L'aéro-polissage sous-gingival dans le maintien parodontal

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La Faculté de médecine, sur le préavis de Monsieur Andrea Mombelli, professeur ordinaire à la Section de médecine dentaire, autorise l'impression de la présente thèse, sans prétendre par là émettre d'opinion sur les propositions qui y sont énoncées.

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A. Introduction

a. Généralités

Toutes les surfaces du corps sont exposées à la colonisation par une large variété de micro-organismes. En général, la flore microbienne établie vit en harmonie avec son hôte. Le renouvellement constant des surfaces par desquamation empêche une accumulation trop importante de ces micro-organismes. Les dents, les implants et les appareils prothétiques fournissent cependant des surfaces dures qui ne se renouvellent pas. Ce phénomène permet le développement de dépôts bactériens importants qui acquièrent les propriétés de biofilms et qui, dans le milieu buccal, sont communément appelés la plaque dentaire.

L'accumulation bactérienne sur les surfaces dentaires est la cause principale de la gingivite et de la parodontite. Ainsi l'ablation régulière de la plaque bactérienne de toutes les surfaces non desquamantes de la cavité orale est considérée comme le moyen principal de prévention et d'arrêt de la progression de la maladie parodontale. Des études longitudinales ont pu montrer l'efficacité du traitement conventionnel qui est une combinaison de surfaçages radiculaires (BADERSTEN et coll. 1981, 1984b, a, HAFFAJEE et coll. 1997, TUNKEL et coll. 2002), d'une pratique quotidienne d'hygiène buccale méticuleuse par le patient (ROSLING et coll. 1976a, NYMAN et coll. 1977, MAGNUSSON et coll. 1984, KORNMAN et coll. 1994) et de visites régulières de maintien pour enlever les dépôts sous-gingivaux nouvellement formés (AXELSSON & LINDHE 1981, AXELSSON et coll. 2004). Dans la plupart des cas, la maladie parodontale peut ainsi être traitée avec succès et les résultats peuvent être maintenus à long terme (TUNKEL et coll. 2002, VAN DER WEIJDEN & TIMMERMAN 2002).

Les principaux effets secondaires du traitement mécanique visant à éliminer le biofilm sont les dommages irréversibles aux tissus durs (RITZ et coll. 1991, ZAPPA et coll. 1991, FLEMMIG et coll. 1998, KOCHER et coll. 2001) et les récessions gingivales (BADERSTEN

et coll. 1981, 1984b). La perte de tissu dur est une des causes principales de l'augmentation de la sensibilité de l'organe dentaire aux stimuli tactiles, thermiques et osmotiques après traitement (FISCHER et coll. 1991, KERNS et coll. 1991, FISCHER et coll. 1992, ORCHARDSON et coll. 1994, CHABANSKI & GILLAM 1997, CHABANSKI et coll. 1997, TAMMARO et coll. 2000, VON TROIL et coll. 2002). Ce phénomène concerne particulièrement les sites ne répondant pas localement ou présentant une maladie récurrente étant donné leurs traitements répétés.

De nombreux facteurs ont été associés à l'échec des traitements mécaniques parodontaux. La présence de concavités radiculaires et d'atteintes de furcations est associée à une fréquence plus faible de gain d'attache (BADERSTEN et coll. 1985, 1987). L'ablation du tartre est également moins efficace dans les poches profondes (WAERHAUG 1978, RABBANI et coll. 1981, CAFFESSE et coll. 1986).

À cause de ces limitations, l'approche conventionnelle de la thérapie parodontale inclut généralement une deuxième phase de traitement chirurgicale des sites n'ayant pas répondu suffisamment bien au traitement initial. Cette phase, donnant un accès visuel direct aux surfaces radiculaires affectées, permet une ablation plus efficace du tartre sous-gingival dans les poches profondes (CAFFESSE et coll. 1986, BUCHANAN & ROBERTSON 1987, BRAYER et coll. 1989), et une meilleure guérison de ces sites (LINDHE et coll. 1982, PIHLSTROM et coll. 1983, LINDHE et coll. 1984, PIHLSTROM et coll. 1984, SERINO et coll. 2001).

En pratique, une élimination complète des poches parodontales, correspondant à une profondeur de sondage n'excédant pas 3 mm, ne peut être accomplie dans tous les sites. En effet, les sites présentant une perte d'attache importante ne peuvent être amenés à ces valeurs sans un sacrifice majeur de tissus parodontaux et d'os. Les poches résiduelles sont donc inévitables et il est clairement établi qu'un maintien professionnel régulier est crucial pour le

succès à long terme du traitement parodontal (ROSLING et coll. 1976b, NYMAN et coll. 1977, AXELSSON & LINDHE 1981, LINDHE & NYMAN 1984, WOOD et coll. 1989, KOCHER et coll. 2000, TUNKEL et coll. 2002, VAN DER WEIJDEN & TIMMERMAN 2002, AXELSSON et coll. 2004, CORTELLINI & TONETTI 2004).

L'élimination de la plaque nouvellement formée dans les poches résiduelles est une partie importante de la phase de maintien. Ces procédures étant répétées de nombreuses fois, il est important qu'elles soient efficaces tout en minimisant les effets secondaires irréversibles sur les tissus dentaires et gingivaux. L'attention des chercheurs s'est donc portée sur les aéro-polisseurs. En effet, cette technologie pourrait permettre une ablation de la plaque sous-gingivale moins désagréable pour le patient et avec moins de traumatismes tissulaires.

b. Objectifs

Les objectifs spécifiques de l'étude clinique randomisée citée dans ce travail étaient d'évaluer la sécurité d'utilisation, l'acceptation par les patients et les effets microbiologiques à court terme d'un nouvel appareil d'aéro-polissage chez des sujets en phase de maintien parodontal. Ces derniers devaient présenter des poches résiduelles de plus de 5 mm dans deux quadrants différents permettant de comparer le nouveau traitement sous-gingival au traitement conventionnel à l'aide de curettes.

c. Méthode en usage

1. fonctionnement

Les méthodes de traitement de surface utilisant l'air associé à de fines particules peuvent être divisées en deux catégories selon leur degré d'abrasivité: l'abrasion par air et l'aéro-polissage. Tous deux utilisent le principe de l'énergie cinétique qui permet d'introduire une poudre

abrasive dans un flux d'air comprimé afin de nettoyer ou de polir une surface en enlevant les dépôts qui y sont attachés ou en lissant sa texture.

