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DE CIÊNCIAS DA SAÚDE

" Guided Biofilm Therapy " : Prevention and management of peri-implant diseases

Alexis François Dorion

Dissertação conducente ao Grau de Mestre em Medicina Dentária (Ciclo Integrado)

Gandra, 28 de maio de 2021

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Trabalho realizado sob a Orientação do Professor Doutor Marco Infante da Câmara

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Eu, Alexis François Dorion, declaro ter atuado com absoluta integridade na elaboração deste trabalho, confirmo que em todo o trabalho conducente à sua elaboração não recorri a qualquer forma de falsificação de resultados ou à prática de plágio (ato pelo qual um indivíduo, mesmo por omissão, assume a autoria do trabalho intelectual pertencente a outrem, na sua totalidade ou em partes dele). Mais declaro que todas as frases que retirei de trabalhos anteriores pertencentes a outros autores foram referenciadas ou redigidas com novas palavras, tendo neste caso colocado a citação da fonte bibliográfica.

Scientific Communications in Congresses in Poster Format

ACKNOWLEDGEMENTS

I would like to thank my Mom and my Dad for everything you have done for me, all the rest of my family and my university friends.

I would like to thank my supervisor Professor Marco Infante da Câmara, it was an honor.

I would like to thank my Professor and car friend, Professor Paulo Rompante, one day we'll drive togheter.

I would like to thank Professor Joaquim Moreira, thank you for everything.

RESUMO

Introdução: Um dos maiores desafios da implantologia é prevenir e tratar a mucosite e a peri-implantite. Isto é conseguido através da combinação de medidas específicas de cuidados domiciliários e da remoção profissional regular do biofilme.

Objetivos: Revisão da literatura a fim de avaliar a eficácia da "Guided Biofilm Therapy" (GBT) na prevenção e gestão de doenças peri-implantares.

Materiais e Métodos: Três pesquisas bibliográficas foram necessárias e realizadas no PUBMED, uma para o agente revelador de placa, outra sobre o *air-polishing* supra e infragengival com pó de eritritol, e por ultimo sobre instrumento ultrasonico com ponta PEEK. São os principais fatores de diferenciação em comparação com uma abordagem convencional. Para as três pesquisas, os critérios de inclusão envolveram artigos publicados na língua inglesa e uma data de publicação com intervalo de dez anos.

Resultados/Discussão: 22 estudos foram incluídos nesta revisão. A aplicação prévia de um agente revelador de placa, serve como guia para a remoção do biofilme e resulta numa remoção mais eficaz. O *air-polishing* com pó de eritritol é eficaz para a descontaminação do biofilme das supraestruturas protéticas fresadas de titânio e implantes duma forma não invasiva. A ponta PEEK é eficaz para remoção de tártaro peri-implantar, pode deixar vestígios microscópicos na superfície do implantes mas que podem ser removidos depois com air polishing, e é menos invasivas do que a ponta ou cureta de aço inoxidável, escova de titânio e curetas de titânio de Langer.

Conclusões: A GBT é eficaz e minimamente invasiva para a prevenção e gestão de doenças peri-implantares.

PALAVRAS-CHAVE

Guided Biofilm Therapy ; Dental implants ; Peri-implants diseases ; Air polishing ; Erythritol ; PEEK tip

ABSTRACT

Introduction: One of the biggest challenges of implantology is to prevent and treat mucositis and peri-implantitis. This is achieved by combining specific home care measures and regular professional removal of the biofilm.

Objectives: To review the literature in order to evaluate the effectiveness of the "Guided Biofilm Therapy" (GBT) in the prevention and management of peri-implant diseases.

Methods: Three literature searches were necessary and perfomed on PUBMED, one for the disclosing agent, another for supra and infragingival air-polishing with erythritol powder, and a last one for ultrasonic instrument with a PEEK tip. They are the main differentiating factors compared with a conventional approach. For the three searches, inclusion criteria involved articles published in the English language and a publication date with an interval of ten years.

Results/Discussion: 22 studies were included in this review. The prior application of a biofilm discloser serves as a guide for biofilm removal and results in a better removal. Air polishing with erythritol powder is effective for biofilm decontamination of milled titanium prosthetic superstructures and implants in a non-invasive way. The PEEK tip is effective for removing peri-implant calculus, may leave microscopic tip debris on the implant surface but can be removed later with air polishing, and is less invasive than the stainless steel tip or curette, titanium brush, and Langer titanium curettes.

Conclusions: GBT is effective and minimally invasive for the prevention and management of peri-implant diseases.

KEYWORDS

Guided Biofilm Therapy ; Dental implants ; Peri-implants diseases ; Air polishing ; Erythritol ; PEEK tip

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LIST OF ABBREVIATIONS

GBT	:	Guided Biofilm Therapy
EMS	:	Electro Medical Systems
APEP	:	Air polishing with erythritol powder
SAPEP	:	Subgingival air polishing with erythritol powder
SB	:	Sodium bicarbonate
CAP	:	Cold atmostferic plasma
COM	:	Erythritol and cold atmostferic plasma
CHX	:	Chlorhexidine
TC	:	Titanium curettes
PS	:	Stainless steel ultrasonic tip
CON	:	Polishing with rubber cup
PEEK	:	Polyether Ether Ketone
PI	:	Peek-coated ultrasonic tip
OHSE	:	Oral hygiene-related self-efficacy
PD	:	Probing Depth
GI	:	Gingival index
BOP	:	Bleeding on probing
CAL	:	Clinical Attachment Loss

