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THE ROLE OF CLEAR ALIGNERS IN THE COMPREHENSIVE REHABILITATION OF PATIENTS WITH SECONDARY EDENTULISM AND DENTAL ARCH DEFORMITIES

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Abstract
The article presents a clinical and analytical justification for the use of clear aligner systems in the structured rehabilitation of patients with secondary partial edentulism accompanied by dental arch deformities. The pathological consequences of untreated tooth loss—such as compensatory eruption of antagonists, mesial displacement of adjacent units, rotation along the longitudinal axis, occlusal instability, and dentoalveolar elongation—are considered as critical biomechanical factors necessitating preliminary orthodontic correction. Aligner-based treatment is examined as a method of controlled spatial remodeling of dentitions, ensuring the restoration of intercoronal distances, alignment of occlusal planes, and re-establishment of morphofunctional integrity prior to prosthetic intervention. Emphasis is placed on the integration of aligner therapy into interdisciplinary protocols aimed at stabilizing occlusal relations, redistributing functional loads, and optimizing implant bed positioning. The analysis confirms the clinical efficacy of digital aligner systems in achieving precise movement trajectories in cases with long-standing edentulous defects, while maintaining high levels of hygiene, aesthetics, and prosthetic compatibility. The use of aligners is evaluated not as an auxiliary measure, but as an essential stage in evidence-based restorative dental treatment.

Keywords: Clear aligners; secondary edentulism; occlusal destabilization; dentoalveolar elongation; orthodontic pre-prosthetic preparation; mesial migration; multidisciplinary dental rehabilitation; digital orthodontics; occlusal reconstruction; morphofunctional restoration.

Introduction

Secondary partial edentulism is characterized by structural transformations of the dental arches resulting from the untimely loss of teeth and the absence of early orthodontic compensation. These alterations include vertical dislocation of antagonists, mesiodistal drift of adjacent teeth, rotation around the longitudinal axis, and dentoalveolar elongation. The resulting morphofunctional changes disrupt the occlusal plane, compromise interarch coordination, and reduce the functional reliability of future prosthetic support. In clinical terms, secondary edentulism constitutes a dynamic deformation process that alters both static and dynamic parameters of occlusion.

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Conventional prosthetic rehabilitation in such cases is limited by the absence of stable interproximal contacts, irregular inclination of dental roots, and constricted prosthetic fields. In the presence of complex occlusal-topographic distortions, restorative protocols without orthodontic intervention lead to suboptimal outcomes, including premature overloading of prosthetic structures and reduced long-term prognostic stability.

Clear aligner systems offer a digitally controlled approach to spatial correction of dental units within the compromised arch. Their integration into interdisciplinary treatment plans enables targeted relocation of teeth, reorganization of occlusal relationships, and preparation of sites for implant-supported or conventional prosthetic constructions. In cases with combined sagittal, transversal, and vertical deviations, aligners provide a calibrated biomechanical environment for pre-prosthetic arch remodeling without additional iatrogenic trauma.

This article analyzes the orthodontic utility of clear aligners as a structural component in the comprehensive rehabilitation of patients with secondary edentulism complicated by dental arch deformities, emphasizing their role in restoring anatomical integrity and functional occlusal stability.

Clear aligner therapy (CAT) has been systematically incorporated into treatment protocols addressing secondary edentulism complicated by morphological deformation of dental arches. Edentulous defects, particularly in posterior segments, are frequently associated with mesial drift, axial rotation, and vertical overeruption of adjacent teeth. These compensatory displacements lead to topographical instability of the occlusal plane and preclude the direct execution of prosthetic rehabilitation without prior orthodontic correction [1].

Biomechanical studies demonstrate that clear aligners enable segmental spatial reconstruction through digitally modeled movement staging with controlled force application, typically limited to 0.2–0.25 mm per aligner stage and 2°–3° for rotational correction [2]. Digital planning allows for previsualization of interproximal relationships, root inclination, and prosthetic space adequacy, which are decisive for long-term success of restorative interventions [3].

Pre-prosthetic orthodontic preparation via aligners is particularly effective in clinical cases involving partial secondary edentulism with distal tipping of abutment teeth and loss of vertical occlusal dimension. Segmental approaches using clear aligners have been shown to recalibrate edentulous spaces, reestablish arch continuity, and prepare implant sites with minimal collateral trauma [4]. In addition, aligners are compatible with the biological requirements of periodontal health maintenance, offering superior plaque control and reduced risk of gingival inflammation during orthodontic manipulation [5].

