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Retrospective Evaluation of Cairo Classification of Gingival Recession Following Orthodontic Debonding Among Different Malocclusion Types

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Abstract:
The present retrospective institutional study aimed to evaluate the Cairo classification of gingival recession following orthodontic debonding among different malocclusion types. A total of 560 patient records from January 2020 to January 2025 were analyzed, including individuals who had completed fixed orthodontic treatment with comprehensive periodontal documentation. Gingival recession was classified according to Cairo's classification (RT1, RT2, RT3), and its association with malocclusion types and periodontal parameters was assessed. Results demonstrated that RT1 recession defects were the most prevalent (44.3%), followed by RT2 (35.9%) and RT3 (19.8%). Class II Division 1 and Class III malocclusions showed a significantly higher prevalence of advanced recession defects (RT2 and RT3), whereas Class I malocclusion predominantly exhibited RT1 defects. Additionally, patients with severe recession (RT3) demonstrated higher plaque index, gingival index, probing pocket depth, and clinical attachment loss, indicating compromised periodontal health. Statistical analysis revealed a significant association between malocclusion type and severity of gingival recession ($p < 0.05$). Within the limitations of the study, it can be concluded that certain malocclusion patterns, particularly Class II Division 1 and Class III, are associated with increased risk and severity of gingival recession following orthodontic debonding. Early identification of at-risk patients and implementation of preventive periodontal strategies during orthodontic treatment may help improve long-term periodontal outcomes.

Keywords: Gingival recession; Cairo classification; Orthodontic debonding; Malocclusion; Periodontal health; Class II Division 1; Class III malocclusion; Clinical attachment loss; Plaque index; Orthodontic treatment

Introduction

Orthodontic treatment is widely performed to improve dental esthetics, occlusal stability, mastication, and overall oral function. Advancements in orthodontic techniques and increased awareness regarding dental appearance have resulted in a growing number of patients seeking orthodontic therapy (1). Despite the functional and esthetic benefits associated with orthodontic treatment, the influence of orthodontic tooth movement on periodontal tissues continues to remain an important area of clinical concern. Maintenance of periodontal health during and after orthodontic treatment is essential for achieving long-term treatment success and stability.Orthodontic tooth movement involves remodeling of the periodontal ligament and alveolar bone in response to controlled mechanical forces (2,3). Although physiologic orthodontic movement can be achieved without significant periodontal damage under ideal conditions, excessive or improperly controlled tooth movement may contribute to undesirable periodontal alterations. Among these complications, gingival recession represents one of the most frequently reported periodontal changes following orthodontic treatment.

Gingival recession is defined as the apical migration of the gingival margin beyond the cemento-enamel junction, leading to exposure of the root surface. The condition may result in dentinal hypersensitivity, root caries, cervical abrasion, plaque accumulation, esthetic concerns, and compromised periodontal stability (4). Gingival recession is considered a multifactorial condition influenced by several predisposing and contributing factors including thin gingival phenotype, alveolar bone dehiscence, traumatic tooth brushing, plaque-induced inflammation, occlusal trauma, and orthodontic tooth movement. Orthodontic treatment may predispose patients to gingival recession through several mechanisms. Excessive labial movement of teeth beyond the alveolar housing may lead to thinning of the cortical plate and development of bone dehiscence, thereby increasing susceptibility to recession defects. In addition, orthodontic appliances may facilitate plaque accumulation and compromise oral hygiene maintenance, resulting in gingival inflammation and periodontal tissue breakdown (5). Prolonged treatment duration, poor plaque control, and unfavorable gingival phenotype may further aggravate the risk of recession development following orthodontic therapy.