L'abrasion par air a été introduite dans les années 40 (BLACK 1945). À l'époque cette technique était utilisée pour préparer des cavités. Les particules, composées d'oxyde d'aluminium, avaient un diamètre de 30 μm et étaient introduites dans un flux de dioxyde de carbone à une pression de 5,6 bar. Les avantages annoncés à l'époque étaient l'absence de vibrations et d'augmentation de température rendant le traitement plus agréable pour le patient. Cette technologie a donc connu une brève popularité comme alternative aux pièces à main de faible vitesse entraînées par courroie. Cependant, l'apparition des turbines entraînées par air vers la fin des années 50 a rapidement supplanté cette nouvelle technique. De nos jours, l'abrasion par air a refait son apparition en médecine dentaire restauratrice pour la préparation de cavités (GOLDSTEIN & PARKINS 1995, HAMILTON et coll. 2001) et la réalisation de restaurations adhésives. Les développements successifs ont ensuite permis de la rendre moins abrasive; l'aéro-polissage était né.

L'aéro-polissage a alors été proposé pour le nettoyage dentaire professionnel (WILLMANN et coll. 1980, KOZLOVSKY et coll. 1989). Contrairement à l'abrasion par air, ce dernier utilise un jet d'eau en plus du mélange air-poudre (MOMBER & KOVACEVIC 1998) qui est ensuite dirigé vers la surface à nettoyer avec une pression d'air de 4-8 bar (400-800 MPa) et une pression d'eau de 1-5 bar (100-500 MPa). Le bicarbonate de sodium ($NaHCO_3$) avec une taille de particule d'environ 200 μm est le composé principal de la poudre abrasive.

Sur l'émail, l'ablation de plaque peut être accomplie facilement et de manière efficace avec les aéro-polisseurs (WEAKS et coll. 1984, HORNING et coll. 1987, BARNES et coll. 1990, KONTTURI-NARHI et coll. 1990, JOST-BRINKMANN 1998, RAMAGLIA et coll. 1999) sans pour autant créer, cliniquement, d'altérations de surfaces ou de pertes de substance significatives (GALLOWAY & PASHLEY 1987, MAHLENDORFF 1989, KONTTURI-

NARHI et coll. 1990). L'étude in vitro de Galloway (GALLOWAY & PASHLEY 1987), portant sur 36 dents extraites, a confirmé que l'utilisation d'aéro-polisseurs avec du $NaHCO_3$ sur une durée continue de 60 s sur l'émail ne provoquait pas de pertes de substance.

2. effets secondaires

L'aéro-polissage utilisant du $NaHCO_3$ peut provoquer des pertes de substance significatives quand le spray est dirigé vers des surfaces radiculaires dénudées ou de la dentine. Plusieurs études in vitro l'ont démontré en quantifiant la perte de substance au niveau des racines après l'application de bicarbonate de sodium par des aéro-polisseurs. Selon l'étude de Petersilka (PETERSILKA et coll. 2003a), la durée et la distance d'application influençaient de manière significative la profondeur des défauts créés. En effet ils atteignaient jusqu'à 473,5 µm après une application de 20 s à une distance de 2 mm. De même, des pertes de substance de plus de 630 µm étaient induites par l'aéro-polissage après 30 s d'utilisation (ATKINSON et coll. 1984). D'autres études (BERKSTEIN et coll. 1987, GALLOWAY & PASHLEY 1987, AGGER et coll. 2001) ont confirmé que cette forme de traitement ne peut être appliquée sans danger à la dentine et au cément. Les retraits gingivaux étant très fréquemment rencontrés chez les patients souffrant de parodontite (ALBANDAR & KINGMAN 1999, KALSBEEK et coll. 2000, THOMSON et coll. 2000), l'intérêt pour le maintien parodontal est donc non négligeable. De plus l'application de l'aéro-polissage aux surfaces radiculaires dénudées peut difficilement être évitée lors de son utilisation supra-gingivale.

Les effets sur les tissus gingivaux, quant à eux, ont été observés dans plusieurs études basées sur la clinique (WEAKS et coll. 1984, MISHKIN et coll. 1986), sur des examens au microscope à balayage (KONTTURI-NARHI et coll. 1989) et sur des analyses histomorphométriques (KOZLOVSKY et coll. 2005). En effet, bien que l'aéro-polissage soit destiné à une utilisation sur les surfaces dentaires, son spray est très proche de la marge gingivale. Des études ont montré que cette thérapie induisait des traumatismes et des

irritations gingivales localisées guérissant 6 à 7 jours plus tard (WEAKS et coll. 1984, MISHKIN et coll. 1986). Ces lésions, également observées au microscope à balayage, présentaient une corrélation positive avec la présence d'inflammation gingivale avant instrumentation (KONTTURI-NARHI et coll. 1989). Par la suite, des examens histologiques chez le chien ont révélé la présence d'érosions des couches cellulaires kératinisées et épithéliales au niveau de la gencive saine (KOZLOVSKY et coll. 2005). L'aéro-polissage dirigé contre la gencive à une distance de 5 mm durant moins de 5 s causait une érosion significative de la couche kératinisée (46-77%) avec extension minimale à la couche épithéliale (25-26%). Une exposition prolongée (10 à 20 s) augmentait l'érosion de la couche épithéliale entre 33 et 61%. De plus, on pouvait même constater après 20 s des zones de perte totale de l'épithélium avec exposition du tissu conjonctif sous-jacent.

L'utilisation d'air sous pression dans les procédures dentaires comporte également le risque de provoquer des emphysèmes. En effet, des cas ont été décrits après utilisation de pièces à main dentaires à haute vitesse, de seringues air-eau et même après prises d'empreintes (PYNN et coll. 1992, HEYMAN & BABAYOF 1995, KARRAS & SEXTON 1996, SEKINE et coll. 2000, AQUILINA & MCKELLAR 2004). Généralement cette condition pathologique se résout rapidement sans traitement et disparaît complètement après quelques jours (ARAGON et coll. 1986, KARRAS & SEXTON 1996). L'utilisation d'aéro-polisseurs en médecine dentaire n'échappe pas à ce risque. Des emphysèmes ont notamment été décrits après aéro-polissage supra-gingival avec du $NaHCO_3$ (FINLAYSON & STEVENS 1988, LIEBENBERG & CRAWFORD 1997, JOSEPHSON et coll. 2001). En se basant sur la littérature disponible, Heyman et Babayof (HEYMAN & BABAYOF 1995) ont conclu que 9% des cas d'emphysèmes étaient associés à cette technique.

Il semble donc que les aéro-polisseurs conventionnels utilisant du $NaHCO_3$ comme poudre abrasive, bien que montrant un potentiel non négligeable pour le nettoyage des surfaces

radiculaires, ne soient pas adaptés à l'utilisation sous-gingivale. Leur trop grande abrasivité au niveau de la dentine et du cément ainsi que le risque de lésions des tissus mous et d'emphysèmes en sont les principales raisons.