1.INTRODUCTION

Modern dentistry often uses dental implants as a trustworthy treatment option to support dental prosthesis in order to restore missing teeth, from single units to full-arch reconstruction[1]. However, this treatment option encounters a frequent biological complication : inflammation of the tissues surrounding the implant, also known as mucositis and peri-implantitis[2]. Peri-implant diseases are increasing, creating a current and future challenge for dental professionals as well as patients[3]. In a recent systematic review, including 11 studies, meta-analyses estimated mean prevalence of 43% and 22% respectively for mucositis and peri-implantitis[3]. The presence of biofilm on implants is the principal etiology of peri-implant diseases[4]. The decontamination of implant surfaces is therefore fundamental for a successful treatment outcome[1]. Non-surgical approach seems to be less invasive and more cost-effective for patients[2]. Treatments that increase surface roughness can lead to higher biofilm adhesion and accumulation, making the search for an effective minimally invasive method a current problem[5]. Different polishing powders seem to result in less surface alteration compared to ultrasonic devices, in particular erythritol powder[6]. The Swiss company Electro Medical Systems (EMS) has gradually developed a systematized 8 steps protocol, the Guided Biofilm Therapy (GBT), in order to propose an effective protocol for the prevention and management of peri-implant diseases.

2.OBJECTIVES AND HYPOTHESES

The purpose of the present study was to review the literature in order to evaluate the effectiveness of the GBT on implants. It was hypothesized that GBT is an effective therapy for peri-implants diseases prevention and treatment. GBT being recent, there is so far a lack of long-term studies of this therapeutic protocol, where whole steps have been tested in conjunction in the same population. This is why this study is particularly relevant, and will attempt to prove the effectiveness of this therapy on implants, by studying the four key differentiating factors compared with a conventional approach: disclose, AIRFLOW®, PERIOFLOW® and PIEZON® with PI tip. This study will attempt to prove that the use of a biofilm discloser serves as a guide for a better biofilm removal, that air polishing with erythritol powder and ultrasonic device with PEEK tip, are efficient for supra and subgingival implant biofilm decontamination.

3.METHODS

Three literature searches were necessary and perfomed on PUBMED, one for the disclosing agent, another for supra and subgingival air polishing with erythritol, and a last one for ultrasonic device with PEEK tip, the four key differentiating factors compared with a conventional approach. For the three searches, inclusion criteria involved articles published in the English language and a ten year interval publication date from 2011/03/25 to 2021/03/25, using NCBI filters. After each search were selected pertinent articles, through their titles and abstracts, also relying on the following criteria of inclusion: Clinical Trial and Randomized Controlled Trial, which were manually sorted.

Search 1 was performed using the following combination of search terms: ("plaque disclosing" OR "disclosing agent") AND (biofilm removal OR plaque removal) NOT orthodontic. All studies that have not tested the effectiveness of a plaque discloser as a guide for biofilm remotion were excluded as well as orthodontic studies.

Search 2 was performed using the following combination of search terms: ("air polishing" OR "air abrasive" OR "air-polisher") AND ("titanium surface" OR "dental implants" OR implant) AND (erythritol OR "cleaning efficiency"). All the studies that have not tested the effectiveness of air polishing with erythritol powder on titanium sufaces in a non-surgical treatment, were excluded.

Search 3 was performed using the following combination of search terms: ("PEEK tip" OR "ultrasonic device") AND ("peri-implant" OR "implant surfaces"). All the studies that have not tested the effectiveness of ultrasonic device with a PEEK tip for titanium surfaces decontamination in a non-surgical treatment, were excluded.

The total of articles was compiled for each search and therefore the duplicates were removed using Mendeley citation manager. Selected articles were individually read and evaluated concerning the purpose of this study. The following factors were retrieved for this review: authors' names, publication year, purpose, results and conclusion.

4.RESULTS

The literature searches identified a total of 46 articles in PubMed, as shown in Fig. 1. One duplicate was removed. After reading the titles and abstracts of the articles, 23 were excluded because they did not meet the inclusion criteria. The remaining 22 potentially relevant studies were then fully read (Fig. 1). Finally 22 studies were included in this review.

Of the 22 studies selected, 2 investigated disclosing agent effect, 12 other articles evaluated supra and subgingival air polishing with erythritol powder, 7 the implant decontamination with ultrasonic with PEEK tip, and 1 compared air-polishing with erythritol powder to ultrasonic with PEEK tip.

