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Original Article

Orthodontic treatment in patients with chronic periodontitis significantly improves periodontal health

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Abstract: Objective: To investigate alterations in inflammatory biomarkers and systemic homeostasis in patients with chronic periodontitis following orthodontic intervention. Methods: Clinical data of 80 chronic periodontitis patients, treated between April 2019 and April 2024, were retrospectively analyzed. Patients were stratified into two groups: a control group (n=32) receiving standard periodontal therapy and a research group (n=48) undergoing additional orthodontic treatment. Comprehensive clinical evaluations were conducted, including assessments of therapeutic outcomes, periodontal parameters (tooth mobility [TM], gingival index [GI], papillary bleeding index [PBI], and probing depth [PD]), inflammatory biomarkers (interleukin [IL]-2 and IL-8), oral health-related quality of life (Oral Health Impact Profile-14 [OHIP-14]), and masticatory efficiency. Additionally, plaque control efficacy was evaluated using the modified plaque index (mPLI) and modified sulcus bleeding index (mSBI), while gingival architecture was assessed by the papilla index score (PIS). Results: Compared to the control group, the research group demonstrated significantly superior outcomes, including higher overall treatment efficacy, improved masticatory function, and greater patient satisfaction ($P<0.05$). Additionally, post-treatment assessments revealed significantly lower values in the research group for TM, GI, PBI, PD, mPLI, mSBI, PIS, IL-2, IL-8, and OHIP-14 scores. Conclusions: Orthodontic therapy in chronic periodontitis patients not only improves periodontal health but also reduces systemic inflammatory responses, thereby promoting the restoration of oral-systemic homeostasis.

Keywords: Chronic periodontitis, orthodontic therapy, inflammatory biomarkers, systemic homeostasis

Introduction

Periodontal disease represents a complex, multifactorial chronic inflammatory disorder that compromises the integrity of the periodontal attachment apparatus, including gingival tissue, root cementum, periodontal ligament, and alveolar bone, ultimately leading to tooth loss and impaired quality of life [1, 2]. Clinically, it encompasses two clinical entities: gingivitis and periodontitis, with untreated gingivitis frequently serving as a precursor to periodontitis [3]. Common clinical presentations include gingival edema, erythema, ulceration, and bleeding upon probing, typically accompanied by progressive destruction of periodontal supporting structures [4, 5].

The pathogenesis of periodontal disease is multifactorial, involving dysbiotic infections by periodontal pathogens in genetically predisposed individuals, coupled with aberrant immune responses [6]. Affecting approximately 50% of the global population, its prevalence continues to rise, making it a major public health concern [7]. Beyond its local manifestations, periodontal disease is closely associated with systemic conditions, particularly diabetes mellitus, cardiovascular diseases, and adverse pregnancy outcomes, highlighting the importance of effective periodontal management in improving overall health outcomes [8]. While conventional periodontal therapy remains fundamental in managing chronic periodontitis, its limitations in addressing patients' multifaceted needs - ranging from aesthetic demands to psychosocial and professional requirements - have driven an increasing demand for adjunctive orthodontic interventions [9]. Contemporary orthodontic treatment, as a sophisticated interdis-

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ciplinary approach, facilitates three-dimensional control of tooth positioning and optimization of occlusal-skeletal relationships, contributing not only to the restoration of functional occlusion but also to enhanced facial aesthetics and improved quality of life [10, 11]. The integration of orthodontic treatment into periodontal therapy has been substantiated by emerging evidence. Gehlot et al. [12] demonstrated that orthodontic intervention not only preserves but also enhances periodontal health compared to conventional therapy alone. Similarly, Papageorgiou et al. [13] confirmed the feasibility of orthodontic treatment in severe periodontitis cases, noting modest improvements in periodontal parameters without compromising treatment stability. However, the current evidence remains inconclusive, with some lower-quality studies indicating neutral effects of orthodontic treatment on periodontal outcomes across various patient populations [14].

