

Effect Of Pre-Treatment Educational Counseling on Psychological and Physiological Stress Responses During Orthodontic Bracket Bonding: A Randomized Controlled Trial

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Abstract

Introduction: Orthodontic bracket bonding may induce psychological and physiological stress responses that influence patient comfort and treatment acceptance. This study evaluated anxiety levels, salivary alpha-amylase activity, pulse rate, blood pressure, and oxygen saturation during initial orthodontic bracket bonding.

Methods: In this prospective observational study, 80 patients undergoing first-time fixed orthodontic treatment were recruited. Anxiety was assessed using the Modified Dental Anxiety Scale (MDAS). Salivary alpha-amylase activity, pulse rate, blood pressure, and oxygen saturation were recorded before, during, and after bracket bonding. Data were analyzed using repeated-measures analysis and correlation tests.

Results: The mean (SD) age of participants was 18.9 (3.4) years. Anxiety scores increased significantly following bracket bonding [11.8 (2.9) vs. 14.6 (3.4), $P < 0.001$]. Salivary alpha-amylase activity increased from 54.7 (18.6) U/mL to 83.2 (24.9) U/mL ($P < 0.001$). Significant increases were also observed in pulse rate and blood pressure during the procedure ($P < 0.05$). Oxygen saturation remained stable ($P = 0.417$). Anxiety scores showed a moderate positive correlation with salivary alpha-amylase activity ($r = 0.46$, $P < 0.001$).

Conclusion: Initial orthodontic bracket bonding was associated with increased anxiety and physiological stress responses. Salivary alpha-amylase may serve as a useful non-invasive biomarker for assessing treatment-related stress in orthodontic patients.

Keywords: Orthodontics; Anxiety; Salivary alpha-amylase; Stress; Blood pressure; Orthodontic bonding.

Introduction

Orthodontic treatment is one of the most commonly performed dental interventions for the correction of malocclusion and improvement of oral function and facial esthetics. Although orthodontic procedures are generally considered safe and minimally invasive, many patients experience anxiety before and during treatment. Anxiety associated with dental care has been recognized as an important psychological factor that may influence patient cooperation, treatment acceptance, appointment attendance, and overall satisfaction with care.^{1,2} Consequently, understanding patient responses during orthodontic procedures has become an important aspect of patient-centered orthodontic practice.

The initiation of orthodontic treatment is often associated with uncertainty and apprehension. For many patients, bracket bonding represents their first direct experience with fixed orthodontic appliances. Concerns regarding pain, discomfort, treatment duration, appearance, and possible complications may contribute to emotional distress before treatment begins. Previous studies have demonstrated that anticipation of dental procedures can activate physiological stress responses even in the absence of significant tissue injury or pain.^{2,4} Such responses may influence both psychological well-being and physiological functioning during treatment.

Stress and anxiety activate the autonomic nervous system, resulting in measurable physiological changes. Increased sympathetic activity may lead to elevations in heart rate, blood pressure, and stress-related salivary biomarkers. Among the available biomarkers, salivary alpha-amylase has emerged as a reliable and non-invasive indicator of sympathetic nervous system activation. Unlike blood-based markers, saliva collection is simple, painless, and well accepted by patients, making it particularly suitable for clinical and behavioral research.^{2,3} Several investigations have reported elevated salivary alpha-amylase levels in individuals exposed to acute psychological stress, including dental and orthodontic procedures.^{1,4}

Previous studies have evaluated stress responses during various dental treatments using both subjective and objective measures. Research has shown associations between dental anxiety and physiological indicators such as pulse rate, blood pressure, salivary cortisol, and salivary alpha-amylase.²⁻⁵ Similarly, studies involving orthodontic patients have reported increased levels of stress-related biomarkers during the early phases of fixed appliance therapy and following orthodontic mini-implant placement.^{1,6,10} These findings suggest that orthodontic treatment may elicit measurable psychophysiological responses. However, the magnitude and pattern of these responses appear to vary according to patient characteristics, treatment stage, and assessment methods.⁷

Although the relationship between dental anxiety and physiological stress has been extensively investigated, limited evidence is available regarding the simultaneous evaluation of psychological, biochemical, and physiological responses during routine orthodontic bracket bonding procedures. Most previous studies have focused on pain perception, salivary biomarkers, or isolated physiological parameters, while fewer investigations have examined these outcomes together during the initiation of fixed orthodontic treatment. Furthermore, oxygen saturation has received relatively little attention as a potential indicator of treatment-related stress in orthodontic patients.

