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Research Article

Impact of Interdental Brushing On Periapical and Gingival Health in Patients with Multi-Rooted RCT-Treated Teeth

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ABSTRACT

High-quality endodontic treatment and good oral hygiene are key factors in the long-term success of root canal treatment (RCT). The aim of the present study was to assess the effects of interdental brushing on periapical health and gingival health of RCT treated multi-rooted teeth. A prospective study was carried out in 170 patients of age group 20–45 years during a period of 6 months in Department of Operative Dentistry and Endodontics. There were two groups of participants: Group A (routine toothbrushing, n = 85) and Group B (routine toothbrushing + interdental brushing daily, n = 85). Gingival health was determined by Gingival Index developed by Löe and Silness (1963) and periapical status was determined by Periapical Index (PAI) developed by Ørstavik, Kerekes and Eriksen (1986) from standardized periapical radiographs. The clinical results at 6 months follow-up showed significant differences between the two groups, with Group B having a mean Gingival Index of 0.64 ± 0.29 versus Group A, which had a mean Gingival Index of 1.21 ± 0.41 ($p < 0.001$). 81.2% of patients in Group B showed favorable periapical healing (PAI score ≤2) while 67.1% of the patients showed favorable periapical healing in Group A ($p = 0.032$). The overall plaque reduction was 43.8% with interdental brushing versus 24.6% with toothbrushing only. All data was analyzed statistically with SPSS version 26.0, at the level of significance $p < 0.05$. The results showed that interdental brushes can be used as an adjunctive treatment to achieve a significant improvement in gingival health and promote periapical healing of multi-rooted RCT treated teeth, and that they are an important part of a routine post-endodontic oral hygiene regimen.

Keywords: Interdental Brushing, Root Canal Treatment (Rct), Periapical Health, Gingival Health, Multi-Rooted Teeth, Apical Periodontitis, Plaque Biofilm, Periapical Index (Pai), Gingivitis, Endo-Perio Relationship, Crown Restorations.

INTRODUCTION

A long-term success of endodontic treatment requires a delicate balance between the abilities of sealing the intracanal space and maintaining the area extra-radicularly. Root canal treatment (RCT) is meant to remove microorganisms from the internal root dentin system, but the prognosis of an RCT is dependent on the periodontal health of the surrounding dentin system (Ng et al., 2021). This relationship is significantly more complex in multi-rooted teeth like maxillary and mandibular molars, because there are multiple root curves, accessory canals, and furcation areas (Ricucci & Siqueira, 2019). Patients with multi-rooted teeth frequently have structural breakdown from the combination of dental caries, access cavity preparation and mechanical instrumentation that must be addressed in the root canal treatment. Zehnder & Belibasakis (2023) routinely use complex restorative procedures (such as custom-cast posts, core build-ups and full-coverage crowns) to protect these teeth. Such restorations are necessary to restore the function but often change the natural contours of the interdental space and may leave behind potential margins to collect pathogenic plaque.

Restorative margins in the posterior area have been shown in previous clinical studies, to be micro-environments that host complex biofilms that are challenging to break down with regular daily oral hygiene (Graziani et al., 2022).

Localized accumulation of biofilm is a major problem in interproximal places in multi-rooted teeth. The current linear bristle design of traditional manual and powered toothbrushes has very limited ability to enter the posterior tooth concave interdental embrasures, which are deep setbacks between the posterior teeth, making them very ineffective at cleaning deep into the tooth's concave areas (Slot et al., 2020). Traditional toothbrushes are only effective in cleaning up to 40% of the interproximal surfaces, which means that bacteria can quickly grow (Chapple et al., 2018). If the bacterial biofilm is not controlled in these interproximal spaces, it triggers an immune response that is non-specific and affects the marginal and attached gingiva, clinically as gingivitis (Chapple et al., 2018). With continued microbial stress, this superficial tissue inflammation can work its way down into the structural attachment apparatus. Uncontrolled stagnation of the proximal plaque increases periodontal attachment loss particularly around compromised molars (Sälzer et al., 2021) has been confirmed in studies on populations at high risk. Additionally, the clinical picture is made more complex by the proximity of the endodontic network and periodontal tissue in teeth that have been subjected to root canal treatment (RCT). Accessory canals, dentinal tubules and the apical foramen can allow the pathogenic microorganisms and their toxic products to pass in both directions between the pulp chamber and the external surface of the root (Zehnder & Belibasakis, 2023). This can cause marginal gingivitis and deep interdental plaque accumulation to spread apically, which can result in retrograde endodontic problems or secondary endo-perio lesions (Ricucci & Siqueira, 2019). This process destabilizes the periapical tissue, affects the surrounding bone structure around the root tips and shortens the life of the restored tooth (Ng et al., 2021).

