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Original Article

The Effect of Single-stage Oral Disinfection and Quadrant Scaling and Root Planing on Serum IL-23 Level and Periodontal Clinical Indices in Periodontitis

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Abstract

Introduction: Periodontitis is a chronic inflammatory condition marked by the gradual destruction of tooth-supporting structures. Interleukin-23 (IL-23) plays a central role in the progression of periodontal disease. Thus, this study aimed to assess serum IL-23 levels and periodontal indices following single-stage full-mouth disinfection (FMD) and quadrant scaling and root planing (Q-SRP) in patients with chronic, moderate-to-advanced periodontitis.

Methods: Twenty patients were included in this double-blind trial study and divided into two groups. One group received single-stage FMD, while the other underwent Q-SRP. Periodontal status was assessed by measuring the clinical attachment level (CAL), bleeding on probing (BOP), plaque index (PI), probing depth (PD), and the modified gingival index (MGI). Evaluations were performed at baseline and at two- and four-month follow-ups. Moreover, serum IL-23 levels were estimated at the time points using an enzyme-linked immunosorbent assay. Data were analyzed with SPSS 16.

Results: Mean serum IL-23 levels decreased after both FMD and Q-SRP treatments, with no statistically significant difference between the groups ($P>0.05$). Periodontal indices, including BOP, CAL, PI, and PD, improved in both groups, again without significant intergroup differences ($P>0.05$). However, the MGI was significantly lower in the FMD group at 2-month and 4-month follow-ups ($P<0.05$).

Conclusion: Both FMD and Q-SRP effectively enhanced periodontal parameters while reducing serum IL-23 levels, with no significant differences between the two methods for most indices. Overall, although the lower MGI observed in the FMD group suggests a potential advantage in reducing gingival inflammation, the findings indicate that both treatments are similarly effective.

Keywords: Chronic Periodontitis, Quadrant Scaling and Root Planing, Full-Mouth Disinfection, IL-23

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Introduction

Periodontitis represents one of the most prevalent diseases of the oral cavity (1). It is a chronic inflammatory condition that is characterized by the progressive destruction of tooth-supporting structures, including the periodontal tissues and alveolar bone (2). Various risk factors influence the development of periodontitis, such as specific subgingival bacterial species, smoking, diabetes, age, environmental and genetic factors, as well as other systemic conditions (1, 3). Chronic periodontitis is frequently associated with pathogens, including *Aggregatibacter actinomycetemcomitans*, *Porphyromonas gingivalis*, and *Tannerella forsythia* (4).

According to research, periopathogens are found not only in periodontal pockets but also on various oral mucosal surfaces, including the tongue and buccal mucosa. These locations can act as reservoirs, potentially contributing to the recolonization of periodontal pockets following treatment (5, 6). A recent study analyzing peri-implant and periodontal plaque reported the presence of opportunistic pathogens in dental implants and adjacent teeth, indicating the possibility of bacterial transmission from neighboring teeth to implants (7). Non-surgical periodontal therapy is generally performed over multiple appointments, treating one section of the mouth at a time. During this approach, untreated periodontal pockets may

serve as a source of reinfection (8). To overcome this issue, the full-mouth disinfection (FMD) technique was developed, which involves scaling and root planing (SRP), along with surface decontamination using chlorhexidine across the gingival sites in two sessions with a 24-hour interval (8, 9).

Several studies on both humans and mice have demonstrated that T helper (Th) 1 cells and their cytokines play a central role in the early stages of periodontal disease, while Th2 cells, together with B lymphocytes, are more involved in the progression of periodontal lesions, particularly in advanced stages (10-12). Nonetheless, given that earlier research has primarily focused on periodontal pathogenesis through the Th1/Th2 framework, the identification of Th17 cells offers new perspectives that may help resolve certain ambiguities in host-pathogen interactions during the development of periodontal disease (13, 14).

Interleukin (IL)-23 and IL-17 are major mediators in the pathogenesis of periodontitis, contributing to inflammatory tissue damage and alveolar bone loss (15). Th17 cells, which are activated by IL-23, can strongly promote osteoclastogenesis via IL-17, inducing the expression of receptor activator of nuclear factor kappa-B ligand (RANKL) on osteoblasts (15-17). Consequently, the IL-23/IL-17 axis regulates Th17 cell function and plays a pivotal role in the immune-mediated destruction of periodontal tissues.