3. utilisation de la poudre de glycine

Les interactions entre particules solides sont responsables de l'érosion produite par les aéro-polisseurs (MOMBER & KOVACEVIC 1998). L'abrasion de la surface radiculaire par le mélange air-poudre-eau est induite par une combinaison d'éclats, de coupes et de fractures de fatigue au niveau du cément et de la dentine (MENG & LUDEMA 1995). Ce processus érosif est fortement influencé par les caractéristiques géométriques et de dureté des particules projetées (BAHADUR & BADRUDDIN 1990, MOMBER & KOVACEVIC 1998). Il semblait donc possible de rendre l'aéro-polissage sans danger pour la dentine et le cément tout en conservant son efficacité en changeant les propriétés mécaniques de la poudre utilisée.

En 2003, Petersilka (PETERSILKA et coll. 2003b) a réalisé une étude in vitro en testant 4 nouvelles poudres abrasives et en les comparant à la poudre traditionnelle de bicarbonate de sodium. Une des poudres s'est avéré réduire l'abrasion sur les surfaces radiculaires d'environ 80%. De plus, elle était transportée de manière efficace par l'aéro-polisseur (EMS Air Flow S1®, EMS Electro Medical System S.A., Nyon, Suisse) et permettait, après 5 s d'application, une ablation complète de la plaque sur les surfaces radiculaires des dents fraîchement extraites. Cette nouvelle poudre (Clinpro Prophypowder®, 3M ESPE, Seefeld, Allemagne), composée à plus de 99% de glycine, est non toxique, soluble dans l'eau et a une taille de particules inférieure à 63 µm (taille moyenne 20 µm) qui contraste avec les 200 µm de celles du bicarbonate de sodium.

Une étude réalisée sur de la dentine bovine (PETERSILKA et coll. 2007) a démontré que l'utilisation de la poudre de glycine ne causait qu'une abrasion minime de ce tissu dentaire et

qu'elle pouvait donc être utilisée sans danger. Ces données ont confirmé les résultats précédemment obtenus par les mêmes auteurs (PETERSILKA et coll. 2003b).

L'utilisation de $NaHCO_3$ pour l'aéro-polissage sous-gingival causant des érosions sévères de l'épithélium avec exposition du tissu conjonctif sous-jacent (WEAKS et coll. 1984, KONTTURI-NARHI et coll. 1989, KOZLOVSKY et coll. 2005), Petersilka (PETERSILKA et coll. 2008) étudia les effets de la poudre de glycine sur la gencive. Il fallait en effet prouver que le mélange air-poudre-eau, lorsqu'il était projeté dans le sulcus, ne présentait pas de danger pour les tissus gingivaux. Les effets sur la gencive de la glycine, du $NaHCO_3$ ainsi que des curettes ont donc été comparés chez 10 patients. Les résultats cliniques et histologiques ont permis de constater que l'aéro-polissage appliqué pendant 5 s avec la nouvelle poudre maintenait la barrière épithéliale intacte, alors que le $NaHCO_3$ ainsi que les curettes provoquaient des dégâts importants à la gencive. Ces résultats corroborent l'absence de dommages aux tissus mous décrite dans d'autres études cliniques (PETERSILKA et coll. 2003c, PETERSILKA et coll. 2003d, FLEMMIG et coll. 2007) et confirment la sécurité d'utilisation de la poudre de glycine dans le traitement parodontal.

De même, les cas d'emphysèmes décrits lors de l'utilisation du $NaHCO_3$ ne sont pas survenus dans les études cliniques réalisées avec de la poudre de glycine lorsque le flux est directement orienté dans la poche parodontale (PETERSILKA et coll. 2003c, PETERSILKA et coll. 2003d, FLEMMIG et coll. 2007).

4. effets immunologiques de la glycine

La glycine, qui est un acide aminé non essentiel, peut être produite par les micro-organismes parodontaux (CHU et coll. 2002). Elle a ainsi pu être détectée dans le fluide gingival (WADDINGTON et coll. 1998) et la salive (SYRJANEN et coll. 1987) de patients atteints de parodontite avancée non traitée. Elle interagit avec les fonctions immunologiques systémiques et locales par différents mécanismes. Il a été démontré que la glycine est capable d'augmenter

la capacité des monocytes à présenter les antigènes et à phagocyter, de diminuer la synthèse de TNF-α et d'augmenter la production de IL-10 par les monocytes activés par les LPS (SPITTLER et coll. 1999). Dans les fibroblastes gingivaux humains, la glycine augmente la production de PGE_2 induite par IL-1β (RAUSCH-FAN et coll. 2005). Cet effet est dû à l'augmentation des niveaux d'enzyme COX-2. La glycine jouerait donc un rôle important dans le processus inflammatoire en modulant la production de médiateurs de l'inflammation dans le système parodontal local.

Cependant, les études cliniques randomisées n'ont pas réussi à montrer de différences dans la guérison gingivale à court terme après instrumentation avec des curettes ou traitement avec les aéro-polisseurs et la poudre de glycine (PETERSILKA et coll. 2003c, PETERSILKA et coll. 2003d). La glycine seule n'induirait donc pas de réponse inflammatoire et n'interférerait pas de manière cliniquement significative avec la guérison parodontale.

d. Justification d'une nouvelle étude

Pour étendre l'utilisation de l'aéro-polissage aux poches parodontales profondes, le système originalement développé pour le nettoyage supra-gingival a été modifié techniquement en vue de son usage sous-gingival. Dessinée par EMS (EMS Electro Medical System S.A., Nyon Suisse), la nouvelle busette, composée d'un matériau moins dur que la surface radiculaire et ayant une extrémité arrondie, permet un accès à la zone sous-gingivale sans risque pour la dentine et le cément. Elle se présente sous la forme d'un long tube fin percé de 3 trous permettant son insertion dans le sulcus et la sortie horizontale du mélange air-poudre. L'eau, quant à elle, sort à l'extrémité de l'embout permettant de rincer la poche et d'évacuer la poudre de glycine soluble dans l'eau. Outre l'accessibilité accrue aux poches parodontales, la nouvelle busette permet d'induire une diminution de pression d'environ 1 bar réduisant encore le risque de dommages aux tissus gingivaux. Afin de pouvoir confirmer les avantages annoncés de ce

nouvel appareil, une étude clinique le comparant au traitement conventionnel devait donc être réalisée.

e. Résumé

Le but de ce travail était d'évaluer la sécurité d'utilisation, l'acceptation par le patient et les effets microbiologiques à court terme d'un nouvel appareil d'aéro-polissage sous-gingival.

