ORIGINAL RESEARCH

The Impact of the Restoration of Invisible Orthodontic Titanium Alloy Implant Without Bracket on Individuals Afflicted with Dental Malocclusion and Arch Deficiency Accompanied by Periodontitis and a Local Periodontal Inflammation

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ABSTRACT

Objective • To investigate the impact of the restoration of non-bracket invisible orthodontic titanium alloy implant on individuals with dental malocclusion and arch deficiency accompanied by periodontitis and local periodontal Inflammation.

Method • A cohort of 120 patients presenting with dental malocclusion and defects compounded by periodontitis, were treated at our institution between January 2021 and January 2022; these patients were enrolled in a randomized controlled trial.. These patients were allocated into two groups. The control group (comprising 60 cases) underwent titanium alloy implant restoration, while the research group (also with 60 cases) received titanium alloy implant restoration following invisible orthodontic treatment without brackets. A one-year post-treatment follow-up was conducted, during which various parameters, including pain levels, aesthetic improvement, inflammatory response, dental function, oral hygiene, and the incidence of adverse events, were evaluated and compared before and after treatment between the two groups.

Results • After six months of treatment, the visual analog scale (VAS) in the study group was lower than that in the control group ($P < .05$). After 6 months of treatment, the research team observed the changes in gingival crevicular interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), Interleuckin-1 (IL-1), plaque index (PLI), and soft dirt index (DI) were all lower than those in the control group ($P < .05$). After 6 months of treatment, the research group had higher scores for tooth functions such as chewing, swallowing, speech expression, and occlusion than the control group, as well as higher pink and white aesthetics indexes ($P < .05$). The difference in the incidence rate of adverse outcomes between the research and control group was not distinct ($P > .05$).

Conclusion • In case of dental malocclusion accompanied by periodontal disease, the utilization of titanium implants for rectifying dental arch deformities without the use of orthodontic brackets, devoid of orthodontic brackets, has demonstrated notable efficacy in alleviating patients' periodontal discomfort, their oral hygiene, and dental functionality. This modality is conducive to augmenting dental aesthetics without incurring heightened rates of unfavorable consequences, thereby enhancing treatment outcomes. (*Altern Ther Health Med.* 2024;30(6):103-109).

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INTRODUCTION

Periodontitis is a significant contributing factor to dental malocclusion deficiency. It is primarily initiated by chronic inflammation of periodontal tissues due to dental plaque biofilm, which progressively infiltrates deeper periodontal tissues. This incursion may induce alveolar bone resorption, culminating in tooth mobility, positional alteration, and eventual tooth loss, exacerbating dental malocclusion. Dental malocclusion deficiency, when concomitant with periodontitis, transcends age boundaries, with an escalated incidence among the aging populace. Permitting the unchecked advancement of dental malocclusion deficiency in tandem with periodontitis not only compromises the esthetic appeal of a patient's dentition but also exerts a profound adverse influence on dental functionality and overall oral health.[1,2] Historically, dental malocclusion deficiency accompanied by periodontitis has commonly been addressed through implant restoration therapy. While this approach effectively resolves periodontal tissue inflammation and alleviates toothache, the exclusive application of this implant restoration methodology necessitates a more demanding prerequisite regarding the

patient's dental alignment. It is notably susceptible to the impact of remaining dentition and periodontal tissues. Consequently, some patients do not achieve the desired restorative outcomes. Currently, the leading technology in invisible orthodontics involves not using orthodontic brackets. This approach is gradually being applied in the clinical treatment of patients with malocclusion accompanied by periodontitis. Research indicates that symptoms such as gingival redness and swelling, pain, bleeding during brushing, and tooth mobility occur during the acute phase of periodontitis. During this period, invisible aligners without brackets can be employed for orthodontic treatment. Bracket-free invisible orthodontic treatment utilizes elastic forces to correct tooth alignment, effectively addressing issues such as irregular tooth arrangement and malocclusion. This, in turn, alleviates the aforementioned discomfort symptoms.[3] Additionally, studies suggest that bracket-free invisible orthodontics during orthodontic treatment can effectively improve the occlusal relationship of teeth in patients with periodontitis, correct improper dental alignment, and prevent the accumulation of food residues in the oral cavity. This approach can, to a certain extent, hinder the continued progression of periodontitis.[4] This research undertakes a comparative analysis for further investigating a comprehensive examination of the potential synergistic effects of titanium alloy implant restoration after invisible orthodontic treatment in patients presenting dental malocclusion deficiency coupled with periodontitis, and with the ultimate objective of enhancing therapeutic outcomes. The assessment encompasses an evaluation of the consequences of titanium alloy implant restoration following invisible orthodontics in terms of pain mitigation, aesthetic enhancement, amelioration of inflammatory responses, enhancement of dental functionality, improvement in oral hygiene, and the incidence of adverse events in individuals afflicted by dental malocclusion deficiency and periodontitis. The ensuing findings are elucidated below.

