis of the tooth	mm	Digital caliper
Clinical crown length	Maximum dimension from gingival margin to incisal edge parallel to the long axis of the tooth	mm	Digital caliper
Anatomical crown length	Distance from CEJ to gingival margin + clinical crown length	mm	Periodontal probe
Free gingiva width	Distance from gingival crevice to gingival margin	mm	Periodontal probe
Keratinized gingiva width	Distance from gingival margin to MGJ	mm	Periodontal probe

Figure 2. Measurement procedures for variables

The study employed a cross-sectional descriptive research design, utilizing a convenient sampling method. Data collected were processed using SPSS 20.0 software.

The data are presented in the form of Mean ± Standard Deviation.

Differences between two groups of results were compared using paired samples t-test.

Statistical significance with $p<0.05$.

3. RESULTS

Our study recorded data from 30 patients, including 13 males and 17 females, who visited the Odonto-Stomatology Clinic at the Hue University Hospital between April 2022 and December 2023, showing the condition of APE in the upper anterior teeth through clinical examinations on-site. The following general characteristics were observed:

Table 3. Distribution of teeth with APE by gender

Tooth No.	Male	Female	Total
13	13	16	29
12	8	13	21
11	9	9	18
21	10	15	25
22	9	13	22

Tooth No.	Male	Female	Total
23	11	15	26
Total	60	81	141

Among 30 patients, a total of 141 upper anterior teeth were diagnosed with APE. Tooth No. 13 was the most commonly affected, followed by teeth No. 23, 21, 22, and 12, with tooth No. 11 being the least affected.

3.1. Morphological characteristics related to upper teeth with APE

Table 4. Width and length of crowns

Tooth Group	Crown Width (W)	Clinical Crown Length (CCL)	Anatomical Crown Length (ACL)
Central Incisors	7.98 ± 0.7	8.43 ± 1.05	11.88 ± 0.65
Lateral Incisors	6.43 ± 0.82	7.09 ± 0.71	10.01 ± 0.79
Canines	7.48 ± 0.44	7.83 ± 0.8	11.24 ± 0.48

Table 5. Correlation between width and length of crowns

Tooth Group	W/CCL (%)	W/ACL (%)	p-value
Central Incisors	95.74 ± 11.16	67.09 ± 3.03	p<0.05
Lateral Incisors	91.31 ± 12.93	64.08 ± 4.28	p<0.05
Canines	96.47 ± 9.62	66.56 ± 2.95	p<0.05

The percentage ratio between the crown width and clinical crown length of the upper anterior teeth was as follows: central incisors 95.74 ± 11.16%, lateral incisors 91.31 ± 12.93%, and canines 96.47 ± 9.62%. These ratios were higher than one between the width and anatomical crown length (67.09 ± 3.03%; 64.08 ± 4.28%; 66.56 ± 2.95%; p<0.05).

3.2. Morphological characteristics related to gingiva of upper teeth with APE

Table 6. Width of free gingiva and keratinized gingiva

Tooth Group	Free Gingiva	Keratinized Gingiva
Central Incisors	3.9 ± 0.31	7.53 ± 0.39
Lateral Incisors	3.57 ± 0.31	7.45 ± 0.43
Canines	3.76 ± 0.37	7.32 ± 0.46

4. DISCUSSION

4.1. Morphological characteristics related to teeth with APE

In this study, the average crown width of the central incisors, lateral incisors, and canines were 7.98 ± 0.7mm, 6.43 ± 0.82mm, and 7.48 ± 0.44 mm, respectively. These dimensions are similar to the findings of previous studies by authors such as Hoang Tu Hung [7], Dao Thi Phuong Dung [8], and Wheeler [9]. Crown width is a stable anatomical feature, unaffected by periodontal structures, and is used as a key criterion in APE treatment to ensure both aesthetic and functional outcomes for patients.

Conversely, the average clinical crown length of the central incisors, lateral incisors, and canines were 8.43 ± 1.05mm, 7.09 ± 0.71mm, and 7.83 ± 0.8mm, respectively. These results differ from other community studies, likely because our study focused on patients with altered passive eruption, where the gingiva does not recede towards the apex and instead remains covering the crown, giving the appearance of shorter clinical crowns [7], [8], [9].

Another important parameter in APE diagnosis and treatment is the anatomical crown length of teeth. In our study, the average anatomical crown length of central incisors, lateral incisors, and canines were 11.88 ± 0.65mm, 10.01 ± 0.79mm, and 11.24 ± 0.09mm, respectively. When compared with Magne's study on Caucasian patients [10] and Marcuschamer's study on Asian patients in the US [11], our findings revealed similarities despite differences in ethnicity, geography, and socioeconomic status.