Ce fut une étude clinique randomisée en aveugle par segment de bouche sur 50 sujets présentant des poches résiduelles de plus de 5 mm en phase de maintien. Une nouvelle busette, permettant l'application de poudre de glycine à une pression limitée dans la zone sous-gingivale, fut comparée aux surfaçages réalisés à l'aide de curettes. Après ablation des dépôts supra-gingivaux, le spray de l'aéro-polisseur était appliqué durant 4 à 5 secondes dans tous les sites de plus de 5 mm du quadrant test, tandis que les curettes étaient utilisées dans le quadrant contrôle. Des échantillons microbiologiques furent prélevés pour chacune des deux thérapies 2 jours avant et 7 jours après traitement. La charge bactérienne totale ainsi que la quantité de six pathogènes parodontaux furent déterminés par réaction de polymérisation en chaîne en temps réel.

Aucun effet indésirable ne fut noté chez les sujets, que ce soit pour le traitement test ou contrôle. À l'aide d'une échelle visuelle analogique, le traitement test fut perçu par les patients comme étant significativement plus agréable que l'instrumentation manuelle. Un gain de temps significatif fut également souligné par l'opérateur pour la procédure test. La réduction du saignement au sondage était significative pour les deux traitements, mais le surfaçage avec des curettes permettait une diminution significativement plus importante. Les différences dans la charge bactérienne totale et la quantité de six pathogènes parodontaux entre les sites test et contrôle ne réussirent pas à atteindre une signification statistique. Seules les réductions longitudinales dans les sites contrôle pour la charge bactérienne totale,

Porphyromonas gingivalis, *Treponema denticola* et *Tannerella forsythia* étaient significatives.

Conclusions : l'aéro-polissage sous-gingival avec la nouvelle busette est sans danger, perçu comme étant plus acceptable par les patients et permet un gain de temps de traitement lorsqu'il est comparé aux surfaçages. Cependant, sur le plan microbiologique, il n'est pas supérieur à la thérapie conventionnelle (MOËNE et coll. 2010).

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B. Publication originale

MOËNE R, DÉCAILLET F, ANDERSEN E, MOMBELLI A: Subgingival plaque removal using a new air-polishing device. J Periodontol 81**:** 79-88 (2010)

Subgingival Plaque Removal Using a New Air-Polishing Device

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Background: The purpose of this study is to evaluate the safety, patient acceptance, and short-term microbiologic effect of a new air-polishing device in subjects in maintenance care with residual pockets ≥5 mm.

Methods: This was an examiner-masked, randomized, split-mouth clinical trial. A new disposable nozzle, allowing the subgingival application of amino acid glycine powder at a limited pressure, was compared to scaling and root planing (SRP) in 50 subjects with residual pockets during the maintenance phase. After removing supragingival deposits, the spray was applied for 4 to 5 seconds in all sites ≥5 mm in the test quadrant, whereas SRP was used in the control quadrant. Microbiologic samples were taken from one treated test and one control site 2 days before and 7 days after treatment. Total bacterial counts and the counts of six periodontal pathogens were determined by real-time polymerase chain reaction.

Results: No adverse event was noted in any subject for the test or control treatment. Using a visual analog scale, the patients perceived the test treatment to be significantly less painful/uncomfortable than the hand instrumentation (P <0.001). Significantly less time was used by the operator for the test procedure (P <0.001). The reduction in bleeding on probing was significant for the treated sites in the test and control quadrants (P = 0.019 and P <0.001, respectively), but traditional SRP reduced the bleeding tendency significantly more than air polishing (P = 0.045). The differences in the total bacterial load and the counts of six periodontal pathogens between the test and control sites did not reach statistical significance. The longitudinal reduction was significant in control sites for total bacteria load (P<0.001), *Porphyromonas gingivalis* (P = 0.01), *Treponema denticola* (P <0.001), and *Tannerella forsythia* (previously *T. forsythensis*) (P<0.001).

Conclusion: Subgingival air polishing with a new device was safe (no adverse events were noted), perceived to be more acceptable by the patients, and was more time-efficient than SRP; however, on a microbiologic level, it was not superior to conventional SRP. *J Periodontol 2010;81:79-88.*

KEY WORDS

Air abrasion, dental; dental plaque; randomized controlled trial; root planing; visual analog scale.

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Accumulation of bacteria on tooth surfaces is the primary cause of gingivitis and periodontitis. Thus, regular mechanical removal of bacterial plaque from all non-shedding oral surfaces is considered the primary means to prevent and stop the progression of periodontal disease. Longitudinal studies have shown the efficacy of the standard treatment approach, consisting of the combination of systematic scaling and planing of the root surfaces,[1-5] the patient's daily meticulous oral hygiene,[6-9] and regular maintenance visits to remove newly formed subgingival deposits.[10,11] In most cases, periodontal disease can be treated successfully in this way, and results can be maintained over prolonged periods of time.[12]

The main adverse effects of the mechanical approach to biofilm removal are irreversible hard tissue damage[13-16] and gingival recession,[3,5] ensuing from the mechanical scraping of tooth surfaces. Hard tissue loss is one of the major causes of increased sensitivity of treated teeth to evaporative, tactile, thermal, and osmotic stimuli.[17-24] Because these procedures may be repeated many times during maintenance, it is important that they are efficient but have minimal side effects.

The air-abrasive technology uses an abrasive powder introduced into a stream of compressed air to clean or polish a surface by removing deposits attached to it or smoothing its texture. Plaque removal from enamel may be

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accomplished conveniently and effectively with air-polishing devices.[25-28] However, air polishing using a slurry of water, sodium bicarbonate ($NaHCO_3$), and pressurized air is highly abrasive to root cementum or dentin.[29-31] To reduce the abrasiveness and render this approach potentially suitable for the removal of biofilm on root surfaces, it was suggested to replace sodium bicarbonate with a powder of the amino acid glycine.[32,33] A randomized, controlled clinical trial[34,35] demonstrated that subgingival debridement of pockets 3 to 5 mm in depth reduced viable counts of the subgingival microbiota immediately after therapy significantly more than hand instrumentation. Another recently published clinical trial[36] showed that air polishing may be as effective in subgingival biofilm removal as hand curets or ultrasonic scalers in periodontal pockets with probing depths (PDs) up to ~4 mm. No study has evaluated the efficacy of an air-polishing device in pockets >5 mm.

Using pressurized air in dental procedures carries the risk for provoking emphysema. Cases of emphysema were reported after the use of high-speed dental handpieces and air-water syringes and even after taking impressions.[37-41] The condition usually resolves rapidly without treatment and disappears completely within a few days.[38,42] Cleaning procedures with air-polishing devices have also been associated with emphysema.[43,44] However, no case of emphysema has been reported after subgingival air polishing in shallow pockets with glycine powder,[34-36] suggesting that this protocol allows gentle cleaning of the sulcular area with no major disruption of the gingival tissues.

