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A Case-Study of Seven Dental Implants Placed in the Maxillary Sinus with Intentional Schneiderian Membrane Perforation

Dr. Ioannis P. Georgakopoulos1 • Dr. Spyros N. Gialidis2 • Dr. Stavros Tsantis3
Dr. Panagiotis Georgakopoulos4 • Dr. Paraskevi V. Itziou2
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Abstract

Background: A growing number of edentulous patients are receiving treatment with dental implants. In cases of vertical alveolar ridge deficiencies of the posterior areas of the maxilla, the prevailing method of treatment is increasingly the sinus floor elevation procedure.

Method: A new and innovative technique named “IPG” utilized for the placement of seven (7) implants in the posterior areas of the maxilla in a 50 year old female patient, is presented. The novelty of the proposed method is that the implants, which were placed in a flapless approach, entered both the sinus cavities with intentional perforation of the Schneiderian membrane. Concentrated growth factors (CGF), as well as alloplastic bone grafting material were employed in this study, following an innovative protocol.

Results: Radiographs were examined at various stages during the process of osseointegration in order to assess the increase and maturation of bone structure formed around the implants and over the sinus floor. Healing was without incident and provided excellent results.

Conclusions: The promising results, derived from the “IPG” DentistEdu technique demonstrate that it can be considered as a reliable alternative to the sinus floor elevation procedure.

KEY WORDS: Dental implants, maxillary sinus, bone augmentation, membrane perforation

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INTRODUCTION

Partially or completely edentulous patients typically have a preference for either tooth-supported or implant-supported fixed partial dentures. With removable dentures becoming less acceptable with modern patients, dental practitioners need considerably less effort to convince patients to receive treatment with dental implants than several years ago. In many occasions, during treatment planning, various procedures such as bone augmentation, bone transplantation, or both are considered necessary in order to acquire the desired alveolar ridge dimensions so as to achieve implant stability and long term aesthetic results.\(^1\)

In cases of vertical alveolar ridge deficiencies of the posterior areas of the upper jaw, either extensive bone transplantation techniques are utilized, or in most cases sinus floor elevation procedures are undertaken in order to create the necessary bone height for implant stability to occur.\(^2\) Previous investigations have reported maxillary sinusitis in up to 20% of patients following Sinus Floor Elevation procedures (SFE).\(^3\) The most common complications of SFE procedures include disturbed and delayed wound healing, followed by haematoma, sequestration of bone, and transient maxillary sinusitis.\(^4,5\) In addition, postoperative acute maxillary sinusitis could even cause implant and graft failures. The aforementioned limitations of the SFE procedures necessitate the implementation of new techniques that could provide us and the patient with more stable and predictable results and relieve the latter from a painful and expensive surgical experience.

The rapid placement of implants in the sinus cavity with intentional perforation of the sinus membrane following a certain protocol – called the “IPG” DentistEdu technique – is introduced in this article. The proposed technique combines the use of concentrated growth factors (CGF with stem cells CD34+), bone grafting and implant placement, in such a manner that the sinus can adapt to the new conditions and form new bone around the implants without the need to perform an SFE procedure. Implants can be placed either using a surgical approach, or by utilizing the flapless technique which is greatly advocated by the authors and was also utilized for the patient presented in this article.\(^6\) In this case-study presentation, seven (7) implants were placed in both sinuses followed by a radiographic (Panoramic radiography and Cone Beam Computed Tomography – CBCT scans) and clinical evaluation (by Osstell measurements) after an 8 month follow-up period showing good implant stability. To the best of our knowledge, the proposed technique of intentional direct implant placement into the sinus with intentional sinus perforation has not been previously reported in the literature.

MATERIALS AND METHODS

A 50 year old partially dentate, non-smoker female patient in good health condition and without any chronic diseases visited the Dentist Education Institute postgraduate center in Athens–Greece, requesting an upper jaw rehabilitation with a non-removable prosthesis. With only the anterior dentition present, the patient was having serious difficulties chewing her food. Since the patient had requested a non-removable prosthesis, the option of placing a total of 7 implants (4 in the left and 3 in the right side) was offered to the patient. After informing the patient in details the procedure that was going to be performed, a written consent was signed.

Cone Beam Computed Tomography (CBCT)
scans confirmed the alveolar ridge deficiency in both sides with a highly resorbed and short ridge of 1–2 mm in height in the area of the upper right 1st molar (#3), and 2–3 mm in the area of the upper left 1st molar (#14), (Figure 1). Since no pathology was found in the posterior segments of the maxilla, the assessment of the CBCT scan allowed for a precise planning of the sites for implant placement. These sites were decided to be at tooth area #5 (upper right first premolar), #4 (upper right second premolar), #3 (upper right first molar), #12 (upper left first premolar), #13 (upper left second premolar), #14 (upper left first molar), and #15 (upper left second molar). Implant placement was planned to be performed atraumatically using the flapless technique which was preferred over the traditional surgical approach in order to reduce the chance for postoperative infections and provide less discomfort to the patient.7

Surgical Procedure and Concentrated Growth Factors (CGF)
As part of the authors everyday clinical practice for all surgical procedures, concentrated growth factors (CGF) with stem cells CD34+, in all its various forms was prepared.8 At first blood was drawn from the patient utilizing eight sterile tubes (9 ml each) and centrifuged in a special centrifuge device (Medifuge, Silfradent srl, St. Sofia, Italy) for approximately 13 minutes (Figure 2). For optimum quality of CGF matrices the blood samples were centrifuged immediately after the blood was drawn.

After centrifugation, in each sterile tube four components can be easily identified from top to bottom: (a) a superior phase represented by the serum (blood plasma without fibrinogen and coagulation factors), (b) an interim phase represented by a very large and dense polymerized fibrin buffy coat, (c) a liquid phase containing the white blood

Figure 1: Computed tomography scan of both sinuses in which the bilateral alveolar ridge deficiency is obvious.
cells and (d) the lower red blood cell portion, a viscous and dense platelet-rich coagulation mass (Figure 3a). A large number of growth factors and stem cells CD34+ are aggregated in the middle layer (between the dense polymerized fibrin buffy coat and the upper 3-4 mm of red blood corpuscles mass of the bottom layer. This growth factor-rich segment is separated from the rest of the red corpuscles using scissors (Figure 3b) in order to obtain the CGF-CD34+ matrix (Figure 3c).

Afterwards, Povidine-iodine solution (Betadine) was first employed extra-orally for disinfection of the surgical site in order to reduce the probability of microbial contamination, and then infiltration was performed using a 2% lidocaine solution containing a ratio of 1:100,000 epinephrine. In each predetermined site, the osteotomy was extended all the way through the whole bone height available. Drilling did not stop only until the sinus membrane was intentionally perforated. A CGF matrix, created in the previous process of blood centrifugation, was then cut in half approximately. One half of the matrix was inserted through the osteotomy site and into the sinus through the membrane perforation using the fibrin injector (Silfradent-Italy – Figure 4a), which proved to be a great tool for the swift insertion of the fibrin gel block (Figure 4b).
The remaining half of CGF matrix (highly concentrated growth factors and stem cells) was then cut into small pieces and mixed with a small quantity of the alloplastic bone grafting material Combioss (0.5ml, by Silfradent-Italy – Figure 5a). This mixture is then placed within the osteotomy site (Figure 5b). For faster osseointegration of the implants, each implant was immersed into a Liquid Phase of the Concentrated Growth Factors (LPCGF) in order to create a “bioactive” membrane around it. The LPCGF was prepared by squeezing some of the remaining seven CGF-CD34+ matrices by means of the CGF-forceps (Silfradent, Italy – Figure 6a) and was collected in a sterilized container. Each implant was carefully and fully immersed into the liquid phase CGF (Figure 6b). All implants were then placed using a hand wrench and the insertion torque was measured to be between 20-25 N/cm². The low insertion torque values are expected due to the small bone heights at all the implant sites.

**RESULTS**

All implants in-situ 8 months later are depicted in Figure 7. The proposed clinical protocol was evaluated by means of Panoramic radiography and CBCT scans and clinically in terms of Osstell readings and stability values.
**Figure 4a:** Fibrin injector (Silfradent-Italy).

**Figure 4b:** Insertion of the fibrin gel block within the osteotomy site.

**Figure 5a:** A mixture of highly concentrated growth factors, stem cells CD34+ and bone grafting material.

**Figure 5b:** Placement of the aforementioned mixture in the osteotomy site.
Radiographic Evaluation

The panoramic radiographs in Figure 8 shows the patient’s mouth before and after the implants placement following the proposed clinical protocol, whereas Figure 9 shows some of the CT scans showing new bone formation around the implants. The new bone formation within the sinus cavity and around the implant in tooth area #4 (middle implant in the right sinus) can be seen in Figure 10.