As a major inducer of the Th17 pathway in periodontal pathophysiology, IL-23 has a central role in the production of cytokines and other inflammation-related mediators. Some studies have shown that the increased levels of IL-23 in the gingival crevicular fluid of patients with periodontitis are associated with the severity of periodontal tissue destruction, highlighting the significant role of this cytokine in periodontal disease pathogenesis (15, 17, 18). Given the essential function of IL-23 in activating Th17 cells and promoting IL-17 secretion – which subsequently enhances RANKL expression and contributes to alveolar bone loss– this cytokine was selected as the primary biomarker for the present study. Therefore, serum IL-23 measurement can serve as a reliable marker of inflammation severity and therapeutic efficacy (15, 18).

Accordingly, the present study aims to compare the inflammatory response between FMD and Q-SRP in patients with chronic periodontitis by assessing serum IL-23 levels. To the best of our knowledge, this is the first study to directly evaluate these two treatment approaches using this biomarker. In addition, the study seeks to assess periodontal indices and compare their changes following the implementation of these two therapeutic methods.

Based on the null hypothesis of this study, there would be no significant difference in serum IL-23 levels or periodontal clinical parameters between the two methods in patients with chronic periodontitis.

Materials and Methods

Study Design

Twenty patients who met the inclusion and exclusion criteria were randomly assigned to two groups using a coin toss. The sample size was calculated using the following formula:

$$\frac{(z_{1-\alpha} + z_{1-\beta})^2 Sd^2}{d^2}$$

where n and Sd represent the sample size and standard deviation of differences in IL-23 levels before and after the intervention, respectively. Moreover, d denotes the mean difference in IL-23 levels before and after the intervention. In addition, α (0.05) and β (0.20) are type I and type II errors, respectively.

Based on a significance level of 0.05 and a power of 80% to detect a meaningful difference of 1.3 units, the estimated sample size was set at 20 participants. The study was conducted as a double-blind trial, implying that both the participants and the analysts were unaware of the intervention method. However, the researchers, who also acted as clinicians, were aware of the applied procedures.

Inclusion Criteria

Patients were included if they were between 25 and 70 years old, had at least 12 natural teeth present (excluding third molars and teeth with orthodontic appliances, bridges, crowns, or implants), were diagnosed with advanced chronic periodontitis, demonstrated clinical attachment loss of ≥ 3 mm in at least 30% of teeth, and exhibited radiographic evidence of alveolar bone loss.

Exclusion Criteria

Patients were excluded if they had systemic conditions (e.g., cancer, diabetes mellitus, acquired immunodeficiency syndrome, bone metabolic disorders, autoimmune or allergic diseases, or other infectious diseases) or had conditions that could impair wound healing. Furthermore, they were excluded if they had a history of radiotherapy or immunosuppressive therapy, were pregnant or lactating, had used systemic antibiotics within the past two months, were on continuous nonsteroidal anti-inflammatory drug therapy, or had undergone SRP within the past year.

The first group underwent FMD, while the second one received the conventional treatment (Q-SRP). To assess serum IL-23 levels, 5 mL of blood was collected from each patient before treatment and at 2-month and 4-month follow-ups. The samples were subsequently frozen for storage. Additionally, serum IL-23 levels were determined using an enzyme-linked immunosorbent assay (ELISA) with a specific human IL-23 ELISA kit (eBioscience, USA), following the manufacturer's protocol.

Following blood sampling, patients in the control group underwent SRP at two-week intervals for each half of the jaw. To minimize pathogenic microorganisms in the test group, the entire mouth was disinfected using an ultrasonic disinfection device over two appointments, with an interval of less than 24 hours. In addition, the gingival irrigation of all periodontal pockets was

performed using 2% chlorhexidine with an insulin syringe to remove residual bacteria, and the tongue was brushed with a 2% chlorhexidine antiseptic solution in order to reduce bacterial load in the oral cavity.