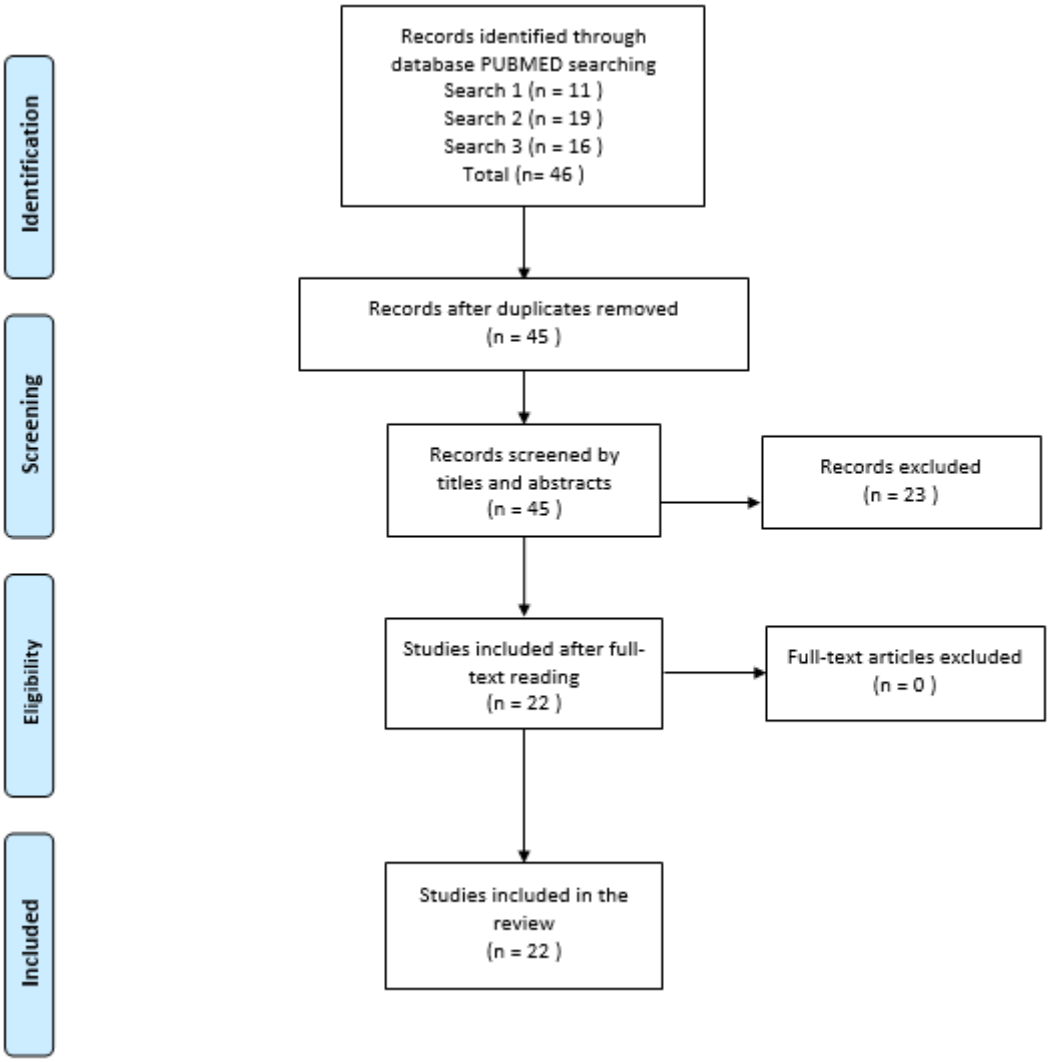

Figure 1 : Flow diagram of the search strategy used in this study.

Table 1. Relevant data gathered from the included studies.

Author (Year)	Population	Purpose	Results	Conclusion
Mensi et al., (2020)[7]	32 patients	Efficacy of a plaque disclosing agent as a visual guide for biofilm remotion with GBT in terms of post-treatment residual plaque. (control group without application of a plaque disclosing agent)	Statistical and clinical significant difference between the two groups with a proportional reduction of 49.2% on the gingival surface to more than 60% on the coronal surface in the group using plaque disclosing agent as a guide.	Previous application of a plaque disclosing agent, serve as a guide for plaque remotion with GBT and result in a better biofilm removal.
Montevecchi et al., (2012)[8]	40 patients	To evaluate the potential support of a disclosing agent on a surgical scaling.	After a first chromatic examination, stained deposits were removed, a second chromatic examination was performed to verify if the use of the disclosing agent could improve the scaling results. Between the first and the second chromatic examination a significant reduction (80%, p=0.0001) of the plaque index (PIi) score was observed.	Disclosing agent seems to be effective for a better biofilm remotion and could be a practical aid.
Matsubara et al., (2019)[1]	20 implants	To compare three diferent powders glycine, erythritol and sodium bicarbonate on twenty implants inserted in a three dimensional (3D) printed bone defect imitating advanced stages of peri-implantitis.	Sodium bicarbonate (SB) removed 49.3 ± 3.6% of the biofilm discloser, erythritol 25.1 ± 0.7% and glycine 33.1 ± 1.2%. SB significantly altered the implant surface. SB and glycine, images showed obliteration in the transition from the collar to the thread.	Smaller powder particles seems to be minimally invasive in comparision with bigger particles such as SB, while being effective in biofilm remotion. SB is effective for biofilm remotion, but damaged the implant surface, it is therefore preferable smaller particles as erythritol or glycine.
Schmidt et al., (2017)[9]	72 healing caps	To compare 4 types of treatments on titanium healing caps: titanium curettes (TC), stainless steel ultrasonic tip (PS), air polishing using erythritol powder (APEP) and polishing with rubber cup (CON).	No significant differences could be found ($p > 0.05$) between the different treatment groups for all the parameters probing depth (PD), bleeding on probing (BOP), MMP-8, bacterial colonization or fibroblast attachment, except with TC showed a significant reduction of PD.	APEP manifest a significant decrease of a large spectrum of bacterias. Significant results were found for the alteration of the surface, with the best results with APEP which left the surface less rough after treatments.
Mensi et al., (2017)[2]	15 patients for a total of 27 implants	To test the efficacy of a multiple anti-infective non-surgical treatment (MAINST) in the non-surgical treatment of peri-implantitis lesions. MAINST consists in the GBT combined with local antibiotics.	At the end of the study no implant failure, complications or adverse events were reported. The treatment resulted in a statistically ($P<0.01$) and clinically significant reduction at baseline and at 1 year of PI, BOP and PB depth.	The MAINST protocol obtained good results in terms of improvement of clinical parameters in a non-surgical approach for peri-implantitis treatment.