Clinical Evaluation

Following implant placement, the primary stability of each implant was investigated by means of Resonance Frequency Analysis (RFA) using the Osstell device. The RFA technique is essentially a bending test of the bone-implant interface in which an extremely small bending force is applied by stimulating a transducer. It can provide valuable and reliable clinical infor-
mation regarding the state of the bone-implant interface since the use of the Osstell device provides the dental practitioner an Implant Stability Quotient (ISQ) value. The measurements can range from 0 to 100 ISQ units, where the higher the ISQ values the more stable the implant. To perform the RFA test, a metal rod is first attached to the implant with a screw connection. The rod has a small magnet incorporated to its top that is stimulated by magnetic pulses from a handheld electronic device. Analysis of the resonance frequency of the rod is then automatically performed by the device and an ISQ measurement is pro-

**Figure 8a:** Panoramic radiograph before implant placement.

**Figure 8b:** Panoramic radiograph after the implant placement.

**Figure 9:** Computed tomography scan of the surgical site 8 months after the procedure.
The aesthetics and functional integrity of the periodontal tissues, as well as the vertical and horizontal dimensions of the alveolar processes are usually compromised following tooth loss. In such cases, various bone regenerative techniques are employed in order to restore the alveolar processes back to their original shape, allowing for a more predictable long term aesthetic and functional success of the implants placed.

DISCUSSION

The aesthetics and functional integrity of the periodontal tissues, as well as the vertical and horizontal dimensions of the alveolar processes are usually compromised following tooth loss. In such cases, various bone regenerative techniques are employed in order to restore the alveolar processes back to their original shape, allowing for a more predictable long term aesthetic and functional success of the implants placed.

For the posterior segments of the maxilla, a regenerative technique called the “sinus floor elevation procedure” (SFA), has spread widely and is taught extensively. A “sinus floor eleva-
tion procedure” can be carried out before, or in the same day with implant placement depending on each case, but nevertheless, it constitutes a more complex treatment plan and an unpleasant and longer surgical procedure for both the surgeon and the patient. Moreover, the predictability of the treatment outcome also depends on the operator’s experience performing this technically demanding surgical procedure. Sinus elevation procedures also increase both the cost and time required for completion of each case. Despite the profound drawbacks, this procedure is generally accepted by patients when they are informed that it is the only way for the posterior areas of the maxilla to be restored with a functional and easily adaptable non-removable prosthesis. Without doubt, patients do not consider SFA as a “minor procedure” and probably would have chosen an alternative non-surgical, non-invasive and painless option if it was offered to them.

The IPG DentistEdu technique described in this study, involves the utilization of bone grafting material, implant placement and concentrated growth factors-CGF (with stem cells CD34+) into the intentionally perforated sinus membranes. This allowed for all implants to be placed atraumatically in both sides of the maxilla and with no sinus elevation procedure. This protocol has demonstrated stable and reliable results with very high implant success rates. The IPG DentistEdu technique has proven to be an absolutely safe procedure without any what-so-ever post-operative complications. Neither of the sinuses presented any signs of infection that affected the well-being of the patient.

Anchorage of the CGF matrix in the sinuses is achieved by platelets released after the penetration and slight haemorrhage of the sinus membranes. Platelets also found in the CGF matrix allow for anchorage on the surface that they are placed on, or at the area where there is trauma. Therefore, when the CGF matrix is placed in the sinus cavities it will not be displaced away from where it is originally placed, forcing the bone to regenerate locally and around the implants. During new bone formation in the sinus cavities following sinus membrane penetration, it is believed by the authors, that the sinus membrane slowly repairs itself and covers the former, while any parts of the sinus membrane under the bone grafting material slowly resorbs.

A metal-acrylic fixed partial denture (with an acrylic masticatory surface) was fabricated, and was preferred over a metal-ceramic because the masticatory forces are generally absorbed better. The fixed partial denture was inserted about 9 months after implant placement in order to allow enough time for new bone growth to occur around the implants. It is believed that a shorter osseointegration period before implant loading could be equally successful in similar cases. Future case studies and research will provide us with the important information of the minimum amount of time that must be allowed before uncovering the implants. Future studies are also required to determine whether the observed augmentation in bone height will be maintained over the long term or, if there will be bone loss due to remodelling.

**CONCLUSION**

The results of the proposed IPG DentistEdu technique support the concept of a one-stage, flapless implant placement with
intentional sinus membrane perforation whenever there is ridge-height deficiency. It must be emphasized that the protocol should be carefully and precisely executed if the desired results are to be expected. Therefore, it is the authors’ belief, that adequate training on how to perform this technique has been completed first, before any attempt is made in utilizing this technique on patients. ●

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The authors report no conflicts of interest with anything mentioned in this article.

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Background: Numerous clinical trials and systematic reviews have observed that mechanical debridement does not seem to be efficient in the treatment of peri-implantitis lesions. New technology methods like air-abrasive devices and lasers have been proposed for biofilm removal and decontamination of implant surfaces. The aim of the present systematic review was to evaluate the effectiveness of lasers and air-abrasive methods when used as a monotherapy in the nonsurgical treatment of periimplantitis.

Material and methods: An electronic search, together with a complemented manual search, was conducted until March 2013 to identify available studies published in English. A three-stage screening process was performed independently and in duplicate.

Results: The search strategy revealed 771 potentially relevant titles and sequential screening identified 5 articles fulfilling the inclusion criteria. Er:Yag laser irradiation and submucosal air-abrasion with glycin powder resulted in a more pronounced short-term reduction of bleeding on probing in periimplantitis lesions compared to mechanical debridement with plastic curettes and chlorhexidine (CHX). No significant differences were detected for any of the other investigated outcome variables between mechanical debridement followed by CHX and air-abrasion or Er:YAG laser.

Conclusions: ER:Yag laser, air-abrasion and mechanical debridement followed by CHX application seem equally efficacious in improving clinical parameters in peri-implantitis cases. A trend for a significant reduction of bleeding tendency was observed after laser and air-polishing therapies over the traditional plastic curettes debridement. However this improvement was sustained for only a short time period.

KEY WORDS: Orthodontics, periodontics, osteopenia, bone graft

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INTRODUCTION

Over the last 30 years, restoration with dental endosseous implants has become a widely accepted treatment modality for the replacement of missing teeth with successful functional and esthetic results. A key factor for the long-term success of dental implants is the maintenance of healthy soft and hard peri-implant tissues since the microbial colonization of implant surfaces can lead to inflammatory changes in the surrounding tissues resembling the periodontal inflammatory conditions.1 Peri-implant mucositis is the reversible inflammatory reaction of the mucosa around dental implants while peri-implantitis is the inflammatory process affecting both soft and hard peri-implant tissues that results in the loss of supporting alveolar bone.1,2 The prevalence of peri-implant mucositis is approximately 80% on a subject and 50% on an implant basis while peri-implantitis affects 28-56% of subjects and 12-43% of the implant sites.2-4 This has resulted in a number of treatment modalities being investigated for the treatment of peri-implantitis.

Removal of the established bacterial biofilm from the implant surface is considered an essential factor in controlling peri-implant diseases5 and several anti-infective therapeutic approaches have been suggested for the resolution of inflammation in peri-implant tissues. A systematic review on the efficacy of anti-infective protocols for the treatment of peri-implantitis including 21 clinical and animal studies reported the low methodological quality of the available publications and pointed out the lack of controlled clinical trials.6

More recent systematic reviews have discussed the inadequacy of standard submucosal mechanical debridement in the resolution of peri-implantitis and reported limited short-term clinical improvements with laser therapy.7,8 The apparent limitations of mechanical debridement in the treatment of peri-implantitis is attributed to the insufficiency of plastic, titanium, or carbon curettes to remove organized bacterial biofilms from threaded rough implant surfaces.9-12 However, the adjunctive use of chemical agents including local delivery of disinfectants and local or systemic antibiotics seemed to improve bleeding on probing (BOP) and probing depth (PD).9,13-15 The drawbacks of mechanical debridement have spurred interest over the years in other nonsurgical therapeutic modalities for the treatment of peri-implantitis.

