

*Review***Removal of bacterial biofilm in patients undergoing fixed orthodontic treatment: a literature review**

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Keywords: *orthodontic treatment, biofilm, oral hygiene, plaque control, RCP, APP*

Received: 20 July 2022
Accepted: 22 December 2022

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ISSN 2974-6140 (online) ISSN 0392-8543 (print).

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ABSTRACT

Orthodontic treatment is highly popular for restoring functional and facial esthetics in juveniles and adults. However, the prevalence of biofilm-related complications remains high. The objectives of this review are to 1) identify which of the two professional prophylaxis systems analyzed, rubber cup polishing (RCP) and air-powder polishing (APP), is the most effective in removing bacterial biofilm in patients undergoing fixed orthodontic treatment, and 2) the comfort expressed by the patient and any damage caused to the orthodontic device. The search yielded 23 scientific articles, 14 of which were excluded, and 6 met the inclusion criteria. From the studies analyzed, it is, therefore, possible to state that the APP technique is more effective than the RCP technique in removing dental plaque, and treatment is less time-consuming and safer concerning orthodontic devices, as none of the scientific articles examined did APP cause any damage to the orthodontic device or debonding of the brackets.

INTRODUCTION

Fixed orthodontic devices cause objective difficulties in performing daily oral hygiene techniques, which, to be effective, require strong patient motivation. Brackets, bands, bows, ligatures, and elastics represent plaque retention factors, as they offer a greater surface area for adhesion (1, 2) and interfere with toothbrushes and other devices used for plaque control (3, 4). In addition, the orthodontic treatment causes a change in the oral bacterial flora both quantitatively and qualitatively (5, 6). There is a significant increase in the abundance of *Streptococcus mutans* (2, 4) but also of Lactobacilli, Staphylococcus, Candida albicans, motile bacteria, gram-negative bacteria, and the change from an aerobic to an anaerobic population (5, 6).

For the mechanical removal of biofilms at home, either a manual (also orthodontic) or an electric toothbrush can be used. The patient must be instructed to pay particular attention to the cervical third, which must be brushed with roller movements, with a circular technique around each bracket or with the modified Stillman technique, and to brush their teeth at least 20 min after meals (1, 3). Oral hygiene performed with an electric toothbrush (if properly used and timed) is significantly more effective than oral hygiene performed with a manual toothbrush in terms of plaque reduction, bleeding, and gingival inflammation (1, 7). The monobloc toothbrush is particularly indicated for cleansing any spaces created by orthodontic movements, the mesial and distal surfaces of two teeth adjacent to an edentulous area, and/or the distal surfaces of the last molars (1). Another study also stated that combining mono and conventional toothbrushes effectively controlled biofilm formation in orthodontic patients (8).

For mechanical interproximal cleansing, the patient can use dental floss with a stiff end or pipe cleaner (1). In particular, it is necessary to use dental floss because of the presence of orthodontic floss. Furthermore, toothpaste containing fluoride is advisable to reduce the risk of demineralization that can be carried inside the oral cavity with a toothbrush or even in the interdental spaces with toothbrushes, toothpicks, or floss (1).

A 0.05% fluoride mouthwash is suitable for daily use; a low concentration combined with high-frequency results in a remineralizing effect that is useful and indispensable for orthodontic patients. One alternative is a mouthwash containing sodium fluoride and 0.05% chlorhexidine. Combining the two active ingredients has a synergistic effect; it combines the remineralizing action of fluoride with the antibacterial action of chlorhexidine (1).

For professional debridement, dental hygienists can use manual instruments such as scalers and curettes and mechanical instruments such as sonic and ultrasonic scalers (1). Using hand instruments around bands and brackets is difficult, so using sonic and ultrasonic scalers is beneficial (3).

The deployment and polishing of tooth surfaces can be carried out with cups, brushes, and prophy paste (PPI) or with air-polishing and different abrasive powders (1).

During professional oral hygiene sessions to reduce the risk of caries, professional fluoroprophylaxis can be carried out with a high concentration of fluoride gel (1.23%), left on for at least 4 minutes (the minimum time for fluoride uptake), or with amorphous calcium phosphate (ACP). The frequency is determined by the patient's degree of compliance and caries risk and can be either quarterly or half-yearly (5).

OBJECTIVE

The primary objective of this literature review was to identify which of the two professional prophylaxis systems analyzed (RCP and APP) was the most effective in removing bacterial biofilms in patients undergoing fixed orthodontic treatment. In addition to the effectiveness of the two techniques, the time required for each technique was also compared.