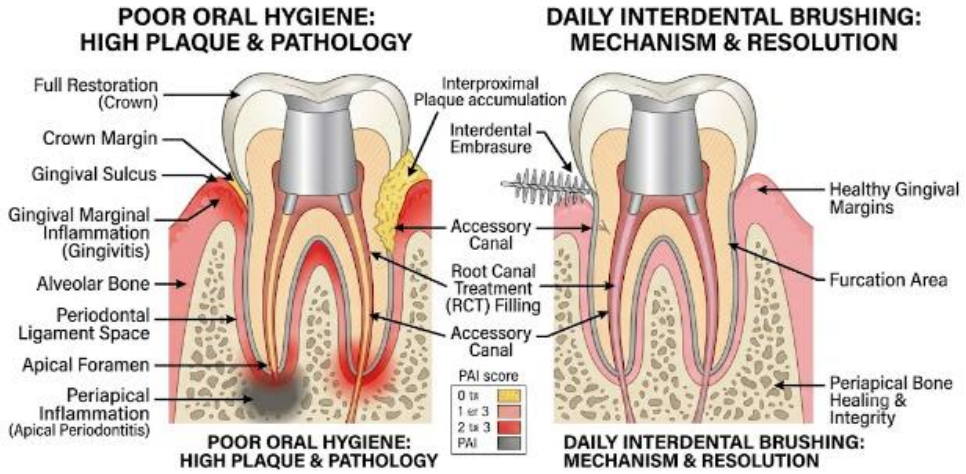


Figure 1: Bi-Directional Pathway of Inflammation in Multi-Rooted RCT-Treated Teeth and the Mechanical Disruption of Interproximal Biofilm via Calibrated Interdental Brushing

IDBs are a specialised form of mechanical oral hygiene product that are designed to overcome these anatomical challenges. The radial bristle design of an interdental brush fits the interproximal space mechanically and is more effective at fitting in the wider interproximal areas of posterior multi-rooted teeth than dental floss (Li et al., 2024). As a result of this expansion the bristles are able to physically break up the sticky biofilm layer both along the gingival margins and the root surfaces (Carrouel, 2025). A recent randomized controlled trial (RCT) found that interdental brushes resulted in a significantly greater mean plaque reduction than floss after a brief follow-up period (Li et al., 2024).

Longitudinal interventional studies have demonstrated that the use of calibrated interdental brushes has a clear benefit over single-flament floss or automatic water flossing in molar areas wider than two teeth (Slot et al., 2020). Interdental brushing is structurally characterized as the specific mechanical removal of interproximal dental plaque with small cylindrical or conical interproximal brushes that are calibrated to

the width of the interdental spaces (Bourgeois et al., 2022). Previously, researchers such as Axelsson (2004) had shown that long-term interproximal mechanical cleaning is effective in preventing reoccurring caries and reducing the rate of attachment loss in posterior teeth. The structural effect of interdental brushing on multi-rooted, RCT treated teeth is an area of clinical dentistry that is less studied in specific patient groups, although there are well documented benefits on periodontal health in general populations (Slot et al., 2020; Bourgeois et al., 2022). This study offers an overall analysis of the effect of regular, daily utilization of these devices on the superficial gingival reaction as well as the deep periapical tissue health of root-canal-treated posterior teeth.