A comprehensive assessment combining subjective anxiety measures with objective physiological and biochemical indicators may improve understanding of patient experiences during orthodontic treatment initiation. Such information may assist clinicians in identifying individuals at increased risk of treatment-related anxiety and support the development of strategies aimed at improving patient comfort and treatment acceptance.

Therefore, the present study aimed to evaluate psychological and physiological stress responses during initial orthodontic bracket bonding by assessing anxiety levels, salivary alpha-amylase activity, pulse rate, blood pressure, and oxygen saturation. In addition, the study sought to determine the relationship between self-reported anxiety and physiological stress markers during the bonding procedure.

Materials and Methods

Study Design and Setting

This prospective observational study was conducted in the Department of Orthodontics and Dentofacial Orthopedics. The study was designed to evaluate psychological and physiological stress responses associated with the initiation of fixed orthodontic treatment, specifically during the bracket bonding procedure.

Participants

Patients seeking fixed orthodontic treatment between January 2024 and December 2024 were screened for eligibility. Participants were recruited using a consecutive sampling approach. Patients were eligible for inclusion if they were between 12 and 30 years of age, scheduled for first-time fixed orthodontic treatment, and willing to participate in the study. Patients with a history of previous orthodontic treatment, systemic diseases affecting cardiovascular or endocrine function, diagnosed psychiatric disorders, ongoing use of anxiolytic medications, tobacco consumption, or acute oral and systemic infections were excluded.

Sample Size Calculation

The sample size was estimated using G*Power software (version 3.1). Based on previous studies evaluating changes in salivary alpha-amylase and anxiety-related parameters during dental procedures, an effect size of 0.30, a significance level of 5%, and a study power of 80% were considered. The minimum required sample size was calculated to be 72 participants. To compensate for possible dropouts and incomplete records, the final sample size was increased to 80 participants.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee Approval No. MDC0602/IEC-34/2023. The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all adult participants before enrollment. For participants younger than 18 years, parental consent and participant assent were obtained.

Data Collection

Data collection was performed on the day of bracket bonding. Demographic information, including age, sex, educational status, and previous dental experiences, was recorded using a structured questionnaire.

Assessment of Psychological Status

Participants' anxiety levels were assessed using the Modified Dental Anxiety Scale (MDAS), a validated instrument widely used to evaluate dental anxiety. The scale consists of five items, each scored on a five-point Likert scale. Total scores range from 5 to 25, with higher scores indicating greater anxiety. The questionnaire was administered 15 minutes before the bonding procedure and repeated immediately after completion of bonding to evaluate changes in anxiety perception.

Physiological Measurements

Physiological responses were assessed using pulse rate, oxygen saturation (SpO₂), and blood pressure measurements. Pulse rate and oxygen saturation were recorded using a calibrated fingertip pulse oximeter. Systolic and diastolic blood pressure were measured using an automated digital sphygmomanometer with the participant seated comfortably for at least five minutes before assessment.

Salivary Alpha-Amylase Analysis

Unstimulated whole saliva samples were collected using the passive drool technique. Participants were instructed to avoid eating, drinking, chewing gum, brushing their teeth, and performing vigorous physical activity for at least one hour before sample collection. Approximately 2 mL of saliva was collected into sterile collection tubes at designated time points. Samples were immediately transferred to a portable ice container and subsequently stored at -20°C until laboratory analysis. Salivary alpha-amylase activity was determined using a commercially available enzymatic colorimetric assay kit according to the manufacturer's instructions. The results were expressed as units per milliliter (U/mL).