New air-abrasive devices have been used for biofilm removal from both infected tooth16 and implant surfaces.17 In these, glycine powder and water are sprayed under pressure via a thin flexible plastic nozzle onto the submucosal environment. A recent report has confirmed the safety of this method and indicated an efficacy comparable to mechanical instrumentation when applied on teeth.18

Laser therapy is another therapeutic option for decontaminating both implant surfaces and peri-implant tissues. Diode, CO2, and erbium-doped yttrium, aluminum, and garnet (Er:YAG) lasers are suitable for implant irradiation because the degree of energy absorption by titanium is low, and there is no significant temperature increase of the implant body.19-22 Whereas electron microscopy has revealed extensive melting of the titanium surface with neodymium-doped:yttrium, aluminum, and garnet (Nd:YAG) laser application.19 Er:YAG and CO2 lasers exhibit
bactericidal effects on implant surfaces in vitro without this drawback. In contrast to diode and CO₂ lasers, the ability of Er:YAG laser to effectively ablate calculus from titanium surfaces has been demonstrated.²³

The aim of the present study was to systematically review the available dental literature in order to critically evaluate the effectiveness of laser and air-abrasive therapies in the non-surgical treatment of peri-implantitis.

**MATERIAL AND METHODS**

**Study Design**

A comprehensive protocol was developed and approved by all the authors as an essential part of the present systematic review. The detailed protocol clarified all aspects of the systematic review including the focused question, search strategy, inclusion/exclusion criteria, screening methodology, data extraction, outcome measures, data analysis/synthesis, and quality assessment of the included studies.

**Focused Question**

What is the efficacy of Er:YAG laser and air-abrasive devices when used as a monotherapy in the nonsurgical treatment of peri-implantitis compared to each other and with standard submucosal mechanical debridement combined with chlorhexidine (CHX) application?

**Search Strategy**

An electronic search on MEDLINE (PubMed) was conducted from 1966 up to and including the 30th of March 2013 using a combination of MeSH terms and text words. The following keywords/search terms and their synonyms limited to clinical human studies were combined as Population AND Intervention AND Outcome as follows: peri-implantitis OR peri implantitis OR peri-implant$ OR peri-implant infection OR peri-implant defect OR peri-implantitis treatment AND non-surgical therapy OR non-surgical treatment OR non surgical treatment OR mechanical disinfection OR mechanical treatment OR mechanical debridement OR ultrasonic treatment OR ultrasonic therapy OR carbon curette treatment OR plastic curette treatment OR carbon curette therapy OR plastic curette therapy OR laser$ OR laser treatment OR Er:Yag laser OR Er-Yag laser OR Er: Yag laser OR air abrasion OR air abras$ OR air flow OR air-flow OR perio flow OR perio-flow OR amino acid glycin OR glycin powder AND failing implant OR surviving implant OR implant failure OR implant loss OR implant survival OR alveolar bone loss OR bone resorption OR bone remodeling OR bone fill OR radiographic bone fill OR probing pocket depth OR clinical attachment level.

Inclusion Criteria

- Articles published in peer-reviewed journals in the English language.
- Human clinical prospective studies including randomized controlled trials (RCTs), controlled clinical trials (CCTs), and cohort studies reporting on patients treated for peri-implantitis with at least one of the three investigated therapeutic methods used as monotherapy.
- Controlled human studies had to report on at least 10 participating patients per treatment group and a follow-up period of at least 3 months for all patients.
- Case series reporting on at least 10 consecutive patients were also included.
- Only studies utilizing screw-type titanium endosseous dental implants with various surface modifications were included in the present systematic review.

Exclusion Criteria

- Studies reporting on implants placed simultaneously or following any form of hard or soft tissue augmentation procedures.
- Case reports, reviews, editorials, and retrospective studies.
- Studies with patients suffering from medical conditions affecting implant therapy.
- Studies with implants placed in extraoral sites.
- Studies reporting on the treatment of peri-implantitis with local or systemic antibiotics.

**SELECTION OF STUDIES AND DATA EXTRACTION**

A three-stage screening process was performed independently by two independent reviewers (GM and CP) to increase the accuracy of the procedure (Fig. 1). In the first stage, the reviewers screened all the retrieved titles and excluded irrelevant and duplicate publications. Screening of the accepted publications at the abstract level was based on the number of patients, nature of the study, intervention and outcome characteristics. The third stage involved full-text reading and independent assessment by both reviewers utilizing a specially constructed data extraction form. During each stage, all disagreements were resolved by discussion and when no consensus was achieved, a third reviewer was consulted (IV). The level of agreement between the examiners for each screening stage was assessed by using the k-score. Whenever required, the corresponding author of the included articles was contacted by email for further clarifications or to obtain unpublished data.

**Types of Intervention**

The following methods were considered for the non-surgical treatment of peri-implantitis: (a) ER:YAG laser and (b) air-abrasion therapy. These therapeutic approaches were considered monotherapies and were performed without the utilization of surgical procedures.

**Types of Outcome Measures**

The primary outcome variable in the present systematic review was the PD changes observed around dental implants after the therapeutic interventions being investigated. Changes of BOP, clinical attachment level (CAL), mucosal recession (MR), and Plaque Index (PI) were considered as secondary outcomes. The outcome measures analysis was patient based on the qualification that the available data were processed accordingly by the authors of the included studies.
Confounding Factors
Adjustment for a series of potential confounding factors such as smoking, medical history and periodontal status in the original data analyses of the included trials has also been evaluated in the current systematic review.

Quality Assessment
Methodological quality assessment of the included studies was carried out independently by two reviewers (IV and CP). This assessment regarding RCTs was based on the recommendations of the CONSORT-statement and the criteria set by Esposito et al., taking into consideration seven basic criteria including sample size calculation, adequate statistical analysis, definition of inclusion/exclusion criteria, randomization and allocation concealment, blindness of examiners, similarity of baseline characteristics between groups, and completeness of follow-up. Each study included in this systematic review was assigned with a high, low, or medium risk of bias score depending on the quality assessment criteria fulfilled by each trial.

RESULTS
A total of 771 articles were identified by the electronic search on PubMed MEDLINE. The manual search did not retrieve any additional publications. Screening of the titles provided 42 potentially relevant publications and abstract reading yielded 10 papers. At the final full-text stages of screening 5 studies met the predetermined selection criteria and were included in the systematic review (Fig. 1). The inter-rater kappa values were 0.85 at the title level, 0.93 at the second stage, and 1.00 for the full-text evaluation with “good” agreement between the reviewers for all the sequential steps of the literature search.

Figure 1: Flowchart of literature search and selection of relevant clinical trials.
laser with air-abrasion reported clinical\textsuperscript{29} and microbiological\textsuperscript{30} outcomes on identical patient populations. Hence, only the clinical results from the Renvert et al. study\textsuperscript{29} were eventually considered in the present systematic review. The 3 RCTs\textsuperscript{27,28,31} were conducted by the same clinical group in Germany, while 2 RCTs \textsuperscript{29,30} were performed by another group in Sweden.

**Population and Intervention Characteristics (Table 1)**
Overall, 215 implants with peri-implantitis were treated with the three modes of therapy in the 4 RCTs \textsuperscript{27-29, 31} included in this systematic review. These implants were placed in 114 patients, 46 men and 68 women with a mean age ranging from 48 to 68.9 years between studies. In one study 2 patients were lost to follow-up, reducing the total number of participating patients to 112.\textsuperscript{31}

The following 8 different implant systems were involved in the 5 publications that fulfilled the inclusion criteria of this systematic review: Brånemark, Camlog, Frialit, IMZ, etc.
Screw Vent, Spline Twist, Straumann, and ZL-Duraplant. These implant systems presented with a diverse surface microarchitecture including the machined, sand-blasted and acid-etched, titanium plasma sprayed, and anodized surfaces ranging from smooth, to medium-rough, to micro-rough topography.

Peri-implant lesions were moderate to advanced (PD 5.4-5.9 mm) in one article, initial to moderate (PD 3.8-4.0 mm) in another one trial, and severe (5.9-6.2 mm) in another study. Finally, in one trial peri-implant lesions were grouped into moderate or advanced based on initial PD and radiographic marginal bone loss.