In order to measure this clinical effect in a scientific way, certain parameters and physiological states need to be monitored systematically, one of the most important is gingival health. Gingival health is defined as a physiological state of the marginal and interdental gingival tissues, which is clinically characterized by absence of gingival changes, including edema, erythema and bleeding (Chapple et al, 2018). In clinical research, this state is recorded using validated indices, such as the Plaque Index (PI), which records the thickness of the biofilm, extending from the base of the sulcus to the free gingival margin (Li et al., 2024); the Gingival Index (GI), which provides an objective measure of the severity of soft tissue inflammation (Slot et al., 2020); and Bleeding on Probing (BOP), which detects the presence of micro-ulcerations in the sulcular epithelium as an indicator of the presence of active local inflammation (Sälzer et al., 2021). longitudinal studies on patients with periodontitis have shown that regular 12-week use of calibrated interdental cleaner (CIC) significantly improves bleeding scores and probing pocket depths (PPDs) (Slot et al., 2020). Even with slight manual dexterity, the use of the sized interdental brushes has been clinically proven by Christou et al. (2022) to reduce active bleeding areas within 14 days. At the same time, periapical health is a key aspect of this study, which is defined as the absence of periapical pathological conditions and structural integrity of the periapical tissues, including the Henderson alveolar bone and periodontal ligament space (Ng et al., 2021). Periapical health in multi-rooted teeth with previous endodontic treatment means a successful resolution or prevention of apical periodontitis (Ricucci & Siqueira, 2019). Secondary periapical lesions commonly occur in endodontically treated molars and are associated with persistent marginal plaque loading extending down the root length, which is a compromise to the apical bone (Ng et al., 2021). Radiographic assessment of the width of the periodontal ligament space and bone density, using standardized Periapical Index scores, is used to monitor this tissue integrity (Graziani et al., 2022). Radiographic changes in the density of the periapical bone as defined by Ørstavik (2018) provide a highly validated scale for the assessment of periapical bone healing or breakdown after a long follow-up period.

METHODOLOGY

In the present study, a prospective comparative clinical study design was followed for the assessment of the effect of interdental brushing on periapical and gingival health of multi-rooted root canal treated teeth. This study was carried out during six months in the Department of Operative Dentistry and Endodontics of a tertiary care dental hospital. The study was carried out following the ethical guidelines of the Declaration of Helsinki. Informed consent was obtained prior to enrollment from all participants, and participants were made aware that their participation was voluntary and that they could withdraw from the study at any time without it impacting their dental care.

The study population comprised of adult patients (age 20-45 years) who visited the outpatient department for follow-up after successful root canal treatment of multi-rooted permanent teeth. The number of samples required was determined using OpenEpi version 3.01 with a 95% confidence level, 80% study power, expected effect size from similar studies and a 5% margin of error. A sample size of 170 participants was estimated. The participants were recruited using non-probability consecutive sampling method until the required number of participants was met.

The inclusion criteria were patients aged between 20 and 45 years, with at least one multi-rooted permanent tooth treated with completed root canal treatment within the last 1 to 3 months, with an adequate coronal restoration, minimum of 20 natural teeth, willingness to attend all follow-up visits within the study period. Patients with systemic diseases which might affect periodontal healing (such as uncontrolled diabetes mellitus

or immunocompromised condition, pregnant or lactating women, smokers who smoke over ten cigarettes daily, patients undergoing orthodontic treatment, patients who had periodontal therapy in the last six months, patients who had taken antibiotics or anti-inflammatory medication in the last four weeks before being enrolled, patients with root fracture/perforation and hopeless periodontal prognosis) were excluded.