Serum IL-23 levels and clinical periodontal parameters, including bleeding on probing (BOP), the clinical attachment level (CAL), probing depth (PD), and the modified gingival index (MGI), were assessed at baseline and at 2-month and 4-month follow-ups. Further, plaque control was monitored using the O'Leary index, with the aim of reducing it below 10% through plaque control interventions conducted during the second, fourth, eighth, and twelfth weeks. Furthermore, PI and gingival index (GI) were treated as control variables, and patients who demonstrated poor compliance (indicated by high indices in periodic assessments) were excluded from the study.

How to Measure Clinical Indices

A. Bleeding on Probing: Four points of each tooth –mesial, distal, buccal, and palatal/lingual– were examined by gently probing the sulcus with a slow and soft motion to the full depth of the pocket. If bleeding occurred within 15 seconds at any of these four points, the tooth was recorded as BOP positive; otherwise, it was considered BOP negative (according to the Gingival Sulcus Bleeding Index introduced by Muhlemann & Son, 1971 (19,20)).

B. Probing Depth: The periodontal probe had to be aligned parallel to the tooth's longitudinal axis and inserted with a force of 25 g to reach the full depth of the pocket. The probe was then moved circumferentially around the tooth following its contour. PDs were recorded in four regions –mesiobuccal, mid-buccal, distobuccal, and mid-palatal/mid-lingual– on the periodontal chart using a UNC-15 probe.

C. Clinical Attachment Level: CAL was determined by measuring the distance from the cemento-enamel junction to the gingival margin and subtracting the pocket depth from this measurement.

D. Modified Gingival Index: It is one of the most widely utilized gingival indices in clinical trials, and the corresponding measurement criteria are presented as follows:

0: Absence of inflammatory signs

1: Mild inflammation characterized by slight color alteration and minimal changes in gingival tissue, without complete involvement of the marginal gingiva or interdental papilla

2: Mild inflammation presenting the above-mentioned features, with complete involvement of the marginal gingiva and/or gingival papilla

3: Moderate inflammation affecting the marginal gingiva or gingival papillae, accompanied by redness, edema, and/or hypertrophy

4: Severe inflammation of the marginal or papillary gingiva, marked by pronounced redness, edema and/or hypertrophy, persistent bleeding, congestion, or ulceration

E. Plaque Index: It represents the proportion of tooth surfaces that become stained following the application of O'Leary disclosing agents.

The initial patient examinations, clinical interventions, blood sampling, and follow-up assessments were conducted at the Periodontics Department and the Oral Research Center of Tabriz Dental School. In addition, paraclinical analyses were performed in the immunology laboratories of Tabriz Medical School and the Applied Research Center of Pharmacy.

Data Analysis

Data were analyzed using descriptive statistics (means ± standard deviations) and parametric tests, including the paired-samples t-test in SPSS, version 16 (Chicago, IL, USA). Data normality was assessed using the Kolmogorov-Smirnov test, and comparisons across different time points were performed using the analysis of variance (ANOVA). Further, a *P*-value of less than 0.05 was considered statistically significant. Finally, figures were plotted using Microsoft Excel 2021 (Microsoft Office LTSC Standard 2021).

Results

In this study, the FMD group consisted of 45% males and 55% females, whereas the Q-SRP group included 60% males and 40% females. The Chi-square test indicated no significant difference in gender distribution between the two groups ($P=0.34$). The mean age of participants was 43 years in the FMD group and 47.7 years in the Q-SRP group. Based on the independent t-test results, there was no statistically significant difference in the mean age between the groups ($P=0.21$).

To evaluate the study objectives, data distribution was assessed at three time points (baseline, 2-month follow-up, and 4-month follow-up) using the Kolmogorov-Smirnov test. The results revealed that all variables were normally distributed ($P>0.05$).

Serum IL-23 levels in the FMD group showed a progressive decline following treatment (Table 1 and Figure 1). The ANOVA results demonstrated a significant difference in IL-23 levels across the evaluated time points (baseline, 2-month follow-up, and 4-month follow-up) ($P=0.02$). Moreover, Scheffé's post hoc analysis represented significant reductions between baseline and both the 2-month and 4-month assessments ($P<0.05$); however, no significant difference was detected between the 2-month and 4-month time points ($P=0.99$).