In 2 RCTs mechanical debridement of peri-implant defects with plastic curettes followed by CHX irrigation was compared with Er:YAG laser irradiation. The remaining 2 RCTs compared air-abrasion with glycine powder against Er:YAG laser and nonsurgical debridement in combination with local use of CHX. The follow-up period was 6 months for most trials. One study with 20 implants in each experimental group reported 1-year results.
Outcome Variables (Table 2)
The primary and secondary outcome variables were provided in most studies incorporated in this systematic review. However, in 2 instances the first author was contacted electronically in order to obtain primary data in the form of mean ± SD.\(^{28,29}\) In the Schwarz et al. trial,\(^{28}\) only data from the advanced peri-implantitis lesions were incorporated in Table 2.
Er:Yag Laser versus Mechanical Debridement and Chlorhexidine

Two studies fulfilled the inclusion criteria and were considered for assessment of the treatment outcome.27,28 Even though both trials were conducted by the same research group, they provided sufficient information on randomization, allocation concealment and blinding of the operators. One study reported clinical parameters 3 and 6 months after treatment and the other after 3, 6, and 12 months. A statistically significant greater reduction of BOP was detected 3 and 6 months following laser irradiation treatment in comparison to plastic curettes debridement combined with CHX (Table 2). Nevertheless a relapse of the initially improved BOP was recorded at the 12-month examination, leading to similar long term values for both treatment modalities. All other clinical parameters showed a similar improvement at 3- an 6 months for both laser therapy and the conventional mechanical debridement followed by CHX.27,28

Air Abrasion versus Mechanical Debridement and Chlorhexidine

Only one study compared the clinical outcome after submucosal air abrasion with glycin powder against the standard plastic curettes debridement of periimplantitis lesions.31 At the 3- and 6 month examination a marked decrease of BOP values was observed for the air abrasion group in comparison to the mechanical debridement and CHX. PD and CAL values improved similarly for both investigated treatment modalities.

ER:Yag Laser versus Air Atrasion

As mentioned above two publications reporting on the efficacy of Er:Yag laser against submucosal air abrasion with glycin powder on periimplantitis lesions were retrieved. However, the two articles were presenting clinical data of the same patient population, so only one trial29 was incorporated in the present systematic review. Both approaches resulted in a reduction of both BOP and PD values 6 months after therapy without a significant difference between treatment groups. In the
other publication, which was finally not included in this systematic review, microbiological outcomes of the two therapeutic approaches were presented. Lower counts of the potential pathogens *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Staphylococcus anaerobius* were detected in the air-abrasive group one month after therapy while reduced levels of *Fusobacterium nucleatum* were reported in the laser group.30

**Complications**

In one study, 1 patient with 2 implants treated with mechanical debridement was dropped from the study because of persisting purulent discharge, 2 months after the intervention.27 For the same reason, 2 patients with 4 implants were withdrawn from the control debridement group in another study.28

In one case, the application of the laser resulted in perforation of the buccal keratinized peri-implant mucosa.28 Healing was uneventful after suturing but was associated with an increased soft tissue recession. In all other cases, the post-treatment period was generally uneventful for all the therapeutic approaches considered in this systematic review without complications such as allergic reactions, swellings, abscesses or infections. Subgingival application of glycine powder under pressure for the treatment of 68 implants with peri-implantitis in 36 patients was not associated with emphysema formation indicating a low risk for air embolism by air-abrasive treatment.29,31 However, timing of the instrumentation with air-abrasive devices was according to the recommendations of the manufacturer.

**Methodological Quality Assessment**

Data on the fulfillment of quality assessment criteria by the studies included in this systematic review are critically presented in Table 3. The reviewers agreed that 2 studies27,28 were at medium risk of bias because they did not provide information on the sample size cal |

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Calculation</th>
<th>Adequate Statistical Analysis</th>
<th>Inclusion Exclusion Criteria</th>
<th>Randomization &amp; Concealment</th>
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<td>Schwarz et al.</td>
<td>RCT, 0 2</td>
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<td>Schwarz et al.</td>
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<td>Renvert et al.</td>
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<td>Persson et al.</td>
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<td>Sahm et al.</td>
<td>RCT, 2</td>
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The score range for each quality assessment criterion is provided within parentheses in the respective column headings controlled clinical trial.
calculation in the protocol of the trials. However, 2 RCTs\textsuperscript{29,31} were regarded as being at low risk because they both fulfilled all the discussed quality assessment criteria (Table 3).

Confounding Factors
Comparisons between treatment groups at baseline revealed no statistically significant differences for any of the investigated parameters in 2 studies.\textsuperscript{27,31} In another trial,\textsuperscript{29} statistical analysis failed to demonstrate differences in years of smoking, medications used, and gender between treatment groups. The same investigators also failed to demonstrate differences in treatment outcomes as a result of implant surface characteristics within each group.

Even though periodontally involved teeth in partially edentulous patients were accordingly treated before enrolment in the included studies\textsuperscript{27,29,31} and received proper periodontal maintenance care,\textsuperscript{31} detailed periodontal status was not provided by any of the trials. Hollow cylinder implants and smokers were excluded from 2 studies\textsuperscript{27,31} while occasional smokers were included in 1 trial because they were considered as nonsmokers.\textsuperscript{28}

Based on these limited data, it is impossible to determine the effect of probable uncontrolled confounding factors such as smoking, periodontal condition, medical history, or implant surface roughness on the efficacy of the investigated nonsurgical approaches in the treatment of peri-implantitis.

**DISCUSSION**
Although a sequential therapeutic strategy termed “Cumulative Interceptive Supportive Therapy” was proposed in the late 90’s for the treatment of peri-implant diseases,\textsuperscript{32} there is very little reliable evidence for the most effective and appropriate protocol for the treatment of peri-implantitis.\textsuperscript{33}

The inadequacy of traditional mechanical debridement in removing microbial biofilms from the threaded and roughened titanium implant surfaces has generated considerable interest over the years in other therapeutic approaches.\textsuperscript{7-9}

This systematic review investigated the effectiveness of nonsurgical therapeutic modalities in the treatment of peri-implantitis based on human clinical studies. Even though the number of available studies in the literature is currently limited, the emerging need for treating peri-implant diseases and the growing interest in nonsurgical therapies will probably lead to an increase in the number of related publications.

The primary outcome variable of this systematic review in evaluating the efficacy of these nonsurgical interventions was PD around dental implants. All the primary studies included in the systematic review provided relevant clinical data.
Survival rate is a common parameter for assessing success in implant therapy, but was not utilized in this systematic review because of the short-term follow-up times of the included publications. The evaluation of PD scores presented by the two primary studies included in this systematic review revealed no differences between Er:YAG laser and mechanical debridement followed by CHX in the treatment of moderate to advanced peri-implantitis (Table 2). Nevertheless there are certain difficulties and limitations associated with PD measurements of peri-implant lesions, especially when probing without removing the suprastructures. After the 6-month examination, a slight relapse of PD and CAL was detected for both treatment modalities, especially in the initially advanced lesions. The observed deterioration was linked to insufficient oral hygiene and associated increases in PI values from the 6- to the 12-month examination. BOP was also regarded as an important outcome measure in this systematic review. The reported 6-month BOP reduction ranged from 40 to 52% for the laser treatment and from 22 to 35% for the mechanical nonsurgical debridement. Clinical observations from the two primary studies included in the present systematic review revealed a more favorable response in bleeding tendency for laser therapy compared to mechanical debridement and CHX. However, the observed difference between the two treatment modalities was apparently neither statistically significant nor long term. Decrease of BOP after Er:YAG laser therapy is attributed to the reported antimicrobial effects of laser irradiation against periodontal pathogens, leading to a reduction of inflammatory reaction and associated bleeding tendency of the surrounding tissues. Nevertheless, the observed relapse of BOP values, 1 year after an initial course of laser therapy, raises questions about the long-term stability of this treatment modality and may indicate the need for repeated laser applications to achieve stable clinical results.

One case series not included in this systematic review provided valuable histological observations from human peri-implant lesions revealing the formation of a loose fibrous tissue with poor attachment to the implant surfaces. The microscopic findings confirmed the apparent lack of efficacy of a single course of laser treatment for the long-term maintenance of advanced peri-implantitis cases. The results of this systematic review are consistent with the descriptive findings of a previous systematic review. The authors also questioned the long-term efficacy of laser therapy in peri-implantitis and discussed the possibility of repeated laser application or the adjunctive use of other therapeutic approaches. Similarly, the conclusion of the Consensus report of the 6th Workshop on Periodontology on the nonsurgical laser therapy of peri-implant diseases was that “The outcome data on laser therapy is incomplete and do not show benefit as compared with conventional mechanical therapy.”

The efficacy of air-abrasion in the treatment of peri-implantitis was compared to mechanical debridement followed by CHX in one study and to Er:YAG laser in another study included in this systematic review. A slightly more favorable reduction of PD for the air-abrasion group over the standard mechanical treatment and CHX application was detected (Table 2). On the other hand, a marked decrease of BOP values was recorded, favoring the air-abrasion therapy over the mechanical approach plus CHX
application (Table 2). Apparently, air-abrasion is more efficient in the disruption of subgingival biofilms compared to mechanical debridement combined with CHX, leading to reduced bacterial load and subsequently decreased bleeding tendency. In support of this, a very recent in vitro study observed a significant cleaning effect of glycine powder on implant surfaces. Using different angulations for sandblasting artificial peri-implant defects, a remarkable removal of stains from the greatest part of implant surfaces was observed in the larger defects. In the second study, PD reduction did not seem to differ between both Er:Yag laser irradiation and glycine powder air-abrasion. Similarly, no differences were detected between the two approaches in the treatment of severe peri-implantitis lesions for BOP, suppuration, and peri-implant bone loss.