Patients were then randomly divided into two groups of 85 patients. The group A received their normal oral hygiene instructions which involved twice-daily toothbrushing with a soft bristle toothbrush and fluoridated toothpaste. Group B was given the same toothbrushing instructions, along with group-specific education on the proper use of interdental brushes. The principal investigator chose appropriate interdental brush sizes based on the interdental space for each individual. The participants in Group B were asked to use the interdental brush once a day, preferably at night after their regular brushing. Dental models were used to demonstrate the technique and participants were encouraged to practise the technique under supervision to ensure correct use. Oral hygiene instructions were reinforced on a monthly follow up visit.

The data collected were baseline demographic details, such as age, gender, educational level, monthly household income, oral hygiene practices, frequency of toothbrushing, previous dental visits, and medical history, which were gathered with a structured questionnaire, which was developed after an extensive review of relevant literature and was validated by a panel of experts from the disciplines of Operative Dentistry, Periodontology, and Dental Public Health. Prior to data collection, the face and content validity were confirmed. A preliminary study with 20 respondents was done to assess the clarity and feasibility of the questionnaire. The above mentioned participants were not included in the final analysis. The internal consistency of the questionnaire was acceptable (Cronbach's alpha = 0.84).

A single calibrated examiner performed the clinical examination with the aid of a mouth mirror, WHO periodontal probe, cotton rolls and adequate illumination in the standard dental operatory conditions. The ten patients not used in the final data sample were used for examiner calibration prior to data collection. After one week, clinical measurements were repeated and intra examiner agreement was established and found to be excellent (ICC>0.85).

The Gingival Index (Löe and Silness, 1963) was used to evaluate gingival health. Four surfaces of each selected tooth (mesial, distal, buccal and lingual) were assessed, and gingival inflammation was assessed on a scale of 0 to 3, based on the standard scores. The Silness and Löe Plaque Index (1964) was employed for estimating the accumulation of dental plaque. Standardised digital periapical radiographs were made with the paralleling technique and analysed using the Periapical Index (PAI) devised by Ørstavik, Kerekes and Eriksen (1986) to assess periapical status. Radiographic assessment was done separately by two experienced endodontists without knowledge of the group assignments. All differences were addressed by consensus discussion.

The clinical and radiographic evaluation was performed at baseline and after 6 months. The participants were repeatedly contacted via a telephone call and reminding messages to increase the compliance rate and to reduce the loss to follow-up. Oral hygiene instructions were repeated every visit and attendance was documented at follow-up appointments. Patient self-report of compliance and inspection of used interdental brushes presented during recall visits were used to determine compliance with the use of interdental brushes.

The Statistical Package for the Social Sciences (SPSS) version 26.0 was used for data analysis. Categorical variables were summarized using frequencies and percentages while continuous variables were summarized using mean and standard deviation. The Shapiro–Wilk test was used to assess the normality of continuous data. Comparisons of the mean clinical scores between the two groups were performed using independent sample t-test and within group comparisons using paired t-test. Chi square tests were used to explore relationships between categorical variables. A multiple linear regression analysis was performed to determine independent predictors of gingival health after controlling for possible confounding variables. The value of $p<0.05$ was considered as statistical significance.

Care was taken during the study to ensure the quality of the data and to minimise bias. To ensure that the findings were reliable and valid, standardized examination procedures,

examiner calibration, validated data collection instruments, as well as identical clinical protocols for both groups, and blinded radiographic assessment were performed. The identities of all participants were kept confidential during the study, and data collected during the study were kept in a secure manner in which only the research investigators could have access.

RESULTS

Table 1. Demographic Characteristics of the Participants (N=170)

Variable	Category	N	%
Age	20–25	38	22.4
	26–30	46	27.1
	31–35	39	22.9
	36–40	28	16.5
	41–45	19	11.2
Gender	Male	94	55.3
	Female	76	44.7

A large number of participants (27.1%) were between the ages of 26 – 30 years. Male accounted for 55.3% of the sample and graduate was the most abundant educational category (42.9%).