Author (Year)	Population	Purpose	Results	Conclusion
Mensi et al., (2020)[10]	64 implants	To compare the cleaning potential, in a simulating model a peri-implant pocket, of 4 types of non-surgical implant decontamination : stainless-steel ultrasonic tip (PS), peek-coated ultrasonic tip (PI), sub-gingival air-polishing with erythritol powder (SAPEP) and sub-gingival airpolishing with glycine powder.	The best results in terms of maximum ink removal were 62.78% and 58.57%, respectively at 90° and 45° angulation, for the SAPEP. The hypothesis is confirmed about the superiority of air-polishing (erythritol or glycine powder) over ultrasonic instrumentation (PS or PI), on different angulation (90° and 45°) and different time application (5 and 45 seconds) The results showed the efficacy of air-polishing to remove ink top, inbetween and under the threads, contrary to ultrasonic instruments, allowing a deep cleening in peri-implant pockets.	Air-polishing allows better ink removal of implant surfaces (top, inbetween and under the threads) over ultrasonic instrumentation (PS and PI tip). No significant differences in cleaning efficacy between erythritol and glycine powders, both have a great cleaning potential. Efficacy of air-polishing was increased by increasing the treatment time.
Hui et al., (2020)[11]	112 titanium discs	To evaluate the decontamination efficacy and titanium surface alterations with APEP and cold atmostferic plasma (CAP).	99.92% and 93.96% cleaning efficacy respectively for group A and group B with APEP, on two types of titanium surfaces. 80,98% and 42.63% cleaning efficacy respectively for group A and group B with CAP. And 95.94% and 88.55% cleaning efficacy respectively for group A and group B with both erythritol and cold atmostferic plasma (COM). Discs decontamination with APEP or COM resulted with better results than CAP, with almost a complete decontamination (99.92%) with APEP on the group A. No post treatment alteration of the titanium discs surfaces were found by SEM analysis.	APEP, CAP or COM did not affect the surface roughness of titanium discs. Erythritol powder is highly effective for titanium discs biofilm decontamination, alone or in combination with CAP. The treatments did not significantly affected the titanium discs surfaces.
Drago et al., (2014)[12]	18 titanium discs	Erythtritol/Chlorhexidine (CHX) and glycine powders were compared in this in vitro study	Glycine was less effective against the three bacterias strains : Staphylococcus aureus, Bacteroides fragilis and Candida albicans. After glycine treatment, the reduction of surviving cells was only 15% for *S. aureus and about* 30% for *B. fragilis* and *C. albicans. After* Erythritol/CHX treatment, the reduction was about 50% for all the strains.	Erythritol/CHX demonstrated a microbicidal effect against all the tested strains contrary to glycine. Erythritol/CHX powder can be a viable alternative to traditional glycine, because it showed better results in terms of bacterias decontamination.
Mensi et al., (2018)[13]	titanium disks	To test the efficacy of erythritol/CHX powder in comparison with SB powder, for biofilm remotion and prevention of bacterial recolonization with air-polishing pre-treatment on the titanium disks before being infected.	For the preventive effect reduction in S. aureus and A. actinomycetemcomitans colonies with the best results with erythritol/CHX powder. For the biofilm remotion they demonstrated that the treatment with either one or the other powders result in a bacterial viability reduction.	The two powders did not caused alteration in the surface roughness and were efficient in the prevention of new bacterias adhesion and direct decontamination.

Author (Year)	Population	Purpose	Results	Conclusion
Matthes et al., (2017)[14]	titanium disks	To test the efficacity of biofilm remotion with APEP or CAP or combination of both (APEP+CAP).	APEP e APEP+CAP no bacteria were found, and the surfaces covered with osteoblast cells respectively with a mean of 85% and 75%. However for CAP or the control no osteoblast cells were found, and bacterias covering the disks respectively with a mean of 96,8% and 94,9%. The best results of osteoblast cells colonization were with APEP.	Air-polishing with erythritol powder (APEP) has a high potential to remove biofilm, and promoted the development of osteoblast cells. The combination of air-polishing and cold plasma treatment did not improve osteoblast spreading.
Chew et al., (2018)[15]	120 healing abutments	To evaluate contamination of used healing abutments after autoclaving and to compare two decontamination methods in addition to autoclaving, APEP and sodium hypochlorite.	The results of residual contamination on the body, top and bottom surfaces were respectively for the group 1 (only autoclaving), 38.2% ± 28.34%, 30.0% ± 19.55%, 18.7% ± 17.87% ; for group 2 (autoclaving and APEP) 3.5% ± 4.90%, 5.3% ± 3.74%, 5.4% ± 8.49% ; for group 3 (autoclaving and sodium hypochlorite NaOCl 25 g/L) 0.3% ± 0.16%, 1.9% ± 2.14%, 0.7% ± 1.02%.	Is it possible reusing used abutment healing, only autoclaving was not sufficient, but adding air polishing or sodium hypochlorite, results in an effective decontamination. Thus, APEP is an effective treatment for titanium healing abutments decontamination.
Drago et al., (2016)[16]	Titanium discs	To test on titanium surface the antibiofilm activity of erythritol/CHX powder, see if it reduces previously grown microbial biofilm and prevent from new biofilm formation.	The Minimum inhibitory concentration and minimum microbicidal concentration values, allowed to conclude that erythritol/CHX have a microbicidal activity on all tested strains.The spectrophotometric analysis revealed that the treatment was effective for decrease the previously developed biofilm and reducing biofilm formation on titanium surfaces. Significant reduction of the total biofilm volume, with an increase of the percentage of dead cells of all the microorganisms tested.	Treatment with erythritol/CHX powder may be promising for peri-implants diseases management, due to the antimicrobial and antibiofilm activity against peri-implantitis pathogens.
Schmidt et al., (2016)[6]	35 implants	To test the titanium surface alteration after the use of different instruments, and capacity of bacterial recolonization.	Stainless steel curettes caused a significantly rougher surface alteration in comparison with the other instruments. The different polishing powders seems to result in less surface alteration compared to ultrasonic devices, in particular erythritol powder, which was even less than the two glycine powders. Between instrumented or control surfaces no significant differences were found after bacterial colonization.	Surface alteration and capacity of bacterial recolonization after the different instrumentations did not show significant differences. Erythritol powder seems to be the least invasive.
Schmidt et al., (2018)[17]	8 patients for a total of 32 implants	To investigate tissue health around implants, they were treated if necessary with titanium curettes (TC) or stainless steel ultrasonic tip	Minimal signs of periodontal inflammation were observed with statistically significant PD improvement and Clinical Attachment Loss (CAL) on patients after 1 year. No statistically significant differences between the treatment options at baseline or 12 months	All treatment modalities tested resulted in comparable clinical improvements.