Instead, the comfort expressed by the patient and any damage caused to the orthodontic device were considered secondary objectives. Specifically, the occupational prophylaxis techniques considered in this study were as follows:

- polishing with a rubber cup and prophy paste henceforth referred to as rubber cup polishing (RCP);
- air-polishing with abrasive powder, henceforth referred to as APP (air-powder polishing).

MATERIALS AND METHODS

In order to perform a review of the available scientific literature regarding the polishing procedure for tooth surfaces in patients undergoing fixed orthodontic treatment, the PICO methodology was used (Table I).

Table I. *PICO for search.*

PICO - Effective plaque removal	
P - Patient	M/F patients undergoing fixed metal orthodontic treatment
I - Intervention	Polishing performed with a rubber cup and prophy paste (RCP)
C - Comparison	Air-polishing with abrasive powder (APP)
O - Outcome	Plaque removal
PICO - Time for plaque removal	
P - Patient	M/F patients undergoing fixed metal orthodontic treatment,
I - Intervention	Polishing was performed with a rubber cup and prophy paste (RCP);
C - Comparison	Air-polishing performed with abrasive powder (APP);
O - Outcome	Shorter treatment time
PICO - Patient-expressed comfort	
P - Patient	M/F patients undergoing fixed metal orthodontic treatment
I - Intervention	Polishing performed with a rubber cup and prophy paste (RCP)
C - Comparison	Air-polishing with abrasive powder (APP)

O - Outcome	Patient comfort
PICO - Damage to the orthodontic device	
P - Patient	M/F patients undergoing fixed metal orthodontic treatment
I - Intervention	Polishing performed with a rubber cup and prophylaxis paste (RCP)
C - Comparison	Air-polishing with abrasive powder (APP)
O - Outcome	Damage to the fixed orthodontic device

A literature search was conducted using the PubMed Medline and Cochrane Library databases.

A second in-depth search was carried out in various journals, such as British Medical Dentistry, British Medical Journal, Journal of Dental Hygiene, International Journal of Dental Hygiene, European Journal of Orthodontics, Journal of International Society of Preventive and Community Dentistry, Journal of Indian Society of Periodontology, Dental Press Journal of Orthodontics, The Angle Orthodontist, European Journal of Paediatric Dentistry, Journal of Pharmaceutical Science and Research, Journal of Periodontology and The Journal of Contemporary Dental Practice. Keywords were identified in the search (Table II).

Table II. *Research keywords.*

Objective	Keywords
Effectiveness in plaque removal	<i>polish, air-polishing, orthodontic, orthodontia, oral hygiene, professional hygiene, polish in orthodontia, fixed orthodontic, polish rubber cup, polish bristle brush, dental hygienist, dental hygiene, cleaning brackets Orthodontic AND polishing Orthodontic polishing</i>
Treatment time	<i>Treatment time, time register</i>
Comfort expressed by the patient	<i>Orthodontic polishing comfort, polish comfort, orthodontic air-polish, perception, sensation</i>
Damage to the orthodontic device	<i>Damage, debonding, breakage, bracket</i>

In order to obtain more scientific articles, neither prophylaxis paste (for RCP) nor abrasive powder (for APP) was specified in the search.

Inclusion criteria

The studies covered by the inclusion criteria were clinical trials, RCTs, and systematic reviews, with no limit on the year of publication of the studies and free full text. The sample of patients met the following inclusion criteria:

- Patients of both sexes and all ages
- Patients that were undergoing fixed metal orthodontic treatment.

No limits were set in terms of the initial plaque index and maximum and/or a minimum number of orthodontic brackets.

Exclusion criteria

The exclusion criteria were in vitro studies with extracted teeth. The following types were excluded:

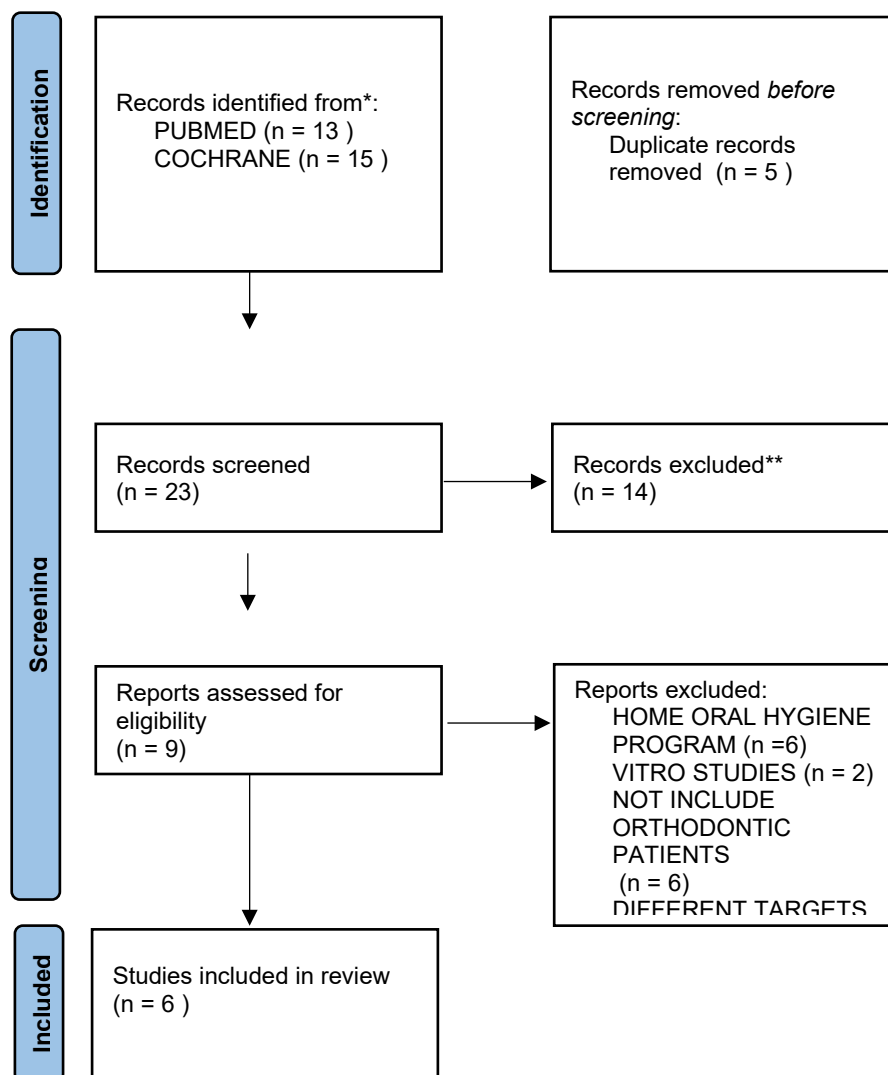
- patients with cardiovascular and blood pressure disorders;

- patients with respiratory diseases;
- haemodialysis patients;
- patients on a low-sodium diet;
- smoking patients.

RESULTS

The search was conducted between October 2019 and August 2020, and the study identification flowchart, according to PRISMA, includes the reasons for excluding articles (Fig. 1).

Fig. 1. Preferred Reporting Items for Systematic Review and Meta-Analysis flow diagram for studies retrieved through the searching and selection process.



The search yielded 23 scientific articles, 14 of which were excluded because they dealt with home protocols (N=6), were in vitro studies (N=2) or had objectives that were not compatible with those selected (N=6). In

addition, of the 9 articles initially included, 3 were excluded because their inclusion criteria did not include orthodontic patients. Six articles met the inclusion criteria (Table III).

Table III. *Included studies.*

Investigators	Year of publication	Title	Journal
Barnes et al.(12)	1990	Effects of an Air-Powder Polishing System on Orthodontically Bracketed and Banded Teeth	American Journal of Orthodontics and Dentofacial Orthopedics
Gerbo et al.(13)	1993	Applications of the air-powder polisher in clinical orthodontics	American Journal of Orthodontics & Dentofacial Orthopedics
Gutmann et al.(14)	1998	Air polishing: a comprehensive review of the literature	The Journal of Dental Hygiene
Ramaglia et al.(11)	1999	A clinical comparison of the efficacy and efficiency of two professional prophylaxis procedures in orthodontic patients	European Journal of Orthodontics
Graumann et al.(16)	2013	Air-polishing: a review of a current literature	The Journal of Dental Hygiene
Poormoradi et al.(10)	2018	The comparison of two professional prophylaxis system in plaque removal and debonding of orthodontic brackets	Journal of Indian Society of Periodontology

Effectiveness of APP and RCP in removing plaque from tooth surfaces

For this first objective, the following items were analyzed and are briefly described in table IV (Table IV).

