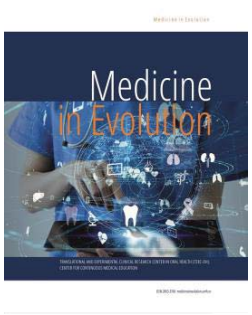
# Biomechanical Strategies and Compliance Monitoring for Orthodontic Treatment in Periodontally Compromised Adults

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## Abstract

Background: Orthodontic treatment in adults with reduced periodontal support requires interdisciplinary sequencing and strict plaque control; however, heterogeneity of periodontal phenotypes, biomechanics, and adjunctive therapies makes standardized clinical outcome evaluation challenging. This study therefore prioritised clinical compliance and cooperation as key modifiable determinants of safe treatment delivery. Biomechanical strategies are presented to contextualize clinical management and were not evaluated as study endpoints. Objective: To assess patient cooperation during late active orthodontic therapy and clinical compliance during early retention in adults with stage I–II periodontitis. Materials and methods: A prospective clinical study was conducted in 25 adults (17 women, 8 men; 29–51 years) diagnosed with stage I–II periodontitis. Following periodontal stabilisation (non-surgical therapy in all cases; adjunctive periodontal surgery in 12%), orthodontic treatment was delivered using individualised, low-force biomechanics with periodic periodontal monitoring. Cooperation was assessed using the Orthodontic Patient Cooperation Scale (OPCS). Compliance during retention was assessed using a Clinical Compliance Evaluation (CCE) form at 6 months (T1) and 12 months (T2) after transition to retention. Non-parametric tests were used to compare timepoints and sex-based differences. Results: Women showed higher compliance scores for motivation/enthusiasm and fewer complaints about wearing appliances. CCE total scores improved significantly from T1 to T2 (86.20±14.73 vs 96.20±2.96; p=0.001), with a concurrent improvement in the oral hygiene subscore (23.12±1.64 vs 23.60±0.82; p=0.010). Conclusions: Structured compliance monitoring can support adherence during retention in periodontitis-susceptible adults undergoing orthodontic treatment. Larger controlled studies integrating standardised periodontal endpoints are required to clarify how compliance trajectories translate into long-term periodontal stability and orthodontic outcomes.

**Keywords:** periodontitis, orthodontic treatment, patient compliance, cooperation, retention, interdisciplinary car

## INTRODUCTION

Periodontal disease is a common chronic condition in adults that leads to progressive loss of the tooth's supporting structures, often resulting in gingival recession, alveolar bone loss, tooth mobility, and pathologic tooth migration [5; 15]. In its advanced form (Stage IV periodontitis), the disease can cause secondary malocclusions such as flaring and drifting of incisors, bite collapse from posterior tooth loss, and occlusal trauma, all of which impair function and aesthetics [5; 29]. With the rising demand for adult orthodontic treatment and the prevalence of periodontitis in middle-aged populations, clinicians are increasingly managing complex cases of malocclusion associated with reduced periodontal support [16; 21]. Orthodontic intervention in periodontitis patients is no longer contraindicated per se – on the contrary, it is often an integral part of comprehensive rehabilitation aimed at restoring a stable occlusion and improving oral health-related quality of life [15; 16]. Recent consensus guidelines emphasize that orthodontic treatment can be performed safely in patients with a history of periodontitis, provided the periodontal inflammation is first controlled and the disease stabilized [3; 16]. Orthodontic realignment in these cases may facilitate better plaque control, redistribute occlusal forces, and aid in periodontal maintenance, thereby potentially improving long-term outcomes [9; 21].