Author (Year)	Population	Purpose	Results	Conclusion
		(PS) or erythritol air-polishing powder (APEP) or rubber cup polishing (CON).	for any parameter, except MMP-8 reduced significantly for PS, and after 12 months plaque control record showed a significant difference between PS and TC.	
Tastepe et al., (2017)[18]	48 titanium discs	To study the behaviour of erythritol powder air-polishing system using a subgingival plastic nozzle on a titanium surface. To evaluate the influence of the different device settings, cleaning movements and pocket depths.	Air pressure was the parameter which had improved the most the cleaning efficacy. Increasing air pressure resulted in a larger clean area. The nozzle depth and excessive powder flow quantity had a weak influence. The cleaning effect went beyond the tip of the nozzle. Without movement the cleaning efficiency decreased. No significant difference between different nozzle movements.	To optimize the effectiveness of the erythritol air-polishing with subgingival plastic nozzle, it must be used with high pressure, with deep insertion of the nozzle and enough water flow. Mouvement of the nozzle is required to get the best cleaning result.
Polizzi et al., (2020)[19]	13 implants	To compare the effectiveness of steel tip, PEEK tip and IS-TiP-STS-3E© in reducing bacterial load and surface alteration.	PEEK tip resulted to be the best of the 3 tips with a highly significant reduction of bacterial load. PEEK tip was less invasive than the steel tip. IS-TiP-STS-3E© was the least invasive.	PEEK tip is effective to reduce peri-implant bacterial load, but the authors recommend IS-TiP-STS-3E© in association with an antimicrobial agent, for being less aggressive.
Sahrmann et al., (2021)[20]	160 titanium discs	To compare the impact of 5 scaler tips made from different materials, on different implant surfaces.	PEEK tip caused minor scratches on the machined surface, slightly flattened the medium rough surfaces. Nothing on the surface without pretreatment. Titanium and steel tips caused a completely flattened surface and a loss of the typical morphology of the moderately rough surfaces. Concentration of carbon increased after treatment with PEEK, carbon and resin tip for the moderately rough surface and the surface without pretreatment, but did not change markedly for the machined.	PEEK tips can change the surface roughness of rough titanium surfaces and abrade on rough surfaces, but both less pronounced than the other materials.
Schmage et al., (2014)[21]	80 titanium discs	To test the cleaning effectiveness of different prophylaxis instruments on titanium discs.	The best results of cleaning were with the sonic-driven and ultrasonic-driven PEEK tips and the air polishing (less than 4% of remaining biofilm). The manual plastic and manual carbon fiber-reinforced plastic curettes showed the worst cleaning effectiveness (up to 18% of remaning biofilm). Rubber cup showed lower cleaning efficiency in comparison to ultrasonic-driven PEEK tip and air polishing.	Sonic-driven and ultrasonic-driven PEEK tip and air polishing were more effective for biofilm remotion than manual plastic and manual carbon fiber-reinforced plastic curettes, sonic-driven prophylaxis brush, rubber cup.

Author (Year)	Population	Purpose	Results	Conclusion
Cha et al., (2019)[22]	72 titanium implants	To evaluate five decontamination protocols influence on implant surfaces.	Ultrasonic stainless steel tip damaged and created macroscopic alterations of the implant surface, the two titanium brush flattened the thread, PEEK tip left remnants of the plastic tip on the implant surface but did not show evident macro-geometrical alterations and the glycine powder air polishing resulted in minimal alterations.	PEEK tips left remnants on the implant surface but did not cause relevant surface alterations. The glycine air polishing seems to be less invasive for the implant surface. Metal scaler generated noticeable damage on the implants surface. The two Titanium brushes flatten the implant thread profiles.
Bertoldi et al., (2017)[23]	60 titanium implants	Titanium implant surfaces alteration after 3 different types of instrumentation.	Surface roughness was significantly compromised after stainless-steel Gracey-curettes (S). After titanium Langer-curettes (T) and ultrasonic-device with the probe covered with a plastic-tip (P) instrumentation, small surface alterations were detected, but to a lesser degree. Plastic debris after P-treatment was found in the space of the fixture-abutment connection. The roughness-parameter was unchanged after P-, slightly increased after T-, and greatly increased after S-treatment.	The PEEK tip can leave behind microscopic plastic debris. Titanium curette and PEEK tip were less invasive than stainless-steel Gracey-curettes.
Harrel et al., (2019)[24]	12 titanium implants	To evaluate if the use of ultrasonic scaler with stainless steel, titanium, and PEEK plastic tips on implants produce titanium particles.	All ultrasonic scalers created some damage of the threads of the implants and the SLA surface at the neck of the implant. The damage using the stainless steel tip appeared more extensive than PEEK plastic tip.	All ultrasonic scaling producted titanium particles and damaged the SLA coating of the implant. They should be used with great caution in the treatment of peri-implant conditions.
Riben-Grundstrom et al., (2015)[25]	37 patients	To compare the clinical treatment effects of glycine powder air-polishing and ultrasonic device with a PEEK tip on peri-implant mucositis.	For both groups, percentages of diseased sites were significantly reduced. Mean plaque score, bleeding on probing and number of periodontal pockets ≥4 mm were statistically significant reduced at 12 months compared to baseline.	The ultrasonic device treatment with the PEEK tip or glycine powder air-polishing is effective in non-surgical treatment of peri-implant mucositis.

