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Influence of Age on Anchorage Loss During Initial Orthodontic Alignment in Extraction Cases

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Abstract

Background: Anchorage control is a critical factor in orthodontic treatment, particularly in extraction cases where unwanted tooth movement can compromise treatment outcomes. Biological factors, including age, may influence the extent of anchorage loss during orthodontic tooth movement.

Objective: To evaluate the influence of age on anchorage loss during the initial leveling and alignment phase in orthodontic patients undergoing extraction therapy.

Materials and Methods: A cross-sectional analytical study was conducted on 20 orthodontic patients aged 13–30 years undergoing fixed appliance therapy with premolar extraction. Patients were divided into two age groups: ≤20 years and >20 years. Anchorage loss was assessed before treatment and after completion of initial leveling and alignment using both lateral cephalometric radiographs and study model analysis. Measurements were made using standardized reference points, and the differences between pre- and post-treatment values were calculated. Statistical analysis was performed to compare anchorage loss between the two age groups.

Results: Anchorage loss was observed in all patients following initial alignment. The younger age group (≤20 years) demonstrated significantly greater anchorage loss compared to the older group (>20 years) in both cephalometric (2.66 ± 1.44 mm vs 1.65 ± 0.89 mm) and model analyses (1.77 ± 1.31 mm vs 1.06 ± 0.51 mm) ($p \leq 0.05$).

Conclusion: Age significantly influences anchorage loss during early orthodontic treatment, with younger patients showing greater susceptibility. Careful anchorage planning is essential, particularly in adolescent patients, to achieve optimal treatment outcomes.

Keywords: Anchorage loss; Age factor; Orthodontic treatment; Cephalometric analysis; Study model; Tooth movement

Introduction

Orthodontic treatment aims to achieve optimal functional efficiency, esthetic harmony, and structural balance, which together define successful treatment outcomes [1]. Among the fundamental principles guiding orthodontic therapy, anchorage plays a critical role in controlling tooth movement and ensuring that desired corrections are achieved without unwanted side effects. Anchorage is defined as the resistance to undesirable tooth movement, and its preservation is essential, particularly in extraction cases where space closure is required [2].

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Anchorage loss, characterized by the unintended mesial movement of posterior teeth, remains a common and often unavoidable consequence during orthodontic treatment [3]. This phenomenon can compromise treatment goals by reducing available space, altering occlusal relationships, and negatively affecting facial esthetics [4]. The extent of anchorage loss is influenced by multiple factors, including the type of tooth movement, force magnitude, treatment mechanics, and patient-related biological variables [5].

Among these factors, age has been suggested as an important determinant in orthodontic tooth movement and anchorage control. Bone density, metabolic activity, and remodeling capacity differ significantly between younger and older individuals, which may influence the rate and pattern of tooth movement [6]. In younger patients, increased cellular activity and less dense bone structure may facilitate faster tooth movement, potentially leading to greater anchorage loss [7]. In contrast, adults often exhibit slower tooth movement due to denser cortical bone and reduced metabolic activity, which may contribute to improved anchorage preservation [8].

Several studies have demonstrated that biological variability associated with age can affect orthodontic outcomes, particularly in terms of treatment duration and tissue response [9]. However, the specific relationship between age and anchorage loss during the early stages of orthodontic treatment remains inadequately explored. The initial leveling and alignment phase is especially critical, as significant tooth movement occurs during this period, and anchorage demands are high [10].

The assessment of anchorage loss can be performed using various diagnostic methods, including cephalometric analysis and study model evaluation. Cephalometric radiographs provide reliable information regarding tooth movement relative to stable craniofacial structures, while study models offer a practical and radiation-free alternative using intraoral landmarks such as palatal rugae [11,12]. Both methods have been widely used and validated for evaluating anteroposterior tooth movement in orthodontic research [13].

In extraction-based orthodontic treatment, particularly involving premolar removal, control of molar position is crucial to ensure effective space management and optimal treatment outcomes [14]. Understanding how age influences anchorage loss during this phase may provide valuable insights for individualized treatment planning and anchorage reinforcement strategies [15]. Despite its clinical importance, limited data are available regarding age-related differences in anchorage loss during the initial stages of orthodontic therapy, especially within specific populations [16].

The aim of this study is to evaluate the influence of age on anchorage loss during the initial leveling and alignment phase of orthodontic treatment in extraction cases.

Materials and Methods

This study was conducted as a cross-sectional analytical investigation in the Department of Orthodontics and Dentofacial Orthopedics at a tertiary dental care institution. The study population consisted of patients undergoing fixed orthodontic treatment with a treatment plan involving bilateral extraction of maxillary first premolars. A purposive sampling technique was used to select participants based on predefined criteria. Patients were categorized into two age groups for analysis: $\leq$20 years and >20 years, in order to evaluate the influence of age on anchorage loss during the initial phase of treatment.