MATERIALS AND METHODS

General Information

This study enrolled a cohort of 120 patients presenting with dental malocclusion deficiency and concurrent periodontitis who sought treatment at our institution from January 2021 to January 2022. These patients were enrolled in a randomized controlled trial, adhering to established principles of randomization, resulting in a control group consisting of 60 cases and a study group comprising 60 cases. Both groups demonstrated favorable baseline homogeneity ($P > 0.05$), facilitating robust comparative analyses. Ethical approval for this study was obtained after a rigorous evaluation by the hospital's ethics committee, bearing the ethics approval number (2020) Ethics Review No. (08). Detailed patient demographics are presented in Table 1.

Table 1. Comparison of the baseline data between the two groups

Baseline data		Control group (n=60)	Research group (n=60)	Statistic	*P* value
Age (`χ±S, year(of age)		45.23±3.26	45.08±3.41	t=0.246	.806
Course of disease ($\bar{x} \pm s$, month)		7.25±2.52	7.23±2.59	t=0.043	.966
gender[case(%)]	male	32 (53.33)	30 (50.00)	χ^2=0.134	.715
	female	28 (46.67)	30 (50.00)		
Body mass index ($\bar{x} \pm s$, kg/m^2)		24.09±0.52	24.06±0.53	t=0.313	.755
Defective tooth position [case(%)]	Single inferior front tooth	20 (33.33)	21 (35.00)	χ^2=0.349	.951
	Single upper front tooth	16 (26.67)	18 (30.00)		
	Single posterior tooth	14 (23.33)	12 (20.00)		
	Front and rear teeth	10 (16.67)	9 (15.00)		

Inclusion and Exclusion Criteria

Inclusion Criteria: Participants who met the following criteria were eligible for inclusion: a confirmed clinical diagnosis of dental malocclusion deficiency with concomitant periodontitis, normal cognitive function, communication abilities, and normal auditory and visual function; suitability for invisible orthodontics without brackets and titanium alloy implant restoration as indicated.

Exclusion Criteria: Participants with any of the following conditions were excluded from the study: abnormal blood coagulation function or a bleeding tendency, concomitant severe primary diseases affecting the endocrine, immune, or hematological systems, presence of other dental conditions, active periodontal disease, contraindications for dental implantation, a history of maxillofacial trauma or surgery, or a history of orthodontic treatment or dental implantation within the past three months.

Methods

Control Group Underwent Titanium Alloy Dental Implant Restoration Treatment. Preoperatively, the condition of the edentulous area in patients was confirmed.

First-stage surgery: In the operating room, surgical drapes were sterilized. Patients were positioned in a supine chair. After thorough disinfection of the oral and perioral skin, a surface injection of 2% lidocaine (Manufacturer: Xi'an Fenghua Pharmaceutical Co., Ltd., National Drug Approval H61020861, Specification: 5 ml: 0.1 g) at a dose of 4.5 mg/kg was administered for local anesthesia. After the local anesthesia took effect, residual dental remnants, calculus, and plaque were meticulously cleaned. Subsequently, a horizontal curved incision was made on the alveolar ridge of the missing tooth. The mucosa and periosteum were separated to completely expose the bone surface. Once the positioning hole was successfully established, a primary twist drill was used to expand the hole to the expected depth, followed by a secondary twist drill to expand the implant socket entrance. After successfully preparing the implant socket, physiological saline was used for cooling. The implant was then inserted and covered with screws, and interrupted sutures were performed to ensure complete closure of the external soft tissue wound. Standard antibiotic prophylaxis was applied to prevent infection, and sutures were removed after 10 to 14 days. Two to three months after treatment, X-ray imaging was performed to confirm stable osseointegration before proceeding to the second-stage surgery.