Table 2. Comparison of Baseline Clinical Parameters between Groups

Variable	**Group A Mean±SD**	**Group B Mean±SD**	**T**	**P**
Plaque Index	2.09±0.39	2.05±0.41	0.64	0.523
Gingival Index	1.62±0.34	1.59±0.37	0.53	0.598
PAI	3.42±0.69	3.39±0.71	0.28	0.781

However, the two groups were not significantly different at baseline ($p > 0.05$) suggesting similar clinical conditions at the start of the intervention.

Table 3. Comparison of Clinical Outcomes after Six Months

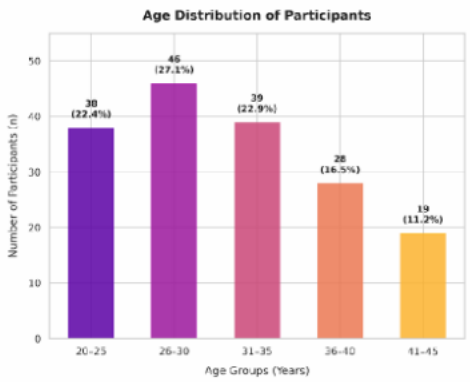
Variable	**Group A**	**Group B**	**T**	**P**
Plaque Index	1.43±0.33	0.88±0.27	11.89	<0.001
Gingival Index	1.21±0.41	0.64±0.29	10.46	<0.001
PAI	2.18±0.74	1.71±0.61	4.52	<0.001

The interdental brushing group showed significantly reduced plaque, gingival inflammation and periapical scores after 6 months compared to the control group.

Table 4. Comparison of Favorable Periapical Healing Between Groups

Outcome	**Group A**	**Group B**	**Chi-square**	**p**
Yes	57 (67.1%)	69 (81.2%)	4.63	0.032
No	28 (32.9%)	16 (18.8%)		

The interdental brushing group had significantly higher incidence of periapical healing that the control group ($p = 0.032$).



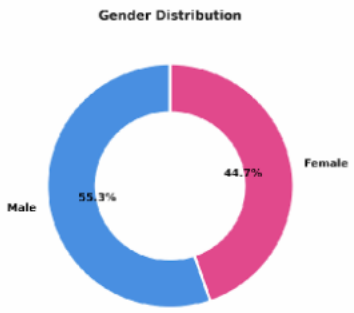


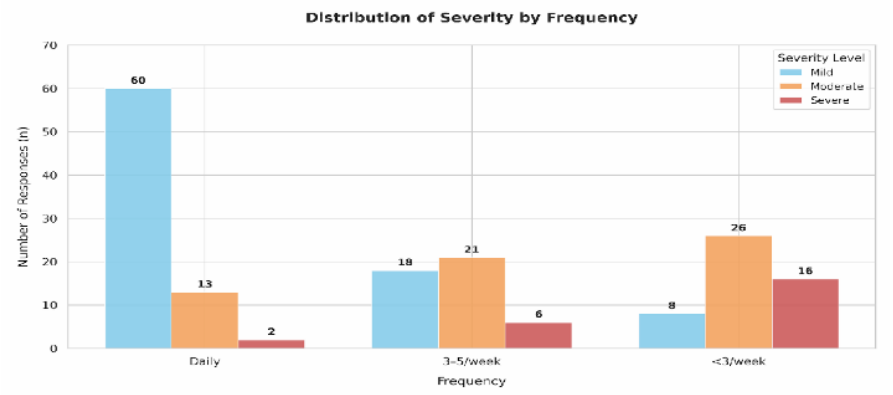
Table 5. Association between Frequency of Interdental Brush Use and Gingival Health

Frequency	Mild	Moderate	Severe	Total
Daily	60	13	2	75
3–5/Week	18	21	6	45
<3/Week	8	26	16	50

The use of interdental brushes every day was significantly correlated with good gingival condition to less frequent use ($p < 0.001$).

