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Aligner orthodontics and preventive dentistry

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All orthodontic therapies are only effective when carried out in conjunction with systematic preventive dentistry. The latter must be based on the work of Axelsson and Lindhe. Both domestic and professional oral hygiene measures are critical to maintaining oral health and preventing therapy-related damage to dental hard substances and soft tissues. The systematic prevention workflow must be based not only on dental biofilm management, but also on the patient's complex medical and dental conditions.

Introduction

The ecological plaque hypothesis proposed by Marsh[1] considers the aetiology of the most common oral diseases (caries lesions and periodontitis) and makes management of the vital sub- and supragingival dysbiotic biofilm the focus of prevention. Dysbiosis occurs when the diversity of microorganisms is reduced and/or the relative proportions of species in the microbial community are pathogenically altered in favour of 'specialists', leading to a disturbance of homeostasis.

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Fixed and removable orthodontic treatments change the ecology of the oral cavity. The appliances employed act as retention elements for the biofilm and complicate administration of home oral hygiene. The pressure exerted to move the teeth leads to dynamic changes in the bone and periodontium. These movements can increase the accumulation of subgingival biofilm and, therefore, the periodontal pathogenic potential[2,3].

There is no doubt that all orthodontic therapies are only effective when carried out in conjunction with systematic preventive dentistry. The latter must be based on the work of Axelsson and Lindhe[4-6] and Axelsson et al[7]. Both domestic and professional oral hygiene measures are critical to maintaining oral health and preventing therapy-related damage to dental hard substances and soft tissues[4-7]. The systematic prevention workflow must be based not only on dental biofilm management, but also on the patient's complex medical and dental conditions.

Orthodontics and biofilm

Fixed orthodontic appliances promote the accumulation of biofilm; this was demonstrated by Ireland et al[8], whose results suggest that fixed orthodontic treatment can lead to lasting changes in the quantity and quality of biofilm. A similar conclusion was reached by Lucchese et al[3] in a systematic review; they found that fixed orthodontic appli-

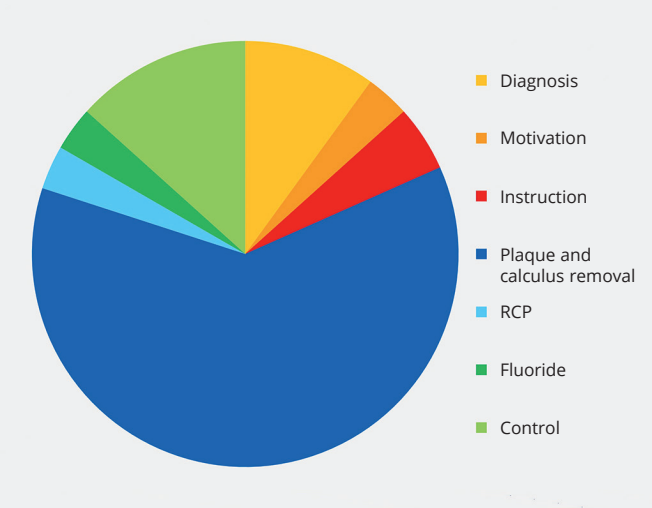

Fig 1 Recall circle according to Axelsson and Lindhe[6].

ances affect the oral microbiome by increasing the number of *S. mutans* and *Lactobacillus spp.*, as well as the proportion of pathogenic Gram-negative bacteria.

In a study by Contaldo et al[9], changes in the quality and quantity of biofilm were already observed in orthodontic treatments carried out with removable appliances 1 month after the start of treatment. The oral microbiome shifted towards a state that was at increased risk of caries lesions and periodontal disease, and this shift was significantly greater for fixed orthodontic devices than for removable appliances[9].

Wang et al[10] compared the changes in the oral microbiome in patients treated using the Invisalign system (Align Technology, San Jose, CA, USA) or with fixed appliances. Both orthodontic treatment with fixed appliances and with removable appliances using the Invisalign system resulted in dysbiosis of the oral microbiome, and the effects of the Invisalign system on the oral microbiome were no better for oral health when compared to fixed appliances[10].