The findings (Table 1 and Figure 1) confirmed that serum IL-23 levels in the Q-SRP group decreased after treatment. Based on the ANOVA test, a significant difference was observed in IL-23 levels across the evaluated time points (baseline, 2-month follow-up and 4-month follow-up) ($P<0.001$). Scheffé's post hoc analysis displayed significant declines between baseline and the 2-month and 4-month assessments ($P<0.05$); nonetheless, there was no significant difference between

Table 1. Comparison of Serum IL-23 Levels Between Single-Stage Full-Mouth Disinfection and Quadrant Scaling and Root Planing at Baseline and Post-Treatment

Index	Time	Mean ± SD*	Treatment Type	*P*-Value
IL-23 serum	Baseline	97.62 ± 86.78	FMD	0.826
		104.11 ± 94.13	Q-SRP	
	2 months	46.68 ± 40.56	FMD	0.50
		38.48 ± 35.67	Q-SRP	
	4 months	45.13 ± 39.45	FMD	0.69
		39.36 ± 34.38	Q-SRP	

Note. *SD: Standard deviation; IL: Interleukin; FMD: Full-mouth disinfection; Q-SRP: Scaling and root planing.

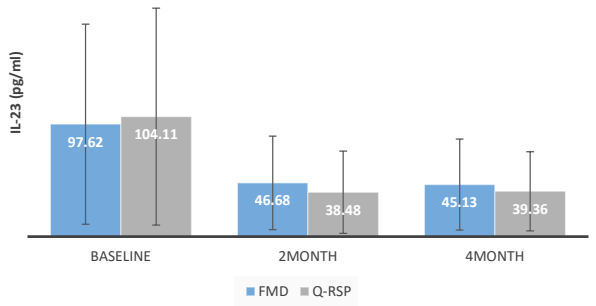

Figure 1. Serum IL-23 Levels Before and After Treatment With Single-Stage Full-Mouth Disinfection and Quadrant Scaling and Root Planning
Note. IL: Interleukin.

the 2-month and 4-month time intervals ($P = 0.99$).

The comparison of serum IL-23 levels between the FMD and Q-SRP groups revealed no statistically significant differences at baseline or at 2-month and 4-month follow-ups ($P > 0.05$, Table 1).

The following observations were made in the Q-SRP group (Table 2 and Figures 2 and 3):

Probing Depth: The mean PD decreased following treatment, and ANOVA indicated a significant reduction across the evaluated time points ($P < 0.001$).

Clinical Attachment Level: A significant decrease in mean CAL was observed after treatment, as confirmed by ANOVA across the studied time intervals ($P < 0.001$).

Plaque Index: The mean PI showed a significant decline over time following treatment, with ANOVA demonstrating a significant difference across the intended time points ($P < 0.001$).

Bleeding on Probing: Mean BOP values decreased significantly after treatment, and ANOVA displayed a significant decrease across the studied time intervals ($P < 0.001$).

Scheffé's post hoc analysis in the Q-SRP group demonstrated significant improvements in PD, PI, BOP, and CAL when baseline values were compared with those obtained at 2-month and 4-month follow-ups ($P < 0.05$). In contrast, no statistically significant differences were detected between the 2-month and 4-month follow-up assessments ($P > 0.05$).

The observations made in the FMD group are as follows

Table 2. Comparison of PD, CAL, PI, and BOP Between Single-Stage Full-Mouth Disinfection and Quadrant Scaling and Root Planing at Baseline and Post-Treatment

Index	Time	Treatment Type	Mean ± SD*	*P*-Value
PD	Baseline	FMD	4.18 ± 0.59	0.992
		Q-SRP	4.18 ± 0.66	
	2 months	FMD	2.76 ± 0.57	0.93
		Q-SRP	2.74 ± 0.63	
	4 months	FMD	2.60 ± 0.52	0.84
		Q-SRP	2.57 ± 0.56	
CAL	Baseline	FMD	4.20 ± 0.57	0.992
		Q-SRP	4.20 ± 0.67	
	2 months	FMD	3.04 ± 0.59	0.93
		Q-SRP	3.02 ± 0.62	
	4 months	FMD	2.78 ± 0.54	0.84
		Q-SRP	2.75 ± 0.56	
PI	Baseline	FMD	69.40 ± 24.20	0.285
		Q-SRP	76.70 ± 17.91	
	2 months	FMD	12.20 ± 19.32	0.78
		Q-SRP	10.85 ± 10.10	
	4 months	FMD	5.45 ± 3.25	0.92
		Q-SRP	5.55 ± 2.93	
BOP	Baseline	FMD	73.85 ± 15.20	0.874
		Q-SRP	72.75 ± 26.77	
	2 months	FMD	17.90 ± 9.32	0.46
		Q-SRP	15.70 ± 9.29	
	4 months	FMD	12.75 ± 13.69	0.07
		Q-SRP	6.6 ± 5.39	