The type and severity of malocclusion may also influence periodontal response during orthodontic treatment. Patients with severe crowding, proclination, deep bite, or skeletal discrepancies may require extensive orthodontic tooth movement, potentially increasing periodontal vulnerability. Certain malocclusion patterns such as Class II Division 1 malocclusion are commonly associated with proclined anterior teeth and thin labial cortical bone, which may predispose patients to gingival recession following orthodontic alignment (6). Similarly, Class III malocclusion may involve compensatory tooth positioning and periodontal stress that contribute to recession development. Accurate classification of gingival recession is important for periodontal diagnosis, treatment planning, and prognosis assessment. Various classification systems have been proposed to evaluate recession defects; however, the Cairo classification system has gained considerable clinical acceptance because it incorporates interproximal attachment loss into recession assessment. According to Cairo classification, gingival recession defects are categorized into RT1, RT2, and RT3 based on the relationship between buccal and interproximal clinical attachment loss. RT1 recession defects demonstrate no interproximal attachment loss, RT2 defects demonstrate interproximal attachment loss less than or equal to buccal attachment loss, and RT3 defects demonstrate greater interproximal attachment loss than buccal attachment loss (7). This classification system provides improved prognostic value and clinical relevance when compared to previous recession classification systems.Evaluation of Cairo classification of gingival recession following orthodontic debonding may provide valuable insight into the periodontal implications of orthodontic treatment among different malocclusion types. Identification of malocclusion patterns associated with increased prevalence or severity of gingival recession may help clinicians implement preventive periodontal measures during orthodontic therapy and improve long-term periodontal outcomes.Although several studies have evaluated gingival recession associated with orthodontic treatment, limited retrospective institutional studies have comprehensively assessed Cairo classification of gingival recession following orthodontic debonding among different malocclusion categories (8,9). Furthermore, assessment of recession patterns in relation to periodontal parameters may provide better understanding of periodontal tissue response following orthodontic treatment. Therefore, the present retrospective institutional study was undertaken to evaluate the Cairo classification of gingival recession following orthodontic debonding among different malocclusion types.

Materials and Methods

Study Design and Study Setting: The present study was designed as a retrospective institutional record-based study and was conducted in the Department of Periodontics in collaboration with the Department of Orthodontics of a dental teaching institution. Ethical clearance for the study was obtained from the Institutional Ethical Committee prior to commencement of data collection. Patient records archived in the institutional electronic database between January 2020 and January 2025 were systematically screened and analyzed. The study aimed to evaluate the Cairo classification of gingival recession following orthodontic debonding among different malocclusion types.

Study Population: Orthodontic patients who had completed fixed orthodontic treatment and underwent debonding procedures during the study period were screened for eligibility. A total of 560 patient records with complete orthodontic and periodontal documentation were included in the final analysis.

The selected records consisted of patients who had undergone comprehensive fixed orthodontic treatment and possessed complete periodontal assessment records before orthodontic treatment and after orthodontic debonding.

Inclusion Criteria

The following patient records were included in the study:

- Patients aged 18 years and above
- Patients who completed fixed orthodontic treatment
- Availability of complete periodontal charting records before and after orthodontic treatment
- Availability of intraoral clinical photographs
- Availability of documented malocclusion classification
- Patients with complete orthodontic treatment records and treatment duration details
- Patients who underwent routine orthodontic debonding procedures

Exclusion Criteria

The following patient records were excluded from the study:

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- Incomplete or duplicated patient records
- Patients with systemic diseases affecting periodontal health
- Smokers and tobacco users
- Patients with history of periodontal surgery prior to orthodontic treatment
- Patients with craniofacial anomalies or syndromes
- Patients treated exclusively with removable orthodontic appliances
- Patients with aggressive periodontitis or severe untreated periodontal disease before orthodontic treatment
- Patients with traumatic oral habits influencing gingival recession

Data Collection Procedure

The selected patient records were retrieved from the institutional digital database and evaluated by calibrated examiners. To minimize observer bias, all clinical findings were cross-verified using intraoral photographs, orthodontic records, and periodontal charting documentation available in the institutional database.

The following variables were recorded from the selected patient records:

Demographic Variables

- Age
- Gender

Orthodontic Variables

- Type of malocclusion
- Duration of orthodontic treatment
- Arch involved
- Presence of crowding or proclination
- Orthodontic debonding status

Periodontal Parameters

- Plaque Index (PI)
- Gingival Index (GI)
- Bleeding on probing (BOP)
- Probing pocket depth (PPD)
- Clinical attachment loss (CAL)
- Presence of gingival recession following debonding

Classification of Malocclusion

Malocclusion was categorized according to Angle's classification as:

- **Class I malocclusion**
- **Class II Division 1 malocclusion**
- **Class II Division 2 malocclusion**
- **Class III malocclusion**