5.DISCUSSION

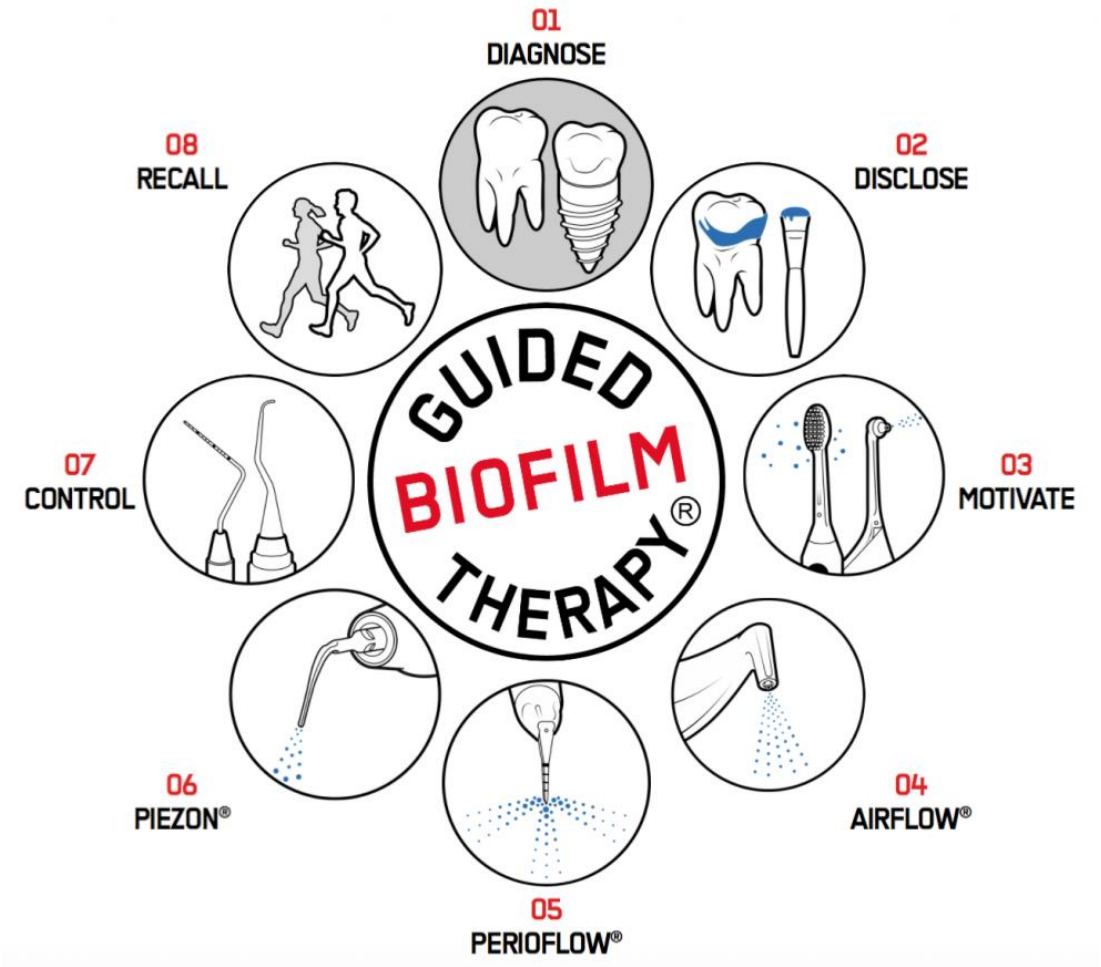

Figure 2 : Diagram of the 8 steps of the Guided Biofilm Therapy protocol. (EMS)

5.1. Assessement and infection control

EMS reminds dental professionals that diagnosis is the first step before any treatment. Focusing this study on implants, the first step of the protocol is to determine the implant condition. According to the 2017 World Workshop who presented the new classification of periodontal and peri-implant diseases ; definitions of peri-implant health, peri-implant mucositis, and peri-implantitis were proposed by Berglundh et al.[4] in a consensus report. The European Federation of Periodontology reminds that the previous classification of 1999 did not include peri-implant diseases and conditions.

5.1.1 Peri-implant health

According to this consensus report, the diagnosis of peri-implant health requires:

« - *Absence of clinical signs of inflammation.*

- Absence of bleeding and/or suppuration on gentle probing.

- No increase in probing depth compared to previous examinations.

- Absence of bone loss beyond crestal bone level changes resulting from initial bone remodeling. » [4].

They added that *« probing depths depend on the height of the soft tissue at the location of the implant. Furthermore, peri-implant tissue health can exist around implants with variable levels of bone support.* » [4].

5.1.2 Peri-implant mucositis

For peri-implant mucositis the requirements for the diagnosis are:

« *- Presence of bleeding and/or suppuration on gentle probing with or without increased probing depth compared to previous examinations.*

- Absence of bone loss beyond crestal bone level changes resulting from initial bone remodeling.

It should be noted that visual signs of inflammation can vary and that peri-implant mucositis can exist around implants with variable levels of bone support. » [4].

The presence of biofilm on implants is the principal etiology of peri-implant diseases[4].

5.1.3 Peri-implantitis

Peri-implantitis is « a plaque-associated pathological condition occurring in tissues around dental implants, characterized by inflammation in the peri-implant mucosa and subsequent progressive loss of supporting bone. » [4].

The Diagnosis of peri-implantitis requires:

« - Presence of bleeding and/or suppuration on gentle probing.

- Increased probing depth compared to previous examinations.

- Presence of bone loss beyond crestal bone level changes resulting from initial bone remodeling.

In the absence of previous examination data diagnosis of peri-implantitis can be based on the combination of:

- Presence of bleeding and/or suppuration on gentle probing.

- Probing depths of ≥6 mm.

- Bone levels ≥3 mm apical of the most coronal portion of the intraosseous part of the implant. » [4].

5.2. Disclose

The first key differentiating factor of the GBT compared with a conventional approach is the application of a biofilm discloser. The main EMS biofilm discloser agent, is erythrosine, a synthetic red iodine dye. The biofilm can be visible or not with the naked eye, hence the interest in using a discloser. Allowing an immediate feedback, it is really usefull for areas difficult to access and for individuals at high risk of carious or periodontal pathology[7]. Previous application of a plaque disclosing agent, serves as a guide for biofilm remotion and result in a better removal[7,8]. The use of the disclosing agent significantly reduced by 80% the PI score[8]. Plaque disclosing is also a tool to help patients to understand and see oral plaque in order to improve their self-performed hygiene and compliance[26].