Table 6. Multiple Linear Regression Analysis for Predictors of Gingival Index at Six Months

Predictor	B	SE	Beta	T	P
Age	0.014	0.008	0.101	1.73	0.085
Gender	0.052	0.063	0.046	0.82	0.414
Plaque Index	0.486	0.071	0.541	6.84	<0.001
Interdental Brush Use	-0.382	0.067	-0.429	-5.71	<0.001



Model Summary: $R^2 = 0.52$, Adjusted $R^2 = 0.50$, $F = 44.83$, $p < 0.001$

Interdental brush use was an independent factor of reduced gingival inflammation, after controlling for age, gender and plaque index. The regression model accounted for 52% of the variance in the scores of Gingival Index.

DISCUSSION

The aim of this clinical study was to assess the changes in physiologic processes within the marginal periodontium and periapical tissues of multi-rooted root canal treated teeth after a structured interdental brushing program. The study's sample size (N=170) was predominantly made up of young to middle-aged adults, with the highest number of participants in the 26-30 age range (27.1%), while the gender distribution was balanced, with 55.3% males and 44.7% females. Clinically important to set up uniformity across treatment arms at the baseline phase for validation of subsequent longitudinal variations. The statistical analysis of the

baseline clinical parameters demonstrated no significant deviations between Group A (Control) and Group B (Interdental Brushing), as observed in the Plaque Index scores (2.09±0.39 versus 2.05 ± 0.41; p=0.523), Gingival Index scores (1.62 ±0.34 versus 1.59 ± 0.37; p=0.598), and the Periapical Index values (3.42 ±0.69 versus 3.39 ± 0.71; p=0.781). This baseline homogeneity also indicates that the primary challenge posed by the microbial challenge, soft tissue inflammatory response, and existing periapical radiolucencies were very similar between the cohorts allowing for solid statistical and scientific analysis of any subsequent improvement that can be attributed to the specific mechanical hygiene interventions tested in the 6-month trial (Trombelli et al., 2018).After the six month observation period, clinical results demonstrated a significant, statically highly significant difference between the two experimental groups. However, when inter-dental brushing was applied in the regular way as in Group B, the Plaque Index scores were significantly lower (0.88 ±0.27) than the Plaque Index scores for the conventional brushing method (Group A) (1.43 ± 0.33, p<0.001). This dramatic contrast illustrates the mechanical constraints of traditional brushing modalities in the posterior, multi-rooted, difficult-to-brush morphology of restored teeth. Proximal configurations are often different with full-coverage crowns and complex restorations, and these areas create protected spaces between teeth where bacteria can stagnate undisturbed (Vogt et al., 2024). Elastomeric or wire-core interdental bristles are arranged radially to enable physical contact with the concave surfaces of molar root trunks, not accessible to standard bristles (Kiger et al., 1991). The significant decrease in Plaque Index in Group B is thus directly reflective of the improved accessibility of these devices. The decrease in bio-burden was exactly the same as the observed changes in Gingival Index at 6 months; there was mild gingival inflammation in Group B (0.64 ±0.29), while there was moderate gingival inflammation observed in Group A throughout 1.21 ± 0.41 (p<0.001).

This study strongly supports the classical principles of Davies et al. (2002) which demonstrated that the key first step needed to achieve the resolution of the localized vascular congestion and epithelial ulceration and the overall inflammatory cascade within the gingival architecture is to control the marginal plaque biofilm.One of the most important results of this research is the marked improvement in the periapical health that was seen over the 6-month period, as determined by the Periapical Index (PAI) scores. The mean PAI score between the two groups was significantly different: 1.71 ± 0.61 for Group B compared to 2.18 ± 0.74 for Group A (p<0.001) with a significantly greater percentage of Group B participants showing favorable periapical healing (81.2% versus 67.1%, p=0.032$). The interrelationship of the marginal periodontium versus periapical tissues can be used to explain this biological phenomenon, especially in molars that were treated endodontically. Micro-organisms can communicate between the periodontium and endodontium (Peters, 2004) and multi-rooted teeth frequently have a network of accessory canals, dentinal tubules and patent furcation communications. Plaque stagnation at the crown margins causes a chronic inflammatory condition of the proximal tissues. This permits the passage of bacterial endotoxins apically through the external root surface or laterally along the root surfaces, which can retard periapical bone healing and can induce secondary apical periodontitis (Siqueira & Rôças, 2008). With focused interdental brushing, there is a continual flow of pathogens stopped by keeping the gingival sulcus in a state of low inflammation. This decreases the total biological load on the periapical tissues and enables the alveolar bone to heal, following the same longitudinal healing that was described by Friedman and Mor (2004).

