

Implant abutment disinfection using plasma of argon and 0.2% and chlorhexidine gel applications immediately before prosthesis delivery: clinical and radiographic status at 5-years of follow-up

A. ALSAHHAF, M. ALRABIAH, K. ALI, F. VOHRA, T. ABDULJABBAR

Department of Prosthetic Dental Science, College of Dentistry King Saud University, Riyadh, Saudi Arabia

Abstract. – OBJECTIVE: The purpose of this five-year follow-up study was to investigate the clinical and radiologic status of implants that had undergone abutment disinfection immediately prior to prosthetic loading (PL) using plasma of argon (PA) or 0.2% chlorhexidine (CHX) gel.

PATIENTS AND METHODS: Sixty patients who had had an implant-supported prosthesis fitted at least five years previously were recruited for this study. In groups 1, 2, and 3, implant abutment disinfection was performed using PA, 0.2% CHX, and a vapor protocol, respectively. Modified plaque index (mPI), modified bleeding index (mBI), probing depth (PD), and mesial and distal crestal bone loss (CBL) were measured. A questionnaire on routine oral hygiene, smoking habits, and systemic health status was also administered. Sample size estimation was performed, and group comparisons were made. Probability values less than 0.05 were considered statistically significant.

RESULTS: Group 1, 2, and 3 included 20 (20 implants) patients each. At five-year's follow-up, there was no difference in mBI, mPI, and PD in all groups. There was no significant difference in peri-implant CBL in all patients. None of the patients were immunosuppressed or had periodontal disease, and or had used nicotinic products within the past five years. Toothbrushing twice daily was reported by at least 90% of individuals in all groups. Flossing of interproximal spaces once daily was reported by at minimum 60% of individuals in all groups.

CONCLUSIONS: Disinfection of implant abutments directly before PL can be performed using AP, or 0.2% CHX gel.

Key Words:

Abutment, Argon of plasma, Chlorhexidine, Disinfection, Prosthetic loading.

Introduction

A deprived oral hygiene status is commonly linked with the etiopathogenesis of peri-implant diseases (PiD)¹⁻³. However, from a prosthodontic point of view components and geometry of implants may also play contribute towards the instigation and advancement of PiD. Canullo et al⁴ reported that implant prosthetic components are susceptible to contamination during handling and laboratory-based procedures. This challenges a bi-phase implant treatment (delayed-loaded implants) as such events increase likelihood of bacterial toxins leaking through micro-voids at the implant-abutment interface (IAI)⁴⁻⁶ thereby developing an inflammatory response that jeopardizes peri-implant osseous and soft tissues^{7,8}.

Decontamination of implant prostheses before delivery or prosthetic loading (PL) is commonly done using an autoclave (steam-disinfection); however, hyperthermia during steam disinfection may damage printed guides⁹. In combination with oxygen, rare gases such as Argon can generate reactive oxygen species *via* energy transfer reactions. A 21-days follow-up histomorphometric study¹⁰ on canine models showed a significantly higher bone to implant contact (>300%) and mean bone area fraction occupancy (>30%) in implant surfaces treated with AP than in controls (untreated surfaces)¹⁰. Correspondingly, in a study on 32 patients, Sinjari et al¹¹ applied 0.2 % chlorhexidine (CHX) gel (16 patients) or a placebo gel (n=16 patients) to the IAI and assessed crestal bone levels at one-year of follow-up. The results showed that crestal bone loss (CBL) was significantly higher

in the placebo-gel group than the test group (0.2% chlorhexidine)¹¹. An appraisal of scientific articles showed that there are no studies that have directly compared peri-implant soft tissue and osseous health in relation to implant abutment disinfection using plasma of argon (PA) and 0.2% CHX. The authors hypothesize that PA and 0.2% CHX are comparatively effective in terms of abutment disinfection before prosthesis delivery.

The purpose of this five-year follow-up study was to compare the clinico-radiographic status of implants that had been disinfected with PA, 0.2% CHX gel or steam instantly prior to PL.