Despite these advancements, critical knowledge gaps remain regarding the therapeutic efficacy of orthodontic treatment in chronic periodontitis patients, particularly concerning its impact on inflammatory biomarkers and systemic homeostasis. This study aims to address these gaps through a systematic evaluation of periodontal outcomes, inflammatory responses, and homeostatic changes following orthodontic intervention in chronic periodontitis patients. The findings are anticipated to contribute to the development of optimized, evidence-based treatment protocols for integrated periodontal-orthodontic therapy.

Materials and methods

Case selection

This retrospective study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Baoding No. 1 Central Hospital. A total of 80 patients with chronic periodontitis, treated between April 2019 and April 2024, were enrolled. Participants were allocated to either conventional periodontal therapy (control group, n=32) or conventional therapy plus orthodontic treatment (research group, n=48). Baseline demographic and clinical characteristics showed no significant differences between groups ($P > 0.05$), ensuring clinical comparability.

Inclusion criteria: (1) Diagnosis of chronic periodontitis according to established criteria [15]; (2) No history of periodontal treatment within the preceding 6 months; (3) Absence of contraindications to the proposed treatments; (4) Complete clinical documentation; (5) No contraindications for radiographic examination; and (6) Normal communication and cognitive abilities.

Exclusion criteria: (1) Severe horizontal or vertical alveolar bone resorption; (2) Presence of periodontal abscesses or oral mucosal diseases (e.g., ulcers, herpes); (3) Cystic lesions or malignancies in the jaw region; (4) Active infectious diseases; (5) Severe cardiovascular disorders; (6) Temporomandibular joint disorders; (7) Hematological disorders; or (8) Recent use of medications that might influence study outcomes.

Intervention methods

The control group underwent conventional periodontal therapy, including scaling and root planing to remove dental calculus and necrotic cementum. Periodontal pockets were thoroughly debrided to eliminate residual calculus, diseased tissue, and defective restorations, ensuring optimal gingival tissue adaptation to tooth surfaces. Additionally, adjunctive antibiotic gels were applied, and patients were instructed to maintain proper daily oral hygiene practices. Upon significant improvement of periodontitis symptoms, conventional removable partial dentures were fabricated and placed.

The research group received adjunctive orthodontic treatment following the same conventional therapy described above. The orthodontic treatment protocol was implemented as follows: A straight-wire appliance system was utilized, with molar buccal tubes replacing conventional bands. Brackets were carefully bonded to the anterior teeth, with careful attention to gingival health. Initial alignment was achieved using titanium alloy archwires, followed by the application of Australian archwires for anterior tooth intrusion. Continuous elastic chain traction was applied in the anterior region, with periodic evaluations of periodontal support capacity. Controlled retraction of both upper and lower anterior teeth was performed, adhering to the principle of light-force mechanics throughout the treatment.

Patients in both groups completed a 12-month treatment period. The research group received

additional monthly clinical evaluations to assess treatment progress and adjust orthodontic forces based on periodontal tissue response and alveolar bone remodeling. Professional periodontal maintenance was performed every month, and radiographic assessments were conducted every three months to monitor treatment progress and periodontal status.

Data collection

(1) Treatment Efficacy Evaluation: Therapeutic outcomes were categorized based on comprehensive clinical and radiographic assessments. *Markedly Effective* was defined as optimal denture comfort and aesthetics, absence of inflammatory signs, restored gingival coloration, significant improvement in masticatory function, and radiographic evidence of clear lamina dura. *Effective* corresponds to satisfactory denture comfort and aesthetics, mild gingival erythema, notable restoration of gingival coloration, substantial recovery of masticatory function, and relatively distinct lamina dura on radiographs. *Ineffective* was defined by poor denture comfort and aesthetics, persistent gingival erythema, minimal improvement in gingival coloration or masticatory function, and radiographic evidence of severe alveolar bone resorption.

(2) Periodontal Parameter Assessment: The following indices were recorded at baseline (before treatment) and 12 months post-treatment: tooth mobility (TM), GI, papillary bleeding index (PBI), and PD.