Timing of Assessments

All measurements were obtained at three predefined time points:

T0 (Baseline): Fifteen minutes before bracket bonding

- Modified Dental Anxiety Scale score
- Salivary alpha-amylase level
- Pulse rate
- Oxygen saturation
- Blood pressure

T1 (During Bonding): Fifteen minutes after initiation of bracket bonding

- Pulse rate
- Oxygen saturation
- Blood pressure

T2 (Post-Bonding): Immediately after completion of bracket bonding

- Modified Dental Anxiety Scale score
- Salivary alpha-amylase level
- Pulse rate
- Oxygen saturation
- Blood pressure

Outcome Measures

The primary outcome measures were changes in anxiety scores and salivary alpha-amylase levels during the bonding procedure. Secondary outcome measures included changes in pulse rate, blood pressure, oxygen saturation, and the correlation between psychological anxiety scores and physiological stress markers.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics software version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as mean and standard deviation for continuous variables and frequency with percentage for categorical variables. Data distribution was evaluated using the Shapiro–Wilk test. Repeated measures analysis of variance (ANOVA) was used to compare normally distributed variables across different assessment time points. When normality assumptions were not met, the Friedman test was applied. Pairwise comparisons were performed using Bonferroni-adjusted post hoc tests. The relationship between anxiety scores and salivary alpha-amylase levels was assessed using Pearson or Spearman correlation analysis, as appropriate. Statistical significance was established at $P < 0.05$.

Results

A total of 80 participants completed the study and were included in the final analysis. No missing data were observed for any of the study variables. The mean (SD) age of the participants was 18.9 (3.4) years. Of the 80 participants, 42 (52.5%) were female and 38 (47.5%) were male. Most participants were between 15 and 20 years of age (61.3%). Changes in psychological and physiological parameters recorded before, during, and after bracket bonding are presented in Table 2. The mean anxiety score increased significantly following the bonding procedure. Similarly, salivary alpha-amylase levels showed a significant rise after treatment. Pulse rate, systolic blood pressure, and diastolic blood pressure increased during the bonding procedure and subsequently decreased following treatment completion. Oxygen saturation remained stable throughout the observation period. Repeated-measures analysis demonstrated significant differences in anxiety score, salivary alpha-amylase activity, pulse rate, systolic blood pressure, and diastolic blood pressure across the assessment periods ($P < 0.05$). No significant difference was observed for oxygen saturation ($P > 0.05$). Correlation analysis demonstrated a positive association between anxiety scores and salivary alpha-amylase activity. Moderate positive correlations were also observed between anxiety scores and cardiovascular parameters, particularly pulse rate and systolic blood pressure. Sex-based comparisons are presented in Table 4. Female participants demonstrated significantly higher anxiety scores and salivary alpha-amylase levels than male participants. No statistically significant sex differences were observed for pulse rate, blood pressure, or oxygen saturation. Overall, the findings indicated that the initial orthodontic bracket bonding procedure was associated with a measurable increase in both psychological anxiety and physiological stress responses. The greatest changes were observed in salivary alpha-amylase activity, pulse rate, and systolic blood pressure. In contrast, oxygen saturation remained largely unaffected by the procedure.

Discussion

The present study investigated psychological and physiological responses during initial orthodontic bracket bonding by evaluating anxiety levels, salivary alpha-amylase activity, pulse rate, blood pressure, and oxygen saturation. The findings demonstrated significant increases in anxiety scores, salivary alpha-amylase levels, pulse rate, and blood pressure during the bonding procedure, whereas oxygen saturation remained relatively unchanged. Furthermore, a moderate positive association was observed between anxiety scores and salivary alpha-amylase activity, indicating that subjective and objective indicators may reflect a common stress response during the initiation of orthodontic treatment.

The initiation of orthodontic treatment represents a unique clinical situation in which patients are exposed to an unfamiliar procedure, anticipated discomfort, and uncertainty regarding treatment outcomes. Although bracket bonding is generally considered minimally invasive, it may trigger anticipatory anxiety and sympathetic nervous system activation. In the present study, anxiety scores increased significantly following the bonding procedure, suggesting that the placement of fixed appliances may be perceived as a stressful event by many patients. Similar observations have been reported in previous investigations evaluating anxiety during dental and orthodontic procedures, where treatment anticipation was identified as a major contributor to emotional stress.^{2,4,5}

A principal finding of the present study was the significant increase in salivary alpha-amylase activity following bracket bonding. Salivary alpha-amylase is recognized as a sensitive marker of sympathetic-adrenal-medullary activation and has gained increasing attention as a non-invasive biomarker of acute psychological stress.² Previous investigations have demonstrated that salivary alpha-amylase levels increase in response to dental anxiety, procedural stress, and orthodontic treatment-related discomfort.^{1,3,4} The present findings are consistent with those

reports and further support the use of salivary alpha-amylase as a practical biomarker for assessing stress responses in orthodontic patients. Similar elevations in salivary alpha-amylase have been documented during the initial phases of fixed appliance therapy and during orthodontic mini-implant placement procedures.^{1,10}