Second-stage surgery: A healing abutment was placed, and sutures were removed one week later. Two weeks later, a silicone rubber impression was taken to fabricate the

permanent crown restoration. One week later, patients were informed to try on the titanium alloy dentures. During the fitting process, the occlusal angle was continuously adjusted until the patient felt comfortable, at which point the titanium alloy dental implant restoration was cemented. Postoperatively, routine prophylactic antibiotics were administered. Patients were instructed to refrain from eating for the first 4 hours after surgery and to avoid chewing hard foods for a 24-hour. Regular follow-up appointmentss were scheduled monthly, and both study groups participated in a comprehensive one-year postoperative assessment period.

The research group conducted invisible orthodontic treatment on the control group. They employed the Invisalign technique from Align Technology, a U.S.-based company. This involved using an Itero scanner to comprehensively scan the oral cavity, creating a digital three-dimensional occlusal model. The ClinCheck software was used to design a 3D simulation plan. In this plan, spaces required for implantation were reserved on the model, and no-bracket invisible orthodontic aligners were custom-made. Attachments were applied, and occlusal splints assisted in proper occlusion. Patients must rigorously adhere to the prescribed sequence of orthodontic appliances, with a recommended replacement interval of every two weeks. They were expected to wear the aligners for 22 hours each day, with an additional 30 minutes for occlusal splint usage. Upon removal of the orthodontic appliance, individuals are encouraged to patients were instructed to perform a thorough oral hygiene routine, including deep cleaning with a toothbrush and rinsing with medicinal anti-inflammatory mouthwash. Follow-up appointments are scheduled at two-month intervals, continuing until the entirety of the initial orthodontic appliance set has been worn. Depending on the oral conditions observed during these follow-up visits, the decision was made to perform three-dimensional scanning for precise adjustments. After the orthodontic treatment, the patient's occlusal attachments were removed. However, the implant restoration treatment was postponed until the bone stability was ensured. During this interim period, patients were required to wear retainers to maintain the results achieved through orthodontic treatment.

Observed parameter

Pain assessment. The Visual Analogue Scale (VAS)[5] was employed to assess patients' pain levels both prior to and six months after the treatment. Pain intensity was categorized as follows: a score of 0 represented the absence of pain, while scores of 1-3, 4-6, and 7-10 signified mild, moderate, and severe pain, respectively. Lower scores on the scale denoted a more substantial amelioration in the patients' pain condition

Inflammatory Response Analysis: Gingival crevicular fluid specimens were procured from the study participants, both prior to treatment and at the six-month post-treatment time, utilizing aseptic Whatman No. 3 filter paper strips. The subsequent serum fraction was isolated through centrifugation, employing a 3K-10 multifunctional centrifuge of American Sigma company, characterized by a rotational speed of 3000 r/min, a 5 cm centrifugation radius, and a 15-minute centrifugation duration. The quantification of interleukin (IL)-6(Normal range is equal or lower than 2.0 pg/ml), tumor necrosis factor (TNF)-α(Normal range is equal or lower than <1540 pg/ml), and IL-1(Normal range is equal or lower than 5.0 pg/m) levels was executed by means of a chemiluminescent immunoassay, the reagents for which were procured from AmiJetech Co., Ltd. All procedural steps adhered rigorously to the protocols delineated within the assay kits and the accompanying instrumentation guidelines.

Oral Hygiene Assessment Parameters. Pertinent indicators, comprising the Plaque Index (PLI) and the Debris Index (DI), were evaluated pre-treatment and at a subsequent 6-month post-treatment follow-up. The PLI assessment involved a meticulous procedure where a small cotton ball saturated with plaque-revealing solution was gently applied to the interproximal tooth surfaces. This application facilitated the dispersion of the plaque-disclosing agent across the tooth surfaces. Subsequently, the subjects rinsed their mouths with water, following which the plaque index was meticulously assessed. The scoring system for the PLI was as follows: 0 denoted the absence of plaque at the gingival margin, 1 indicated the presence of a thin plaque not discernible to the naked eye but visible upon probe scraping, 2 represented a moderate quantity of plaque perceptible at the gingival margin or on adjacent surfaces, and 3 was assigned to denote a substantial accumulation of plaque within the gingival sulcus, along the gingival margin, and on adjacent tooth surfaces. The DI, on the other hand, was determined based on the quantity and thickness of soft debris present on the labial or cheek surfaces of teeth in dental positions number sixteen, eleven, twenty-six, and thirty-one, as well as the lingual surfaces of teeth thirty-six and forty-six. The scoring scale for the DI spanned from 0 to 10, with higher scores indicative of a more pronounced accumulation of soft debris.