In a comparative systematic meta-analysis, Wu et al[11] concluded that patients treated with removable orthodontic appliances exhibited better periodontal status than those treated with fixed appliances.

Zhao et al[12] conducted a study on changes in the microbiome in patients treated with aligners and did not observe any significant change in biodiversity or deterioration in oral health.

Principles of prevention

As the causes of oral diseases are largely known, cause-related prevention is possible. The ultimate goal of oral medicine must be to maintain the natural teeth and periodontium in a healthy, functionally acceptable and pain-free condition for a lifetime[13]. All modern preventive dentistry can be attributed to the work of Axelsson and Lindhe[4-6] and Axelsson et al[7] in the early 1970s and are based on two pillars: domestic and professional oral hygiene measures. Axelsson and Lindhe[4,6] also proposed a workflow protocol for their "recall hour" (Fig 1).

New workflow protocols for the prevention appointment must take into account both the scientific and technical advances of the last 50 years. New insights into the aetiology of oral diseases require new objectives and tools. Whereas the focus was previously on removing hard deposits with hand instruments and classic polishing (rubber cup polishing [RCP], brushes and polishing paste), greater attention is now being paid to biofilm management, hard and soft tissue preservation, and patient and practitioner comfort (airflow technology with low-abrasive powders and ultrasonic scalers).

Scientific findings and technical progress in preventive dentistry

In previous centuries, dental practitioners primarily aimed to eradicate the perceived cause of oral disease, namely supra- and supragingival dental calculus, infected soft tissue and infected root cementum. Insights into the importance of biofilm and the body's responses to biofilm metabolism have now redirected the therapeutic focus towards biofilm management. As knowledge surrounding aetiology has increased, the objectives of modern initial and maintenance therapy have changed accordingly, and are now as follows:

- regular destruction or elimination of biofilm;
- establishment of permanent homeostasis and control of inflammation;
- preservation of hard and soft tissues (substance preservation);
- optimal patient and practitioner comfort.

The tools available should satisfy these new objectives. The current literature comparing the different tools used for biofilm management (scalers, curettes, rotary instruments with rubber polishers and brushes and polishing paste, air scalers [ASs], magnetostrictive ultrasonic [MUS] and piezoelectric ultrasonic scalers, and AIRFLOW [EMS Dental, Nyon, Switzerland]) has examined cleaning performance, substance preservation, patient comfort and practitioner comfort.

Cleaning performance

Some studies have compared classic polishing (RCP) and AIRFLOW. RCP only allows incomplete biofilm removal in fissures, pits, crowded teeth, the interdental space and the sulcus and on implants, and particularly in the case of fixed orthodontic appliances. RCP is too abrasive for exposed tooth necks and subgingival biofilm removal is not possible. In a comparative study, Haas et al[14] examined sub- and supragingival tooth cleaning with hand instruments, ultrasound, AIRFLOW and RCP and their combinations, and found that the best deep cleaning of enamel, dentine and cementum was achieved with erythritol powder AIRFLOW (EPAF) alone. Frankenhauser[15] compared RCP (Cleanic, Kerr Dental, Orange, CA, USA) and EPAF for supragingival biofilm removal. The Plaque Index values obtained after cleaning with RCP and AIRFLOW differed significantly, and a better cleaning result was obtained with AIRFLOW in both the anterior and posterior teeth[15].

Wennström et al[16] compared classic scaling and root planing (SRP) with "single full-mouth PIEZON (EMS Dental) ultrasonic debridement" (single-Fm-PUS) in initial therapy. The clinical outcomes were substantially identical, the treatment time with single-Fm-PUS was three times shorter and anaesthetic consumption was two-and-a-half times less[16].

Petersilka et al[17,18] found that use of AIRFLOW with a low-abrasive powder (glycine) resulted in a significantly greater reduction in subgingival bacterial levels than with hand instruments.