To extend the use of air polishing to deep pockets, a system originally developed for supragingival cleaning was technically modified in view of its subgingival use. By using the newly designed nozzle, the jet spray has a lower flow and pressure than used for supragingival cleaning. This article reports the first usage of the modified method, focusing on safety and patient acceptance.

The specific aim of this study is to evaluate the safety of the new device, patient acceptance, and the short-term microbiologic effect of this newly developed system in subjects in maintenance care with residual pockets ≥5 mm.

MATERIALS AND METHODS

This was a 7-day, single-center, examiner-masked, randomized, split-mouth two-arm parallel-design clinical trial. The protocol was approved by the Ethical Committee of the University Hospitals of Geneva. Research was conducted according to the principles outlined in the Declaration of Helsinki on experimentation involving human subjects.

Subjects

Fifty systemically healthy subjects were recruited between December 2007 and June 2008 from patients previously treated for periodontal disease at the School of Dental Medicine, University of Geneva. The subjects were included based on the following criteria: in maintenance for 3 to 24 months after completion of comprehensive periodontal therapy, aged 18 to 70 years, and the presence of at least one residual periodontal pocket with PD ≥5 mm in two separate quadrants in the area between the distal aspect of the first incisor and the mesial aspect of the second molar, with no obvious signs of persisting massive subgingival calculus deposits.

Exclusion criteria included chronic bronchitis, asthma, major systemic illnesses (i.e., diabetes mellitus, cancer, human immunodeficiency virus, bone metabolic diseases, disorders that compromise wound healing, radiation, or immunosuppressive therapy), antibiotics, anti-inflammatory drugs or other medication taken within the previous 28 days that may affect the outcome of the study, confirmed or suspected intolerance to the test product (amino acid glycine), and any physical limitations or restrictions that might preclude normal oral hygiene procedures. The smoking history was recorded, but smoking was not an exclusion criterion.

Written informed consent was obtained from all subjects entered in the study. Each accepted participant was given a patient number in ascending order.

Test Products and Randomization

To make the principle of air abrasion suitable for the cleaning and polishing of subgingival root surfaces without inducing substantial tissue damage, an air-polishing system originally developed for supragingival cleaning was modified by changing the abrasive agent and the physical conditions of application. A powder of the amino acid glycine,† a non-toxic, soluble material with a mean grain size of 20 μm replaced sodium bicarbonate, and a special nozzle was designed to allow access to the subgingival area (Fig. 1). A long, thin tube was fitted with three holes perpendicularly oriented to the long axis at 0°, 120°, and 240°, allowing the air-powder mixture to exit horizontally. The nozzle was attached to an air-polishing handpiece.‡ The nozzle design induced a pressure drop in the jet spray of up to 1 bar, reducing the effective working pressure. The recommended instrumentation time was limited to 5 seconds.

The test procedure consisted of subgingival treatment accomplished by inserting the tip into the pocket and applying the spray for 5 seconds (Fig. 2). The

† AIR-FLOW Powder PERIO, EMS Electro Medical Systems, Nyon, Switzerland.
‡ PERIO-FLOW handpiece for AIR-FLOW Master, EMS Electro Medical Systems.

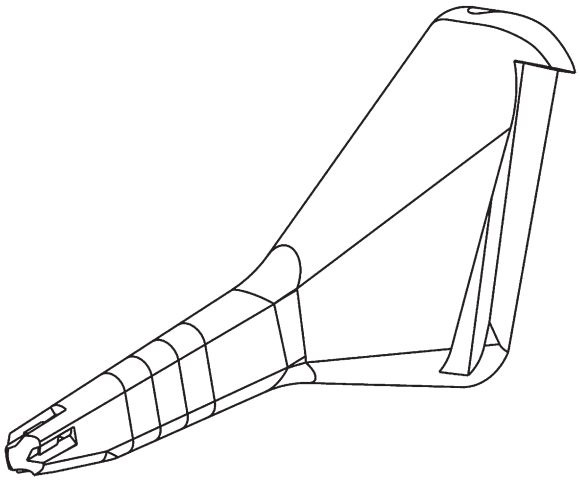

Figure 1.
New nozzle design allowing access to the subgingival root surfaces.

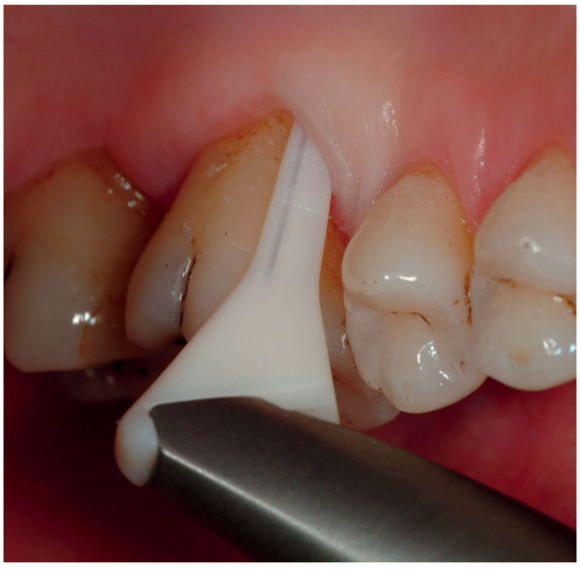

Figure 2.
Clinical application of the device in a periodontal pocket.

control procedure was deep scaling and root planing (SRP) with Gracey curets, without local anesthesia, for no longer than 5 minutes per site. Subjects were randomly assigned to receive the test treatment in one quadrant and the control treatment in another quadrant. Once the subject was ready for subgingival debridement, an envelope with the subject's number was opened to reveal the treatment assignment for the two study quadrants and the sequence of treatment.

Clinical Protocol

Two independent clinicians (RM and FD) performed all procedures involving contact with the subjects. The examiner (RM) enrolled the patients and recorded all parameters. The operator (FD) instructed the participants in proper oral hygiene, removed any hard or soft supragingival deposits, and performed the subgingival treatments. The operator was not involved in any evaluations before or after treatment. With the exception of the periodontal pocket chart, necessary to deliver the treatment, he was unaware of previously recorded data.

The chronologic sequence of the trial was as follows: at the enrollment visit, the examiner recorded the medical history and obtained informed consent. Two study quadrants were chosen based on the availability of at least one residual periodontal pocket with PD ≥5 mm in the area between the distal aspect of the first incisor and the mesial aspect of the second molar. One site with PD ≥5 mm was selected in each of the two quadrants for microbiologic testing.