(3) Plaque and Gingival Health Indices: The modified plaque index (mPLI), modified sulcus bleeding index (mSBI), and papilla index score (PIS), were assessed at baseline and 12 months post-treatment. Grading criteria were as follows: mPLI: 0 (no visible plaque), 1 (presence of plaque); mSBI: 0 (no bleeding), 1 (isolated bleeding points), 2 (bleeding line along the gingival sulcus), or 3 (spontaneous bleeding); PIS: 0 (absence of papilla), 1 (papilla height <50% of the interdental space), 2 (papilla height ≥50%), 3 (papilla fully fills the interdental embrasure space), or 4 (papillary hyperplasia).

(4) Inflammatory Biomarker Quantification: Fasting venous blood samples (3 mL) were collected at baseline and 1 month after treatment. Serum levels of IL-2 and IL-8 were quantified using enzyme-linked immunosorbent assay (ELISA, Wuhan Yipu Biotechnology Co., Ltd., CSB-E04626h, CSB-EQ027463HU) following standard centrifugation protocols.

(5) Oral Health Impact Assessment: Oral health-related quality of life was evaluated using the OHIP-14 scale [16], covering seven domains: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap. The 14-item questionnaire yields a total score ranging from 0 to 56, with lower scores indicating better oral health-related quality of life.

(6) Masticatory Function Analysis: Masticatory efficiency was assessed at baseline, 6 months, and 12 months after treatment using the sieving method. Patients were instructed to chew 3g of dried peanuts for 20 cycles, followed by expectoration and sieving. The weight of the dried residue was measured to quantify masticatory performance.

(7) Treatment Satisfaction Survey: At 12 months, a validated 100-point questionnaire was administered to assess satisfaction across four domains: treatment methodology, service quality, procedural comfort, and therapeutic effectiveness. Satisfaction levels were categorized as highly satisfied (≥85), satisfied (76-84), moderately satisfied (61-75), or dissatisfied (≤60). The overall satisfaction rate was calculated as the sum of highly satisfied, satisfied, and moderately satisfied percentages.

Primary outcome measures included treatment efficacy, TM, GI, PBI, PD, mPLI, mSBI, PIS, IL-2, IL-8, and OHIP-14 scores. Secondary outcomes comprised masticatory function and treatment satisfaction.

Statistical methods

All data were analyzed using SPSS 22.0 (IBM Corp., Armonk, NY, USA) and visualized with GraphPad Prism 7.0. Continuous variables were presented as mean ± standard error of the mean (Mean ± SEM). Between-group comparisons were conducted using independent samples t-tests, while within-group comparisons (pre- vs. post-intervention) were performed using paired t-tests. For variables measured at multiple time points, repeated-measures analysis of variance (ANOVA) was applied to assess the effects of time, group, and their interaction. When a significant interaction was detected,

Table 1. Comparison of baseline data between the two groups

Baseline characteristics	Control group (n=32)	Research group (n=48)	χ^2/t	*P*
Gender			0.330	0.566
Male	22 (68.75)	30 (62.50)		
Female	10 (31.25)	18 (37.50)		
Age (years)	62.47±6.75	62.42±8.21	0.029	0.977
Disease duration (months)	14.66±3.54	14.33±4.86	0.330	0.742
Smoking history	16 (50.00)	16 (33.33)	2.222	0.136
Alcoholism history	14 (43.75)	20 (41.67)	0.034	0.854

Table 2. Comparison of therapeutic efficacy between the two groups

Efficacy	Control group (n=32)	Research group (n=48)	χ^2	*P*
Markedly effective	15 (46.88)	28 (58.33)		
Effective	9 (28.13)	17 (35.42)		
Ineffective	8 (25.00)	3 (6.25)		
Total effective rate	24 (75.00)	45 (93.75)	5.692	0.017

simple effects were analyzed using independent t-tests for between-group comparisons at each time point and paired t-tests for within-group comparisons across time points. Bonferroni correction was applied to adjust for multiple comparisons. Categorical data were presented as frequencies (percentages) and compared using chi-square (χ^2) tests. Statistical significance was defined as a *P*-value less than 0.05.