The inclusion criteria were patients of both sexes aged between 13 and 30 years, diagnosed with Class I malocclusion accompanied by mild to moderate crowding, and indicated for extraction-based orthodontic treatment. All participants had a full complement of permanent teeth (excluding third molars) and were planned for comprehensive orthodontic therapy using fixed appliances. Patients were required to be medically fit and willing to provide informed consent. The exclusion criteria included patients with craniofacial anomalies, facial asymmetry, or congenital deformities such as cleft lip and palate. Individuals with a history of previous orthodontic treatment, maxillofacial trauma, systemic diseases, or medication affecting bone metabolism were excluded. Additionally, patients with missing teeth anterior to the first molar, non-extraction treatment plans, or poor compliance were not included in the study.

All selected patients were treated with pre-adjusted edgewise fixed appliances with a 0.022-inch slot. Standardized bonding and bracket positioning techniques were followed for all cases to ensure consistency. Initial leveling and alignment were performed using a sequence of arch wires, progressing to a 0.019 × 0.025-inch stainless steel wire, which was considered the endpoint of the alignment phase. No auxiliary anchorage reinforcement methods such as trans palatal arches, headgear, or skeletal anchorage devices were used, as the selected cases were categorized as minimum anchorage cases.

Data collection was carried out using both lateral cephalometric radiographs and maxillary study models obtained at two time points: before extraction and after completion of initial leveling and alignment. Anchorage loss was assessed by measuring the positional change of the maxillary first molars. In cephalometric analysis, a reference system was established using the Sella–Nasion (SN) plane and an occlusal plane perpendicular (OPP), and the horizontal distance from the molar to this reference line was recorded. On study models, measurements were taken from the mesial contact point of the first molar to the third palatal rugae, which served as a stable intraoral landmark. The difference between pre-treatment and post-alignment measurements

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represented the amount of anchorage loss. All measurements were performed using standardized instruments to ensure accuracy and reproducibility, and the data were analyzed statistically to determine the effect of age on anchorage loss.

Results

A total of 20 patients were included and categorized into ≤20 years (n=12) and >20 years (n=8). Anchorage loss was evaluated using cephalometric and model analysis after initial alignment.

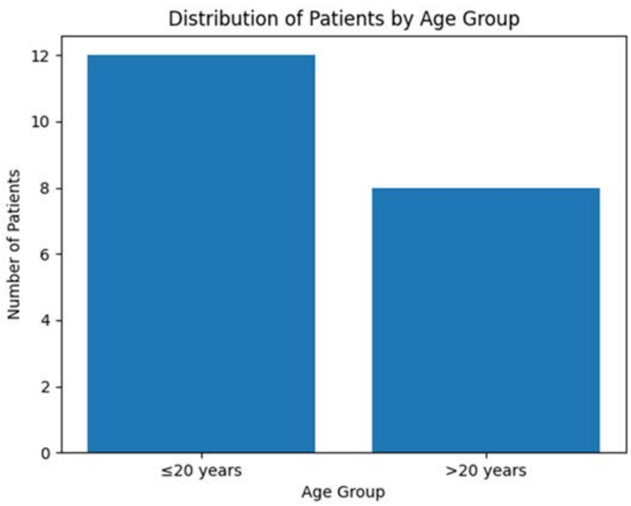

Figure 1: Distribution of Patients by Age Group (n=20).

Table 1: Age Distribution of Patients (n=20).

Age Group	Frequency (n)	Percentage (%)
≤20 years	12	60%
>20 years	8	40%

Table 1 presents the number and proportion of participants in each age category. Most of the patients were aged 20 years or below, accounting for 60% of the total sample (n=12), whereas 40% (n=8) were older than 20 years. This reflects a higher representation of younger individuals in the study population.

Table 2: Anchorage Loss by Age (Cephalometric Analysis) (n=20).

Age Group	Frequency (n)	Mean (mm)	SD
≤20 years	12	2.66	1.44
>20 years	8	1.65	0.89

Table 2 demonstrates the mean anchorage loss measured through cephalometric analysis across different age groups. Patients aged ≤20 years showed a higher mean anchorage loss (2.66 ± 1.44 mm) compared to those aged >20 years (1.65 ± 0.89 mm). This suggests that younger patients experienced greater posterior tooth movement during the initial leveling and alignment phase.

Table 3 presents the anchorage loss values obtained from study model analysis in both age groups. The younger group (≤20 years) exhibited a higher mean anchorage loss (1.77 ± 1.31 mm) compared to the older group (>20 years), which showed a mean value of 1.06 ± 0.51 mm. These findings indicate a tendency for increased anchorage loss in younger patients during the early stage of orthodontic treatment when assessed using model measurements.