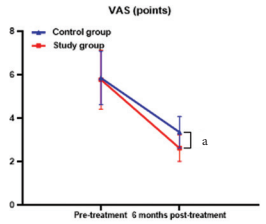
Dental Function Evaluation: The functional aspects of the patient's oral health, including mastication, swallowing, speech articulation, and occlusal characteristics, were subject to assessment both prior to the initiation of treatment and following a 6-month post-treatment interval. These parameters were individually quantified using a graded scale from 0 to 100, where heightened numerical values reflected superior dental functional performance.

Aesthetic Evaluation: Aesthetic outcomes for patients were assessed before and 6 months after treatment, following the criteria outlined by Furhauser et al.[6] and Belser et al. [7]. (1) Pink Aesthetic Index: This index comprises seven distinct elements, encompassing [proximal gingival papilla, distal gingival papilla (both papillae being intact are assigned 2 points, one intact is awarded 1 point, and none intact receives 0 points)], [labial gingival margin curvature, labial gingival margin highest point, root convexity, soft tissue color and texture (bearing similarity to the corresponding natural tooth is scored as 2 points, slight similarity merits 1 point, and dissimilarity is attributed 0

Table 2. Comparison of pain before and after treatment ($\bar{x} \pm s$, point)

Group	Case number	Pretherapy	After 6-month treatment	*t* value	*P* value
Control group	60	5.85±1.23	3.35±0.73	14.801	<.001
Research group	60	5.77±1.36	2.62±0.61	18.070	<.001
t value		0.338	5.944		
P value		.736	<.001		

Figure 1. Comparison of pain before and after treatment



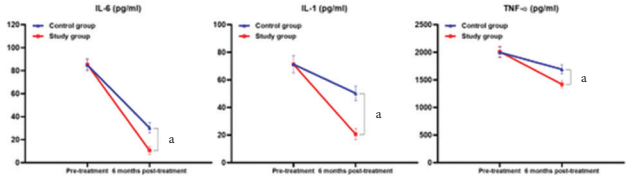
[a]*P* < .001

Table 3. Comparison of inflammatory factors in the gingival sulcus before and after treatment between the two groups ($\bar{x} \pm s$, pg/ml)

Group	Case Number	IL-6		IL-1		TNF-α	
		Pre-treatment	Six-month Treatment later	Pre-treatment	Six-month Treatment later	Pre-treatment	Six-month Treatment later
Control group	60	85.02±5.24	10.32±4.51[a]	71.26±6.32	20.32±5.25[a]	2000.25±100.29	1690.84±80.85[a]
Research group	60	85.32±4.29	5.65±1.65[a]	71.29±6.35	3.65±0.98[a]	2010.38±95.95	1320.26±60.84[a]
t value		.343	5.478	0.026	17.175	0.565	22.142
P value		.732	<.001	.979	<.001	.573	<.001

[a]Compared to this group before the treatment, *P* < .05

Figure 2. Comparison of gingival crevicular inflammatory factors before and after the treatment



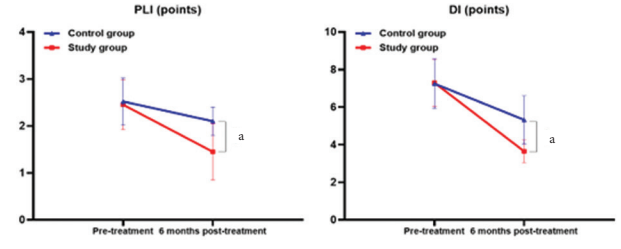
[a]*P* < .001

Table 4. Comparison of oral hygiene indicators before and after treatment ($\bar{x} \pm s$, point)