Despite these potential benefits, the scientific evidence on orthodontic outcomes in periodontally compromised adults remains difficult to interpret. Every patient presents a unique combination of disease severity, anatomical bone loss patterns, and treatment needs, making standardized protocols and outcome measures challenging to establish [17; 30]. Traditional orthodontic success metrics (e.g., tooth movement achieved or occlusal indices) may be less meaningful in this context than periodontal stability and tooth survival – outcomes which are multifactorial and heavily influenced by patient behavior. Research shows that when periodontal health is stabilized, orthodontic tooth movement usually does not exacerbate attachment loss [3; 17]. However, variability in case presentations and the necessity of individualized biomechanics have led to heterogeneous study designs and often inconclusive or low-quality evidence [17; 19]. Considering these challenges, the present study focuses on a critical modulator of success that transcends individual techniques or appliances: patient cooperation and clinical compliance. We hypothesize that in periodontally compromised adults, adherence to oral hygiene and maintenance regimens, as well as compliance with orthodontic instructions, are pivotal determinants of favorable outcomes, potentially outweighing the choice of specific biomechanical strategies. This article outlines the rationale and aims of our investigation into biomechanical approaches for these patients, and why patient cooperation was chosen as a central variable of interest. Biomechanical considerations are therefore included as background to the clinical pathway; the present study does not compare specific mechanics or quantify orthodontic tooth movement as an endpoint. This rationale is based on the fact that methodologically, "outcomes" in periodontal-orthodontic care are rarely comparable across patients because both orthodontic objectives and periodontal baselines (defect morphology, tooth mobility, and selectively indicated adjunctive procedures) are case-specific. Pooling periodontal endpoints would require extensive stratification by phenotype and planned movements/anchorage, which quickly becomes underpowered and drives heterogeneity in the evidence base [17; 30]. Therefore, we treated biomechanics as individualized clinical context (after periodontal stabilisation) and prioritised cooperation/compliance as the cross-cutting endpoint enabling safe execution of the interdisciplinary plan.

Orthodontic treatment and periodontal health are deeply interrelated, especially in adult patients. Active periodontitis causes attachment loss and often leads to pathologic tooth

migration – for example, flared or extruded anterior teeth and formation of diastemas as bone support is lost [5; 29]. These changes can further impair oral function and aesthetics, creating a clear indication for orthodontic intervention once the disease is controlled. Conversely, malocclusion itself can exacerbate periodontal problems: crowding and malpositioned teeth hinder oral hygiene, and deep overbites or traumatic occlusion can injure the periodontium [16]. A synergistic approach has therefore emerged in which combined periodontal-orthodontic therapy is employed to restore oral health. After initial periodontal therapy to eliminate inflammation, gentle orthodontic forces are applied to reposition teeth in more favorable alignment, which can reduce plaque stagnation areas, distribute forces evenly, and facilitate restorative procedures [16; 21]. Recent systematic reviews have indeed noted that periodontitis patients treated with integrated orthodontic therapy show improved clinical parameters compared to periodontal treatment alone, although the gains tend to be modest [19; 29]. Importantly, long-term follow-up studies up to 10 years demonstrate that such interdisciplinary treatment can achieve stable outcomes, with minimal recurrence of periodontal breakdown when maintenance care is rigorous [3; 13]. These findings underscore that orthodontic treatment, when performed on a stabilized periodontium, is not only safe but can also enhance overall prognosis of a compromised dentition [3; 15].

Performing orthodontics on a reduced periodontium necessitates special biomechanical considerations and presents several challenges. By definition, periodontally compromised adults have lost varying amounts of alveolar bone support, which alters the center of resistance of teeth and makes them more susceptible to damage from excessive forces. Therefore, light and controlled forces, longer pauses between activations, and shorter treatment phases are generally recommended to minimize risks such as orthodontic-induced root resorption or further bone loss [7; 23]. The presence of infrabony defects or furcation involvements adds complexity: certain movements (for instance, uncontrolled tipping or extrusion of teeth with vertical defects) can aggravate periodontal breakdown if done improperly or in the presence of inflammation [15; 26]. Biomechanical strategies in these patients often include using sectional mechanics or splints to stabilize teeth with reduced support, intrusion of supra-erupted teeth to level the occlusal plane (only after inflammation is resolved), and skeletal anchorage devices (TADs) or splinted anchorage to distribute forces more safely [11; 14]. Each case must be planned individually: for example, pathologically migrated anterior teeth in a patient with Stage IV periodontitis may require intrusion and retraction with very mild continuous forces, whereas a different patient might need molar uprighting using a segmented arch to avoid stressing adjacent periodontally involved teeth (Chele 2016; 11). This individualized planning is compounded by patient-specific factors (age, smoking status, systemic health, etc.) that affect healing and tissue response. Because of these variables, research gaps remain in our knowledge – there is a lack of high-level evidence (few randomized trials) and existing studies are hard to compare due to inconsistent case selection and outcome measures [17; 30]. A systematic review by Kloukos et al. (2022) highlighted that evidence on combined ortho-perio treatment in severe periodontitis is limited and heterogenous, with many studies being retrospective or case series prone to bias [17]. Similarly, a 2016 review by Zasčiurinskienė et al. noted that while numerous case reports document successful outcomes, there was insufficient standardized data to quantify the periodontal effects of orthodontics in periodontitis-susceptible patients [30]. Key questions – such as the optimal timing of orthodontics relative to periodontal therapy, or the extent to which orthodontic movement can regenerate bone in vertical defects – are still difficult to answer definitively due to these research challenges [16; 25].