Note. *SD: Standard deviation; CAL: Clinical attachment level; BOP: Bleeding on probing; PI: Plaque index; PD: Probing depth; MGI: Modified gingival index; FMD: Full-mouth disinfection; Q-SRP: Scaling and root planing.

(Table 2 and Figures 2 and 3):

Probing Depth: The mean PD represented a decrease after treatment, and ANOVA confirmed a significant reduction across the evaluated time intervals ($P < 0.001$).

Clinical Attachment Level: Based on ANOVA results across the studied time points, there was a sharp decrease in mean CAL after treatment ($P < 0.001$).

Plaque Index: The mean PI displayed a significant decrease over time following treatment, with ANOVA displaying a considerable difference across the examined time points ($P < 0.001$).

Bleeding on Probing: Mean BOP values decreased significantly after treatment, and analysis of variance confirmed a significant decline across the intended time intervals ($P < 0.001$).

Scheffé's post hoc analysis in the FMD group revealed substantial improvements in PD, BOP, PI, and CAL when baseline values were compared with those at 2-month and 4-month follow-ups ($P < 0.05$). No statistically significant differences were observed between the 2-month and 4-month follow-up measurements ($P > 0.05$).

Finally, there were no significant differences between the FMD and Q-SRP groups in any of the assessed parameters, including PI, PD, CAL, and BOP ($P > 0.05$).

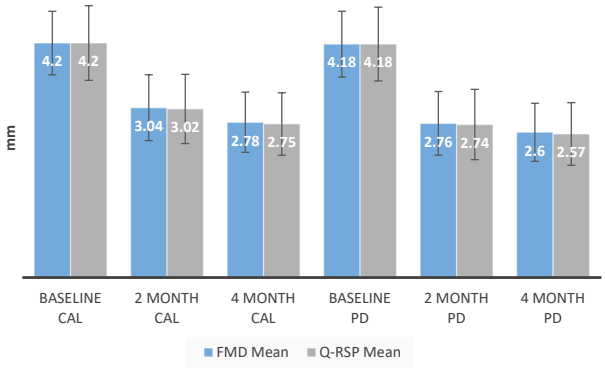

Figure 2. Comparison of PD and CAL Before and After Treatment With Single-Stage Full-Mouth Disinfection and Quadrant Scaling and Root Planning
Note. PD: Probing depth; CAL: Clinical attachment level.

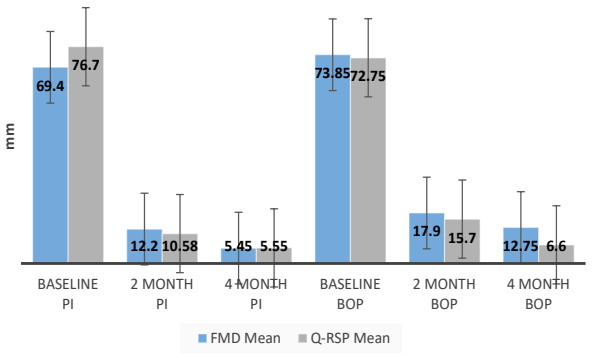

Figure 3. Comparison of PI and BOP Before and After Treatment With Single-Stage Full-Mouth Disinfection and Quadrant Scaling and Root Planning
Note. PI: Plaque index; BOP: Bleeding on probing.

The distribution of MGI scores improved in both groups over time (Table 3). In the Q-SRP group, higher severity scores were more frequent at baseline, whereas lower severity scores predominated at 2-month and 4-month follow-ups. Similarly, in the FMD group, the frequency of severe MGI scores decreased after treatment, with milder scores becoming more common at follow-ups.

The chi-square test demonstrated a significant change in MGI severity across the evaluated time points within each group ($P < 0.05$).