5.3. Motivate

Motivation is the action of stimulating someone or a group of people to accomplish something. Often neglected in dental office for lack of time or resources, but very important to achieve better clinical outcomes. There is a wide variety of motivational and instructional techniques for oral hygiene. Clinical improvement of periodontal parameters were observed after motivation and/or instruction to oral health[27–36]. Preus et al.[32], found a statistically significant and profound reduction in plaque, BOP and PD. Oral hygiene instruction therefore offers benefits for periodontal health[29]. Basic instruction slightly improved oral hygiene[27]. A more developped instruction with motivational interview had much better results[27]. The patients successfully manage to incorporate new oral hygiene behaviours into their daily routine[31]. A motivational video was efficient in improving oral hygiene in the short term[28]. However for example WhatsApp messages does not seems to add extrabenefit to oral hygiene (plaque index and Gingival index) in the patients with gingivitis, compared to traditional motivation and education[36]. Oral hygiene education and lifestyle change by motivational interviewing improve both glycemic and periodontal status on type 2 diabetes patients[30]. A trans-sectional observational study conducted by Vatne et al.[34], found that 84% of patients, answered that the received information had been necessary to make them change their cleaning behavior. Decrease of plaque index from 61.9% to 13.5% and 18.4% answered to have quit smoking one year after treatment[34]. Higher scores in oral hygiene-related self-efficacy (OHSE) significantly decrease gingival bleeding scores for non-smoking patients, increase inter-dental and professional tooth cleaning, and reappearance to the

follow-up appointment[33]. Sarsilmazer et al.[35], noticed that patients with OHSE-high scores showed better performance in daily plaque control (lower plaque index), after motivation and oral hygiene instructions. Motivation is a real challenge for every professional, it is a necessary step to reach a better treatment, and oral health for the patient.

5.4. AIRFLOW®

AIRFLOW® elaborated by the Swiss company EMS, is a cleaning procedure around implant mucosa. According to EMS, AIRFLOW® is an air polishing with powder technology for early calculus, stains, supragingival biofilm removal and subgingival biofilm removal up to 4mm and stains. Air polishing with erythritol powder (APEP) was found to be effective for biofilm decontamination on implants, healing abutments and titanium discs[1,11–15]. EMS informs that the handpiece combine air pressure and the powder, who will be project on the target with a 30° minimum angle and a 60° maximum angle, at a distance between 3 and 5mm. This projection is surrounded by water, the superior water projection serves for guiding and warming, the inferior serves for rinsing the rubbish at a debit of 60 mL/min. They recommended to dismantle the crown before cleaning.

Smaller powder particles are less invasive, while being effective in biofilm remotion in comparision with bigger particles such as sodium bicarbonate[1]. This last damaged the implant surface, it is therefore preferable smaller particles such as erythritol or glycine[1]. The EMS PLUS® powder contains erythritol with a granule-metric size of only 14µm. Erythritol is a polyol, a natural sugar substitute, naturally found in some fruits and fermented food. The PLUS® powder also contains 0.3% of chlorhexidine (CHX). Erythritol/CHX powder can be a viable alternative to traditional glycine powder, because it showed better results in terms of bacterias decontamination[12]. It manifests a significant decrease of a large spectrum of bacterias[6]. Erythritol/CHX powder has an antimicrobial and antibiofilm activity against peri-implantitis pathogens[16]. An important quality for a powder, is to be as minimally invasive as possible in such a manner to not create roughness on the target surface. Erythritol powder did not caused noticiable alteration on titanium surface roughness[1,11,13]. APEP is efficient in the prevention of new bacterias adhesion[13]. And also promote the development of osteoblast cells[14]. The combination of air-polishing and cold plasma did not seem to improve the treatment[11,14]. Polishing powders seem to result in less surface alteration compared with ultrasonic devices and stainless steel curettes, in particular erythritol powder, which was

even less than two glycine powders[6]. APEP left the surface less rough after treatment than titanium curettes (TC), stainless steel ultrasonic tip (PS), and polishing with rubber cup (CON)[9]. Schmidt et al.[9], did not found statistical significant differences between the treatment with TC or PS or APEP or CON, all treatments resulted in comparable clinical improvements. APEP, is effective and minimally invasive for titanium surfaces decontamination with no risk of scratching.

5.5. PERIOFLOW®

According to EMS, PERIOFLOW® technology is composed of a handpiece and a subgingival plastic nozzle, in order to eliminates biofilm in peri-implant pockets from 4 to 9mm, with a minimum of 5 seconds per site. PERIOFLOW® is a subgingival air polishing technique used for implant maintenance allowing an easy access, without the need to remove crowns and implant abutments to clean subgingival. It should not be used immediately after any subgingival treatment, or when profuse bleeding or suppuration is present.

The nozzle is graduated (3mm, 5mm, 7mm, 10mm) for measurements of pocket depth and a better controlled pocket application, and has a trilateral powder exit and an apical water spray, creating a vortex. Application of GBT with AIRFLOW® for supragingival and PERIOFLOW® for subgingival decontamination of pockets, combined with local antibiotics obtained good results in terms of improvement of clinical parameters for peri-implantitis treatment[2]. Erythritol or glycine subgingival air-polishing allows better ink removal of implant surfaces (top, inbetween and under the threads) over ultrasonic instrumentation[10]. Efficacy of subgingival air polishing was increased by increasing the treatment time[10]. To optimize the effectiveness of the erythritol air-polishing with subgingival plastic nozzle (SAPEP), it should be used with high pressure, deep insertion of the nozzle and enough water flow[18]. Mouvement of the nozzle is required to get the best cleaning result[18]. SAPEP, is therefore effective and minimally invasive for peri-implant pockets decontamination.

