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Study on the Levels of Gingival Crevicular Fluid Cytokines and Periodontal Status in Patients with Anterior Teeth Fan-shaped Displacement Treated with Orthodontic-periodontal Splint Therapy

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Abstract

Objective: This study focuses on the combined application of orthodontic treatment and periodontal splinting, aiming to deeply explore the specific effects of this therapy on the levels of gingival crevicular fluid cytokines and periodontal health status in patients with anterior tooth fan-shaped displacement. **Methods:** A total of 62 patients with anterior tooth fan-shaped displacement who received combined orthodontic and periodontal splinting treatment between January 2022 and December 2023 were included in the study. They were divided into two groups based on different treatments. The control group (31 cases) received periodontal splinting treatment, while the observation group (31 cases) received combined orthodontic and periodontal splinting treatment. The levels of gingival crevicular fluid cytokines [tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6)] and plaque index (PLI) scores were compared between the two groups. **Results:** After treatment, the IL-6 and TNF-α levels in the observation group were lower than those in the control group, and the PLI score was also lower than that in the control group ($P < 0.05$). **Conclusion:** Combined orthodontic and periodontal splinting treatment for patients with anterior tooth fan-shaped displacement can reduce the levels of gingival crevicular fluid cytokines and improve periodontal status.

Keywords

Orthodontics; periodontal splint; anterior tooth fan-shaped displacement; gingival crevicular fluid cytokines; periodontal status

Periodontitis is a common oral disease that easily causes anterior teeth to shift outward, severely affecting patients' masticatory function and tooth aesthetics [1]. This outward shifting of anterior teeth not only disrupts the integrity of the dental arch but may also lead to a series of oral health issues, reducing the patient's quality of life. Currently, there are various treatment methods for anterior teeth outward shifting caused by periodontitis in clinical practice, but single treatment approaches often have limitations. Periodontal splints can stabilize loose teeth, distribute occlusal forces, and improve masticatory function. Orthodontic treatment can realign loose and shifted teeth, alter their long axis and force direction, eliminate traumatic bite forces, and aid in the recovery and healing of periodontal tissues [2, 3]. This study aims to explore the impact of this combined treatment method on the levels of gingival crevicular fluid cytokines and periodontal status in patients, providing more scientific and effective references for clinical treatment and enhancing the therapeutic outcomes for anterior teeth outward shifting caused by periodontitis. The results are reported as follows.

1. Data and Methods

1.1 General Data

A study was conducted on 62 patients with anterior tooth fan-shaped displacement who received orthodontic combined periodontal splint treatment between January 2022 and December 2023. The patients were divided into two groups based on different treatment methods: the control group (31 patients) received periodontal splint treatment, while the observation group (31 patients) received combined orthodontic and periodontal splint treatment. This study has been approved by the Medical Ethics Committee. Inclusion criteria: diagnosed with periodontitis, accompanied by anterior tooth fan-shaped displacement; varying degrees of looseness and inclination of anterior teeth [4]; signed informed consent; aged over 18 years old, with no severe systemic diseases. Exclusion criteria: pregnant or lactating women; coagulation dysfunction; major organic lesions in the liver, kidney, or other tissues and organs; cognitive or communication disorders. There was no significant difference in baseline data between the two groups ($P > 0.05$), making them comparable, as shown in Table 1.

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

Grouping	Number of cases	Gender (n, %)		Age (years), ($\bar{x} \pm s$)	Deep coverage (n, %)		
		Male	Female		I	II	III
Observation group	31	13 (41.94)	18 (58.06)	37.64±5.85	14 (45.16)	11 (35.48)	6 (19.35)
Control group	31	14 (45.16)	17 (54.84)	38.17±5.79	15 (48.39)	9 (29.03)	7 (22.58)
$t/\chi^2/F$	-	0.066		0.359		0.053	
P	-	0.798		0.721		0.958	

1.2 Methods

Before starting treatment, patients need to receive oral care guidance. They should brush their teeth twice a day, once in the morning and once in the evening, and rinse their mouths with water or mouthwash after each meal. Additionally, patients should undergo routine periodontal basic treatment. Once the patient's periodontal inflammation is effectively alleviated and their oral hygiene improves to a good level, the subsequent treatment process can begin.

The control group received periodontal splint treatment. The procedure involved using stainless steel wire combined with composite resin splints. Stainless steel wire was used to tie an '8' shape around the labial and lingual sides of the abutment teeth in the interdental space, and the ends were folded into the interdental space after tying. The tooth surfaces were thoroughly cleaned, followed by drying with an air gun. A bonding agent was evenly applied to the tooth surfaces and light-cured for 1 minute. Then, high-strength flowable resin was placed over the wire surface, and its shape was carefully adjusted. After adjusting the shape, the resin was light-cured again, and the surface was polished. Finally, the patient's occlusion was adjusted.