On balance, current knowledge supports the notion that orthodontic treatment is feasible and beneficial in periodontally compromised adults under certain conditions. First and foremost, the periodontal disease must be stabilised: clinicians agree that active

periodontal inflammation is a contraindication to orthodontic force, because moving teeth in the presence of uncontrolled periodontitis can accelerate attachment loss [15; 16]. The European Federation of Periodontology S3 guidelines [16] stipulate that orthodontic therapy should commence only after successful initial periodontal therapy – defined by the absence of deep pockets and bleeding on probing – and this often involves re-evaluating the patient after each phase of periodontal treatment. Studies have explored different sequencing; for example, one clinical trial found that starting orthodontics concurrently with cause-related periodontal therapy yielded similar attachment level gains as waiting until after periodontal treatment, though pockets tended to heal slightly better when orthodontics was deferred [28]. Another multicenter trial examined timing orthodontics after periodontal regenerative surgery and reported no significant difference in outcomes whether orthodontic movement began 1 month versus 6 months post-surgery [16; 25]. These findings suggest a degree of flexibility in treatment timing, provided that meticulous plaque control is maintained. Nonetheless, a common theme is that supportive periodontal therapy (maintenance) is essential throughout orthodontic care and beyond. Patients must be kept on a strict maintenance schedule (e.g., professional cleanings every 3–4 months) to monitor periodontal indices and address any signs of recurrence immediately [2]. Indeed, a 30-year follow-up study demonstrated that with regular supportive periodontal care, even patients with initially advanced periodontitis could retain the vast majority of their teeth, whereas those who became erratic in maintenance had significantly higher risk of tooth loss [2]. Thus, while biomechanical techniques (such as force selection, anchorage methods, and use of adjunctive surgery) are important, they operate on a foundation that is fundamentally biological and patient dependent.

Given the multifactorial nature of these cases, one of the most decisive factors is the patient's own cooperation. Successful periodontal-orthodontic treatment requires the patient to maintain impeccable daily oral hygiene, comply with periodontal maintenance visits, and follow orthodontic instructions [3; 4]. Poor plaque control will quickly negate any potential benefit of orthodontic alignment by allowing gingival inflammation to recur, potentially leading to progressive bone loss even during treatment. Similarly, if patients do not attend regular maintenance or if they smoke or neglect risk factor modification, the carefully calibrated orthodontic movements could result in undesired outcomes like increased pocket depths or recession [3; 15]. On the orthodontic side, compliance may involve wearing elastics or removable aligners as instructed, avoiding detrimental habits or excessive forces on teeth, and generally engaging with the treatment process. Adults with periodontal histories may have complex treatment plans (for instance, alternating periodontal surgeries with orthodontic adjustments), which absolutely require the patient's understanding and cooperation to succeed [26]. Unfortunately, clinical studies that focus on hard outcomes (attachment level changes, bone fill on radiographs, etc.) often cannot fully capture this human element. The decision to center our study on clinical compliance and patient cooperation arises from both clinical experience and evidence in the literature: high compliance has been correlated with favorable long-term results in periodontally compromised cases. For example, Aimetti et al. (2022) reported that in a cohort of severe periodontitis patients treated with combined orthodontics, all the teeth with initial "hopeless" prognoses remained stable over 10–15 years if the patients were highly compliant with maintenance – a remarkable outcome attributed to strict plaque control and maintenance care. By contrast, teeth in non-compliant patients or those lost to follow-up were far more likely to be lost (3). This aligns with earlier observations that orthodontics in periodontitis patients "improves the possibilities of saving a deteriorated dentition" only when periodontal support is meticulously preserved by the patient's and clinician's efforts [15]. Thus, focusing on compliance is not to downplay the importance of biomechanics, but rather to acknowledge that even the best biomechanical plan will falter in the absence of patient cooperation. Our

study aims to explore this often-under-emphasized aspect, examining how different strategies to engage and motivate patients – as well as the design of treatment plans those patients can realistically adhere to – might influence overall treatment success.