Müller et al[19] demonstrated the advantages of use of PERIOFLOW technology (EMS Dental) with low-abrasive powder (erythritol) for residual pockets ≥ 4 mm in maintenance therapy versus ultrasonic technology. The clinical parameters and bacterial counts were the same with the exception of *Aggregatibacter actinomycetemcomitan*, with AIRFLOW recording significantly lower values, and pain levels were also significantly lower with AIRFLOW; as such, patients preferred AIRFLOW over ultrasonic technology[19].

Hägi et al[20] compared hand instruments, PUS and EPAF in an in vitro study. The greatest amount of bacterial reduction was achieved with AIRFLOW, and the least with curettes. Ultrasound and AIRFLOW have both demonstrated greater attachment of periodontal ligament fibroblasts compared with hand instruments[21].

Substance preservation

Flemmig et al[22] postulated that a loss of > 0.50 mm cementum/dentine over a 10-year period is unacceptable in maintenance therapy; thus, a maximum of 0.05 mm (50.0 µm) per year should be removed during the maintenance phase. As such, if the patient attends four sessions per year, a maximum of 12.5 µm may be removed in each session. As early as 1991, Ritz et al[23] demonstrated that these values cannot be achieved with ASs, curettes and diamond burs, and only with difficulty when using ultrasound.

Rupf et al[24] compared curettes and MUS and PUS devices in the removal of dental calculus and significant improvements in all clinical and microbiological parameters were observed for all groups. PUS devices preserved the tooth structure best, but cleaned somewhat less well[24].

In a comparative in vivo study (curettes, PUS, PUS and AIRFLOW, AIRFLOW), Bozbay et al[25] found that the amount of cementum remaining in the coronal root region was 65% for curettes, 84% for PUS, 80% for PUS and AIRFLOW, and 94% for AIRFLOW.

Hägi et al[20] also compared hand instruments, PUS and EPAF with regard to substance loss and surface roughness in an in vitro study. Curettes showed the greatest amount of substance loss, followed by PUS and EPAF, and in terms of surface roughness, curettes demonstrated significantly greater arithmetic mean roughness (Ra) values than PUS and EPAF[20].

Petersilka et al[26] compared curettes, PUS, and AIRFLOW with erythritol and glycine powder with regard to soft tissue preservation. AIRFLOW caused only marginal injuries to the gingiva with both powders, followed by PUS, whereas curettes caused significant injuries to the gingiva[26].

Barnes et al[27] compared different powders used in AIRFLOW technology with regard to substance preservation (enamel, composite resin and glass-ionomer cement). Glycine and erythritol powders were not found to cause any