Significant increases in pulse rate and blood pressure were also observed during bracket bonding. These findings are biologically plausible because activation of the sympathetic nervous system results in increased cardiac output and peripheral vascular resistance, leading to transient cardiovascular changes. Previous studies evaluating dental anxiety have similarly reported elevations in pulse rate and blood pressure during stressful dental procedures.^{4,5} The reduction of these parameters after completion of bonding suggests that the observed cardiovascular responses were temporary and associated primarily with procedural stress rather than any underlying pathological condition. In contrast, oxygen saturation remained stable throughout the assessment period. This observation is consistent with previous studies demonstrating that healthy individuals generally maintain normal oxygenation despite experiencing acute psychological stress.^{5,8} While anxiety-related sympathetic activation may influence cardiovascular parameters, its effect on peripheral oxygen saturation appears limited in healthy populations. Therefore, oxygen saturation may be less sensitive than salivary biomarkers or cardiovascular measurements for detecting treatment-related stress during orthodontic procedures.

Another important finding was the positive correlation between anxiety scores and salivary alpha-amylase activity. Participants who reported greater anxiety demonstrated higher levels of salivary alpha-amylase, suggesting a relationship between perceived psychological stress and physiological stress responses. Similar associations have been reported in studies examining dental anxiety and salivary biomarkers.^{2,3} However, not all investigations have reported consistent findings, and some authors have observed weak or non-significant associations between self-reported anxiety and biological stress markers. Differences in study populations, age groups, procedural characteristics, and saliva collection protocols may explain these discrepancies.⁷ Nevertheless, the present findings support the concept that salivary alpha-amylase may provide complementary information beyond that obtained through questionnaire-based assessments alone.

Female participants exhibited higher anxiety scores and salivary alpha-amylase levels than male participants. These findings are in agreement with previous studies reporting greater dental anxiety among females.^{4,8} Several explanations have been proposed, including differences in emotional processing, coping strategies, hormonal influences, and willingness to report anxiety-related symptoms. However, the clinical significance of sex-related differences remains uncertain, and additional studies involving larger and more diverse populations are required to clarify these observations.

From a clinical perspective, the findings highlight the importance of recognizing anxiety during the early stages of orthodontic treatment. Anxiety may influence patient cooperation, treatment acceptance, appointment attendance, and overall treatment experience. Early identification of anxious individuals may allow clinicians to implement targeted behavioral interventions, provide enhanced patient education, and improve communication during treatment initiation. Such approaches may contribute to improved patient satisfaction and more positive treatment experiences.

The present study has several strengths. First, both subjective and objective measures of stress were evaluated simultaneously, providing a comprehensive assessment of patient responses during bracket bonding. Second, repeated measurements allowed the evaluation of temporal changes throughout the procedure. Third, salivary alpha-amylase was assessed using a non-invasive approach that can be readily applied in clinical settings.

Several limitations should also be considered. The study was conducted at a single institution, which may limit the generalizability of the findings. Salivary cortisol was not evaluated; therefore, comparison between sympathetic nervous system activation and hypothalamic-pituitary-adrenal axis responses was not possible. In addition, long-term psychological adaptation following appliance placement was not investigated. Future multicenter studies with larger sample sizes and extended follow-up periods are warranted to better understand stress responses throughout orthodontic treatment.

Conclusion

Initial orthodontic bracket bonding was associated with significant increases in anxiety levels, salivary alpha-amylase activity, pulse rate, and blood pressure. A positive relationship between anxiety scores and salivary alpha-amylase activity was identified, supporting the usefulness of combining subjective and objective measures when evaluating treatment-related stress. These findings emphasize the importance of patient-centered anxiety management

strategies during the initiation of orthodontic treatment and support the potential application of salivary alpha-amylase as a non-invasive biomarker of procedural stress.

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Authors' Contribution

Conceptualization, Methodology, and Data collection was made by Siddharth Sonwane. Data analysis and interpretation, Writing – original draft, Writing – review and editing was made by dr. Shweta Sonwane. The authors have read and approved the final manuscript.