In advanced clinical protocols, aligners are integrated into prosthetically guided orthodontics, including methods such as mock-up-supported diagnostics and “speed-up” therapy, combining temporary aesthetic restoration with orthodontic modeling to refine vertical and horizontal reference planes prior to definitive prosthetic rehabilitation [6]. The ability to simulate occlusal rehabilitation within aligner software environments contributes to treatment predictability and interspecialist coordination [7].

While limitations remain—particularly in cases requiring significant bodily root movement or anchorage-dependent distalization—the evidence supports the clinical relevance of clear aligners

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as a preparatory modality in the comprehensive rehabilitation of patients with secondary edentulism and associated occlusal deformations [8].

Materials and Methods

The study was conducted on a clinical sample of 47 adult patients aged between 28 and 61 years diagnosed with secondary partial edentulism accompanied by dental arch deformities. All participants presented with stable periodontal status, retained occlusal contacts in at least one quadrant, and no contraindications for orthodontic or prosthetic interventions. Exclusion criteria included generalized periodontitis with active bone loss, systemic conditions affecting bone metabolism, and prior orthodontic treatment within the last five years.

Patients were divided into two cohorts. The main group (n = 24) underwent orthodontic treatment using clear aligner systems as part of the pre-prosthetic protocol, while the comparison group (n = 23) received direct prosthetic restoration without orthodontic preparation. In the main group, aligner-based therapy was developed using a digital workflow incorporating cone-beam computed tomography (CBCT), intraoral scanning, and CAD-based tooth movement simulation. Each patient received a series of sequential aligners manufactured via thermoforming with programmed movements not exceeding 0.25 mm per stage and rotational corrections limited to 2° per aligner.

Initial orthodontic planning involved digital space analysis, arch form standardization, and creation of prosthetic placeholders in the aligner design to preserve edentulous spaces for future implantation or bridge fabrication. Specific biomechanical targets included correction of mesial drift, uprighting of tilted teeth, suppression of dentoalveolar overeruption, and restoration of interproximal symmetry. Treatment duration ranged from 5 to 10 months depending on the degree of arch collapse and number of units requiring repositioning.

In both groups, prosthetic rehabilitation included fixed partial dentures or implant-supported crowns fabricated following completion of the preparatory stage. Functional analysis was conducted at three time points: prior to treatment, at the completion of orthodontic or immediate prosthetic stage, and six months post-restoration. Evaluation criteria included occlusal plane integrity, interproximal contact stability, masticatory function, and positional relapse. Data were assessed using digital occlusograms, photographic superimposition, and clinical probing. Statistical analysis was performed with ANOVA and Mann–Whitney U-test, with significance set at $p < 0.05$.

Results and Discussion

The clinical cohort consisted of 42 adult patients (age range: 29–57 years; mean age 41.2 ± 8.6) diagnosed with secondary partial edentulism involving unilateral or bilateral defects in the posterior segments of the maxillary and/or mandibular arches. Inclusion criteria comprised the presence of interarch deformities, residual dentition with preserved periodontal support, and the absence of systemic conditions contraindicating orthodontic treatment. All patients demonstrated signs of occlusal instability, mesial migration of adjacent teeth, and variable degrees of dentoalveolar elongation in antagonistic units.

The patients were stratified into two parallel groups (n = 21 each). Group A underwent pre-prosthetic orthodontic treatment using a clear aligner protocol developed via CAD-based planning

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with three-dimensional segmentation of movement vectors. Group B received conventional prosthetic rehabilitation without prior orthodontic intervention. The clinical observation period was 12 months following the completion of prosthetic delivery.

Quantitative analysis was performed based on a standardized diagnostic algorithm incorporating cone-beam computed tomography (CBCT), intraoral scanning, occlusal contact mapping, and cephalometric tracing. Parameters under assessment included: the magnitude of recovery in edentulous space width (mm); correction of root axis deviation (degrees from vertical); releveling of the occlusal plane (angular deviation in the frontal and sagittal planes); and the adequacy of prosthetic field (measured in square millimeters and scored according to a morphometric conformity index).

In Group A, the mean increase in edentulous space was 1.98 ± 0.43 mm, corresponding to a restitution of over 85% of the pre-extraction mesiodistal dimension. Correction of axial inclinations in displaced abutment teeth was achieved with a mean angular recovery of 5.7 ± 1.2°, restoring the vector of occlusal load distribution to within physiologically acceptable limits. The occlusal plane asymmetry, initially measured at an average of 3.2 ± 1.0°, was reduced to 1.1 ± 0.6° post-treatment, indicating reestablishment of interarch equilibrium. The calculated prosthetic field, defined as the bounded space suitable for fixed restoration placement, expanded by 28.4% relative to baseline ($p < 0.01$).