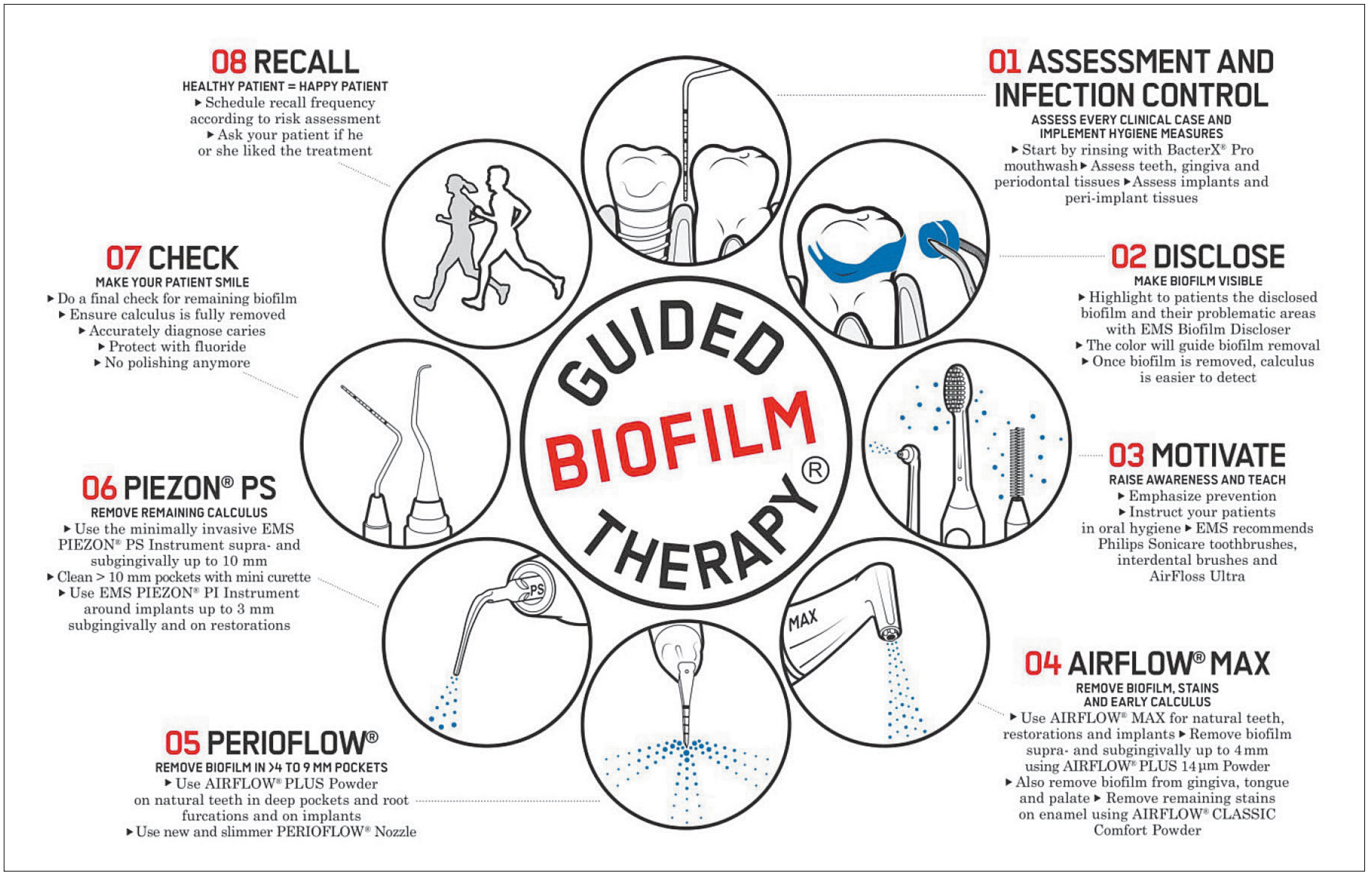

Fig 2 Steps involved in guided biofilm therapy. Reprinted from EMS Dental with permission.

damage (in terms of defect depth and volume) to enamel, composite resin and glass-ionomer cement compared to other powders (sodium bicarbonate, aluminium trioxide, calcium sodium phosphosilicate and calcium carbonate)[27].

Patient comfort

Wennström et al[16] and Müller et al[19] highlighted the major advantage of AIRFLOW technology with low-abrasive powders versus hand instruments and ultrasound with regard to patient comfort.

Wennström et al[28] compared PUS and AIRFLOW with low-abrasive powders in maintenance therapy and found no differences in clinical and microbial values, but patient comfort was considerably better in the AIRFLOW group.

In a systematic review, Bühler et al[29] concluded that levels of pain and discomfort during nonsurgical periodontal therapy are lower when AIRFLOW is used than with ultrasonic devices and hand instruments.

Practitioner comfort

Lalumandier and McPhee[30] found that the prevalence of hand problems and carpal tunnel syndrome was highest among dental hygienists when compared to all other professions within dentistry.

Graetz et al[31] reported that when wrist flexion/extension exceeds 46 degrees, the risk of excessive work-related wrist strain increases. Rotation of the wrist is significantly less when using ultrasound and ASs than hand instruments, and the former options are therefore gentler on the wrists.

Guided biofilm therapy

All current workflow protocols for preventive dentistry can be attributed to the recall hour, a notion proposed by Axelsson and Lindhe[4,6] (Fig 1). The recall hour specifies a strict schedule as part of a standardised procedure, which

Fig 3 AIRFLOW MAX (EMS Dental) handpiece with laminar flow. Reprinted from EMS Dental with permission.