Table 3: Anchorage Loss by Age (Model Analysis) (n=20).

Age Group	N	Mean (mm)	SD
≤20 years	12	1.77	1.31
>20 years	8	1.06	0.51

Table 4 shows the comparison of anchorage loss between the two age groups using an independent t-test. The results indicate a statistically significant difference in anchorage loss between younger (≤20 years) and older (>20 years) patients in both cephalometric and model analyses ($p \leq 0.05$). The mean difference was higher in the younger group, suggesting that age has a significant influence on anchorage loss during the initial phase of orthodontic treatment.

Table 4: Comparison of Anchorage Loss Between Age Groups (n=20).

Variable	Mean Difference	t-value	p-value
Cephalometric Analysis	1.01	2.739	0.025*
Model Analysis	0.71	2.053	0.000*

Table 5 summarizes the overall anchorage loss observed after completion of the initial leveling and alignment phase using both measurement methods. The mean anchorage loss recorded through cephalometric analysis (2.28 ± 1.25 mm) was higher than that obtained from model analysis (1.50 ± 1.12 mm). This indicates a slight variation between the two methods, although both demonstrate measurable anchorage loss during early orthodontic treatment.

Table 5: Overall Anchorage Loss After Alignment (n=20)

Method	Mean (mm)	SD
Cephalometric Analysis	2.28	1.25
Model Analysis	1.50	1.12

Discussion

Anchorage control remains one of the most critical aspects of orthodontic treatment, particularly in extraction cases where space closure is required. The present study evaluated the influence of age on anchorage loss during the initial leveling and alignment phase. The findings demonstrated that anchorage loss occurred in all patients; however, significantly greater anchorage loss was observed in younger individuals (≤20 years) compared to older patients (>20 years). These results highlight the importance of age as a biological factor influencing orthodontic tooth movement.

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The increased anchorage loss observed in younger patients in this study may be explained by differences in bone physiology and metabolic activity. Younger individuals typically exhibit higher cellular activity, faster bone turnover, and less dense alveolar bone, which facilitate more rapid tooth movement [17]. These biological characteristics may lead to increased susceptibility to unwanted tooth movement, including mesial migration of molars. In contrast, adult patients generally demonstrate slower bone remodeling due to reduced metabolic activity and increased cortical bone density, which may contribute to better anchorage preservation [18].

The findings of the present study are in agreement with previous research indicating that anchorage loss is influenced by patient-related biological factors, including age. Geron et al. reported that anchorage loss is a multifactorial phenomenon affected by variables such as age, crowding, and treatment mechanics, although age was considered a secondary factor [19]. Similarly, a large retrospective study demonstrated that adolescents are more prone to molar mesial tipping and anchorage loss compared to adults during orthodontic treatment [20]. These observations support the present study's results, where younger patients exhibited greater anchorage loss than older individuals.

However, some studies have reported contrasting findings. Geron et al. found a slightly greater anchorage loss in adults compared to adolescents, although the difference was not statistically significant [19]. This discrepancy may be attributed to differences in study design, sample size, type of mechanics used, and variation in anchorage preparation methods. Additionally, the present study focused specifically on the initial leveling and alignment phase, whereas other studies often evaluate anchorage loss during space closure, which may produce different outcomes.

In the current study, anchorage loss was assessed using both cephalometric and model analyses. The results showed consistent trends across both methods, with greater anchorage loss in the younger age group. This supports previous studies that have validated both cephalometric radiographs and study models as reliable tools for evaluating anteroposterior tooth movement [21]. The slightly higher values observed in cephalometric measurements compared to model analysis may be due to differences in reference points and measurement techniques.

The clinical implications of these findings are significant. Since younger patients are more prone to anchorage loss, clinicians should consider reinforcing anchorage during the early stages of treatment in this group. Various methods, including transpalatal arches, Nance appliances, and temporary anchorage devices (TADs), have been suggested to enhance anchorage control and minimize unwanted tooth movement [22]. The use of such adjuncts may be particularly beneficial in adolescent patients to prevent excessive anchorage loss and improve treatment outcomes.

Despite these findings, it is important to recognize that anchorage loss is influenced by multiple factors beyond age alone. Factors such as treatment mechanics, magnitude of force, amount of crowding, and patient compliance also play crucial roles in determining anchorage behavior [23]. Therefore, age should be considered as one of several contributing factors rather than the sole determinant of anchorage loss.

Conclusion

Anchorage loss was observed during the initial leveling and alignment phase in extraction cases, with a significantly greater magnitude in younger patients compared to older individuals. Age plays a notable role in influencing the extent of unwanted tooth movement. These findings highlight the importance of appropriate anchorage control strategies, especially in adolescent patients, to ensure effective and predictable orthodontic outcomes.

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