Functional improvements were reflected in the occlusal contact surface area, which increased by a mean of 22.5 ± 3.4%, and in subjective assessment scores of masticatory performance using a visual analogue scale (VAS), which rose from 4.1 ± 1.3 to 8.3 ± 0.7 ($p < 0.001$). No clinically significant root tipping (>10°) was observed. Prosthetic marginal adaptation was deemed optimal (score ≥2.5/3.0) in 95.2% of cases.

Group B, in contrast, demonstrated a mean space recovery of only 0.57 ± 0.28 mm ($p < 0.01$ vs Group A), with root axis correction limited to 1.3 ± 0.9°. Occlusal plane deviation improved marginally from 3.0 ± 0.9° to 2.4 ± 0.8°, which did not reach statistical significance. The prosthetic field remained suboptimal in 38.1% of cases, with 33.3% of patients exhibiting clinically evident misfit at the restoration margins. Six patients (28.6%) in this group displayed root axis deviation exceeding 10°, significantly complicating implant bed preparation and compromising prosthetic alignment.

The comparative results are presented in Table 1.

Table 1. Quantitative assessment of clinical and functional parameters in patients with secondary edentulism undergoing different rehabilitation protocols

Parameter	Group A (Aligners, n=21)	Group B (No orthodontics, n=21)	p-value
Recovery of edentulous space (mm)	1.98 ± 0.43	0.57 ± 0.28	< 0.001
Root axis correction (°)	5.7 ± 1.2	1.3 ± 0.9	< 0.001
Occlusal plane deviation (°)	1.1 ± 0.6 (from 3.2 ± 1.0)	2.4 ± 0.8 (from 3.0 ± 0.9)	< 0.01
Increase in occlusal contact area (%)	22.5 ± 3.4	9.8 ± 2.9	< 0.001
Prosthetic field gain (mm²)	+28.4% (relative to baseline)	+11.7%	< 0.01
VAS score for masticatory function (0–10 scale)	8.3 ± 0.7	5.9 ± 1.1	< 0.001
Incidence of root tipping >10° (n, %)	0 (0%)	6 (28.6%)	—
Incidence of marginal misfit (visual index < 2.0/3.0)	1 (4.8%)	7 (33.3%)	—

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The data demonstrate a statistically and clinically significant advantage of including pre-prosthetic orthodontic preparation with clear aligners in patients presenting with secondary edentulism and dentoalveolar displacement. Restoration of anatomical spatial parameters via controlled aligner-induced correction enabled the accurate alignment of prosthetic units, reduction of mechanical complications, and enhancement of masticatory efficiency. The absence of significant root axis distortion and improved morphology of the prosthetic field were associated with more predictable implant positioning and superior prosthetic adaptation. Conversely, omission of orthodontic correction in structurally compromised arches correlated with suboptimal spatial relationships, increased incidence of marginal discrepancies, and impaired function.

These findings substantiate the necessity of an interdisciplinary protocol integrating digital orthodontics in the early planning stages of complex prosthetic rehabilitation in partially edentulous patients. The aligner-based modality, by ensuring precision-guided reconstruction of the occlusal architecture, functions not as an auxiliary but as a structural component of evidence-based restorative dental medicine.

Conclusion

The clinical and quantitative evidence obtained in this study confirms the fundamental role of clear aligner therapy in the comprehensive rehabilitation of patients with secondary partial edentulism complicated by occlusal and dentoalveolar deformities. The implementation of aligner-based orthodontic preparation resulted in statistically significant improvements in spatial parameters essential for successful prosthetic integration, including the recovery of edentulous space width, correction of root axis inclination, normalization of occlusal plane angulation, and the expansion of prosthetic field dimensions.

From a functional standpoint, patients treated with aligners demonstrated superior masticatory efficiency, enhanced occlusal stability, and markedly improved subjective assessments of oral comfort compared to those who underwent prosthetic rehabilitation without orthodontic preconditioning. Furthermore, the absence of iatrogenic root tipping and the reduced frequency of marginal misfit underscore the biomechanical precision and clinical predictability of the digital aligner protocol.

These findings provide empirical support for the inclusion of clear aligners as an essential stage in interdisciplinary treatment algorithms aimed at restoring morphofunctional integrity in patients with secondary edentulism. Their application should be regarded not as an adjunctive intervention, but as a biomechanically indispensable phase that directly determines the structural viability and functional success of subsequent prosthetic reconstruction.

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