Group	Case number	PLI		DI	
		Pre-treatment	Six-month Treatment later	Pre-treatment	Six-month Treatment later
Control group	60	2.52±0.50	2.10±0.30[a]	7.25±1.32	5.32±1.28[a]
Research group	60	2.45±0.53	1.45±0.60[a]	7.30±1.25	3.65±0.61[a]
t value		0.744	7.506	0.213	9.123
P value		.458	<.001	.832	<.001

[a]Compared to this group before the treatment, *P* < .05

Figure 3. Comparison of oral hygiene indicators between the two groups before and after treatment



[a]*P* < .001

points)]. The individual scores are aggregated, resulting in a composite score within the 0 to 14-point range, where elevated scores signify heightened aesthetic excellence. (2) White Aesthetic Index: This comprehensive assessment encompasses five critical dimensions, namely the morphology of the restored tooth crown, the external coloration of the tooth crown, its contour, surface texture, and transparency/personalization. Each aspect is meticulously scrutinized in relation to the corresponding natural tooth, with a rating system that assigns 2 points for pronounced similarity, 1 point for moderate similarity, and 0 points for dissimilarity. The individual ratings are then consolidated to derive a cumulative score falling from 0 to 10. Elevated scores are indicative of a heightened level of aesthetic refinement.

Adverse Event Incidence: This classification encompassed conditions including tooth mobility, oral mucosal lesions, tooth malposition, gingivitis, and an expansion of interdental gaps.

Statistical analysis

Statistical analysis was conducted employing Statistic Package for Social Science (SPSS) version 22.0 software (IBM, Armonk, NY, USA). Continuous data, encompassing parameters such as inflammatory response, pain assessment, oral hygiene metrics, dental functionality, and aesthetic evaluations, were presented as ($\bar{x} \pm s$) and subjected to analysis through the *t* test. Categorical data, such as the adverse event incidence, were expressed as n (%) and analyzed using the χ^2 test. A significance level of $P < .05$ was used to determine statistically significant differences.

RESULT

Pain Condition

The VAS scores in the study group, as compared to the control group, showed no notable difference ($P > .05$). However, after 6 months of treatment, the VAS scores in the study group were lower than those in the control group ($P < .05$). Please refer to Table 2 and Figure 1 for details.

Inflammatory Response

Prior to treatment, the levels of IL-6, IL-1, and TNF-α in gingival crevicular fluid did not exhibit a significant difference between the research group and the control group ($P > .05$). However, after 6 months of treatment, the levels of IL-6, IL-1, and TNF-α in the gingival crevicular fluid were lower in the study group compared to the control group ($P < .05$). Please refer to Table 3 and Figure 2 for further details.

Oral Hygiene Indicators

Prior to treatment, there was no significant difference in PLI and DI between the study group and the control group ($P > .05$). However, after 6 months of treatment, both PLI and DI were lower in the study group compared to the control group ($P < .05$). Please refer to Table 4 and Figure 3 for further details.

Table 5. Comparison of dental function before and after treatment ($\bar{x} \pm s$, point)

Group	Case number	masticatory function		function of deglutition		Voice expression function		occlusal function	
		Pre-treatment	Six-month Treatment later	Pre-treatment	Six-month Treatment later	Pre-treatment	Six-month Treatment later	Pre-treatment	Six-month Treatment later
Control group	60	50.62±5.25	68.35±6.24[a]	52.27±7.13	66.32±6.25[a]	60.53±6.51	74.35±5.24[a]	49.22±5.34	60.20±5.38[a]
Research group	60	51.55±5.22	79.03±6.22[a]	53.40±7.18	75.65±6.91[a]	61.48±6.52	85.83±6.21[a]	49.25±5.36	72.18±5.50[a]
t value		0.973	9.390	0.865	7.757	0.799	10.944	0.031	12.061
P value		.333	<.001	.389	<.001	.426	<.001	.976	<.001

[a]Compared to this group before the treatment, $P < .05$

Dental Function

Comparative analysis between the study group and the control group revealed no statistically significant disparities in tooth functionality prior to the commencement of treatment ($P > .05$). However, after a 6-month treatment period, the study group exhibited notably elevated scores in masticatory efficiency, swallowing capability, articulation proficiency, and occlusal performance in contrast to the control group ($P < .05$). Further elaboration can be found in Table 5 and Figure 4.