This is further supported by looking at the clinical significance of this intervention in terms of the response of the gingival tissue following interdental cleaning. Daily users had a strong dose-response association (p<0.001), with most of the patients in the mild inflammation group (60 out of 75), while those cleaning less than 3 times a week had a significant shift toward moderate and severe gingival inflammation. This shows the maturing speed of the posterior oral cavity biofilms. Mechanical disruption is infrequent and the interproximal plaque changes its ecology in 48-72 hours, shifting to more virulent, anaerobic, Gram-negative pathogens, and thus reactivating tissue inflammation (Asadoorian, 2006). Thus, when cleanings are not performed regularly, the biofilm cannot be kept at a sub-pathogenic level. When attempting to achieve long-term tissue

stability in highly susceptible areas, consistency and frequency are as important as the design of the device, as reported by Hennequin-Hoenderdos et al. (2018).

A multiple linear regression analysis was carried out with the six-month Gingival Index as the main outcome criterion, to gain a better insight into the compounding clinical elements. The last regression model resulted in a significant model with an R^2 of 0.52, Adjusted R^2 of 0.50, $F=44.83$ and $p<0.001$. In this predictive model, interdental brush use was a strong and independent negative predictor of gingival inflammation ($\beta=-0.429$, $t=-5.71$, $p<0.001$), indicating a direct connection between higher levels of interdental brush use and less gingival inflammation. On the other hand, the post-treatment Plaque Index was a good positive predictive value ($\beta=0.541$, $t=6.84$, $p<0.001$), showing that the amount of plaque biofilm remaining after treatment is a strong positive predictor of the degree of soft tissue degradation. The age and gender were not statistically significant predictors within the model of the model variable, which is interesting (respectively, $\beta=0.101$, $p=0.085$ and $\beta=0.046$ $p=0.414$). Such a lack of demographical significance reinforces the fact that the resolution of gingival inflammation is largely dependent on the mechanical disruption of the biofilm via regular mechanical stimulation, and not on factors such as the age or gender of the patient (Lang & Tonetti, 2015). In conclusion, the results indicated that a calibrated interdental brush is necessary to achieve the optimal mechanical control to maintain the gingival margin stability and promote periapical bone healing in root-canal treated multi-rooted teeth (Nair, 2006; Kim et al., 2013).

CONCLUSION

The results of this study reveal that when interdental brushes are used as an adjunctive treatment along with regular toothbrushing, a significant improvement in gingival health and periapical health in multi-rooted root canal treated teeth is achieved. The participants who used interdental brushes regularly had lower plaque scores, less gingival inflammation and greater number of periapical healing scores than those who were not using interdental brushes. The findings indicate that interdental brushing should be included in a patient's post-endodontics oral care regimen to help achieve good long-term results and maintain oral health.

Limitations of Study:

The present study has certain limitations which must be taken into consideration when interpreting its results. Results of the research may be limited to the generalizability because the research was conducted at one dental centre using a non-probability consecutive sampling technique. Partly compliance with interdental brush use was reported by the patient, which might have resulted in reporting bias. Moreover, the follow-up period was relatively short (6 months) to assess long-term periapical healing and periodontal stability.

Future Suggestions:

Larger multicenter samples with a longer follow-up period are recommended for future studies to evaluate the long-term effects of interdental brushing on endodontic and periodontal results. Randomized controlled trials of various types and sizes of interdental cleaning aids are also suggested. In addition, future studies should assess patient compliance with the use of interdental brushes, cost-effectiveness and the effect of systemic health conditions on the effectiveness of interdental brushing following root canal treatment.

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