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Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethical Approval

The study protocol was approved by the Institutional Ethics Committee of Mansarovar Dental College and Hospital, Bhopal, India (Approval No. MDC0602/IEC-34/2023). Written informed consent was obtained from all participants before enrollment. For participants younger than 18 years, parental consent and participant assent were obtained.

Competing Interests

The authors declare that they have no competing interests.

Research Highlights

What is the current knowledge?

- Dental anxiety is frequently observed during the initiation of orthodontic treatment.
- Salivary alpha-amylase is a recognized biomarker of acute psychological stress.
- Physiological parameters such as pulse rate and blood pressure may change during stressful dental procedures.

What is new here?

- Orthodontic bracket bonding was associated with significant increases in anxiety scores, salivary alpha-amylase activity, pulse rate, and blood pressure.
- Salivary alpha-amylase demonstrated a positive correlation with self-reported anxiety levels.
- Oxygen saturation remained stable despite significant psychological and physiological stress responses.
- Salivary alpha-amylase may serve as a practical non-invasive biomarker for assessing procedural stress during orthodontic treatment.

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Tables

Table 1. Demographic Characteristics of the Participants (n=80)

Variable	n (%)
Sex	
Male	38 (47.5)
Female	42 (52.5)
Age group (years)	
12–14	12 (15.0)
15–20	49 (61.3)
21–30	19 (23.7)
Previous invasive dental experience	
Yes	28 (35.0)
No	52 (65.0)
Educational status	
School student	43 (53.8)
Undergraduate student	37 (46.2)

Table 2. Changes in Psychological and Physiological Parameters during Bracket Bonding (n=80)

Variable	Baseline (T0) Mean (SD)	During Bonding (T1) Mean (SD)	Post-Bonding (T2) Mean (SD)	P value
MDAS score	11.8 (2.9)	—	14.6 (3.4)	<0.001
Salivary alpha-amylase (U/mL)	54.7 (18.6)	—	83.2 (24.9)	<0.001
Pulse rate (beats/min)	76.3 (8.1)	84.7 (9.5)	79.8 (8.6)	<0.001
Systolic blood pressure (mmHg)	116.4 (9.2)	123.8 (10.1)	118.9 (8.8)	<0.001

Diastolic blood pressure (mmHg)	74.6 (6.4)	78.9 (7.2)	75.8 (6.7)	0.003
Oxygen saturation (%)	98.1 (0.8)	97.9 (0.9)	98.0 (0.8)	0.417

Table 3. Correlation between Post-Bonding Anxiety Scores and Physiological Parameters

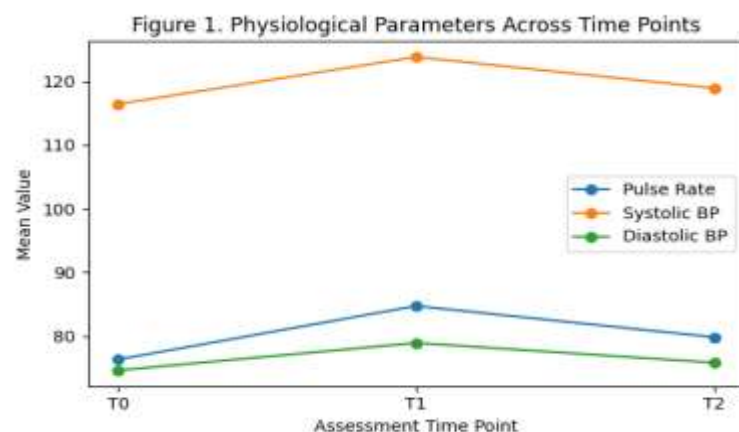
Variable	Correlation coefficient (r)	P value
Salivary alpha-amylase	0.46	<0.001
Pulse rate	0.39	0.001
Systolic blood pressure	0.34	0.003
Diastolic blood pressure	0.28	0.014
Oxygen saturation	-0.08	0.482