The observation group received combined orthodontic and periodontal splint treatment. On the basis of the periodontal splint treatment plan, orthodontic treatment was also conducted. The straight-wire appliance technique was used, with brackets bonded to the surfaces of the teeth that needed to be moved. For the correction of anterior teeth, titanium-nickel round wire was used for alignment; multi-curve labial arches were employed to push down the upper and lower anterior teeth, while simultaneously ligating the canines and hanging an elastic chain between the two canines to promote the retraction of the anterior teeth. Subsequently, retainers were used to maintain the fixed state of the teeth. Throughout the entire treatment process, the oral and periodontal conditions of the patients were closely monitored, and based on the health status of the periodontal support tissues and the patients' tolerance, the magnitude of orthodontic force was adjusted in a timely manner. During the orthodontic treatment period, it was clearly stipulated that patients should have a follow-up visit every month and undergo periodontal cleaning every three months. Both groups strictly adhered to the treatment plan, receiving continuous treatment for 12 months.

1.3 Observation indicators

(1) Levels of cytokines in gingival crevicular fluid. During treatment, samples of gingival crevicular fluid were collected from the bottom of the gingival sulcus before and after treatment. Enzyme-linked immunosorbent assay (ELISA) technology was used to quantitatively detect levels of tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6) in the collected gingival crevicular fluid samples.

(2) Periodontal status. The plaque index (PLI) was measured at the beginning of treatment and after treatment completion for each patient. The PLI score ranges from 0 to 5, with higher scores indicating poorer periodontal health.

1.4 Statistics handling

Data analysis was conducted using SPSS 26.0 software. Count indicators were expressed as frequency/percentage (n/%), and chi-square (χ^2) tests were used. For measurement indicators, data were presented as mean ± standard deviation ($\bar{x} \pm s$) and t-tests were applied. A P-value of less than 0.05 was considered statistically significant.

2. Results

2.1 Comparison of cytokine levels in the gingival crevicular fluid between the two groups

After treatment, the levels of IL-6 and TNF-α were lower in the observation group than in the control group ($P < 0.05$) (see Table 2).

Table 2. Comparison of gingival crevicular fluid cytokine levels between two groups ($\bar{x} \pm s$)

Grouping	Number of cases	IL-6 (pg/ml)		TNF-α (ng/ml)	
		Before treatment	After treatment	Before treatment	After treatment
Observation group	31	10.83±2.72	3.43±0.41[a]	20.67±2.36	5.50±0.54[a]
Control group	31	11.05±2.80	4.89±0.53[a]	21.18±2.58	7.19±0.65[a]
t	-	0.314	12.131	0.812	11.135
P	-	0.755	0.000	0.420	0.000

Note: a represents a comparison with this group before treatment, $P<0.05$.

2.2 Comparison of periodontal status between the two groups

After treatment, the PLI scores in the observation group were lower than those in the control group ($P < 0.05$) (See Table 3).

Table 3. Comparison of periodontal status between two groups ($\bar{x} \pm s$)

Grouping	Number of cases	Before treatment	After treatment
Observation group	31	1.87±0.36	0.99±0.17[a]
Control group	31	1.88±0.38	1.23±0.20[a]
t	-	0.106	5.091
P	-	0.916	0.000

Note: a represents comparison with this group before treatment, $P<0.05$.

3. Discussion

Anterior tooth fan-shaped displacement is a common manifestation of periodontal disease when it reaches a certain stage. Teeth gradually spread apart and tilt due to the absorption of alveolar bone and reduction of supporting tissues, forming a fan-like arrangement, which severely affects aesthetics and oral function [5]. Periodontal splints connect and stabilize loose front teeth into a single unit, increasing their stability and reducing movement when force is applied. This provides a stable oral environment for orthodontic treatment, ensuring effective results [6]. Moreover, it can distribute bite force, reduce the load on individual teeth, and promote the healing and repair of periodontal tissues. Orthodontic treatment involves doctors applying appropriate corrective forces to precisely move teeth, realigning displaced front teeth to their normal positions, improving tooth alignment and bite relationships, restoring normal functions such as chewing and speech, and enhancing facial aesthetics.

In this study, after treatment, the levels of IL-6 and TNF-α in the observation group were lower than those in the control group, and the PLI scores were also lower ($P < 0.05$). The results are similar to those found by Pei Zhuangmin [7]. Periodontal splints can stabilize loose teeth, prevent further displacement, distribute bite force across multiple teeth, fully utilize the compensatory function of periodontal tissues, reduce the periodontal burden on affected teeth,

promote healing and repair of periodontal tissues, improve periodontal status, and consequently lower the levels of cytokines in gingival crevicular fluid [8]. Orthodontic treatment can align crowded and misaligned teeth, correct fan-shaped displacement of anterior teeth, close gaps, and form a well-coordinated arch shape, allowing normal transmission of forces to the periodontium, avoiding imbalance in jaw force, eliminating occlusal trauma and interferences, restoring normal masticatory function stimulation, which is beneficial for physiological self-cleaning of teeth, controlling plaque, maintaining periodontal health, thereby lowering the levels of cytokines in gingival crevicular fluid and improving periodontal status [9]. The combined orthodontic and periodontal splint treatment, where the splint helps improve periodontal status and maintain normal physiological functions of periodontal tissues, while orthodontic treatment corrects displacement caused by periodontal disease, together significantly enhances treatment outcomes, reduces inflammation levels, lowers cytokine levels in gingival crevicular fluid, and improves periodontal status [10].

In summary, orthodontic combined with periodontal splint therapy can reduce the levels of cytokines in the gingival crevicular fluid and improve the periodontal condition in patients with anterior tooth fan-shaped displacement.

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