Two days before the subgingival treatment (day –2), the examiner collected a subgingival plaque sample in the two study sites with one sterile paper point inserted to the bottom of the pocket and left in situ for 10 seconds. The following clinical parameters were recorded at six sites of each tooth, except third molars, in the two study quadrants: plaque index (PI),[45] PD, bleeding on probing (BOP), and recession (REC; positive if the gingival margin was located apical to the cemento-enamel junction, negative if it was located coronal to the cemento-enamel junction). In addition, oral tissue safety was evaluated using a checklist. This examination included a visual inspection for changes in color and texture, signs of abrasion, or any other irregularity of the lips, tongue, gingivae, sublingual area, cheeks, mucobuccal folds, hard and soft palate, pharyngeal area, and cervical area of all teeth.

On the day of subgingival treatment, the operator removed supragingival hard and soft deposits (calculus, stain, and plaque) in the entire dentition and instructed the subjects in proper oral hygiene for 5 to 10 minutes (review of toothbrushing and interdental cleaning). Next, the randomization envelope for the subject number was opened to reveal the treatment assignment. All pockets ≥5 mm in the test quadrant were treated with the air-polishing device, whereas in the control quadrant they were treated by SRP. The operator noted the time spent for the subgingival debridement in the test and control quadrants. The subjects were asked to rate the pain/discomfort felt after each treatment using a visual analog scale (VAS) and were asked for any comment they had about the treatment.

The subjects were recalled after 7 days. The examiner collected a subgingival plaque sample in the two study sites, recorded PI and BOP, and evaluated oral tissue safety. The medical history, any concomitant medication, and all adverse events were recorded.

Microbiologic Procedures

Samples were analyzed for the detection and quantification of *Aggregatibacter actinomycetemcomitans* (previously *Actinobacillus actinomycetemcomitans*; *Aa*), *Fusobacterium nucleatum* spp. (*Fn*), *Porphyromonas gingivalis* (*Pg*), *Prevotella intermedia* (*Pi*), *Treponema denticola* (*Td*), and *Tannerella forsythia* (previously *T. forsythensis*; *Tf*), as well as total bacterial load (TBL), using a commercially available real-time polymerase chain reaction-based method.§ The highly automated analysis (barcode-labeled sample tubes and pipetting robot) was performed in a specialized laboratory.‖ Primers and probes were designed to match specifically to the ribosomal DNA of the six bacterial pathogens. The detection limit for each of the six pathogens was 100 bacteria per sample. The details of the method were described elsewhere.[46-48]

Statistical Analysis

Data were entered into a database and were checked for entry errors by two persons. Average scores were generated for each subject for the test and the control quadrant by summing the scores and dividing by the number of sites graded in that segment. The mean PI, PD, and REC was calculated for all sites at baseline. In addition, an average score of all treated sites was generated for PD and BOP.

The primary outcome measures of the study were oral tissue safety and pain/discomfort, rated by the patient on a VAS from 0 to 10. Secondary outcomes included differences between the groups for changes in BOP and seven microbial parameters (*Aa*, *Fn*, *Pg*, *Pi*, *Td*, *Tf*, and TBL) in subgingival plaque samples.

To verify baseline comparability of the two treatment quadrants, statistical comparisons between the quadrants were made for each efficacy variable using the Mann-Whitney U test. The differences for each quadrant before and after treatment were determined using the Wilcoxon signed-ranks test. Differences in the perception of pain/discomfort and the time needed for treatment were tested using the Mann-Whitney U test. Univariate linear regression was used to study the relationship between pain/discomfort (dependent variable) and time of treatment, number of sites treated, treatment method, and gender (predictor variables). Backward stepwise logistic regression was used to study the relationship between the detection or non-detection of *Aa*, *Fn*, *Pg*, *Pi*, *Td*, and *Tf* after treatment (dependent variable) and their respective detection or non-detection at baseline, the group affiliation (test/control), and initial PD (predictor variables).

Adverse events were summarized by treatment group.

One statistical program package¶ was used for all statistical analyses. P values <0.05 were accepted for statistical significance.

RESULTS

Table 1 displays the baseline characteristics of the 50 participants.

A total of 3,414 sites (six per tooth) were monitored clinically. There were no significant differences between the test and control quadrants for any of the clinical variables. The treated sites in the test and control groups had a mean PD of 5.4 and 5.5 mm (range, 5 to 9 mm) and mean BOP of 73% and 68%, respectively.

All 50 patients finished the study. No adverse event was noted by any subject during the study. The evaluation of pain or discomfort on a VAS from 0 to 10 immediately upon completion of treatment revealed that the patients perceived the treatment with air polishing to be significantly more comfortable than the instrumentation with curets (VAS 0.9 versus 2.2; P<0.001; Fig. 3). The most frequent comment made by the subjects upon questioning after treatment was that they felt sensitivity to cold during air polishing (Table 2). As expected, the mean time needed by the operator to treat one site was significantly shorter with the air-polishing device than with the curets (0.5 minutes/site versus 1.4 minutes/site; P <0.001; Fig. 4). Figure 5 shows the relationship between the treatment time per site and pain or discomfort in the test and control quadrants. Univariate linear regression analysis indicated that pain/discomfort, rated on a VAS, was significantly related to the treatment method (P <0.0001) but not to gender, treatment time, or the number of sites treated.

Both treatment methods significantly reduced BOP at the treated sites (Table 3). The differences between the test and control treatments were not significant for the whole quadrant; when considering the treated sites only, the percentage of bleeding sites was significantly lower 7 days after hand instrumentation (P = 0.045).

Table 4 shows the frequency of six microorganisms and their mean counts in positive samples before and after treatment. Differences in the frequencies of the six monitored microbiologic parameters in samples from test and control sites were not significant at baseline or at day 7. A significant reduction in counts was noted for the samples positive for *Pg*, *Td*, and *Tf* in the control quadrants (Table 4). In addition, a significant reduction in total bacterial counts was observed in the control sites (P <0.001). In the test quadrants, the reduction did not reach a level of significance.

Table 5 shows, for each of the six tested microorganisms, the number of positive sites before treatment and the number of these sites still positive

§ Meridol, Perio Diagnostics, GABA International, Therwil, Switzerland.
‖ Carpegen, Münster, Germany.
¶ SPSS 16 for Mac OS X, SPSS, Chicago, IL.

Table 1.