5.6. PIEZON® PI

According to EMS, PIEZON® with the PI instrument is designed to remove calculus from implants neck, abutments and crowns in a non-invasive way. PIEZON® is an ultrasonic instrument for surfaces scaling. The PI instument is a tip-coating in Polyether Ether Ketone (PEEK) fiber. PEEK is a thermostable semi-crystalline thermoplastic. Ultrasonic-driven PEEK

tip and air polishing were more effective for biofilm remotion than manual plastic and manual carbon fiber-reinforced plastic curettes, sonic-driven prophylaxis brush, rubber cup, with less than 4% of remaining biofilm[21]. Mensi et al.[10], compared the cleaning potential of SAPEP to PI, in a simulating model of a peri-implant pocket. They conclued the superiority of air polishing over ultrasonic instrumentation for a better ink removal of implant surfaces. The GBT use first the air polishing then ultrasonic with PEEK tip because it seems to allow an easier calculus detection, an easier access, to save time and to reduce the scratching risk. Stainless steel tip and metal scalers generated noticeable damage on the implants surface, PEEK tip was less invasive[19,20,22,24]. PEEK tip was also less invasive than titanium brush[22] and stainless-steel Gracey-curettes but comparable with titanium Langer-curettes[23]. All ultrasonic scaling with stainless steel, titanium, and PEEK plastic tips producted titanium particles[24]. Sahrmann et al.[20], detected that PEEK tip caused minor scratches on the machined surface, nothing on the surface without pretreatment, slightly flattened the medium rough surfaces but always less invasive than titanium and steel tips. The PEEK tip can left remnants of the plastic tip on the implant surface but did not cause relevant surface alterations[22,23]. Plastic debris PEEK tip treatment was found in the space of the fixture-abutment connection[23]. The debris can be removed after with air polishing. PEEK tip is effective to reduce peri-implant bacterial load[19]. On peri-implant mucositis, the mean plaque score, bleeding on probing and number of periodontal pockets ≥4 mm were statistically significant reduced at 12 months compared to baseline using an ultrasonic device with a PEEK tip, reducing significantly the percentages of diseased sites[25].

5.7. Check

After the treatment completed, the penultimate step is to do a final check using non scratching instruments for the implant surface and gentle for the peri implant tissues. The check includes verification of possible remaining biofilm, calculus, stain, a soft tissue assessment, mobility and stability respectively of the prosthesis and the implants.

5.8. Recall

If the recall sessions are respected, the AIRFLOW® treatment is often sufficient to eliminate the biofilm and newly formed calculus. The PIEZON® treatment sometimes becomes unnecessary. EMS recommends to ask the patient if he liked the treatment.

A regular implants maintenance results with a lower incidence of peri-implant diseases[37–40]. Monje et al.[37], found 86% less conditions of peri-implantitis associated with regular compliance. Gay et al.[38], noticed that patients with regular maintenance therapy, reduced by 90% the implant failure rate in comparison with no maintenance. The frequency of maintenance visits played an important role for implant survival[38]. The maintenance visit at least once a year is recommended[38]. Maintenance frequency MF<1 per year group had a higher peri-implant bleeding index, peri-implant bleeding on probing index, implant bone loss and peri-implant probing depth index PDi≥5mm compared with the MF≥1 per year group[39]. Significantly lower total bacterial load and lower values of plaque index with preventive maintenance therapy[40]. The recall frequency varies according to risk assessment. EMS recommends a recall every 6 months for peri-implant health, 3 months for peri-implant mucositis and 1 month for peri-implantitis with or without suppuration. For a healthy implant, the recall serve as a maintenance in order to prevent from peri-implant mucositis and the practitioner will only require AIRFLOW® and PIEZON® with PI instrument if needed. For peri-implant mucositis, the purpose of the recall is to improve the mucositis and to prevent re-inflammation and the practitioner will require AIRFLOW® and PIEZON® with PI instrument if needed. For peri-implant health or mucositis if the implant abutment is long, PERIOFLOW® could be necessary. For peri-implantitis, recall to control and prevent re-inflammation, and requiring AIRFLOW®, PERIOFLOW® and PIEZON® with PI instrument if needed.

6.CONCLUSION

In the present review, relevant articles reported significant findings on the four key differentiating factors compared with a conventional approach: disclose, AIRFLOW®, PERIOFLOW® and PIEZON® with PI tip:

- The use of a biofilm discloser serves as a guide for a better biofilm removal.
- Air polishing with erythritol powder is effective for supra and subgingival implant biofilm decontamination.
- Erythritol powder did not caused significant alteration on titanium surface roughness.
- Air polishing with erythritol is efficient in the prevention of new bacterias adhesion and promoted the development of osteoblast cells.

- Erythritol/CHX powder can be a viable alternative to traditional glycine powder, showing better results in terms of bacterias decontamination and being even less aggressive.
- PEEK tip can left microscopic remnants of the tip on the implant surface, but who could be removed later with air polishing.
- PEEK tip is less invasive than stainless steel tip, metal scalers, titanium brush and stainless-steel Gracey-curettes.
- PEEK tip is more effective for biofilm remotion than manual plastic, manual carbon fiber-reinforced plastic curettes, sonic-driven prophylaxis brush, rubber cup.
- If the recall sessions are respected, the supra and subgingival air polishing treatment is often sufficient to eliminate the biofilm and newly formed calculus. The ultrasonic with PEEK tip treatment sometimes becomes unnecessary.

The GBT is therefore an effective minimally invasive therapy on implants, preventing or treating peri-implants diseases.

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APPENDIX :

Figure 3 : Poster “Guided Biofilm Therapy” : prevenção e gestão de doenças peri-implantares. Presented at the XXIX IUCS / CESPU Dental Science Conference.