Results

Comparison of baseline characteristics between the two groups

No significant differences were observed between the control and research groups in baseline characteristics, including gender, age, disease duration, smoking history, or alcohol consumption history (all *P*>0.05, **Table 1**).

Comparison of therapeutic efficacy between the two groups

The total effective rate was 93.75% in the research group, significantly higher than 75.00% in the control group (*P*<0.05, **Table 2**).

Comparison of TM, GI, PBI, and PD values between the two groups

There were no significant differences in TM, GI, PBI, or PD between the two groups at baseline (*P*>0.05). After treatment, all parameters showed significant reductions in both groups (*P*<0.05), with the research group demonstrating significantly lower values compared to the control group (all *P*<0.05) (**Figure 1**).

Comparison of mPLI, mSBI, and PIS values between the two groups

The research group exhibited significantly lower mPLI, mSBI, and PIS values compared to the control group (all *P*<0.01) (**Figure 2**).

Comparison of IL-2 and IL-8 levels between the two groups

No significant differences were observed between groups in IL-2 or IL-8 at baseline (*P*> 0.05). Post-treatment, both groups demonstrated significant reductions (*P*<0.05), with the research group achieving markedly lower levels compared to the control group (*P*<0.05) (**Figure 3**).

Comparison of OHIP-14 scores between the two groups

No significant differences in OHIP-14 scores were observed between groups at baseline (*P*>0.05). At 6- and 12- months post-treatment, both groups exhibited progressive declines in OHIP-14 scores (*P*<0.05), with the research group consistently scoring significantly lower than the control group (*P*<0.001) (**Table 3**).

Comparison of masticatory function between the two groups

Baseline masticatory function showed no significant intergroup differences (*P*>0.05). At 6-