The importance of bacterial plaque biofilm in the initiation and progression of peri-implant diseases has been established and the disruption of subgingival microbial communities is considered a primary objective for the treatment of these conditions. Therefore, a significant drawback of all the controlled human studies included in this systematic review was the lack of microbial monitoring in the investigated nonsurgical approaches for the treatment of peri-implantitis.

Only one trial fulfilling the inclusion criteria of this systematic review presented microbiological outcomes comparing Er:YAG laser with air-abrasion. This study originated from the same Swedish group and was conducted on the same patient population but focused mainly on the impact of these therapeutic approaches on subgingival biofilms. Lower counts of *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Staphylococcus anaerobius* were detected in the air-abrasive group, 1 month after therapy. Although these species are not putative periopathogens, they have been associated with peri-implantitis lesions and seem to play a significant role in the development of biofilm on implant surfaces. Reduced levels of *Fusobacterium nucleatum* were detected in the laser group, respectively. However, a relapse was monitored at the 6-month evaluation, indicating the inability of both air-abrasion and laser treatments to sustain microbial suppression for longer time periods. The microbiological observations further confirm the inadequacy of these nonsurgical methods in the long term maintenance of the clinical improvements observed after a single application in moderate to severe peri-implantitis cases.

The results of one recent systematic review reporting on the efficacy of non-surgical therapy of periimplantitis are in agreement with the findings of the present trial. More specifically lower BOP scores were detected 6 months following Er:Yag laser irradiation or air-abrasion with glycine powder in comparison with the traditional plastic curettes debridement followed by CHX. No difference in the evaluated clinical parameters was reported 12 months post treatment between the investigated therapeutic approaches, indicating the short term advantage of laser and air-abrasion therapy over the standard mechanical therapy of periimplantitis.

A very recent RCT compared the combination of mechanical debridement, air-abrasion with glycine, and photodynamic therapy with phenothiazine chloride to the combination of mechanical debridement, air-abrasion, and local application of minocycline microspheres. In cases of initial peri-implantitis, adjunctive photodynamic therapy was equally effective as adjunctive
local delivery of the antibiotic in reducing BOP and PD. However, even though the treatments were repeated at sites with residual BOP, complete resolution of inflammation was not attained with either of the adjunctive approaches.39

The extent of response to alternative nonsurgical treatments may be related to the severity of the disease. Renvert et al.29 noted that despite good levels of oral hygiene, patients presented clinically visible inflammation expressed with BOP and suppuration, indicating inadequacy of both laser and air-abrasion in the treatment of advanced peri-implantitis cases. The limited success was attributed to the inability of these nonsurgical approaches to adequately control the microbial etiology because of disease severity. In accordance to this observation, improved clinical parameters were reported in moderate compared to advanced peri-implantitis defects for laser and mechanical debridement followed by CHX.28 However, Sahm et al.31 reported limited clinical efficacy of both air-abrasion and mechanical debridement to control disease progression in initial to moderate peri-implantitis cases.

Single applications of alternative nonsurgical treatments seem inadequate to control intense inflammation, especially in advanced peri-implantitis cases. Consequently, controlled clinical trials are needed to evaluate the results of a single compared to repeated applications of these nonsurgical approaches. In addition, the short-term improvements in clinical parameters after nonsurgical methods in peri-implantitis cases may represent a beneficial step in the preparation of the inflamed tissues for treatment with regenerative procedures to improve the osseointegration levels.27,28

Because clinical improvements from these nonsurgical treatments appear to be similar, another important issue is a cost-effectiveness analysis to maximize the level of benefits relative to the resources available.27,28 In addition, removal of the prosthetic suprastructures may be advantageous in providing adequate access for the laser tip or the air-abrasive nozzle to reach the deepest parts of peri-implant lesion.29 Removal and repositioning of the suprastructures implies both increased treatment time and greater expense.

Two of the trials included fulfilled all the predetermined quality assessment criteria and were judged to be at low risk of bias,29,31 two were graded at medium risk of bias because they did not provide data on power calculation of the optimal sample size.27,28 Furthermore the fact that the included studies in this systematic review originated from one German27,28,31 and one Swedish29,30 group represents a reduced risk of heterogeneity because of the similar experimental design along with an increased risk of bias because of the small number of the involved centers.

The limited number of available clinical controlled studies on the efficacy of laser and air-abrasion therapies on peri-implantitis may be considered a potential drawback of the present systematic review. Additionally, the 5 studies included in this systematic review originated from one German27,28,31 and one Swedish29,30 research groups. However all the included studies are well designed, provide data on randomization, allocation concealment and blinding of the operators and were judged to be at low to medium risk of bias. Therefore, more studies with larger sample sizes and longer follow-up periods are required to draw definitive conclusions on the long term effects of the two novel therapeutic approaches evaluated in the present systematic review.
CONCLUSIONS
Er:YAG laser irradiation, submucosal air-abrasion with glycin powder and mechanical debridement combined with CHX application seem to be equally efficacious in the treatment of peri-implantitis.

Even though the two novel approaches investigated in this systematic review resulted in similar improvements in PD reduction, a trend for significant, albeit short-term decrease in BOP was observed when compared to traditional mechanical debridement followed by CHX application. Whereas a single application of alternative nonsurgical therapies induced only short-term clinical improvements, the impact of repeated use remains to be elucidated.

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Dental implants have become routine therapy for the replacement of missing teeth and have an excellent success rate. Proper patient selection prior to implant therapy and home-care are crucial to this success. The direct impact of oral hygiene maintenance by the patient will determine long-term prognosis and success of the dental implant. An implant maintenance protocol with routine in-office implant evaluation and maintenance should be established for each implant patient. Clinicians must know how to assess and maintain implants and which techniques and instruments to use and also make awareness in the patient to set up a proper home care for long term success of dental implants. The overall goal of this article is to explain about implant assessment, monitoring, home & in office maintenance protocol.

**KEY WORDS:** Dental implants, maintenance, home care

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INTRODUCTION

“Over the past 30 years, research has validated the success of osseointegrated implants as a viable alternative to fixed or removable prosthetic restorations.”¹ It is now well-accepted that the success rate for single tooth endosteal implant is up to 97% over 10 years.²,³ Since implants have become a routine therapy, the entire team needs to understand how implants are placed and restored in order to be able to confidently talk to patients about implants as an option for tooth replacement.

Patient selection for implant therapy is based on a number of factors, including medical history, oral health, and hygiene status. Endosteal implants are placed in the bone, an abutment is attached to the implant, and the prosthesis is then placed on the abutment.⁴ In the presence of a tooth, force is transmitted to the surrounding bone, which stimulates and helps maintain it. Implants also stimulate bone and help to maintain and increase bone density in the absence of a natural tooth, which in turn can help preserve facial structure. The key benefits of implants are functional and esthetic: to enhance appearance, restore normal eating, improve removable denture retention, and in the case of single implants, replace teeth without the need for a bridge that may involve preparing virgin or minimally restored teeth.

Does peri-implantitis progress faster than periodontitis?⁵ Peri-implantitis is similar to periodontitis. They both involve alveolar bone loss. However, there are some differences. There is a zone of connective tissue being attached to the root surface in periodontitis. But in peri-implantitis, the connective tissue does not attach directly onto implants and there is no periodontal ligament, so the inflammatory lesion in peri-implantitis always extends closer to the bone surface. Therefore, it progresses faster and it is potentially a more aggressive disease and it is very hard to treat. Nevertheless, tissue degradation may be a slow process, as in chronic periodontitis, a function time exceeding 5 years for implants may be required to detect biological peri-implant complications.

Finally, the steps necessary for successful peri-implant maintenance must be taken: provide safe implant maintenance, and monitor the tissue and the bone level surrounding the implant. In-office maintenance protocols and home-care recommendations are crucial for the success of implants. This requires clinical knowledge on how to assess implants at maintenance appointments, how to safely instrument implants, and which products can safely be recommended for home care.⁶

The signs and symptoms of failing implants must be recognized during the evaluation phase of maintenance. Once implants have been successfully placed, the patient must follow a proper home-care program and an implant maintenance protocol must be developed for the patient. Home-care recommendations should begin at the time of implant placement and should be reevaluated each time the patient presents for implant maintenance therapy.