No significant difference in MGI was observed between the FMD and Q-SRP groups at baseline ($P = 0.44$). However, at 2-month and 4-month follow-ups, significant differences emerged ($P < 0.05$), with the Q-SRP group exhibiting higher MGI scores, whereas the FMD group predominantly showed milder scores.

Discussion

This study evaluated the effects of FMD versus Q-SRP on serum IL-23 levels and clinical periodontal indices in patients with moderate-to-advanced periodontitis. Both approaches were effective in managing periodontal conditions, which conforms to the findings of multiple studies (21, 8, 22, 23). The goal of single-stage FMD is to quickly minimize periodontal pathogens throughout the oral cavity, including the oropharyngeal region, thereby preventing bacterial recolonization until the periodontal pockets have healed (8). This technique is relatively recent and offers several advantages concerning efficacy, rationale, patient and clinician convenience, systemic outcomes, and cost-effectiveness (24, 25).

An emerging and reliable approach for assessing periodontal disease involves measuring serum biomarkers. Subsequent studies focused on examining the changes in IL-23 (a pro-inflammatory IL) levels throughout the course of the treatment.

IL-23 is an important inflammatory cytokine that is essential for the expansion of Th17 cells, which are responsible for IL-17 production (26, 27). Moreover, IL-17 contributes to inflammation and tissue damage by promoting neutrophil migration and activation through increased chemokines and neutrophil-stimulating factors (28, 29). To the best of our knowledge, this is the first study comparing two therapeutic approaches in terms of inflammation, assessed by IL-23 levels.

Although limited research has assessed serum IL-23 levels in patients with chronic periodontitis, several studies have explored the IL-23/IL-17 axis in different populations. For instance, Ohyama et al reported that the expression of IL-23 and IL-17 was elevated in periodontal lesions compared to control sites. Furthermore, the levels of IL-23 and IL-12 were higher in periodontal lesions than in healthy sites (27). Additionally, Murphy et al found that rheumatoid arthritis (RA) serves as a relevant model for tissue destruction in periodontal disease, and their findings indicated that IL-23, rather than IL-12, is the key cytokine driving the pathogenesis of RA (30). In mouse models, the absence of IL-23 or the deficiency of its IL-23p19 subunit was found to be protective. In contrast, IL-12 deficiency resulted in collagen-dependent arthritis. The deletion of the *IL-23* gene not only prevented clinical manifestations but also conferred resistance to bone marrow and fetal bone pathology. Given that RA and periodontitis are inflammatory conditions, elevated IL-23 levels may play a role in the pathogenesis of both conditions (31).

Likewise, Takatori et al investigated the complex role of Th17 cells in autoimmune diseases and highlighted the IL-23/IL-17 axis as a critical factor in the development of periodontal lesions, suggesting its important contribution to periodontal biology. Their experiments revealed that the pathogenic effects of IL-23 were mediated by the IL-23p19 subunit, resulting in premature death, systemic inflammation, elevated serum levels of inflammatory cytokines, and an acute-phase response (32).

Based on the study findings, serum IL-23 levels changed significantly over time (at baseline, 2-month follow-up, and 4-month follow-up) within each treatment group. Levels were sharply lower after treatment compared to baseline, with no significant difference between the 2-month and 4-month measurements. Additionally, no significant differences were observed between the two groups.

Regarding most periodontal indices, including PI,

Table 3. Comparison of Modified Gingival Index Between Single-Stage Full-Mouth Disinfection and Quadrant Scaling and Root Planing at Baseline and Post-Treatment

		Q-SRP		FMD		
Time	**MGI**	**%**	**N**	**%**	**N**	***P*-Value**
Baseline	1	0	0	0	0	0.44
	2	5	1	0	0	
	3	55	11	70	14	
	4	40	8	30	6	
2 months	1	15	3	40	8	0.03
	2	80	16	40	8	
	3	5	1	20	4	
	4	0	0	0	0	
4 months	1	25	5	50	10	0.04
	2	70	14	30	6	
	3	5	1	20	4	
	4	0	0	0	0	

Note. FMD: Full-mouth disinfection; Q-SRP: Quadrant scaling and root planing; MGI: Modified gingival index; *SD: Standard deviation.