Patients and Methods

Ethical Approval

Ethical approval was granted by Ethics Committee, Center for Dental Practice and Clinical Research, Saudi Arabia (SDPRC/051D-06OR). The guidelines for human experimentation recognized by the Helsinki Declaration were respected. All participants were required to read and sign an informed consent form. The right to withdraw without penalty was granted and a written information sheet about the objectives of this study was given to all patients.

Inclusion and Exclusion Criteria

Patients with a history of periodontal disease, and patients with implant prosthesis placed at least in the previous 5 years were included in the study. Current users of tobacco products and those using electronic nicotine delivery systems were excluded. In addition, patients with self-reported systemic diseases such as cancer, diabetes mellitus (DM) and cardiovascular anomalies were not included in the study as well as individuals who reported to have used antibiotics, steroids, and/or anti-inflammatory drugs in the past 40 day.

Grouping, Randomization, and Allocation Concealment

Group-1 consisted of patients whose abutments underwent PA disinfection. According to the records, PA disinfection was performed at -10 MPa pressure and 75 W at room temperature for 12 minutes in a plasma reactor (Diener Electronic, Ebhausen, Germany) as described in another study⁴. In group-2, a 0.2% CHX gel had been placed on the internally connected abutments prior to placement of the prosthesis¹¹. In Group-3, steam-disinfection had been performed immedi-

ately before PL. The assignment of individuals to their particular assemblies was obscured by principal investigator.

Blinding

All investigators that performed clinical, radiologic, and statistical analyses were blinded to the study groups.

Patient Demographic Data and Dental Implants

A questionnaire was used to collect information on gender, age, recent visits to dentists and/or hygienists, and tooth brushing and interproximal-flossing habits. Moreover, data on implant geometry, functional duration, insertion torque, insertion depth and type of prosthesis retention were reconstructed from patient's dental records. Patients were also asked if they ever experienced loosening of implant prosthesis since loading. This data was recorded and concealed by the principal investigator.

Clinical and Radiographic Parameters

Peri-implant modified bleeding index (mBI)¹², PD¹³ and PI¹² were measured on 6 surfaces per implant by a skilled examiner (kappa score 0.86). Using the long-cone paralleling technique^{14,15} digital intraoral radiographs were taken; and CBL was demarcated as a vertical void from 2 mm under IAI till crestal bone¹⁶. Clinical (kappa score 0.88) and radiographic investigations (kappa score 0.86) were performed by a researcher.

Statistical Analysis

Statistical analyses were performed using the commercial software SPSS version 22 (IBM Corp., Armonk, NY, USA). Group comparisons were done using one way analysis of variance and Bonferroni post-hoc adjustment tests. Statistical significance was noted for *p*-values which were less than 0.05. Associations between sex, age, oral hygiene habits (flossing/brushing), and implant dimensions and longevity were evaluated using logistic regression models. Power and sample sizes (nQuery Advisor 6.0, Statistical Solutions, Boston, MA, USA) were established using a pilot data. In order to detect a 2 mm difference in peri-implant PD in the study groups (alpha of 5%), it was estimated that with inclusion of at least 19 individuals per group, the study would have a power of 88%.

Results

Demographics

Groups 1, 2 and 3 comprised of 20 (9 females and 11 males), 20 (8 females and 12 males) and 20 (5 females and 15 males) participants with comparable mean ages, respectively. Brushing-teeth twice a day was reported by 90%, 95% and 90%, among subjects of groups 1, 2 and 3, respectively. Similarly, 70%, 60% and 75% patients in groups 1, 2 and 3 reported once daily interproximal flossing, correspondingly. All patients were receiving dental prophylaxis and periodic oral examinations semiannually as recommended by their oral healthcare professionals (Table I). Loosening of implant-retained prostheses since loading was reported by none of the participants.

Implants

Sixty implants (20, 20 and 20 in groups 1, 2 and 3, respectively) were assessed clinically and radiographically in the study participants. Implants were located in the region of missing mandibular bicuspid or molars. All implants were platform-switched and delayed-loaded; and had diameters and lengths ranging between 4-5 mm and 11-13 mm, respectively. All implants had been placed at bone level and had been restored with screw-retained restorations. In groups 1, 2 and 3, implants were functional for 5.28 ± 0.25 , 5.18 ± 0.16 and 5.22 ± 0.27 years, respectively.