Aesthetic Evaluation

Comparative analysis of aesthetic attributes prior to treatment between the research and control group yielded results that did not manifest statistically significant differences ($P > .05$). Nevertheless, after a 6-month course of treatment, the study group demonstrated notably superior outcomes in both the red aesthetic index and the white aesthetic index when contrasted with the control group ($P < .05$). Further elaboration and data can be found in Table 6 and Figure 5.

Adverse Event Incidence

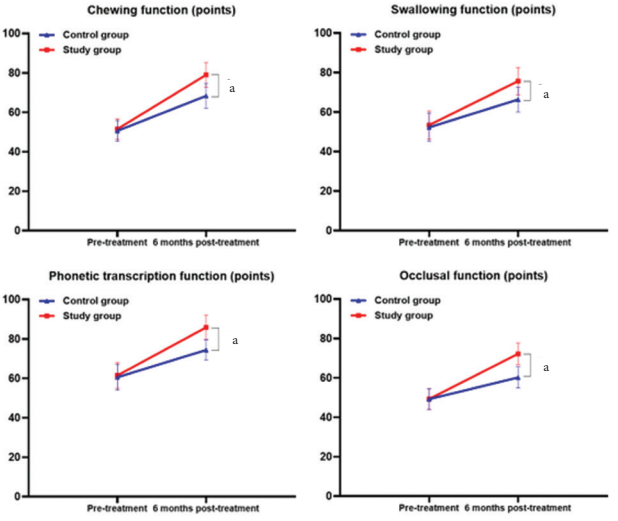
Upon comparison of adverse event incidences between the study group and the control group, no statistically notable differences were noted ($P > .05$). Please consult Table 7 for comprehensive information.

DISCUSSION

Individuals afflicted with dental malocclusion and periodontitis frequently exhibit a higher prevalence of dental plaque and soft deposits. The concomitant presence of severe gum inflammation exacerbates distressing dental symptoms, including toothache, tooth mobility, deepening of periodontal pockets, and attachment loss. These detrimental oral conditions can significantly compromise fundamental physiological processes such as mastication and occlusion.[8,9] Patients may encounter heightened gastrointestinal stress due to insufficient mastication of food. Furthermore, adjacent teeth retained in the vicinity of malocclusion interdental spaces may experience tilting and shifting, engendering aberrant contact and occlusal relationships among the teeth. This aberration in dental alignment elevates the susceptibility to dental caries, periodontal ailments, and temporomandibular joint disorders. Consequently, these multifaceted oral health issues exert a profound influence on both the physical and psychological well-being of affected individuals, underscoring the imperative need for timely intervention.[10,11]

In recent years, dental implant restoration technology

Figure 4. Comparison of dental function before and after treatment



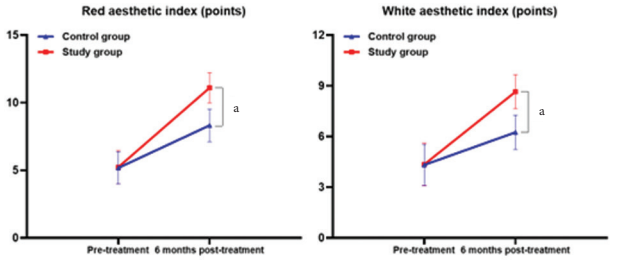
[a]$P < .001$

Table 6. Comparison of aesthetics between the two groups before and after treatment ($\bar{x} \pm s$, point)

group	case number	pink aesthetic index		White aesthetic index	
		Pre-treatment	Six-month Treatment later	Pre-treatment	Six-month Treatment later
Control group	60	5.18±1.19	8.32±1.21[a]	4.32±1.21	6.25±1.02[a]
Research group	60	5.23±1.24	11.10±1.13[a]	4.35±1.26	8.65±1.01[a]
t value		0.225	13.007	0.133	12.951
P value		.822	<.001	.894	<.001

[a]Compared to this group before the treatment, $P < .05$

Figure 5. Comparison of aesthetics before and after treatment



[a]$P < .001$

Table 7. Comparison of adverse event incidence in the two groups n (%)