Table IV. *Description of articles included for the objective “effectiveness of RCP and APP in removing plaque from tooth surfaces”.*

Article	Prophylaxis paste (CPR)	Abrasive powder (APP)	Plaque index
Barnes et al.(12)	Pumice	Sodium bicarbonate	Plaque Control Record or O'Leary Index of 1972
Ramaglia et al.(11)	Prophy Paste (Smart Practice, USA)	Sodium bicarbonate	Modified 1970 Turesky-Quigley-Hein
Poormoradi et al.(10)	Pumice	Sodium bicarbonate	Plaque Control Record or O'Leary Index of 1972

The effectiveness of plaque removal from the tooth surfaces was evaluated using the plaque index. Each study measured the plaque index of patients sampled before and after treatment with APP and RCP.

The tables below show the average value of the plaque index improvement obtained after APP and RCP treatments, respectively (Table V).

Table. V. *Δ Improvement in plaque index after treatment (Plaque Control Record or O'Leary Index of 1972) in percentage value.*

Method	Barnes et al.(12)	Poormoradi et al.(10)
PLAQUE INDEX (APP)	Δ72.4%	Δ66.2%
PLAQUE INDEX (CRP)	Δ59.9%	Δ30.8%

It should be noted that the data presented in the table for the studies were processed from the values mentioned above provided by the scientific article in question. In contrast, a comparative study conducted by Barnes et al. (12) directly reported the data presented in Table VI (Table VI).

Table VI. *Plaque Index value pre-post treatment.*

Ramaglia et al.(11)	Group I (Chlorhexidine mouthwash 0,12%)	Group II (Chlorhexidine mouthwash 0,12%)
Baseline		
Plaque Index (APP)	1,88*	1,34
Plaque Index (RCP)	1,92*	1,27*
Post-treatment		
Plaque Index (APP)	0,22*	0,05*
Plaque Index (RCP)	0,31*	0,12*

P value refers to the significance at a level =0,05; the Plaque index of Quigley-Hein was modified by Turesky as reported by Fischman (1988).

Of the three studies selected to address this first objective, two of them, that of Barnes et al. (12) and that of Poormoradi et al. (10), used the same plaque index: the Plaque Control Record or O'Leary Index (11, 9) (Table V).

The study by Ramaglia et al. (11), unlike APP, appeared to be more effective than RCP for dental plaque removal in Group II, and APP was significantly more effective than RCP (Table VII).

Both treatment methods analyzed, APP and RCP, were able to cause a statistically significant reduction in the plaque index; at the same time, however, there was a significant difference between the two methods: by analyzing the percentages, it can be concluded that the improvement in the plaque index is greater for the APP method in all three studies examined. Therefore, the APP technique was more effective than the RCP for plaque removal in patients undergoing fixed orthodontic treatment.

Treatment time is taken by APP and RCP, respectively, to achieve an effective removal of bacterial plaque from the tooth surface

The scientific articles recorded each technique's time spent (treatment time). Table VII shows the average values in minutes taken for the APP and RCP methods presented in the studies analyzed for this objective. The data proposed in the table have been partially reworked; seconds were converted into minutes to allow easy comparison. Ramaglia et al. (11) provided the treatment time for each of the two groups into which the sample was divided. In order to facilitate the comparison with information from the other two studies shown in the table, data from the two groups were averaged. The result was then a single number transformed from seconds to minutes.

Table VII. *Treatment time taken (*calculated value).*

	Minutes		
Method	Barnes <i>et al.</i>	Ramaglia <i>et al.</i>	Poormoradi <i>et al.</i>
APP	4.0 minutes	5.2*minutes	1.8 minutes
CPR	6.8 minutes	8.3*minutes	4.4 minutes
Δ APP-RCP	-2.8	-3.1	-2.6

It can be deduced from Table VII that the RCP technique required more treatment time than the APP technique in all three studies analyzed.

There was a statistically significant difference in treatment time between the two techniques. On average, the APP method takes 2.8 minutes less than the RCP treatment. Therefore, APP is a faster technique than RCP for effectively removing bacterial plaque from the tooth surface.

Comfort expressed by patients for both professional prophylaxis methods APP and RCP

The scientific articles included in the analysis of patients' expressed comfort with APP and RCP are described in the table below (Table VIII).

Table VIII. *Description of items included per objective “Patient-expressed comfort”.*

Article included	Prophylaxis paste (RCP)	Abrasive powder (APP)	Methods used for comfort analysis
Barnes <i>et al.</i>	Pumice	Sodium bicarbonate	/
Poormoradi <i>et al.</i>	Pumice	Sodium bicarbonate	VAS Visual Analog Scale, the scale ranges from 0 to 100, and each patient assigns a number to each of the two techniques used.