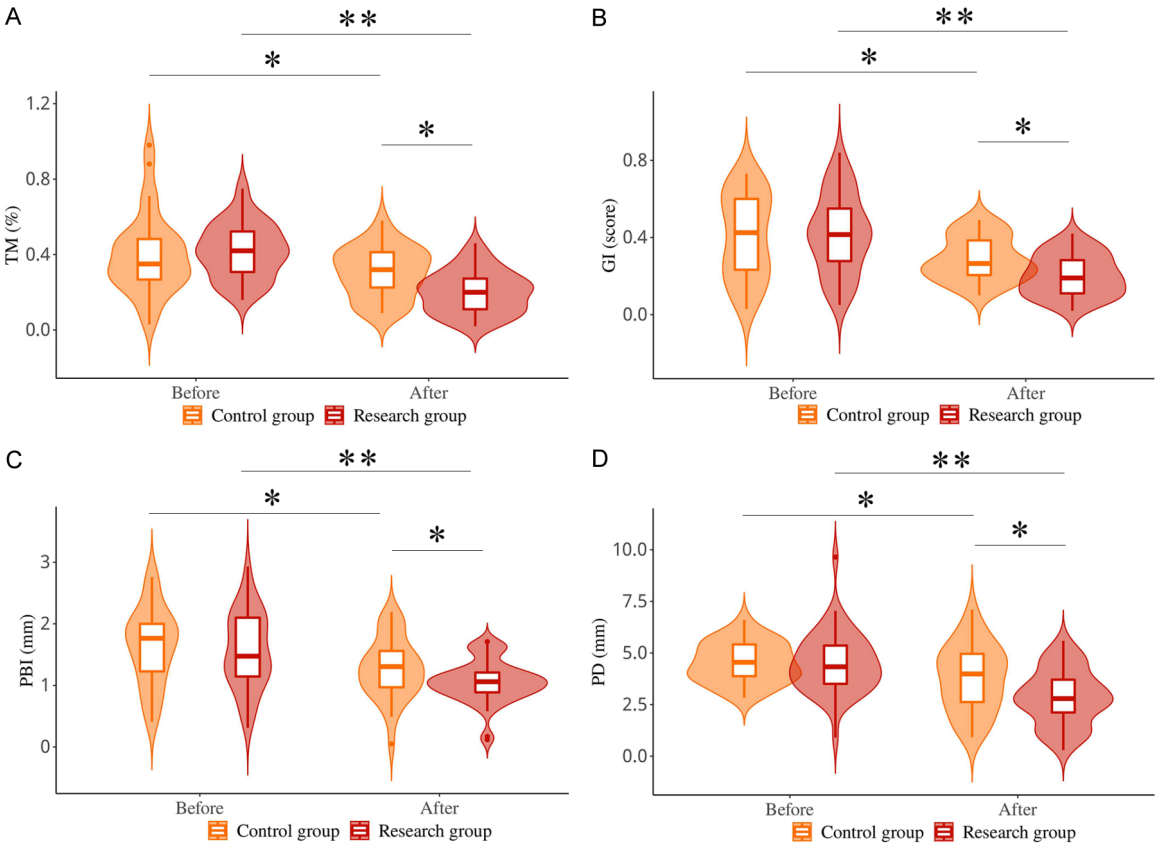

Figure 1. Comparison of TM, GI, PBI, and PD between the two groups. A. Pre- and post-treatment TM in the control and research groups. B. Pre- and post-treatment GI in the control and research groups. C. Pre- and post-treatment PBI in the control and research groups. D. Pre- and post-treatment PD in the control and research groups. Notes: *P<0.05, **P<0.01 (between-group comparison). TM, tooth mobility; GI, gingival index; PBI, papillary bleeding index; PD, probing depth.

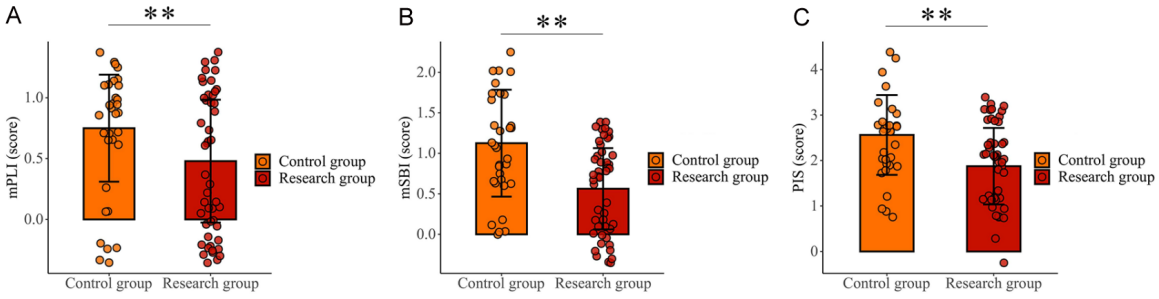

Figure 2. Comparison of mPLI, mSBI, and PIS between the two groups. A. Post-treatment mPLI in control and research groups. B. Post-treatment mSBI in control and research groups. C. Post-treatment PIS in control and research groups. Note: **P<0.01. mPLI, modified plaque index; mSBI, modified sulcus bleeding index; PIS, papilla index score.

and 12- months post-treatment, both groups demonstrated significant improvements in masticatory function (P<0.05), with the research group outperforming the control group (P< 0.001) (**Table 4**).

Comparison of treatment satisfaction between the two groups

The research group reported a significantly higher overall treatment satisfaction rate