Group	Case number	tooth mobility	Tooth mis-alignment	gingivitis	Oral mucosal injury	dental arch gap widening	total
Control group	60	1 (1.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (1.67)
Research group	60	1 (1.67)	1 (1.67)	1 (1.67)	0 (0.00)	0 (0.00)	3 (5.00)
χ^2 value							0.259
P value							.611

has undergone consistent and progressive evolution in dental implant restoration technology, establishing it as the preeminent therapeutic modality for patients contending with dental malocclusion and periodontitis. The dental implant restoration process entails the meticulous preparation of biological or non-biological materials, thereby fabricating artificial tooth roots designed for subsequent implantation within the alveolar bone. Subsequent to integrating these artificial tooth roots with the alveolar bone in a robust and harmonious manner, dental crowns, designed to closely mimic the natural dentition, are affixed atop these root structures. This method serves as a highly efficacious means of reconstituting the structural soundness of maloccluded dental arches while concurrently enhancing dental aesthetics.

Moreover, scholarly investigations have posited that dental implant restoration plays a pivotal role in mitigating the damage inflicted upon periodontal tissues by adjacent retained teeth, thereby mitigating post-treatment pain and expediting the restoration of biting functionality. Implants characterized by robust fixation exert a direct and favorable influence by transmitting chewing forces directly to the contiguous jawbone, thereby catalyzing the recuperation of masticatory function post-treatment.[12] However, a subset of studies has intimated that the efficacy of exclusive reliance on implant restoration for patients grappling with dental malocclusion and periodontitis remains circumscribed. Particularly, individuals with diminished occlusal force might not achieve the desired restorative outcomes.[13] Conversely, emerging research suggests that a strategic recourse to orthodontic interventions antecedent oral implant restoration holds the promise of rectifying patients'occlusal misalignments and addressing adjacent relationships. This sequential approach yields a dual benefit, enhancing aesthetic appeal and functional restoration. Consequently, this integrated methodology engenders more optimal treatment outcomes, as substantiated by recent scholarly inquiries.[14] The omission of orthodontic brackets facilitates orthodontic treatment devoid of wires and brackets. This approach not only preserves dental aesthetics but also substantially mitigates discomfort throughout the corrective procedure. In comparison to conventional orthodontic interventions, it confers several merits, including aesthetic refinement, enhanced comfort, procedural simplicity, and facile disassembly.

The findings of this investigation demonstrate that, following a six-month treatment period, the research cohort exhibited diminished Visual Analog Scale (VAS Although the study group did not meet the standard of painless pain, the pain was significantly lower than that before treatment) scores compared to the control group. Moreover, levels of interleukin-6 (IL-6), interleukin-1 (IL-1), and tumor necrosis factor-α (TNF-α). The values in the study group were within the normal range, within the gingival sulcus were notably lower in the research group as opposed to the control group. Additionally, Plaque Index (PLI) and Dental Index (DI) values were also lower in the research group relative to the control group. These outcomes affirm the positive impact of titanium alloy implant restoration subsequent to orthodontic intervention devoid of brackets on patients afflicted with dental malocclusion and periodontitis. This approach effectively ameliorates periodontal discomfort and inflammation while concurrently augmenting oral hygiene practices among the patients. Several factors contribute to this salutary effect. First and foremost, orthodontic treatment involving bracketless invisible aligners is characterized by its convenience of wear and necessitates regular removal for cleaning purposes. This procedural attribute efficaciously diminishes the likelihood of gingival plaque accumulation and the deposition of soft matter in anatomically intricate areas such as tooth intrusions, root concavities, and root bifurcations. Consequently, this proactive measure serves to mitigate the impact of bacterial microorganisms on the periodontal tissues, thereby resulting in a reduction of inflammation factor levels. Furthermore, this practice fosters an improved periodontal healing milieu, thereby catalyzing the reparative processes within the periodontal tissue framework. Ultimately, the titanium alloy implant repair treatment can better help these concerted effects contribute positively to the mitigation of post-treatment pain.[15,16]

The utilization of non-bracket invisible orthodontic appliances has demonstrated a capacity to effectively rectify the tilting and misalignment of adjacent retained teeth, thereby facilitating the restoration of normal occlusion and interdental alignment. In addition to this, the adoption of such orthodontic modalities not only mitigates harm to periodontal tissues and ameliorates periodontal discomfort but also streamlines the comprehensive elimination of residual teeth, dental calculus, and dental plaque during subsequent implant restoration procedures when carrying out titanium alloy implant repair treatment. This multifaceted approach contributes to a reduction in the accrual of periodontal plaque and soft deposits, concomitant with a decrement in the levels of inflammatory mediators.[17] Studies have pointed out that the invisible orthodontic treatment combined with implant repair in patients with dentition deformity defects associated with periodontitis is of positive significance to improving the tooth function and tooth aesthetics of patients.[18] The outcomes of this investigation delineate that, following a six-month intervention, the experimental cohort exhibited heightened scores in various functional domains, including mastication, deglutition, phonetic articulation, and occlusal functionality in comparison to the control group.