Fig 4 PIEZON NO PAIN PS ultrasonic handpiece. Reprinted from EMS Dental with permission.

now needs to be replaced by an age-specific, individualised, indication-orientated approach. The aids for the actual professional mechanical plaque removal (PMPR) (Axelsson and Lindhe[4-6] and Axelsson et al[7] spoke of "active interventions"), such as hand instruments (scalers and curettes) and rotary handpieces, rubber polishers, brushes and polishing pastes, must be modified according to scientific findings that suggest biofilm management is paramount, and technical progress (cleaning performance, substance preservation and patient and practitioner comfort).

New technologies and current literature, some of which were discussed in the earlier section on "Scientific findings and technical progress in preventive dentistry", require a shift from the classical recall hour principle[4,6] to guided biofilm therapy (GBT)[32,33] (Fig 2). GBT is an indication-based, systematic and modular prevention and treatment protocol developed by EMS Dental, the Swiss Dental Academy (SDA), universities and practitioners. It aims to achieve effective cleaning performance with maximum substance protection and optimal patient and practitioner comfort. GBT can be used for both new patients and those undergoing maintenance therapy, and can be applied universally in both healthy patients (prevention) and those affected by oral disease (initial and maintenance therapy for caries lesions, gingivitis, periodontitis, peri-implant mucositis and peri-implantitis). The eight steps (modules) involved in GBT are as follows:

1. Controlling infection, collecting and documenting medical history and findings;
2. Making biofilm visible using a disclosing solution and collecting and documenting the Plaque Index;
3. Providing information and instruction and motivating patients about home care, dietary management and products that chemically support home oral hygiene (fluoride, chlorhexidine digluconate, cetylpyridinium chloride, etc.);
4. Performing targeted supra- and subgingival (up to 4 mm) biofilm removal with AIRFLOW/PLUS powder (EMS Dental) (Fig 3);
5. Performing targeted subgingival biofilm removal (from 4 to 9 mm) with PERIOFLOW/PLUS powder;
6. Performing targeted removal of supra- and subgingival dental calculus with PUS (Fig 4);
7. Conducting quality control including final diagnoses by the dental practitioner;
8. Scheduling an individual, risk-orientated recall appointment.

The individual steps in GBT have been studied extensively in terms of both the technique and materials, and there is scientific evidence of the effectiveness of all these steps, including patient satisfaction[14-31,34,35]. There have been some major changes from the old protocols; first, the supragingival biofilm is always made visible using disclosing solution; second, this is followed by fine cleaning (removal of supra- and subgingival biofilm and discolouration) with AIRFLOW/PLUS and/or PERIOFLOW/PLUS; and third, only then is the targeted removal of remaining hard deposits performed with ultrasound (PIEZON NO PAIN PS [EMS Dental]). Polishing is not necessary.

Summary

Compared to patients not having undergone orthodontic treatment, orthodontic patients exhibit significant qualita-

tive and quantitative differences in the amount and microbial composition of biofilm present throughout the entire treatment period. Aligner orthodontics is less associated with worsening of periodontal indices and caries lesions as aligners can be removed easily despite being worn for almost 24 hours, thus allowing for adequate oral hygiene[36]. These results are consistent with those of a recent meta-analysis by Jiang et al[37] that compared studies of patients having received orthodontic treatment with aligners or fixed appliances and found that patients with aligners demonstrated better overall oral health, including periodontal parameters. The conclusion drawn by Jiang et al[37] and also by Flores-Mir[38] is that aligners are recommended for treatment of patients at high risk of developing gingivitis or periodontitis (primarily adults). Furthermore, another study found that subjects with fixed appliances exhibited a significant increase in the number of streptococci and lactobacilli and thus a higher risk of caries lesions than those with aligners[39].

The literature emphasises that all orthodontic treatments require simultaneous stringent preventive dentistry, and GBT offers this. GBT is based on the latest scientific findings and technical advances, and the clinical protocol for prevention and treatment is indication-based, systematic and modular. GBT is based on an individual diagnosis and risk assessment to achieve targeted (guided), optimal results with maximum efficiency, substance preservation and patient and practitioner comfort.

Conclusion

The GBT protocol enables the requirements of modern biofilm and calculus management to be met.