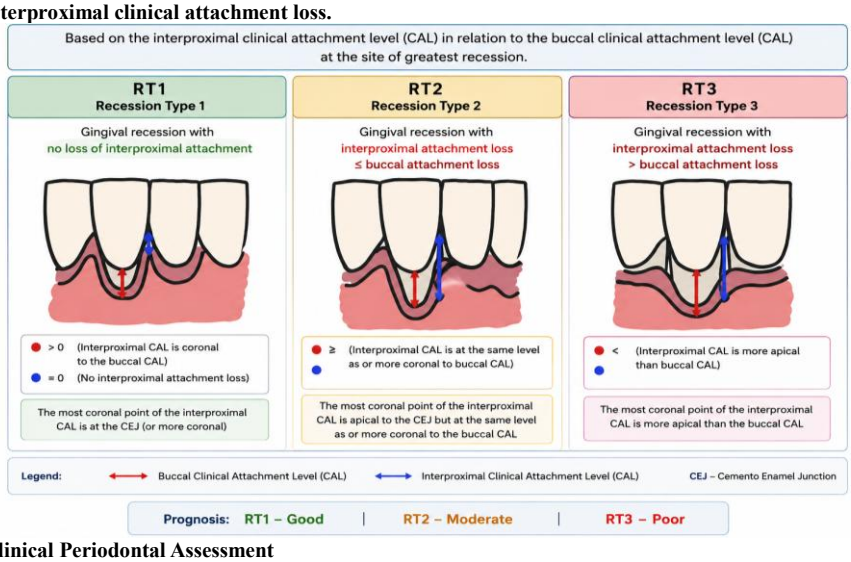
Assessment of Gingival Recession: Gingival recession following orthodontic debonding was evaluated from periodontal charting records and intraoral clinical photographs. Recession was assessed based on the apical migration of the gingival margin relative to the cemento-enamel junction.

Cairo Classification of Gingival Recession

Gingival recession defects were classified according to Cairo classification as follows (depicted in Figure 1)

- **RT1:** Gingival recession without loss of interproximal attachment. Interproximal cemento-enamel junction was not clinically detectable at both mesial and distal aspects.
- **RT2:** Gingival recession associated with interproximal attachment loss less than or equal to buccal attachment loss.
- **RT3:** Gingival recession associated with interproximal attachment loss greater than buccal attachment loss.
- The classification was performed using recorded clinical attachment levels and periodontal charting data.

Figure 1 : Diagrammatic representation of Cairo's classification of gingival recession (RT1, RT2, and RT3) based on the relationship between buccal and interproximal clinical attachment loss.



Clinical Periodontal Assessment

Plaque Index (PI)

Plaque accumulation was assessed using Plaque Index scores documented in patient records. Increased plaque accumulation following orthodontic treatment was considered indicative of compromised oral hygiene maintenance.

Gingival Index (GI)

Gingival inflammation was evaluated using Gingival Index scores based on gingival color, edema, and bleeding tendency.

Bleeding on Probing (BOP)

Presence or absence of bleeding on probing was recorded as an indicator of gingival inflammation.

Probing Pocket Depth (PPD)

Probing pocket depth measurements were obtained from recorded periodontal charting using a graduated periodontal probe.