CAL, PD, and BOP, both treatment groups demonstrated significant clinical improvements over time, with no statistically significant differences between the groups. As a sensitive clinical measure for assessing the severity of gingival inflammation and early superficial changes, MGI is particularly capable of detecting subtle improvements in gingival health due to its expanded lower-end scale (33, 34). At the second and fourth months, the distribution of MGI scores in the FMD group indicated a greater reduction in gingival inflammation compared to the Q-SRP group, with the predomination of milder scores. Notably, this intergroup difference was limited to the MGI, while other clinical parameters and serum IL-23 levels did not significantly differ between the two treatment modalities. Consistent with a meta-analysis from 2008, the current findings indicated that FMD and quadrant scaling and Q-SRP are not significantly different in most outcomes, with only slight further improvements observed in certain indices (35).

Koshy et al (2005) and Jervøe-Storm et al compared the effectiveness of FMD and Q-SRP in improving clinical and microbial indices, reporting no significant differences between the two approaches (36, 37). In contrast, Bollen et al and Teughels et al found that FMD led to greater improvements in clinical and microbiological outcomes in patients with advanced chronic periodontitis compared to conventional periodontal therapy (38, 39). In a systematic review, there was only a very small difference in the clinical outcomes of chronic periodontitis treatment in adults (35).

Consistent with our findings, Predin et al observed that both approaches significantly improved clinical indices, without notable differences between the two groups (40). In other studies, Apatzidou and Kinane (41) and Koshy et al (36) reported similar findings. Likewise, De Genaro Modanese et al assessed immunological and clinical parameters, concluding that FMD significantly reduced PI, PD, and BOP in patients with generalized periodontitis (42). Moreover, Quirynen et al compared full-mouth SRP with the Q-SRP and suggested that treatment success was attributed to the rapid completion of therapy rather than the use of chlorhexidine (43). Several studies, however, identified chlorhexidine as a key factor contributing to the success of FMD compared to Q-SRP (44, 45). Conversely, many other investigations found no significant differences between Q-SRP and FMD performed without chlorhexidine (41, 45-47).

It is noteworthy that single-stage FMD substantially reduces the prevalence of abnormal periodontal pathogens, particularly in the subgingival region, and to a lesser extent throughout the oral cavity. Various mechanisms have been proposed to explain the success of this approach. According to previous studies, minimizing the risk of intra-oral transmission of periodontal pathogens enhances the outcomes of non-surgical periodontal therapy. Although the precise mechanisms of intra-oral pathogen shifts remain unclear, saliva, which can harbor a wide range of bacterial species, appears to play an important role. Direct transfer of periodontal pathogens via salivary flow into periodontal pockets is unlikely due to the outward movement of gingival crevicular fluid. In this regard, a more plausible mechanism involves indirect effects, whereby changes in supragingival plaque gradually influence the subgingival microbiota. Indeed, multiple studies indicate that at least part of the gingival microbial community depends on the presence of substantial supragingival plaques (47-50).

This study had several limitations. Despite a formal sample size calculation, the relatively small number of participants per group may have limited statistical power and the generalizability of our findings. The four-month follow-up precluded the assessment of long-term outcomes. In addition, evaluations were limited to conventional periodontal indices while excluding additional clinical parameters. Although serum IL-23 was measured, analyzing other inflammatory mediators could provide a more comprehensive understanding of treatment effects. Accordingly, future studies with larger samples, extended follow-ups, and broader inflammatory profiling are warranted. Moreover, further research is needed to compare serum IL-23 changes after surgical procedures (e.g., periodontal flap surgery) and to explore its immunological role in periodontal disease using animal models.

Conclusion

Based on the results of this study, both single-stage FMD and Q-SRP effectively improved clinical periodontal parameters while reducing serum IL-23 levels. While most periodontal indices and IL-23 levels did not significantly differ between the two treatments, FMD demonstrated a significantly greater improvement in MGI compared to Q-SRP ($P < 0.05$), indicating the potential advantage of FMD for certain clinical outcomes.

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Competing Interests
The authors declare they have no potential conflict of interests with respect to the research, authorship, and publication of this study.

Ethical Approval
This study was conducted following approval by the Research Committee of the Research Vice-Chancellor of Tabriz University of Medical Sciences. Moreover, written informed consent was obtained from all participants before they were enrolled in the study.

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