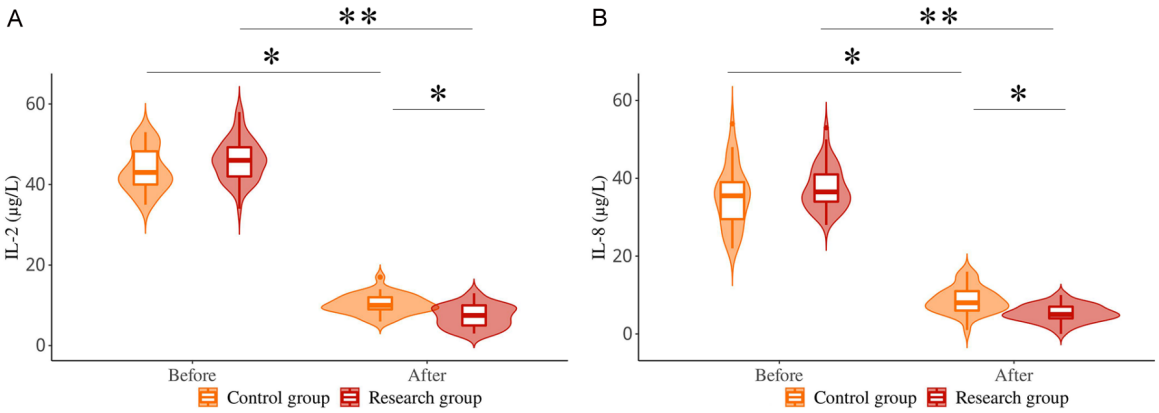

Figure 3. Comparison of IL-2 and IL-8 between the two groups. A. Pre- and post-treatment IL-2 levels in control and research groups. B. Pre- and post-treatment IL-8 levels in control and research groups. Note: *P<0.05, **P<0.01. IL, interleukin.

Table 3. Comparison of OHIP-14 scores between the two groups

OHIP-14 (points)	Control group (n=32)	Research group (n=48)	t	P
Before treatment	26.88±4.96	26.17±5.01	0.623	0.535
6 months after treatment	20.31±4.87[b]	15.52±4.25[b]	4.657	<0.001
12 months after treatment	16.47±2.75[c,d]	12.88±3.87[c,d]	4.535	<0.001

Notes: OHIP-14, Oral Health Impact Profile-14. [b]P<0.01 vs. pre-treatment; [c]P<0.001 vs. pre-treatment; [d]P<0.05 vs. 6-month post-treatment.

Table 4. Comparison of masticatory function between the two groups

Masticatory function (%)	Control group (n=32)	Research group (n=48)	t	P
Before treatment	52.91±4.67	51.92±5.51	0.835	0.406
6 months after treatment	83.59±6.69[b]	90.60±4.77[b]	5.473	<0.001
12 months after treatment	88.38±4.69[c,d]	92.69±4.96[c,d]	3.890	<0.001

Notes: [b]P<0.01 vs. pre-treatment; [c]P<0.001 vs. pre-treatment; [d]P<0.05 vs. 6-month post-treatment.

Table 5. Comparison of treatment satisfaction between the two groups

Treatment satisfaction	Control group (n=32)	Research group (n=48)	χ^2	P
Highly Satisfied	14 (43.75)	25 (52.08)		
Satisfied	9 (28.13)	20 (41.67)		
Moderately satisfied	3 (9.38)	1 (2.08)		
Dissatisfied	6 (18.75)	2 (4.17)		
Total satisfaction	26 (81.25)	46 (95.83)	4.537	0.033

compared to the control group (P<0.05) (**Table 5**).

Discussion

Researchers have increasingly explored innovative strategies to enhance periodontal disease management. For instance, Sllamniku Dalipi Z et al. [17] highlighted that calcium and vitamin D supplementation serves as a non-surgical adjunctive therapy for periodontal disease, leveraging its dual benefits in modulating bone metabolism and remodeling. Similarly, Gheisary Z et al. [18] revealed that probiotic supplementation not only improves clinical periodontal parameters but also reduces pathogenic microbial colonization and suppresses pro-inflammatory cytokine levels. In a novel approach, Constantin M et al. [19] developed a biocompatible polyvinyl alcohol (PVA)/chito-

san film incorporating silver nanoparticles and ibuprofen, exhibiting robust bioadhesion and minimal cytotoxicity, thus offering promising potential for localized periodontal therapy.