## MATERIAL AND METHODS

A prospective clinical investigation was conducted within the Department of Orthodontics at University Dental Clinic No. 2 of "Nicolae Testemitanu" State University of Medicine and Pharmacy (Ethics Committee approval – no. 1 of 08.11.2024). The study evaluated patient compliance in adults undergoing periodontal-orthodontic management. Orthodontic therapy was delivered only after periodontal stabilization, and adjunctive prosthodontic and/or implantological interventions were performed when clinically indicated as part of comprehensive rehabilitation.

The study group comprised 25 adult patients (17 women and 8 men) aged 29–51 years. All participants were diagnosed with Stage I or Stage II periodontitis according to the 2017 classification of periodontal diseases and presented orthodontic treatment needs related to dento-maxillary anomalies (e.g., crowding, interdental spacing, and/or pathological tooth migration). Given the multifactorial nature of clinical outcomes in periodontal patients receiving orthodontic treatment, the present investigation focused on clinical compliance as the primary study endpoint rather than on heterogeneous clinical outcomes. This methodological choice is supported by evidence showing that, even among adult orthodontic patients in general, cooperation/compliance and—critically—oral-hygiene maintenance varies across treatment stages and tend to deteriorate as treatment progresses, which can directly affect the risk profile and management needs during mechanotherapy [20].

Consequently, standard clinically investigated periodontal variables (probing data) were used for eligibility and safety monitoring (confirmation of stabilisation before appliance placement and periodic surveillance), but changes in periodontal indices were not modelled as primary endpoints because baseline- and intervention-related variability would confound between-patient comparisons. By contrast, adherence behaviours – plaque control, appointment attendance, appliance wear and maintenance – are required in all cases and directly determine whether the planned low-force biomechanics and supportive periodontal therapy can be delivered as intended. For this reason, validated compliance instruments (OPCS and CCE) were selected as the primary outcome measures.Moreover, the periodontal–orthodontic interface is particularly sensitive to plaque-mediated inflammation: fixed appliances favor biofilm retention and shifts in periodontal conditions, and the literature emphasizes completing periodontal therapy and maintaining strict inflammation control before and throughout orthodontic tooth movement to reduce the likelihood of periodontal breakdown [18].

Accordingly, structured compliance monitoring and reinforcement (including targeted communication strategies shown to improve oral-hygiene adherence) represent a clinically justified approach for standardizing follow-up in a cohort where clinical outcome variability is intrinsically high [8]. Prior to initiation of orthodontic therapy, each patient underwent comprehensive periodontal evaluation and a treatment protocol aimed at controlling inflammation and stabilizing the periodontal condition. This phase included individualized oral-hygiene instruction, professional plaque and calculus removal by scaling, and root surface debridement. In 3 out of 25 cases (12%), deep periodontal pockets and persistent inflammation required surgical intervention; these patients received flap surgery combined with root planning to improve access for decontamination and to facilitate periodontal healing. Periodontal monitoring included periodontal probing, assessment of tooth mobility, evaluation of plaque and calculus indices, and documentation of gingival recession. The

periodontal status was reassessed after initial therapy to confirm resolution of active inflammation before orthodontic planning and appliance placement.

Orthodontic treatment was initiated using individualized biomechanical strategies adapted to each patient's periodontal status. Anchorage planning, force calibration, and appliance selection were tailored to minimize stress on compromised periodontal structures. Throughout treatment, patients were periodically re-evaluated to monitor periodontal stability and to ensure that orthodontic forces remained within biologically acceptable limits. These biomechanical strategies were individualized as part of routine care and are reported descriptively only; no standardized or comparative biomechanical analysis was undertaken.Orthodontic documentation and baseline characterization included medical history and standard extraoral and intraoral clinical examination, extraoral photostatic assessment, and paraclinical investigations (panoramic radiography/OPG, computed tomography/CT when indicated, cephalometry including lateral cephalogram/TRG, and study model analysis).