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Clinical Attachment Loss (CAL)
Clinical attachment loss was evaluated using periodontal charting records and documented in millimeters.
Calibration and Reliability
Clinical records and photographs were independently evaluated by calibrated examiners to reduce inter-examiner variability. Random re-evaluation of selected records was performed to ensure consistency of recorded findings.
Statistical Analysis
All collected data were entered into Microsoft Excel spreadsheets and analyzed using SPSS software version 23.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as frequency, percentage, mean, and standard deviation. Association between malocclusion type and Cairo classification of gingival recession was analyzed using Chi-square test. Comparison of periodontal parameters among malocclusion categories was performed using one-way ANOVA followed by post hoc analysis wherever required. A p-value less than 0.05 was considered statistically significant for all statistical analyses.
Results
A total of 560 orthodontic patient records archived between January 2020 and January 2025 were included in the final analysis. Among the study population, 302 patients (53.9%) were females and 258 patients (46.1%) were males. The mean age of the study population was 23.8 ± 4.6 years.
Among the evaluated malocclusion types, Class I malocclusion constituted the highest proportion with 218 patients (38.9%), followed by Class II Division 1 malocclusion with 176 patients (31.4%), Class II Division 2 malocclusion with 92 patients (16.4%), and Class III malocclusion with 74 patients (13.2%).
Assessment of Cairo classification following orthodontic debonding demonstrated that RT1 recession defects were the most frequently observed category overall. RT1 recession was identified in 248 patients (44.3%), RT2 recession in 201 patients (35.9%), and RT3 recession in 111 patients (19.8%).
Class II Division 1 malocclusion demonstrated a comparatively higher prevalence of gingival recession following orthodontic debonding. Among Class II Division 1 patients, RT1 recession defects were observed in 72 patients (40.9%), RT2 recession defects in 69 patients (39.2%), and RT3 recession defects in 35 patients (19.9%). Similarly, Class III malocclusion demonstrated increased prevalence of advanced recession defects, with RT3 recession observed in 26 patients (35.1%).
Class I malocclusion predominantly demonstrated RT1 recession defects, which were identified in 118 patients (54.1%), whereas RT3 recession defects were comparatively less frequent in this group and observed in only 24 patients (11.0%). Class II Division 2 malocclusion demonstrated comparatively lower prevalence of severe recession defects compared to Class II Division 1 and Class III malocclusion.
Evaluation of periodontal parameters demonstrated increased plaque accumulation and gingival inflammation among patients with advanced recession defects. Patients with RT3 recession demonstrated the highest mean Plaque Index score (2.12 ± 0.42), Gingival Index score (1.94 ± 0.37), probing pocket depth (4.2 ± 0.6 mm), and clinical attachment loss (3.1 ± 0.7 mm). In contrast, RT1 recession defects demonstrated comparatively lower periodontal parameter values.
Statistical analysis demonstrated a significant association between malocclusion type and Cairo classification of gingival recession following orthodontic debonding ($p = 0.001$). A statistically significant association was also observed between severity of recession defects and periodontal parameters including Plaque Index, Gingival Index, probing pocket depth, and clinical attachment loss ($p < 0.05$).
Table 1. Comparison of Cairo classification of gingival recession and periodontal parameters among different malocclusion types following orthodontic debonding. (n = 560)

Variable	Class I n=218 (%)	Class II Div 1 n=176 (%)	Class II Div 2 n=92 (%)	Class III n=74 (%)	Total n (%)	p-value
Male	96 (44.0)	88 (50.0)	42 (45.7)	32 (43.2)	258 (46.1)	0.684
Female	122 (56.0)	88 (50.0)	50 (54.3)	42 (56.8)	302 (53.9)	
RT1 Recession	118 (54.1)	72 (40.9)	42 (45.7)	16 (21.6)	248 (44.3)	0.001*
RT2 Recession	76 (34.9)	69 (39.2)	38 (41.3)	18 (24.3)	201 (35.9)	0.003*
RT3 Recession	24 (11.0)	35 (19.9)	12 (13.0)	26 (35.1)	111 (19.8)	0.001*
Plaque Index	1.21 ± 0.32	1.84 ± 0.41	1.58 ± 0.36	2.12 ± 0.42	—	0.002*
Gingival Index	1.08 ± 0.24	1.67 ± 0.35	1.42 ± 0.29	1.94 ± 0.37	—	0.001*
Mean Probing Pocket Depth (mm)	2.6 ± 0.4	3.5 ± 0.5	3.1 ± 0.4	4.2 ± 0.6	—	0.002*
Clinical Attachment Loss (mm)	1.1 ± 0.3	2.3 ± 0.5	1.8 ± 0.4	3.1 ± 0.7	—	0.001*

*Statistically significant ($p < 0.05$)