Barnes et al. (12), in their study, consider the aspect of patient comfort with the two techniques analyzed only at the time of the ‘discussion’, with the following statement: ‘patients (...) did not find the APP method unpleasant, but they did find the pressure required used with the RCP method unpleasant or painful’. Unfortunately, the study does not state how the authors arrived at this conclusion; one assumes with questions posed to the patients. Therefore, the conclusion drawn from this study is that the APP method is more comfortable than the RCP method for patients undergoing fixed orthodontic treatment (11).

The study conducted by Poormoradi et al. (10) to understand which technique offers greater comfort uses the VAS Visual Analog Scale, which ranges from a score of 0 to 100, where 0 stands for ‘absolute discomfort’ (not at all comfortable) and 100 stands for ‘absolute comfort’ (absolutely comfortable) (9).

The average comfort recorded was 93.04% for the RCP technique and 59.53% for the APP. The value of 93.04% for the RCP method falls within the SEA range, corresponding to ‘great convenience, which can be translated as ‘very comfortable. On the other hand, 59.53% fall within the “good comfort” range translated as “comfortable”. A statistically significant difference was observed between the comfort levels of the two methods. The average comfort level of the RCP technique was higher than that of the APP. The authors of the study pointed out that, in the opinion of most patients, APP is rated less comfortable because of the bitter taste that sodium bicarbonate leaves in the mouth (9).

Damage caused by APP and RCP to the orthodontic device.

The last aspect assessed was the presence or absence of any damage caused by the APP and RCP methods to parts of the orthodontic device, such as orthodontic wires, brackets, and bands.

What can be seen from Table IX is that, taking into consideration the first two articles, that of Barnes et al. (12) and that of Ramaglia et al. (11), damage to the orthodontic wires, brackets and bands is caused in both cases by the RCP technique. In contrast, APP does not cause any damage.

Table IX. *Damage to the orthodontic device.*

Articles	Damage		Debonding	
	APP	RCP	APP	RCP
Barnes et al. (12)	No	Yes, to orthodontic wires and bands	/	/
Ramaglia et al. (11)	No	Yes, minor damage to orthodontic brackets or wires	/	/
Poormoradi et al. (10)	/	/	No	No

Taking the debonding aspect, assessed exclusively by Poormoradi et al. (10), the latter does not occur in any patients with any of the methods analyzed. The authors also state that “there is no objective evidence of fractures and disconnections of the bracket attachment”.

In summary, referring to the three studies in the table, APP did not cause any damage to the orthodontic device or debonding of brackets (9, 10, 11), unlike the RCP method, which caused some damage to orthodontic wires, bands and brackets (9, 2).

DISCUSSION

The objective of this study was to seek an effective method for the professional removal of plaque at a low cost, without damaging the bonding of brackets and teeth, and to provide patients with oral and dental health during orthodontic treatment, in addition to health education and medical aids.

From the studies analyzed, it is possible to state that the APP technique is more effective than the RCP in removing dental plaque in patients undergoing fixed orthodontic treatment (9-14), is less time-consuming (9, 10, 12), and is safer against orthodontic devices, as none of the scientific articles examined whether the APP caused any damage to the orthodontic device or debonding of the bracket (9, 11, 12).

Barnes et al. also showed that APP was very effective for plaque removal, and its advantage over the method was that it required less time and made the patient more comfortable (15). The same conclusions were also reported by Gerbo et al., Gutmann et al., and Graumann et al. in their respective reviews (13, 14, 16). Conflicting opinions were found regarding the comfort expressed by patients.

The discussion of the scientific article by Poormoradi et al. (10), one of the two studies analyzed to compile the results regarding comfort, suggests a reflection. The authors stated that “according to most patients, the cause of this discomfort is associated with the bitter taste of the applied powder”, and again “surely, if other powders had been used, such as glycine, for example, patients would have experienced greater comfort” (9). In this regard, some studies have reported symptoms of respiratory problems during or immediately after gum polishing or damage to the mucus surface of the lower lip following the use of pressurized air (17, 18, 19, 20).

CONCLUSIONS

This literature review aimed to identify which of the two tooth surface polishing techniques, air polishing with abrasive powder (APP) or polishing with a rubber cup and prophylaxis paste (RCP), is more effective in

removing biofilms in patients undergoing fixed orthodontic treatment the least expensive in terms of time, the most comfortable for the patient, and the safest concerning the orthodontic device.

From the studies analyzed, it is, therefore, possible to state that the APP technique is more effective than the RCP technique in removing dental plaque in patients. However, conflicting opinions were found concerning the comfort expressed by the patients.

The literature review results suggest that in clinical practice, the dental surfaces of patients with fixed orthodontic appliances performed with air polishing and abrasive powder are recommended while evaluating each patient's case.

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