Declaration

Dr Klaus-Dieter Bastendorf is a consultant for EMS Dental (Nyon, Switzerland). His consulting work had no influence on the content or findings of the present study.

References

1. Marsh PD. Are dental diseases examples of ecological catastrophes? Microbiology (Reading) 2003;149:279–294.
2. Giugliano D, d'Apuzzo F, Majorana A, et al. Influence of occlusal characteristics, food intake and oral hygiene habits on dental caries in adolescents: A cross-sectional study. Eur J Paediatr Dent 2018;19:95–100.
3. Lucchese A, Bondemark L, Marcolina M, Manuelli M. Changes in oral microbiota due to orthodontic appliances: A systematic review. J Oral Microbiol 2018;10:1476645.
4. Axelsson P, Lindhe J. Effects of controlled oral hygiene procedures on caries and periodontal disease in adults. Results after 6 years. J Clin Peridontol 1981;8:239–248.
5. Axelsson P, Lindhe J. The effect of a preventive program on dental plaque, gingivitis and caries in school children. Results after one and two years. J Clin Peridontol 1974;1:126–138.
6. Axelsson P, Lindhe J. The significance of maintenance in the treatment of periodontal disease. J Clin Periodontol 1981;8:281–294.
7. Axelsson P, Nyström B, Lindhe J. The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults. Results after 30 years of maintenance. J Clin Periodontol 2004;31:749–757.
8. Ireland AJ, Soro V, Sprague SV, et al. The effects of different orthodontic appliances upon microbial communities. Orthod Craniofac Res 2014;17:115–123.
9. Contaldo M, Lucchese A, Lajolo C, et al. The oral microbiota changes in orthodontic patients and effects on oral health: An overview. J Clin Med 2021;10:780.
10. Wang Q, Ma JB, Wang B, Zhang X, Yin YL, Bai H. Alterations of the oral microbiome in patients treated with the Invisalign system or with fixed appliances. Am J Orthod Dentofacial Orthop 2019;156:633–640.
11. Wu Y, Cao L, Cong J. The periodontal status of removable appliances vs fixed appliances: A comparative meta-analysis. Medicine (Baltimore) 2020; 99:e23165.
12. Zhao R, Huang R, Long H, Li Y, Goa M, Lai W: The dynamics of the oral microbiome and oral health among patients receiving clear aligner orthodontic treatment. Oral Dis 2020;26:473–483.
13. Eickholz P, Walter C, Dannewitz B. Unterstützende Parodontitistherapie (UPT). Inhalt, Nutzen, Effekt. Parodontologie 2017;28:7–17.
14. Arefnia B, Koller M, Wimmer G, Lussi A, Haas M. In vitro study of surface changes induced on enamel and cementum by different scaling and polishing techniques. Oral Health Prev Dent 2021;19:85–92.
15. Wolgin M, Frankenhauser A, Shakavets N, Bastendorf KD, Lussi A, Kielbassa AM. A randomized controlled trial on the plaque-removing efficacy of a low-abrasive air-polishing system to improve oral health care. Quintessence Int 2021;52:752–762.
16. Wennström JL, Tomasi C, Bertelle A, Dellasega E. Full-mouth ultrasonic debridement versus quadrant scaling and root planing as an initial approach in the treatment of chronic peridontitis. J Clin Peridontol 2005;32:851–859.
17. Petersilka GJ, Steinmann D, Häberlein I, Heinecke A, Flemmig TF. Subgingival plaque removal in buccal and lingual sites using a novel low-abrasive air-polishing powder. J Clin Periodontol 2003;30:328–333.
18. Petersilka GJ, Tunkel J, Barakos K, Heinecke A, Häberlein I, Flemmig TF. Subgingival plaque removal at interdental sites using a low-abrasive air polishing powder. J Periodontol 2003;74:307–311.
19. Müller N, Moëne R, Cancela JA, Mombelli A. Subgingival air-polishing with erythritol during periodontal maintenance. Randomized clinical trial of twelve months. J Clin Periodontol 2014;41:883–889.