Discussion
The present retrospective institutional study evaluated the Cairo classification of gingival recession following orthodontic debonding among different malocclusion types. The findings demonstrated a significant association between malocclusion pattern and severity of gingival recession following orthodontic treatment. Class II Division 1 and Class III malocclusion demonstrated comparatively higher prevalence of advanced recession defects, whereas Class I malocclusion predominantly exhibited RT1 recession defects with relatively lesser periodontal involvement (10).
Orthodontic treatment is primarily aimed at improving dental esthetics, occlusal stability, and oral function; however, orthodontic tooth movement may also influence periodontal tissues when movement exceeds the physiologic limits of the alveolar housing. Gingival recession following orthodontic treatment is considered multifactorial and may result from excessive labial tooth movement, thin gingival phenotype, plaque accumulation around orthodontic appliances, traumatic brushing habits, and inadequate periodontal support. The present study assessed recession defects using the Cairo classification system, which is considered clinically relevant because it incorporates interproximal attachment loss into recession assessment and provides improved prognostic value (11).
In the present study, RT1 recession defects were the most frequently observed category overall. RT1 recession represents buccal gingival recession without interproximal attachment loss and is generally associated with favorable periodontal prognosis and improved predictability for root coverage procedures. The predominance of RT1 defects suggests that mild periodontal changes following orthodontic debonding are more common when periodontal support is relatively preserved (12). This finding may indicate that controlled orthodontic tooth movement with adequate oral hygiene maintenance can minimize severe periodontal destruction.
Class I malocclusion predominantly demonstrated RT1 recession defects with comparatively lower prevalence of RT3 recession. This may be attributed to less complex orthodontic mechanics and reduced requirement for excessive anterior proclination in Class I malocclusion patients. Orthodontic correction in these patients generally involves comparatively lesser movement beyond the alveolar envelope, thereby reducing periodontal stress and susceptibility to severe recession defects (13).
In contrast, Class II Division 1 malocclusion demonstrated increased prevalence of RT2 and RT3 recession defects. This finding may be associated with proclined maxillary anterior teeth and thin labial cortical bone commonly observed in these patients. Orthodontic correction involving significant labial movement may predispose teeth to alveolar bone dehiscence and gingival recession, particularly in patients with thin periodontal phenotype. Excessive proclination and inadequate periodontal thickness may therefore contribute to increased recession severity following orthodontic treatment (14).

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Class III malocclusion demonstrated the highest prevalence of RT3 recession defects in the present study. RT3 recession defects are characterized by interproximal attachment loss greater than buccal attachment loss and are generally associated with poorer root coverage prognosis. The increased prevalence of RT3 recession among Class III patients may be related to compensatory orthodontic tooth movement, skeletal discrepancies, and compromised periodontal support. Orthodontic treatment in Class III malocclusion frequently requires significant incisor compensation and extensive tooth movement, which may increase periodontal stress and contribute to greater attachment loss (9).

The present study also demonstrated significantly higher Plaque Index and Gingival Index scores among patients with advanced recession defects. Orthodontic appliances create plaque-retentive areas around brackets and wires that may compromise oral hygiene maintenance. Persistent plaque accumulation can initiate gingival inflammation, which further contributes to periodontal tissue breakdown and recession progression. Increased gingival inflammation observed in RT2 and RT3 recession defects highlights the importance of maintaining adequate plaque control throughout orthodontic treatment.

Patients with advanced recession defects also demonstrated increased probing pocket depth and clinical attachment loss. Chronic inflammatory changes associated with plaque accumulation and prolonged orthodontic treatment may contribute to apical migration of junctional epithelium and periodontal attachment loss. These findings emphasize the need for routine periodontal monitoring during orthodontic therapy, particularly in patients with predisposing malocclusion patterns and thin gingival phenotype (15).

The present study has certain limitations. Being retrospective in nature, the study depended on the accuracy and completeness of archived patient records, clinical photographs, and periodontal charting. Factors such as gingival phenotype, brushing technique, orthodontic force magnitude, treatment duration variability, and patient compliance could not be standardized. Long-term periodontal follow-up after orthodontic debonding was also not available for all patients. In addition, radiographic evaluation of alveolar bone thickness and dehiscence was not performed. Despite these limitations, the study included a considerable sample size and utilized Cairo classification for recession assessment, thereby providing valuable insight into the periodontal implications of orthodontic treatment among different malocclusion types.

Conclusion

Within the limitations of the present retrospective study, Class II Division 1 and Class III malocclusion demonstrated increased prevalence and severity of Cairo classified gingival recession following orthodontic debonding. RT1 recession defects were most commonly observed overall, while advanced RT2 and RT3 recession defects were more frequently associated with severe malocclusion patterns and compromised periodontal parameters.

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