Table 4. Comparison of Post-Bonding Stress Parameters According to Sex

Variable	Male (n=38) Mean (SD)	Female (n=42) Mean (SD)	P value
MDAS score	13.2 (3.1)	15.8 (3.4)	0.002
Salivary alpha-amylase (U/mL)	77.5 (22.8)	88.4 (25.3)	0.041
Pulse rate (beats/min)	79.2 (8.4)	80.3 (8.8)	0.562
Systolic blood pressure (mmHg)	118.2 (8.7)	119.5 (8.9)	0.487
Diastolic blood pressure (mmHg)	75.1 (6.5)	76.4 (6.8)	0.351
Oxygen saturation (%)	98.1 (0.8)	97.9 (0.9)	0.276

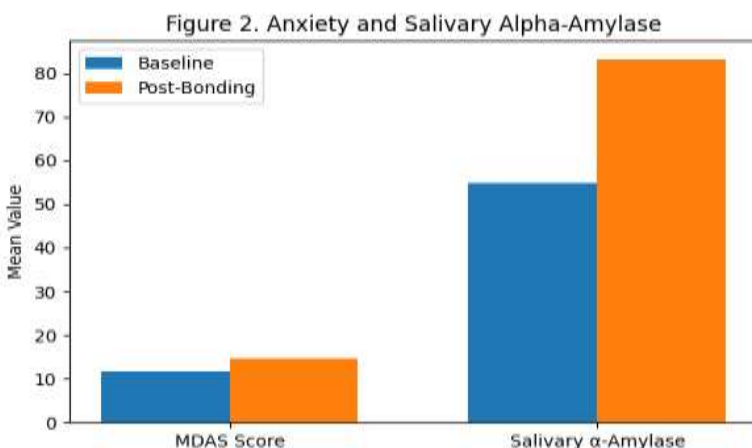
Figure Legends

Figure 1. Changes in physiological parameters during orthodontic bracket bonding.



Mean pulse rate, systolic blood pressure, and diastolic blood pressure measured before bracket bonding (T0), during bracket bonding (T1), and immediately after bracket bonding (T2). Significant increases in pulse rate and blood pressure were observed during the bonding procedure, followed by partial recovery after treatment completion. Abbreviations: T0, baseline assessment; T1, assessment during bracket bonding; T2, post-bonding assessment.

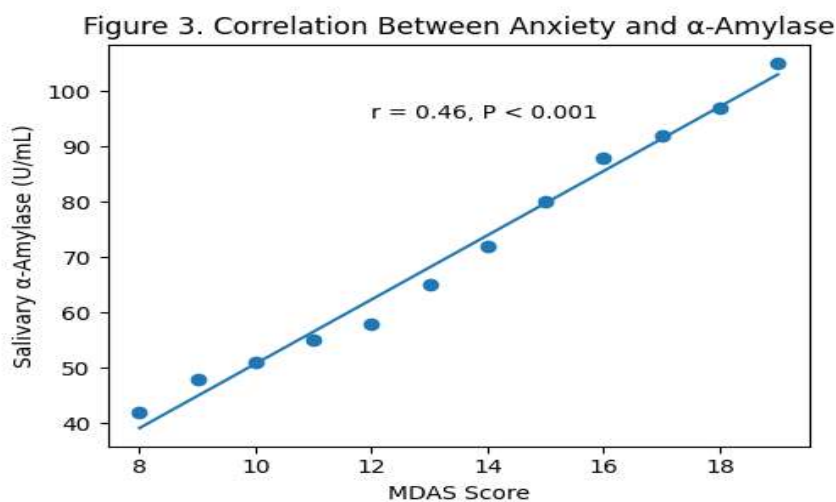
Figure 2 .Changes in anxiety scores and salivary alpha-amylase activity before and after orthodontic bracket bonding.



Comparison of mean Modified Dental Anxiety Scale (MDAS) scores and salivary alpha-amylase activity measured before bracket bonding and immediately after treatment completion. Both parameters demonstrated significant increases following the bonding procedure.

Abbreviations: MDAS, Modified Dental Anxiety Scale; U/mL, units per milliliter.

Figure 3. Correlation between anxiety scores and salivary alpha-amylase activity.



Scatter plot illustrating the relationship between post-bonding anxiety scores and salivary alpha-amylase levels. A moderate positive correlation was observed, indicating that participants with higher anxiety scores generally exhibited higher salivary alpha-amylase activity.

Abbreviations: MDAS, Modified Dental Anxiety Scale; U/mL, units per milliliter.