*Study design and outcome focus*

Participants were evaluated in both the active phase (fixed appliance therapy) and the passive phase (retention). At the end of the active phase, overall adherence was assessed using the Orthodontic Patient Cooperation Scale (OPCS). After transition to retention, patients were followed for 12 months, and compliance was longitudinally recorded using the Clinical Compliance Evaluation (CCE) instrument. Compliance levels were compared at 12 months (T2) versus 6 months (T1), both for the overall CCE score and across its specific domains. Patient cooperation throughout orthodontic therapy was measured using the OPCS (Orthodontic Patient Cooperation Scale), developed by Slakter et al. (1980) [24]. The instrument comprises 10 items capturing distinct behavioral aspects and is rated on a 5-point Likert scale (Never, Rarely, Sometimes, Frequently, Always). OPCS includes five positively worded and five negatively worded items; negatively phrased items are reverse scored, such that higher total scores indicate better compliance. The scale can be applied at different time points during treatment as clinically indicated. Clinical compliance during retention was assessed using the Clinical Compliance Evaluation (CCE) instrument proposed by Richter et al. (1998) [22]. The CCE provides a quantitative appraisal of patient compliance across four determinants of treatment success: oral hygiene status, appointment punctuality, adherence to prescribed appliance wear, and maintenance of orthodontic devices. The four compliance domains are equally weighted, yielding similar maximum domain scores (approximately 24–25 points each), for a maximum total score of 99 points; the CCE wording was adapted to the retention appliances used. Oral hygiene was evaluated using a modified version of the Simplified Oral Hygiene Index (OHI-S; Green–Vermillion) with a dental mirror, dental probe, and plaque-disclosing agent (Plaquefinder, Curaprox, Switzerland). The buccal surfaces of the maxillary permanent first molars, the maxillary right permanent central incisor, the mandibular left permanent central incisor, and the lingual surfaces of both mandibular permanent molars were examined. Scoring reflected the location and extent of plaque at the tooth/retainer interface (4 points: no deposits; 3 points: <1/3; 2 points: >1/3 to ≤2/3; 0 points: >2/3), with a maximum total hygiene score of 24 points. Appointment punctuality was scored on a five-level scale (25 points for delay <15 minutes; 20 points for 15–30 minutes; 15 points for >30 minutes; 10 points for rescheduling within 24 hours; 0 points for non-attendance). Retainer wear was scored on a nine-level scale based on the percentage of prescribed wear time achieved, and retainer maintenance was scored on a four-level defect scale. For each CCE domain, raw scores were additionally converted into grades.

Patient data were entered into a tabular database using Microsoft Excel 2019 (Microsoft, USA). Statistical analyses were performed in RStudio (Posit Software, USA), including descriptive statistics, between-group comparisons using Student's t-test (Welch

modification), and repeated-measurement analyses using the paired Wilcoxon test. Statistical significance was set at $p < 0.05$.

A B

Figure 1. Example of plaque control and patient instruction before orthodontic treatment (A. Result after application of plaque revealer (Plaquefinder, Curaprox, Switzerland); B. Result after oral hygienization procedure)

## RESULTS

The study enrolled 25 adult patients (women: n=17, 68%; men: n=8, 32%) with stabilized Stage I–II periodontitis who had completed the active phase of orthodontic treatment; retention was initiated. Participants were aged 29–51 years. The evaluated patients were examined using the OPCS (*Orthodontic Patient Cooperation Scale*) questionnaire at the end of active orthodontic treatment (Table 1). Based on this instrument, the patient's behaviors and their degree of compliance were assessed by the orthodontist. Thus, in general, we observe that according to the total OPCS score, the given patients had a fairly high level of compliance (34.08±6.714 points), but the analysis of individual cases revealed that compliance was quite variable (range of values from 23-40 points). Women generally demonstrated a higher level of compliance than men (35.82±5.434 vs. 30.38±7.99 points), but this trend did not approach statistical significance ($p = 0.111$). Comparable scores were observed in men and women for most of the items, without any statistical significane, such as appointment adherence and punctuality; family/support network involvement; family-related problems/strained relationships; complaints about treatment procedures. Although non-significant, per case scoring showed that men have a trend in lower compliance scores regarding appliance integrity, hostile attitude, cooperation with adjuncts to treatment (eg. elastics) and oral hygiene quality. It is to be noted that statistically significant sex-related differences were identified for patient enthusiasm/motivation in treatment ($p = 0.046$) and complaints about wearing appliances ($p = 0.045$), with women demonstrating higher compliance scores on both items, while men showing lower compliance on these items.