Peixoto suggests that the optimal ratio of crown

width to clinical crown length for central incisors should be 75% to 80% [12]. Magne's study reports that the width-to-clinical crown length ratios are 78% for anterior central incisors, 73% for lateral incisors, and 73% for canines [10]. According to Chu, the aesthetic ratio of Chu's caliper is 78% for the upper anterior teeth [13]. A recent study by Orce-Romeo on the most influential individuals worldwide, as voted by Times magazine from 2006 to 2010, has proposed a golden ratio between the width and length of the clinical crown of the upper anterior teeth. Specifically, it is 75 - 80% for the central incisors, 66 - 70% for the lateral incisors, and 80 - 85% for the canines, with no statistically significant difference between males and females [14]. According to our study, the average width-to-length ratios of the clinical crown of the central incisors, lateral incisors, and canines are 95.74 ± 11.16%, 91.31 ± 12.93%, and 96.47 ± 9.62%, respectively. These ratios suggest that the width of the clinical crown closely matches its length, causing the teeth to appear shorter and almost square-shaped. This can impact the overall harmony and aesthetics of the smile and may be a contributing factor for the patients seeking treatment in this study.

However, the ratios of crown width to anatomical crown length of central incisors, lateral incisors, and canines were recorded as 67.09 ± 3.03%, 64.08 ± 4.28%, and 66.56 ± 2.95%, respectively. Sterret's study evaluated these ratios in the maxillary anterior teeth as 85%, 76%, and 77% for males and 86%, 79%, and 81% for females [15].

4.2. Gingival dimensions related to teeth with APE

In our study, the average width of the free gingiva or gingival sulcus depth in central incisors, lateral incisors, and canines were 3.9 ± 0.31mm, 3.57 ± 0.31mm, and 3.76 ± 0.37mm, respectively. Normally, in individuals with healthy gingival tissues, gingival sulcus depth ranges from 0 to 3.5 mm, with an average of 0.69 mm [16]. Excessive gingival sulcus depth can lead to difficulties in oral hygiene maintenance, bacterial accumulation, and gingival inflammation. Studies have been conducted to determine the relationship between APE and periodontal health, suggesting that APE is a potential risk factor for the development of periodontal disease. Coslet pointed out that in APE type 2A, the gums are not supported by connective tissue fibers, often characterized by thin and easily damaged tissue. For APE types 1B and 2B, insufficient keratinized gingiva can lead to gingival diseases [2]. Prichard suggested that when the gingival margin is closer to the incisal edge, the gums are more susceptible to trauma during chewing and more prone to periodontal diseases [17]. Factors such as trauma, food impaction, and debris can lead to chronic inflammation at the gingival margin. Additionally, when the gingiva does not recede to its normal position and remains on the tooth's convex surface, it may be subjected to repeated trauma. Excessive gingival tissue can also complicate oral hygiene practices, leading to increased plaque accumulation and potentially resulting in gingivitis. Restorations and orthodontic appliances placed near the gingival margin can further cause inflammation and attachment loss, especially in patients with sensitive gingiva. Weinberg noted that excessive keratinized gingiva can lead to the formation of pseudo pockets, which contribute to plaque buildup and inflammation, potentially affecting aesthetics [18]. Volchansky also found a link between APE and acute necrotizing ulcerative gingivitis, suggesting that deep gingival pockets create anaerobic conditions conducive to disease development [4]. While such severe conditions are rare, the gingiva over teeth with APE typically remains healthy if plaque is well-managed.

Keratinized gingiva dimensions are essential in APE treatment. In our study, the average width of keratinized gingiva was 7.53 ± 0.39 mm for central incisors, 7.45 ± 0.43 mm for lateral incisors, and 7.32 ± 0.46 mm for canines. APE is classified into two groups based on the width of the keratinized gingiva. If the width is significant, a gingivectomy is performed to ensure a minimum keratinized gingiva depth of 2 mm remains after surgery. If the width is not adequate, an apically repositioned flap surgery is conducted to preserve gingival health following the procedure.

In summary, APE is a prevalent condition that can impact smile aesthetics and potentially lead to various periodontal diseases. Despite its significance, research on APE has been limited, possibly due to the absence of standardized diagnostic criteria. This study contributes by detailing the anatomical and morphological characteristics of upper anterior teeth affected by APE, providing valuable insights and establishing a foundation for future, more comprehensive research.

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