Baseline Characteristics by Treatment Group (N = 50)

Parameter	Test Group	Control Group	*P* Value*
Age (years; mean ± SD)	54.9 ± 10.9		–
Females (n [%])	24 [48]		–
Smokers (n [%])	25 [50]		–
Teeth (N; mean ± SD)	5.6 ± 1.2	5.7 ± 1.3	NS
PI, whole quadrant (mean ± SD)	0.5 ± 0.3	0.5 ± 0.3	NS
PD, whole quadrant (mm; mean ± SD)	3.1 ± 0.4	3.1 ± 0.4	NS
REC, whole quadrant (mm; mean ± SD)	1.3 ± 0.9	1.4 ± 1.0	NS
BOP, whole quadrant (%; mean ± SD)	41 ± 13	45 ± 18	NS
Treated sites (n; mean ± SD)	4.1 ± 3.3	3.8 ± 3.5	NS
PD, treated sites (mm; mean ± SD)	5.4 ± 0.5	5.5 ± 0.5	NS
REC, treated sites (mm; mean ± SD)	1.3 ± 1.2	1.5 ± 1.3	NS
BOP, treated sites (%; mean ± SD)	73 ± 29	68 ± 39	NS

NS = not statistically significant.
* Difference between groups.

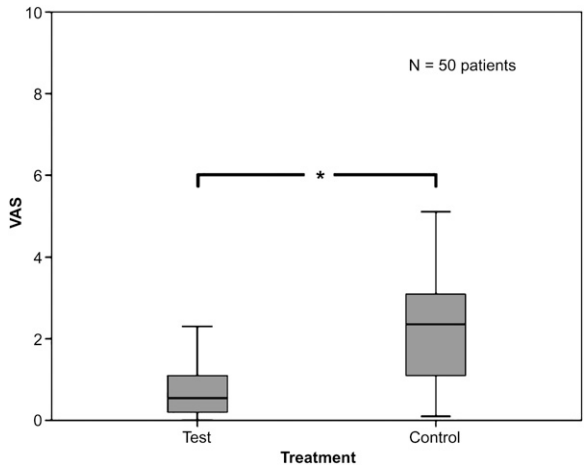

Figure 3.
*Evaluation of pain/discomfort after test and control treatments on a VAS from 0 to 10. *Significant difference (P <0.001).*

after treatment. The reduction in the number of sites positive for *Aa*, *Fn*, *Pg*, and *Pi* was similar for test and control sites. However, for *Td* and *Tf*, the reduction was more pronounced after conventional SRP than after subgingival air polishing. Backward stepwise logistic regression was used to study the relationship between the detection or non-detection of *Aa*, *Fn*, *Pg*, *Pi*, *Td*, and *Tf* after treatment (dependent variable) and their respective detection or non-detection at baseline and the group affiliation (test/control) and initial PD (predictor variables). For *Aa*, *Fn*, *Pi*, *Td*, and *Tf*, a positive test at baseline was the only variable with a positive value to predict whether a site would be positive at day 7 ($P<0.001$).

DISCUSSION

The primary purpose of this trial was to evaluate the safety of a new method for subgingival air polishing in deep pockets. To allow air polishing in deep pockets, several modifications were made to the traditional procedure. A new nozzle design allowed access to deep pockets, reduced the air pressure by ~1 bar, and deflected the air and powder spray horizontally. In addition, sodium bicarbonate was replaced by the amino acid glycine, a non-toxic, soluble material with a mean grain size of 20 μm.

One concern was the risk for inducing emphysema. In the past, air emphysemas were noted in several studies[43,44,49] after supragingival air polishing with sodium bicarbonate powder. Emphysema did not occur in any of the 50 subjects treated in our study. The absence of emphysema is in accordance with other studies[34-36] using glycine powder. In these studies, subgingival air polishing was limited to shallow pockets, whereas in the present study pockets ≤9 mm were treated. Also, in these studies, the spray was directed to the base of the periodontal pocket, whereas with the nozzle tested in the present study, air and powder exited horizontally.

Previous studies[32,50] indicated a potential risk for soft tissue damage. The application of an air-abrasive jet with sodium bicarbonate powder on healthy dog gingiva induced erosive changes in the keratin and epithelial cell layer.[50] The extent of the damage was correlated positively with the time of exposure. Therefore, we carefully inspected the soft tissues after treatment for changes in color and texture, signs of abrasion, or any other irregularity using a checklist. No signs of soft tissue damage were observed. These findings are in line with Petersilka et al.,[32] who evaluated the safety and efficacy of air polishing with glycine powder at the histologic level in human biopsies. They concluded that air polishing with glycine powder resulted in significantly less tissue damage than polishing with bicarbonate powder. We noted no clinically visible changes in the hard

Table 2.

Comments About the Treatment

Comment*	Test Group (n [%])	Control Group (n [%])
No comment	23 (46)	33 (66)
Sensitivity to cold	7 (14)	–
Not comfortable	–	10 (20)
Comfortable	4 (8)	–
No pain	7 (14)	3 (6)
Slight tenderness	6 (12)	1 (2)
Gum tenderness	–	2 (4)
Uncomfortable noise	1 (2)	–
Disliked the cold water	1 (2)	–
Liked the rapidity of treatment	1 (2)	–
Time consuming	–	1 (2)

– = not mentioned.
* Recorded directly after the treatment.

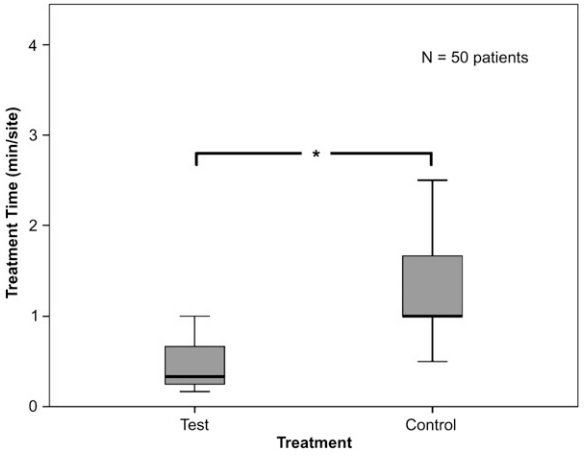

Figure 4.
*Mean time needed by the operator to treat one site with test or control treatment. *Significant difference (P <0.001).*

tissues, confirming previous reports[32-35] about the low abrasiveness of glycine powder.

With regard to patient acceptance, the treatment with air polishing was perceived to be significantly more comfortable than SRP with curets. This may be due to the minimal gingival irritation ensuing from this treatment. Our results are in agreement with a previous study,[34] in which the patients rated the mean comfort of subgingival air polishing in shallow pockets at 8.7, whereas they rated hand instrumentation at 4.6 on a VAS from 0 to 10. The comments made by the patients treated in our study also favor air polishing, because hand instrumentation was judged uncomfortable by 20% of the subjects. Only three subjects in the control group felt no pain compared to seven subjects in the test group.