20. Hägi TT, Klemensberger S, Bereiter B, et al. The relative effects of root-debridement on biofilm-removal and hard-substance-alterations using a new in-vitro pocket model. Quintessence Int 2015;6:31–41.
21. Hägi TT, Klemensberger S, Bereiter R, et al. A biofilm pocket model to evaluate different non-surgical periodontal treatment modalities in terms of biofilm removal and reformation, surface alterations and attachment of periodontal ligament fibroblasts. PLoS One 2015;10:e0131056.
22. Flemmig TF, Petersilka GJ, Mehl A, Rüdiger S, Hickel R, Klaiber B. Working parameters of a sonic scaler influencing root substance removal in vitro. Clin Oral Investig 1997;1:55–60.
23. Ritz L, Hefti AF, Rateitschak KH. An in vitro investigation on the loss of root substance in scaling with various instruments. J CiIn Peridontol 1991;18:643–647.
24. Rupf S, Brader I, Vonderlind D, et al. In vitro, clinical, and microbiological evaluation of a linear oscillating device for scaling and root planing. J Periodontol 2005;76:1942–1949.
25. Bozbay E, Dominici F, Gokbuget AY, et al. Preservation of root cementum: A comparative evaluation of power-driven versus hand instruments. Int J Dent Hyg 2018;16:202–209.
26. Petersilka G, Heckel R, Koch R, Ehmke B, Arweiler N. Evaluation of an ex vivo porcine model to investigate the effect of low abrasive air-polishing. Clin Oral Investig 2018;22:2669–2673.
27. Barnes CM, Covey D, Watanabe H, Simetich B, Schulte JR, Chen H. An in vitro comparison of the effects of various air polishing powders on enamel and selected esthetic restorative materials. J Clin Dent 2014;25:76–87.
28. Wennström JL, Dahlén G, Ramberg P: Subgingival debridement of periodontal pockets by air polishing in comparison with ultrasonic instrumentation during maintenance therapy. J Clin Periodontol 2011;38:820–827.
29. Bühler J, Amato M, Weiger R, Walter C. A systematic review on the patient perception of periodontal treatment using air polishing devices. Int J Dent Hyg 2016;14:4–14.
30. Lalumandier JA, McPhee SD. Prevalence and risk factors of hand problems and carpal tunnel syndrome among dental hygienists. J Dent Hyg 2001;75:130–134.
31. Graetz C, Plaumann A, Rauschenbach S, Bielfeldt J, Dörfer CE, Schwendicke F. Removal of simulated biofilm: A preclinical ergonomic comparison of instruments and operators. Clin Oral Investig 2016;20:1193–1201.
32. Cianter M. Time to shift: From scaling and root planing to root surface debridement. Prim Dent J 2014;3:38–42.
33. Strafela-Bastendorf N, Bastendorf KD. PZR-neu gedacht. ZM 2016;106:26–32.
34. Strafela-Bastendorf N, Bastendorf KD. Die Patientenzufriedenheit in der Prophylaxe. ZMK 2020;36:452–456.
35. Furrer C, Bättig R, Votta I, Bastendorf KD, Schmidlin PR. Patient acceptance of "Guided Biofilm Therapy" [in German]. Swiss Dent J 2021;131:229–234.
36. Chhibber A, Agarwal S, Yadav S, Kuo CL, Upadhay M. Which orthodontic appliance is best for oral hygiene? A randomized clinical trial. Am J Orthod Dentofacial Orthop 2018;153:175–183.
37. Jiang Q, Li J, Mei L, et al. Periodontal health during orthodontic treatment with clear aligners and fixed appliances: A meta-analysis. J Am Dent Assoc 2018;149:712–720.
38. Flores-Mir C. Clear aligner therapy might provide a better oral health environment for orthodontic treatment among patients at increased periodontal risk. J Evid Based Dent Pract 2019;19:198–199.
39. Mummolo S, Nota A, Albani F, et al. Salivary levels of Streptococcus mutans and Lactobacilli and other salivary indices in patients wearing clear aligners versus fixed orthodontic appliances: An observational study. PloS One 2020;15:e0228798.