IMPLANT HOME CARE

A daily meticulous home-care routine is essential for the long-term success of implants. An individual home-care routine should be developed that considers the type of implant prosthesis and the patient’s dexterity, and should be kept as simple and as effective as possible for the patient. Post-surgically, good oral hygiene is necessary to maintain a healthy field as well as to help with
healing, and the patient should do the following:

● Drink only clear liquids for the rest of the day
● Take antibiotics and analgesics as prescribed and recommended
● Eat soft foods for the first few days of healing
● Avoid wearing a temporary prosthesis or denture to let the gum tissue heal (if the implant was not immediately loaded)
● Use an extra soft toothbrush to clean the dentition, preexisting implants and the gingiva (and do not brush the incision area)
● Use warm saline rinses or an antiseptic rinse if prescribed or recommended.

**ORAL CARE FOR IMPLANTS**

Oral care for single-tooth implants involves a number of steps. The patient should be instructed to brush the implant(s) twice a day with a low-abrasive dentifrice. Using a low-abrasive dentifrice ensures that it will not scratch the surface or irritate the tissue cuff surrounding the implant. A soft toothbrush should be used – options include a manual brush, electric or sonic brush (e.g., Sonicare®, Oral-B® Sonic, or Pulsonic), end tuft brush, or proxabrush. The Oral-B® Pulsonic has a slim sonic brush that can fit under bar-retained implants or around ball implants used with overdentures. The interdental brushes that have coated wires are also recommended to clean around single implants or under a Hader bar. The end-tuft brushes clean around hard-to-reach implants and around bar-retained or ball-implant abutments. Instruct the patient to floss once a day on the mesial and distal aspects. For implants, it is also recommended to floss implants on the facial and lingual aspects. This is accomplished by wrap-
ping the floss around the tooth or looping the floss to remove all plaque on the implant surface. The biological differences between an implant and a natural tooth make the implant more susceptible to inflammation and bone loss from bacterial plaque, making meticulous oral hygiene essential. There are many types of floss in the market today, and generally a single-tooth implant can be flossed with the patient’s regular floss. Alternatively, implant floss can be used (e.g., Thornton’s bridge and implant interdental floss). For bar-retained prostheses or wider interproximal spaces, thicker floss or one with a built-in threader (e.g., Oral-B® Super Floss; Butler® Postcare) is recommended.

Antimicrobial rinses may be recommended, especially if inflammation is present or the patient has dexterity problems with an area that is difficult to clean. If the patient is prone to inflammation, the use of chlorhexidine gluconate or another antimicrobial rinse, in conjunction with a rubber tip stimulator, is recommended. Water irrigation units (e.g., Hydro Floss) can be beneficial if used twice daily (following proper instruction to ensure that the perimucosal seal is not damaged). The water must be directed only interproximally and horizontally on a low speed to avoid damaging the perimucosal seal.
IMPLANT MAINTENANCE

After osseointegration has been confirmed and the final prosthesis or restoration is complete, the patient is largely responsible for the success of an implant and needs to understand the importance of proper in-office implant maintenance appointments every three months for the first year, to help prevent infection or failure of the implant. After one year the bone surrounding the implant maintains a mature level of bone and the interval between maintenance visits should be based on the patient’s general health, assessment of the implant, and home care.

THE IMPLANT MAINTENANCE APPOINTMENT

The implant maintenance appointment consists of the following: 1) Review of the patient’s medical history and general health; 2) Assessment of the implant(s); 3) Proper instrumentation and polishing of the implant(s); 4) Reinforcement of home-care routine and specific recommendations.

Step 1: Review of the patient’s medical history and general health. The patient’s medical history should be updated and reviewed at every routine oral evaluation and implant maintenance appointment, to check if there has been any change in the patient’s health status that could impact the implants or treatment. If the patient has uncontrolled diabetes, increasing the risk of peri-implantitis and ultimately implant failure, it will be necessary to work in collaboration with the patient’s physician and the patient to gain control of the diabetes. Overall good general health is one of the keys to the success of implant(s) and may affect the length of time between implant maintenance visits.

Step 2: Assessment of implants. Implant assessment starts with a visual soft tissue examination of the perimucosal seal. Any signs of inflammation or bleeding upon probing, including peri-mucositis (a reversible inflammatory reaction with no bone loss) or peri-implantitis (an irreversible inflammation with bone loss) should be recorded as well as any clinical symptoms present such as pain and mobility. These assessments must be performed at every maintenance appointment. Accurate radiographs...
are necessary to monitor the crestal bone level.

Visual soft tissue assessment: The soft tissue should be visually examined for color, texture, form, bleeding, and inflammation. The assessment and any tissue changes should be recorded in the patient’s charts as well as with a regular intraoral or digital camera. This photograph or digital image can be used to help educate the patient on the appearance of healthy tissue and, if present, the patient can be shown the inflamed tissue. Images can also be an excellent visual tool to reinforce the importance of good home care.

Protocol for proper probing around the implant: There are a number of considerations and guidelines that should be followed when probing the tissue surrounding an implant. A plastic-coated probe (e.g., PDT EasyView; Hu-Friedy Colorvue®) should be used to reduce the risk of scratching the implant’s surface; plastic probes are also more flexible enabling them to follow the anatomy for a more accurate clinical reading. The perimucosal seal is fragile and more susceptible to trauma and penetration during probing than the periodontal ligament around teeth, which could introduce pathogens and jeopardize the success of the implant. Probing in the perimucosal seal may not be recommended by some clinicians in the first three months following abutment attachment to avoid disrupting the biologic seal. Guidelines for proper implant probing are described below. A probe baseline measurement at a specific location should be recorded, to establish a clinical parameter for the patient’s record. This baseline should be recorded in the patient’s notes at the first maintenance appointment after three months. The measurement should ideally read 2.5 mm to 5.0 mm or less, depending on soft tissue depth, and there should be no signs of inflammation. Measurements at appointments should be compared to baseline, and if the probe depths change, this must be noted in the patient’s chart.

Figure 6: Dental flossing.

Figure 7: Antimicrobial rinse.
**PROTOCOL FOR RADIOGRAPHIC MONITORING**

(Bone level): This final step is a critical one. A radiograph is taken to accurately monitor crestal bone level around the implant(s) using a measurable device and to verify that the prosthesis is seated properly on the implant following placement of the prosthesis. Subsequent radiographs are used to determine if any crestal bone loss around the implant has occurred and, if so, to measure this. Periapical or vertical bitewings for one to four implants and a panoramic or full mouth series for five or more implants is recommended to enable accurate determination of the crestal bone level. Radiographs should show indentations in the implant or the screw clearly in focus to help visual confirmation that the X-ray is the correct way round. A measurement of 0.5 mm to 1 mm horizontal bone loss is acceptable in the first year, with an anticipated 0.1 mm of bone loss each subsequent year. If more than 1 mm of horizontal or vertical bone loss is detected in the first year, a referral to the periodontist may be given. Any signs of peri-mucositis, mobility, peri-implantitis, or bone loss need to be recorded at each appointment and appropriately treated. After carefully assessing the implant and recording the findings, evaluate if calculus is present on the implant or abutments. Minimal or no instrumentation is necessary for an implant with a healthy gingival attachment. If an implant does fail with loss of osseointegration it is generally due to bacterial infection, occlusal overload or a poorly designed prosthesis. The cause of a failing implant and a treatment plan must be determined by the dentist.

Step 3: Proper Instrumentation: Selecting instruments that will effectively remove all plaque and calculus deposits without scratching the surface of the implants is essential. Calculus deposits on implants are generally softer than on teeth and are more often found supragingivally than subgingivally. Generally, proper hand instrumentation is all that is needed. Excessive pressure or trauma to the perimucosal seal during instrumentation is contraindicated to avoid damaging it, the surface
of the implant, or any exposed abutment surface. Stainless steel–tipped instruments, as well as metallic sonic and ultrasonic scalers, have been found to gouge titanium\(^2\),\(^2\),\(^3\) and are contraindicated for implant instrumentation as scratching or roughening the implant surface can cause bacteria to adhere more easily, with an increased risk of inflammation.\(^2\) Clinicians also need to avoid damaging the surfaces of ball, bar-retained or locator abutments as this can result in increased plaque formation and retention.\(^2\) Metal tipped sub-gingival irrigators are also contraindicated.