Table 1. OPCS (Orthodontic Patient Cooperation Scale) questionnaire scores administered at the end of active orthodontic treatment

| | Gender | Mean±SD | Minimum | Maximum | Statistic (Welch t) | *p* |
|---|---|---|---|---|---|---|
| ***OPCS Item 1.* Appointments/punctuality** | M (n = 8) | 3.75±0.707 | 2 | 4 | 0.5123 | .616 |
| | F (n = 17) | 3.59±0.795 | 1 | 4 | | |
| ***OPCS Item 2.* Appliance integrity (damage/loose components)** | M (n = 8) | 2.88±1.126 | 1 | 4 | -1.3709 | .201 |
| | F (n = 17) | 3.47±0.717 | 2 | 4 | | |
| ***OPCS Item 3.* Support-person engagement (partner/family/caregiver involved)** | M (n = 8) | 3.50±0.926 | 2 | 4 | -0.4220 | .683 |
| | F (n = 17) | 3.65±0.493 | 3 | 4 | | |
| ***OPCS Item 4.* Family/relationship stressors affecting cooperation** | M (n = 8) | 3.88±0.354 | 3 | 4 | -0.0494 | .961 |
| | F (n = 17) | 3.88±0.332 | 3 | 4 | | |
| ***OPCS Item 5.*** | M (n = 8) | 2.38±1.408 | 1 | 4 | -2.3662 | **.046** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Motivation/enthusiasm for treatment** | F (n = 17) | 3.59±0.507 | 3 | 4 | | |
| ***OPCS Item 6*. Negative/hostile demeanor (sad, sullen, rude, aggressive)** | M (n = 8) | 2.88±1.246 | 1 | 4 | -1.5589 | .157 |
| | F (n = 17) | 3.59±0.507 | 3 | 4 | | |
| ***OPCS Item 7*. Cooperation with auxiliaries (e.g., elastics/headgear)** | M (n = 8) | 2.13±1.553 | 1 | 4 | -1.6231 | .134 |
| | F (n = 17) | 3.12±1.111 | 1 | 4 | | |
| ***OPCS Item 8*. Complaints about procedures** | M (n = 8) | 3.13±0.835 | 2 | 4 | -1.0089 | .333 |
| | F (n = 17) | 3.47±0.717 | 2 | 4 | | |
| ***OPCS Item 9*. Oral hygiene quality (excellent hygiene).** | M (n = 8) | 3.38±0.916 | 2 | 4 | -1.3285 | .220 |
| | F (n = 17) | 3.82±0.393 | 3 | 4 | | |
| ***OPCS Item 10*. Complaints about wearing appliances** | M (n = 8) | 2.50±1.309 | 1 | 4 | -2.3257 | **.045** |
| | F (n = 17) | 3.65±0.702 | 2 | 4 | | |
| ***OPCS Total Score*** | M (n = 8) | 30.38±7.999 | 23 | 40 | -1.7463 | .111 |
| | F (n = 17) | 35.82±5.434 | 26 | 40 | | |

At the start of the retention (passive) phase, appliances were prescribed on an individual clinical basis. Overall, combined retention involving a fixed retainer and at least one removable appliance was used in 17/25 patients (68%), fixed-only retention was used in 7/25 patients (28%), and removable-only retention was used in 1/25 patients (4%). After fabrication and application of these devices, at repeated follow-up visits (6 and 12 months), patients were assessed for their degree of compliance with the retention phase using the CCE (Clinical Compliance Assessment) tool. The comparison was made from the perspective of the degree of change in parameters at visit 2 (T2 – 12 months of retention) compared to visit 1 (T1 - 6 months of retention). Regarding the Oral Hygiene section of the CCE, at visit T1 adequate hygiene was observed for the first molars assessed within the CCE (16, 26, 36, 46), and the same level was maintained at T2 (all four teeth had a mean score of 4.00 at both time points; $p = 1.000$ for each paired comparison). In contrast, hygiene issues during the intermediate retention period were predominantly identified in the frontal region. Within the CCE, the central incisors 11 and 31 showed greater variability at T1 (mean 3.56 ± 0.821) than at T2 (mean 3.80 ± 0.408), consistent with the clinical observations. The paired comparisons demonstrated a statistically significant improvement in hygiene for both incisors between T1 and T2 ($p = 0.010$ for 11; $p = 0.010$ for 31). Accordingly, the total hygiene score (Igiena_T) increased at T2 compared with T1 (23.60 ± 0.816 vs. 23.12 ± 1.641), and this change was statistically significant ($p = 0.010$). We assume that this improvement may reflect reinforcement of oral-hygiene instruction at the intermediate visit (T1) and increased patient motivation as treatment progresses toward completion.