In this study, we compared conventional periodontal therapy (control group) with a multidisciplinary orthodontic intervention (research group). The orthodontic approach achieved a substantially higher total efficacy rate compared to conventional methods (93.75% vs. 75.00%). This superiority may stem from the effective correction of malocclusion under orthodontic intervention, which facilitates the restoration and stabilization of periodontal tissues [20]. Furthermore, orthodontic treatment often involves a multidisciplinary team comprising periodontists, orthodontists, prosthodontists, hygienists, implantologists, and endodontists. Such interdisciplinary collaboration enables biomechanically optimized treatment plans, integrating functional rehabilitation with biological preservation - a hallmark of evidence-based periodontal care [21]. Consistent with our findings, Zhang J et al. [22] reported favorable clinical outcomes with combined orthodontic-periodontal therapy in the management of periodontitis.

In addition, orthodontic intervention led to significant reductions in periodontal parameters, including TM, GI, PBI, PD, mPLI, mSBI, and PIS, in patients with chronic periodontitis, indicating its efficacy in improving periodontal status and reinforcing its therapeutic potential in periodontal management. Consistent with our findings, Li Y et al. [23] demonstrated that adjunctive orthodontic treatment following basic periodontal therapy significantly improved periodontal parameters, including GI, PBI, PD, and mPLI. Concurrently, inflammatory markers IL-2 and IL-8 exhibited pronounced downregulation following orthodontic treatment, indicative of suppressed local inflammatory cascades. Prior studies have established the intimate association of IL-2 and IL-8 with orthodontic tooth movement. Notably, IL-2 is linked to chronic periodontitis exacerbated by hyperglycemia and smoking, whereas IL-8 gene polymorphisms correlate with susceptibility to chronic periodontitis [24-26]. These findings are supported by Matsuda S et al. [27], who reported IL-6 reduction following periodontal therapy in systemically healthy individuals, and Xin TY et al. [28], who documented controlled inflammation in orthodontically treated grade C periodontitis patients.

Furthermore, orthodontic intervention also resulted in progressive and significant declines in OHIP-14 scores, demonstrating its positive impact on oral health-related quality of life. Malocclusion critically exacerbates functional limitations, psychological distress, and disabilities across OHIP-14 domains, underscoring the necessity of orthodontic integration in comprehensive periodontal care [29]. Supporting our results, Olkun HK et al. [30] found that orthodontic intervention markedly enhanced oral health-related quality of life (OHRQoL) across patients with varying treatment complexities.

Moreover, diminished periodontal support adversely impacts masticatory efficiency and quality of life [31], deficits that were effectively mitigated by orthodontic intervention in our cohort. This finding aligns with prior studies demonstrating improved masticatory function following orthodontic treatment in adult patients with cleft lip and palate [32]. Finally, patients receiving orthodontic treatment reported significantly higher levels of treatment satisfaction, underscoring its clinical acceptability. Wu P et al. [33] similarly observed that combining periodontal regeneration with orthodontic therapy significantly enhanced patient satisfaction compared to conventional periodontal treatment alone, reinforcing our conclusions.

This study has several limitations that warrant further investigation. First, the underlying mechanisms by which orthodontic treatment exerts its effects remain incompletely understood. Future studies should explore how orthodontic forces modulate inflammatory signaling pathways in periodontal ligament cells, particularly fibroblasts and immune cells. Second, the absence of long-term follow-up (beyond five years) limits the evaluation of post-treatment periodontal stability and relapse risk. Longitudinal studies with extended follow-up are needed to better assess the durability of treatment outcomes. Finally, the study did not compare the efficacy of different orthodontic modalities (e.g., clear aligners vs. fixed appliances). A comparative analysis in future research could help determine the optimal treatment approach for specific clinical scenarios.

In summary, orthodontic intervention in patients with chronic periodontitis delivers comprehensive therapeutic advantages. It significantly enhances clinical efficacy, optimizes periodontal parameters (TM, GI, PBI, PD, mPLI, mSBI, and PIS), and restores oral health homeostasis by suppressing inflammatory mediators (IL-2 and IL-8). Concurrently, it improves masticatory function and patient satisfaction, addressing both functional malocclusion and aesthetic concerns. These findings offer valuable insights for local dental practitioners, offering actionable strategies to refine therapeutic paradigms in periodontally compromised populations.

Disclosure of conflict of interest

None.

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