Treatment with the new subgingival air-polishing device was three times faster than conventional SRP (0.5 versus 1.4 minute per site). Using a conventional air-polishing device, Petersilka et al.[34,35] showed that 5 seconds of air polishing per site was sufficient to remove subgingival biofilm. However, because of the low pressure and abrasiveness, subgingival air polishing may not be able to remove subgingival calculus. Because more aggressive instruments, such as curets or ultrasonic scalers, must be used to remove such deposits, initial periodontal therapy may not be the primary indication for subgingival air polishing. However, after the completion of comprehensive periodontal therapy, minimal amounts of residual calculus are normally present in periodontal pockets.[51-53] In one study,[36] only 4.7% of the subgingival root surfaces were still covered with hard deposits 3 months after SRP.

Time efficiency, high patient acceptance, and minimal tissue damage are essential requirements for treatments that need to be repeated many times. This applies to all procedures used in the context of long-term periodontal maintenance care and relates to

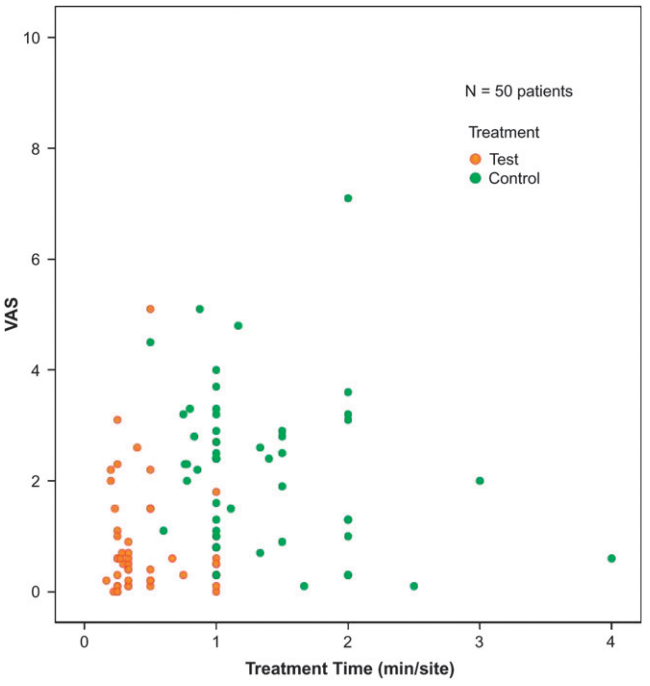

Figure 5.
Relationship between treatment time per site (minute/site) and pain/discomfort on a VAS (0 to 10).

Table 3.

Changes in BOP (percentage of positive sites) From Baseline to Day 7 (N = 50)

Area	Time	Test Group	Control Group	*P* Value*
Whole quadrant	Baseline (mean ± SD)	41 ± 13	45 ± 18	NS
	Day 7 (mean ± SD)	36 ± 46	34 ± 15	NS
	P value†	0.002	<0.001	
Treated sites	Baseline (mean ± SD)	73 ± 29	68 ± 39	NS
	Day 7 (mean ± SD)	58 ± 35	43 ± 35	0.045
	P value†	0.019	<0.001	

NS = not statistically significant.
* Difference between the groups.
† Difference between time points.

Table 4.

Frequency of Six Microorganisms and Their Mean Counts in Positive Samples Before and After Treatment (N = 50)

	Test Group				Control Group			
	Baseline		Day 7		Baseline		Day 7	
Bacteria	Frequency (%)	Count	Frequency (%)	Count	Frequency (%)	Count	Frequency (%)	Count
Aa	14	4,135	10	6,820	12	15,255	14	1,811
Fn	64	82,787	56	259,974	60	156,171	60	164,076
Pg	44	401,970	36	1,108,729	44	1,635,074	36	592,911*
Pi	32	221,557	28	217,687	24	118,758	20	16,672
Td	52	329,161	48	219,353	58	444,442	42	183,987†
Tf	60	275,317	56	337,922	68	391,808	52	129,154†

* *P* = 0.01, reduction between baseline and day 7.
† *P* = 0.001, reduction between baseline and day 7.

Table 5.

Number of Positive Sites Before Treatment, Number of Those Sites Still Positive After Treatment, and the Percentage Reduction in Positive Sites (N = 50)

	Test Group			Control Group		
Bacteria	Baseline (n)	Day 7 (n)	Reduction (%)	Baseline (n)	Day 7 (n)	Reduction (%)
Aa	7	4	43	6	4	33
Fn	32	28	13	30	27	10
Pg	22	18	18	22	18	18
Pi	16	13	19	12	9	25
Td	26	22	15	29	20	31
Tf	30	26	13	34	24	29

subgingival debridement in residual pockets specifically. Given the fact that an exposed root surface is more susceptible to tissue damage and pain and that subgingival bacterial deposits may not mineralize to form subgingival calculus between two maintenance visits, air polishing may be useful for periodontal patients with residual pockets in the maintenance phase, provided that mineralized deposits are not present.

In the present study, we also evaluated the short-term effects of treatment on BOP and microbiologic parameters. Conventional SRP and air polishing reduced BOP at the treated sites significantly, but hand instrumentation was slightly better. The clinical effects on periodontal parameters should be interpreted with caution, because the healing of periodontal tissues is known to require more than 1 week. Clinical performance compared to standard protocols remains to be demonstrated in long-term studies.

The microbiologic results obtained in this study did not demonstrate any dramatic decrease in total counts or the frequencies and counts of six periodontal marker organisms after 7 days for subgingival air polishing or conventional SRP. In comparing these results with other trials, one needs to differentiate studies in which microbiologic samples are taken immediately before and after the intervention from studies evaluating the effects after several days (as in the present study) or several months. In addition, studies reporting results after initial treatment need to be separated from studies reporting results of treatments of residual pockets. In general, articles[54,55] reporting results immediately before and after treatment showed significant reductions of total counts after mechanical debridement. The same holds true for subgingival air polishing in shallow pockets.[34,35] However, studies[56,57] reporting data 4 to 8 days after mechanical treatment showed no difference compared to baseline values. Goodson et al.[58] showed a very low and non-significant reduction in the total counts and counts of spirochetes, motile rods, and non-motile rods 1 month after SRP. In contrast, longer-term studies[59,60] showed significantly reduced bacterial loads 2 to 4 months after mechanical therapy. Other studies[2,61-64] also showed significant reductions in periodontal marker organisms, such as *Pg*, *Tf*, *Pi*, and *Td*. *Aa* is not affected significantly by hand instrumentation alone, as demonstrated by several studies.[60,65-67] Long-term microbiologic results for subgingival air polishing are lacking, and it would be of great interest to compare this new treatment to conventional SRP.

CONCLUSIONS

Subgingival air polishing with a new device was safe, because no adverse events were noted in any of the 50 patients, and it was perceived as being more acceptable and more time-efficient than SRP; however, on a microbiologic level, it was not superior to conventional SRP.

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