Device wearing scores improved significantly at T2 compared with T1 (22.80 ± 2.236 vs. 20.68 ± 4.697; Wilcoxon $W = 6.00$; $p = 0.003$), with reduced variability at T2. Maintenance scores improved markedly between visits (25.00 ± 0.000 at T2 vs. 19.00 ± 7.071 at T1; $p < 0.001$), consistent with the absence of detected device defects at T2 following replacements when indicated. Punctuality/appointments also improved significantly from T1 to T2 (24.80 ± 1.000 vs. 23.40 ± 3.136; $p = 0.013$), again with lower variability at T2. These dynamics are broadly consistent with reports that compliance can vary across treatment stages and may deteriorate over time if not actively reinforced [20]. Overall, the total CCE score increased significantly, with 96.20 ± 2.958 at T2 vs. 86.20 ± 14.725 at T1 ($W = 1.00$; $p = 0.001$).

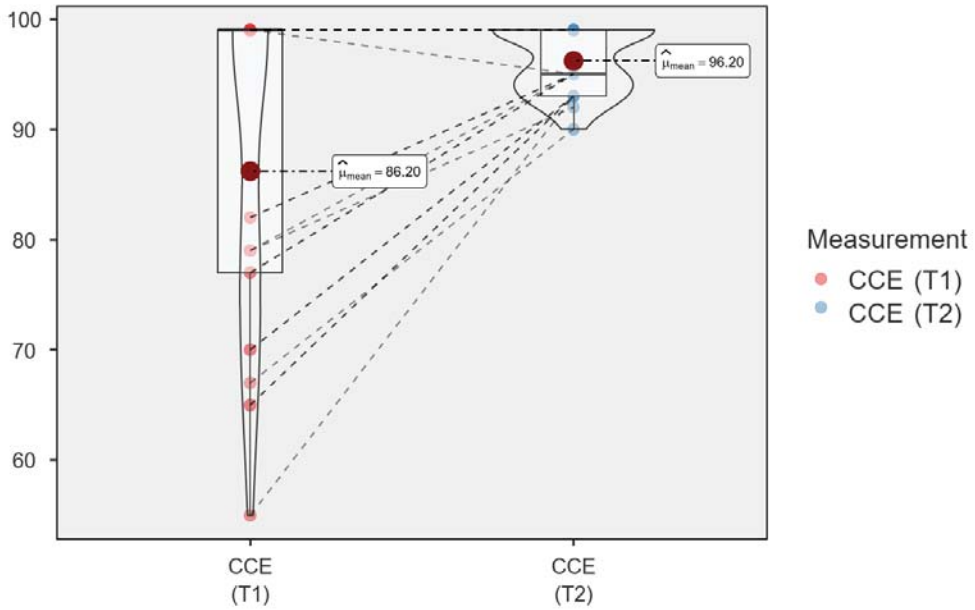


Figure 2. Total CCE score at different time periods (T1/T2) in the examined patients

We assume that this high level of compliance is due to several factors: the impact of the extended approach at visit T1 (additional patient education, patient verification according to the CCE), as well as the psycho-emotional aspect of awareness of treatment completion. In this context, our preliminary results reveal the usefulness of applying these tools both for documenting patient compliance with treatment, and for detecting gaps during treatment and correcting patient behaviors.

## DISCUSSIONS

The present study followed 25 adults with stage I–II periodontitis who required orthodontic correction and were managed through a structured, interdisciplinary sequence (periodontal stabilisation followed by orthodontic treatment and retention). The primary observation was an improvement in clinical compliance during early retention, accompanied by improved oral-hygiene scores and significant gains in device-wearing behaviour, device maintenance, and appointment punctuality. In a complex periodontal–orthodontic context, this suggests that monitoring and reinforcing patient behaviour can produce measurable short-term gains in adherence. The feasibility of orthodontic tooth movement in a reduced periodontium is well supported when inflammation is controlled and biomechanics are adapted, with particular emphasis on low forces, careful anchorage management, and close periodontal surveillance. Contemporary reviews and clinical guidance highlight plaque control and supportive periodontal therapy as prerequisites for safe treatment progression in periodontitis-susceptible adults [11; 12; 14; 17].