Furthermore, the experimental group manifested elevated scores in both the red and white aesthetic indices following the same duration of treatment relative to the control group. It is more consistent with the above studies. These findings substantiate the efficacy of titanium alloy implant restoration subsequent to orthodontic intervention utilizing non-bracket invisible techniques in enhancing both the functional and aesthetic aspects of dentition in patients afflicted with dental arch deformities coupled with

periodontal pathologies. The rationales underpinning these observed enhancements are expounded upon as follows:

Non-bracket invisible orthodontic treatment encompasses the utilization of elastic materials for the formulation and construction of full-coverage braces. These braces facilitate the controlled displacement of teeth, exerting their influence by applying a rebound force by the orthodontic apparatus. The salient characteristic of this rebound force lies in its equitable distribution, affording precise management of the orthodontic force's magnitude and the resulting extent of tooth displacement. Such a controlled orthodontic force administration strategy minimizes the undesirable and excessive to-and-fro movement of the affected teeth. In doing so, it mitigates the potential for occlusal trauma, averts the development of abnormal adjacent relationships between teeth, and establishes a conducive environment for the gradual rehabilitation of periodontal supporting tissues. This, combined with titanium alloy implant repair treatment, fosters the eventual restoration of both dental functionality and aesthetics during the later stages of treatment.[19,20.]

The utilization of non-bracket invisible orthodontic aligners, which envelop the teeth, leads to a more rational distribution of stress on the dental structures. This is particularly significant during tooth displacement, as the aligners apply force in proximity to the center of resistance. This orchestrated and incremental approach, characterized by segmented movement, promotes a holistic tooth migration pattern, culminating in optimal root parallelism. Enhanced root parallelism, in turn, fosters a harmonious relationship between the tooth crown and root. Subsequently, titanium alloy implant-based restorative treatments are administered, guided by three-dimensional (3D) planning, and implant specialists gain greater precision in determining inter-root distances. This heightened precision significantly elevates the accuracy and safety of the titanium alloy implantation procedure, resulting in more secure and aesthetically pleasing treatment outcomes. Such outcomes, in addition to contributing to improved post-treatment dental functionality, also enhance the aesthetic aspects of dental restoration.[21] In addition, from a safety standpoint, our study observed one adverse reaction in the control group and three in the research group. There was no statistically significant disparity in the incidence of adverse outcomes between the research and control group. This substantiates that the utilization of titanium alloy implant restorations subsequent to non-bracket invisible orthodontics for patients presenting with dental arch deformities and concomitant periodontitis does not escalate the rate of adverse outcomes. Consequently, this approach maintains treatment safety.

In synopsis, the application of titanium alloy implant restoration subsequent to non-bracket invisible orthodontic interventions in patients presenting with dental arch deformities and concomitant periodontitis demonstrates a noteworthy capacity to mitigate periodontal pain, diminish inflammatory responses, ameliorate oral hygiene, optimize dental functionality, and enhance dental aesthetics. Importantly, these therapeutic benefits are achieved without a concomitant escalation in the potential for adverse outcomes, thereby underscoring a substantial enhancement in the overall efficacy of the treatment protocol.

ETHICAL COMPLIANCE

This study was approved by the ethics committee of the Second Affiliated Hospital of Qiqihar Medical University ((2020) Ethics Review No. (08)). Signed written informed consents were obtained from the patients and/or guardians.

CONFLICT OF INTEREST

The authors have no potential conflicts of interest to report relevant to this article.

AUTHOR CONTRIBUTIONS

QW and BF designed the study, BF collected the data, YG analyzed the data, and QW prepared the manuscript. All authors read and approved the final manuscript.

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