The appropriate instruments for implant maintenance are plastic, graphite, or solid titanium scalers and curettes. These have been proven to be safe and effective for the removal of plaque and other deposits on titanium implants.\(^2\),\(^3\) If ultrasonic or sonic scalers need to be used, caution is required to avoid damaging the perimucosal seal and they must have a nonmetal tip or plastic sleeve to prevent scratching of the implant surface during use.\(^2\) Several manufacturers have developed implant power scaler tips and silicone covers to place on ultrasonic scaler tips to prevent possible scratching of the implant surface (Cavitron\(^\text{®}\) SofTip\(^\text{™}\); GentleCLEAN\(^\text{™}\); EMS Piezon\(^\text{®}\) Implant cleaning tip; Periosoft\(^\text{™}\) carbon composite mini-tip; SensiTtips\(^\text{®}\)). Plastic sleeve tips may become loose in the patient’s mouth and should be used with caution to avoid the risk of aspiration.

Hand implant scalers and curettes are available in polycarbonate plastic (e.g., Prophy+\(^\text{™}\), Advanced Implant Technologies) and graphite (e.g., Premier Dental), can be sharpened and are autoclavable. Implant scalers are also available with a sturdy handle and plastic disposable tips (Implacare\(^\text{™}\), Hu-Friedy) – these are single-use and must be disposed of after one use. Solid titanium scalers and curettes are also now available that can be used to scale on “like metal” titanium implants, are thinner than plastic or graphite instruments and provide more strength to dislodge calculus.\(^2\),\(^3\) (Nordent ImplaMate\(^\text{™}\)). Titanium instruments have been adapted with a shorter radius blade length and rounded tips.
Table 1: Dental Implants Versus Natural Teeth

<table>
<thead>
<tr>
<th>Natural Teeth</th>
<th>Implants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface: Cementum</td>
<td>Titanium or coated</td>
</tr>
<tr>
<td>Held in by periodontal ligament</td>
<td>Osseointegrated directly with bone</td>
</tr>
<tr>
<td>Heat sensitive: pulpitis possible</td>
<td>No sense of temperature</td>
</tr>
<tr>
<td>Mobility occur due to periodontitis</td>
<td>Mobility occur due to peri-implantitis</td>
</tr>
<tr>
<td>Susceptible to decay</td>
<td>No decay possible</td>
</tr>
</tbody>
</table>

specifically for peri-implant therapy (Paradise Dental Technologies), as well as with replaceable titanium tips (ImplantPro™, Brasseler).

Protocol for Polishing: Basic steps for proper coronal polishing around implants include using a soft rubber tip, not brush, with appropriate nonabrasive paste. Aluminum oxide, tin oxide, APF-free prophy paste, and low-abrasive dentifrice are all considered acceptable polishing abrasives for implants.²⁹ Coarse abrasive polishing pastes are contraindicated, as is airpolishing.³⁰ It should be noted that acidulated phosphate fluoride (APF) products are also contraindicated, as they may etch the surface of implants.³¹ It may be helpful to polish first around implants to remove any plaque or debris present and then to determine deposits that need instrumentation.

CONCLUSION
During the infancy years of dental implantology, the emphasis for long-term success of osseointegrated implants was the surgical phase of dental implantology. In the years that followed, the emphasis for success has switched from a purely surgical influence to focusing more on the proper fixture placement which would be dictated by the prosthetic and aesthetic needs of each particular case. In more recent years, the dental professional has recognized professional implant maintenance and patient home care as two critical factors for the long-term success of dental implants.

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1. Data on file at Exactech.

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1. Data on file at Exactech.
Background: There currently exists neither a clinical measure defining an acceptable level of fit between the mating surfaces of an implant prosthesis and its intended implant or abutment platform, nor which clinical procedures are best to optimize that fit. Several techniques using resin to splint implant components have been suggested in order to improve the accuracy of impressions and working casts in the fabrication of an implant prosthesis. These include: the use of resin to splint adjacent impression copings before impressioning, or laboratory analogs before pouring a working cast; or lastly, the use of resin to splint both impression copings and laboratory analogs. The purpose of this article is to determine the effect of splinting impression copings and/or implant analogs compared to non-splinting on the accuracy of the resulting cast.

Materials and methods: A control standard was fabricated by incorporating implant replicas secured to a CAD/CAM milled titanium framework into a cast of Type V dental stone that served as the control for the present investigation. The interface between the framework and the analogs were positioned above the stone in the control cast to allow visual access. Standardized impressions and working casts of the control were made using six techniques: Group N: neither copings nor analogs splinted, Group A: splinted analogs, Group C: splinted copings, Group CA: splinted copings, and analogs, with two additional groups involving a pre-made resin splint that was sectioned and then reconnected on the control: Group S: sectioned splint reconnected on the control, and Group SA: sectioned splint reconnected on the control, with splinted analogs. The resulting working casts were evaluated and measurements of the framework-analog interface gap were made using photographs under high magnification. The incidence of the framework having all four analog interface gaps less than 150 microns was also noted.

Results: Group A had significantly larger gaps than all the other groups. There was no statistically significant difference found between any other groups.

Conclusion: Within the limitations of the present investigation’s study design, it was found that: 1) Splinting analogs with resin resulted in a working cast with significantly diminished accuracy; 2) There was no significant difference in working cast accuracy if impression copings were unsplinted or splinted with resin.

KEY WORDS: Dental implants, prosthetics, impression accuracy, analog
A dental impression is defined as a negative imprint of an oral structure used to produce a positive replica of the structure for use as a permanent record or in the production of a dental restoration or prosthesis.1 Achieving an accurate fit between a prosthesis framework and its’ supporting implants is related to the accuracy of the impression.2,3 An inaccurate impression would result in an inaccurate working cast as well as the prosthesis made from it. Misfit of an implant prosthesis’ framework may induce strain causing mechanical or biologic complications. Mechanical complications may include screw loosening, screw fracture, or implant fracture.4 Biological complications may include plaque accumulation, gingival inflammation and bone loss.5 Therefore, framework must fit as precisely and passively as possible to minimize interface gaps and strain.

Some authors have attempted to define passivity of fit for an implant prosthesis. Brånemark in 1983 defined a passive fit as minimum of 10 µm between the implant platform and the superstructure.6 Klineberg et al considered a passive fit to be unacceptable if the gap between the implant and the abutment is greater than 30 µm for more than 10% of the interface circumferentially.7 The results of a prospective study by Jemt et al. suggests that misfit should be less than 150 µm.8

Complications in dental implant treatments occur for a variety of reasons, and some of these have been attributed to poor prostheses fit.4, 9 Production of a prosthesis that fits passively and precisely is dependent on an accurate transfer of the intraoral position of implants to the working cast. Because dimensional change is inherent in materials used for impression making and the production of a working cast, numerous techniques involving variety impression trays, materials, or copings, have been suggested in order to reduce this error.10

Included in these are techniques that involve splinting impression copings or laboratory analogs, with auto polymerizing resin. However resins are subject to a potentially significant dimensional change upon polymerization. Polymethylmethacrylate (PMMA) has been shown to shrink 6.5% by volume.11 At room temperature, PMMA continues to shrink up to 24 hours after mixing power and liquid.11 Eighty per cent (80%) of the total shrinkage occurs in the first 17 minutes, with no significant shrinkage after 24 hours.11 Therefore, when using a technique that directly splints impression copings with resin, it
is unclear if this continued shrinkage will affect the fidelity of that impression given the common clinical practice of delayed working cast fabrication. In an attempt to overcome this, it has also been suggested that the resin splint be made indirectly on a preliminary working cast well in advance of the definitive impressioning procedure. That premade resin splint would then be sectioned and reconnected intraorally with a minimal volume of additional PMMA. By resplinting a preformed resin pattern, the volume of resin used in this approach significantly minimizes polymerization shrinkage when compared to a bulk application. A systematic review by Lee H. et al compared the accuracy of implant impressions.\textsuperscript{10} Seven studies advocated the splinting technique, seven studies reported no difference between the splinting and non-splinting, and 3 studies advocated the non-splinting technique as being the most accurate technique.\textsuperscript{10,11,12,13,14} The purpose of the present investigation was to record impressions of a standard with prepositioned implant replicas to measure the effect of splinting impression copings or analogs compared to not splinting. The null hypothesis is there would be no statistically significant differences between unsplinted impression copings or analogs compared to those that are splinted.

**MATERIALS AND METHODS**

Four implant analogs (Replace Select narrow platform, Nobelbiocare, Mahwah, NJ)
were attached to a milled titanium framework, and the assembly was embedded into a mold filled with a Type V high strength, low expansion dental stone, (Silky Rock, Whip Mix, Louisville, KY) to create a control platform (Figures 1 and 2). The interface between the framework and analogs was positioned 5 millimeters above the level of the stone in order for the framework analog interface to be visually accessible.