A major methodological challenge in periodontal–orthodontic research is the heterogeneity of clinical presentations and treatment protocols (periodontitis stage/grade, defect morphology, tooth migration patterns, adjunctive regenerative or restorative procedures, appliance systems, and differing maintenance regimens). This heterogeneity limits the comparability of conventional periodontal or orthodontic endpoints across cohorts and explains why compliance and cooperation—high-impact, modifiable determinants of treatment safety—were selected as the principal endpoint in this investigation [11; 17; 19]. In our cohort, the biomechanical approach was deliberately individualised (force calibration,

anchorage strategy, and sequencing with periodontal care) with the primary aim of maintaining periodontal stability. The scientific question was therefore not whether one mechanics protocol outperforms another, but whether patients can adhere to the strict behavioural requirements that make any protocol safe in a reduced periodontium. This distinction is clinically relevant because even optimally planned low-force mechanics cannot compensate for inadequate plaque control or irregular maintenance attendance – factors repeatedly linked with long-term tooth retention in periodontitis-susceptible patients managed within supportive care programmes [2; 3].

Cooperation and compliance are inherently multidimensional constructs. The OPCS and the CCE operationalise these domains by capturing appointment adherence, fixed-appliance maintenance, removable-appliance wear, and oral hygiene. While these instruments do not replace objective measures, they provide a pragmatic framework for structured chairside appraisal and targeted behavioural reinforcement—an approach supported by behavioural-modification trials in orthodontics and by studies showing that cooperation and oral hygiene can fluctuate across treatment stages in adults [1; 8; 20; 22; 24]. Retention represents a particularly vulnerable period for periodontitis-susceptible patients because relapse control relies on a combination of fixed and removable protocols, and plaque accumulation around retainers can jeopardise periodontal stability if hygiene is suboptimal. Evidence from randomised studies indicates that adherence to retainer wear can be improved through structured reminders and patient education, supporting the clinical value of ongoing reinforcement beyond active therapy [6; 27].

This study is limited by its small sample size, single-centre design, and the absence of a group for comparison. In addition, periodontal clinical endpoints were not standardised as primary outcomes, and compliance instruments, while practical, remain partly subjective. Nonetheless, the findings support systematic compliance monitoring as a low-cost, clinically actionable strategy in interdisciplinary periodontal–orthodontic care. Future controlled studies should combine behavioural metrics with standardised periodontal and orthodontic outcomes to identify which compliance trajectories best predict long-term stability [10,11]. According to the present design, periodontal indices were monitored primarily to confirm disease control and to ensure safe treatment delivery within individualised protocols; therefore, the analysis cannot quantify baseline-to-end periodontal changes attributable to specific biomechanics or compare such changes across patients.

Given the multifactorial nature of periodontal–orthodontic rehabilitation and the ongoing refinement of interdisciplinary guidance, future research should be designed with explicit, a priori consideration of key sources of clinical heterogeneity (baseline periodontal phenotype and defect morphology, case-specific orthodontic objectives, anchorage/force systems, adjunctive periodontal procedures, and maintenance intensity). In this context, strict standardization and fully balanced sampling across all relevant strata may be difficult to achieve in prospective clinical cohorts; therefore, pragmatic study designs with robust phenotyping and transparent reporting are essential to ensure interpretability and external validity.

## CONCLUSIONS

In this prospective cohort of 25 adults with stage I–II periodontitis treated with orthodontics after periodontal stabilisation, clinical compliance during early retention improved significantly over time, with significant gains in the total CCE score and in the oral-hygiene, device-wearing, device-maintenance, and appointment-punctuality domains. Sex-based differences in cooperation were limited to two OPCS items (motivation/enthusiasm and complaints about wearing appliances), with women demonstrating higher compliance

scores in this sample. These findings support the routine incorporation of structured compliance monitoring tools, reinforced oral-hygiene education, and periodontal maintenance when delivering orthodontic therapy in a reduced periodontium. Future studies should employ larger, controlled designs with standardised periodontal and orthodontic outcome measures to reduce heterogeneity and to identify which compliance trajectories best predict long-term stability.

***Conflicts of Interest***

The authors declare no conflicts of interest.

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