A stock resin impression tray (Benco disposable, Benco dental, Pittston, PA) with holes drilled to access impression coping guide pins was placed on the control platform, and an outline of the tray borders was traced. After removing the tray, 2 channels were made 3 to 4 millimeters wide buccolingually at a depth of 2 millimeters. Light polymerized resin (Triad tray VLC, Dentsply Inc., York, PA) was placed in this channel, and the rim of the stock impression tray was reseated into the unpolymerized resin. The assembly was placed into a light polymerization unit (Triad 2000 curing unit, Dentsply Inc., York, PA) for ten minutes to polymerize the resin following the manufacturer’s instructions. This channel allowed subsequent stock impression trays to be positioned in a standardized manner (Figures 3-5).

Impressions of the control platform were then made with a variety of techniques: Group N: No splinted copings, no splinted analogs;
group C: Splinted copings, no splinted analogs; group A: No Splinted copings, splinted analogs; group CA: Splinted copings, splinted analogs; group S: Sectioned splint reconnected on the control platform, no splinted analogs; group SA: Sectioned splint reconnected on the control platform, and splinted analogs.

A template was made of the first stock tray in order to standardize the position of these holes for subsequent trays. All techniques used the same size stock trays with 4 openings to allow access to the impression coping guide pins. A fast set vinyl polysiloxane (VPS) impression material (Exafast NDS Monophase, GC America, Alsip, Il) was used for all impressions. For the techniques that included a polymethylmethacrylate (PMMA) splint, a floss scaffold (Glide, Proctor and Gamble, Cincinnati, OH) was overlaid with autocuring PMMA (Pattern resin, GC America, Alsip, Il) (Figure 6). For Groups S and SA, impression copings were connected in the same manner and then sectioned. The individual sections in Groups S and SA were placed into water at 100 degrees centigrade for 20 minutes in order to minimize the residual monomer content and ongoing setting reaction of the set polymer. After 5 minutes of bench cooling, these individual sections were then reconnected with additional pattern resin on the stone platform and an impression was made.

Twelve impressions were made for each of the various techniques after hand-tightening impression copings onto the implant replicas imbedded into the control platform. This sample size was chosen based on a pilot study (n= 10) which was conducted and showed that at least 12 samples would be required for each group to satisfy the constraints of \(a = 0.01\), power, 0.80, and a difference of 20% between means. In addition to that, one way ANOVA power analysis was used to determine the new sample size \((n=12)\) of the six groups. Twelve samples for each of the six groups ensured a power over 0.80 according to a one way ANOVA of power analysis. After the impression material had completely polymerized according to manufacturer instructions, the impression coping guide pins were unscrewed and the impression was separated from the control standard. Implant analogs were then carefully hand-tightened to the impression copings maintaining their position within the impression (Figure 7). Each of the impressions with attached analogs were placed into the same base forming mold and working casts were poured using the same stone used to make the control platform, following the manufacturer instructions. After the stone was set, the guide pins were unscrewed, and the working casts were recovered from their impressions and base forming mold. A single operator attached the reference framework to each working cast by using a single screw hand tightened to the posterior left analog. To assess the accuracy of the working cast, a previously described method was used to measure the vertical gap between the framework and analogs. Each working cast was positioned in a reproducible manner on the stage of a photographic microscope (Olympus SZX12, Olympus America, Valley, PA) (Figure 8) using a silicone putty matrix (Sil-Tech Super, Ivoclar vivadent, Amherst, NY) for consistent positioning. Photographs were taken at each of the 4 framework and analog interfaces at 100X magnification at a set distance from the stage. Measurements of the vertical gap between the framework and each analog were made using imaging software (Bioquant image analysis soft-
ware, Bioquant Corp., Nashville, TN). A single operator made measurements of each mesial, distal and midfacial gap for each interface and recorded the average of those three measurements. In addition, the average of the 4 interfaces for each framework were calculated and recorded. Means and standard deviations were determined for each study group (Table I). An analysis of variance was performed to test for significant differences among the different groups and a chi-square test was used to determine if those percentages were significant (Table II). This analysis was followed by a Tukey HSD post hoc test to determine which groups were statistically different from each other (Table III).

Results casting with all 4 gaps at the framework analog interface of less than 150 µm was considered to be a clinical threshold for a working cast. It was noted that Group C had the highest number of casts were all framework analog interfaces were less than 150 µm.

### RESULTS

The mean and standard deviation was calculated for each study group [Table I]. Group A had the highest mean framework analog gap of 183.19 µm, which an ANOVA test revealed to be statistically significant. The remaining Groups N, C, CA, S and SA were not statistically different from each other. The Tukey HSD post hoc test showed that Group A had statistically larger gaps than all the other groups, and there was no statistically significant difference in the other groups (Table III).

Working casts with all 4 gaps at the framework analog interface of less than 150 µm was considered to be a clinical threshold for a working cast. It was noted that Group C had the highest number of casts were all framework analog interfaces were less than 150 µm.

**DISCUSSION**

The results of the present study show a significant decrease in the fidelity of a working cast when implant analogs alone were splinted compared to all other techniques studied. Of the remaining techniques, there was no statistically significant difference found. Only Group A was shown to have a significantly larger mean gap between the framework and the analogs compared to all other groups (183.19 µm). In this study, splinting the analogs alone caused a significantly increased gap between the framework and the

<table>
<thead>
<tr>
<th>Technique</th>
<th>N</th>
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<th>SD</th>
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<td>12</td>
<td>99.74</td>
<td>23.09</td>
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</table>
working cast analogs, and therefore appears to be counterproductive. The elastomeric nature of the impression material allows movement of the analog and coping. It would appear that in the course of splinting the analogs, the floss that was used as a scaffold for resin placed a force on those analogs that altered the position of the analogs and impression copings to a significant degree. The results indicate that this technique is to be avoided. In Groups CA and SA the resin that splinted the impression copings was apparently able to counteract that force that the floss had applied to the analogs in Group A. Group C showed the smallest mean gap of 43.32 µm between the framework and the analogs, however, an analysis of variance with post hoc test showed that the mean of the average gaps between Groups N, C, CA, S, and SA were not significant. In Groups S and SA the use of prepolymerized resin sections greatly reduced the volume of resin needed to directly splint the impression copings compared to Groups C and CA. The use of prepolymerized resin sections did not significantly improve the fidelity of a working cast compared to direct placement of the entire volume of resin (Group C) or the group that had non-splinted impression copings (Group N). Overall, splinting impression copings whether directly or with the use of prepolymerized sections was not shown to be an effective method for improving the accuracy of working casts.

In addition to analyzing the mean gap among the different techniques, the authors noted the number of times that a particular technique resulted in a mean gap of less than 150 µm for each of the 4 implant positions. If all gaps were less than 150 µm for each of the framework analog interfaces of any individual working cast, that cast was considered to be able to produce a framework that would not need to be corrected or remade. If any of individual framework analog interfaces were greater than 150 µm, the authors considered the working cast would produce a framework that would need to be corrected or remade.

It was interesting to note that Group C showed the highest percentage of implant frameworks that fit (83.3%) followed by Group N (75%). This difference amounted to only one framework between the groups. Although the sample size is too low to apply meaningful statistical analysis to this observation, it does help to support the conclusion that splinting impression copings with either method described was not shown to be an effective method for significantly improving the accuracy of working casts.

One limitation of the study was the variation in the overall volume resin used for splinting as well as variation in the liquid to powder ratio of the resin used. A larger volume of resin would presumably have a greater amount of dimensional change, as would an increased liquid to powder ratio. Although care was taken to use a minimum of resin, the degree of dimensional change could have been different between samples, albeit within a limited range.

Additionally, the stock plastic impression trays used are not as rigid as custom made impression trays. However, because the control platform was flat, no meaningful force was required to recover the impressions from it or the working casts. Therefore, the rigidity of the stock resin impression trays was adequate for the present investigation.

Additional research is needed to better establish the level of misfit beyond which, one can expect a significant increase in clinical complications. Current research lacks focus on an upper
Table 2: Analysis of Variance for Different Groups

<table>
<thead>
<tr>
<th>Technique</th>
<th>Count</th>
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<th>Total</th>
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<td>C</td>
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### Table 2: Analysis of Variance for Different Groups

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An equally important question for future research would be how best to determine that upper limit in a clinical setting. Studies that compare the ability of various clinical techniques to provide accurate measurements of misfit would give clinicians valuable information. These two questions are interrelated, as knowing that threshold of misfit is of limited value if it cannot be reliably measured clinically.

CONCLUSION

Within the limitations of the present study design, it was found that: 1) splinting analogs with resin resulted in a working cast with significantly diminished accuracy; 2) there was no significant difference in working cast accuracy if impression copings remained individual, or were splinted with resin.

Disclosure

The authors report no conflicts of interest with anything mentioned in this article.

References

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