Peri-Implant Soft-Tissue Parameters and Crestal Bone Loss

Statistical comparisons showed no difference in peri-implant mPI, CBL, mBI, and PD in the patient population (Table II). A nonsignificant correlation was observed between clinical and radiologic peri-implant parameters and gender, age,

brushing, and dentists' visits. There was no correlation between clinical and radiologic parameters and with implant dimensions and longevity (data not shown).

Discussion

The IAI is often criticized in the scientific literature for its role in the development and advancement of peri-implant disease¹⁷. The reason is that micro-gaps present at the IAI can allow toxins to escape and damage peri-implant tissues^{5,6}. We hypothesized that disinfection of abutments can be done using AP, 0.2% CHX or steam-disinfection and there is no difference in their disinfection effectiveness. Our 60 months' follow-up results are in accordance with this hypothesis as statistical evaluations showed no difference in the radiologic and clinical peri-implant parameters around implants in which abutment disinfection was done using AP (Group-1), 0.2% CHX gel (Group-2) or steam-disinfection (Group-3). These results are shown in Table II. Nevertheless, it is endorsed that these results be interpreted cautiously, as the results are by no means meant to debar the disinfection efficacy of AP and 0.2% CHX gel in comparison with steam disinfection.

Survival of dental implants is often linked with protocols such as insertion torque, surgical technique, and use of adjunct treatments like photobiomodulation and growth-factor therapy^{18,19}. However, we perceive that a critical factor irrespective of the protocols referenced above, that influences implant success and long-term survival is daily oral hygiene maintenance (DOHM). We support results of a two-year observational study in which, influence of DOHM on peri-implant clinical and

Table I. Characteristics of the study groups details.

| Parameters | Group-1 | Group-2 | Group-3 |
|---------------------------------------|-----------------------|-----------------------|-----------------------|
| Patients (n) | 20 | 20 | 20 |
| Gender | 11 males 9 females | 12 males 8 females | 15 males 5 females |
| Age in years | 49.8 ± 4.1 years | 47.4 ± 3.3 years | 45.7 ± 2.1 years |
| Daily toothbrushing | | | |
| Once daily | 2 (10%) | 1 (5%) | 2 (10%) |
| Twice daily | 18 (90%) | 19 (95%) | 18 (90%) |
| Interproximal flossing | | | |
| Once daily | 14 (70%) | 12 (60%) | 15 (75%) |
| 2 to 3 times per week | 6 (30%) | 8 (40%) | 5 (25%) |
| Routine visits to dentists/hygienists | | | |
| Annual | 0 | 0 | 0 |
| Every 6-months | 20 (100%) | 20 (100%) | 20 (100%) |

Table II. Peri-implant soft-tissue parameters and crestal bone loss.

| Parameters | Group-1 | Group-2 | Group-3 |
|---------------------------------|----------------|----------------|-----------------|
| Implants (n) | 20 | 20 | 20 |
| Modified plaque index | 0.3 ± 0.08 | 0.4 ± 0.04 | 0.5 ± 0.006 |
| Modified bleeding on probing | 0.2 ± 0.007 | 0.3 ± 0.004 | 0.3 ± 0.002 |
| Probing depth (mm) | 0.4 ± 0.05 mm | 0.4 ± 0.06 mm | 0.3 ± 0.03 mm |
| Crestal bone loss (mesial) (mm) | 0.2 ± 0.004 mm | 0.2 ± 0.002 mm | 0.3 ± 0.0005 mm |
| Crestal bone loss (distal) (mm) | 0.1 ± 0.005 mm | 0.2 ± 0.001 mm | 0.2 ± 0.005 mm |

radiologic status in medically compromised and healthy subjects was investigated¹. In an observational study¹, the authors demonstrated that as long as DOHM is strictly carried out, dental implants can remain clinically and radiologically stable in medically challenged as well as healthy individuals. We administered a questionnaire to all patients in which information related to DOHM was extracted. It is notable that at least 90% subjects in all groups were faithfully performing DOHM by brushing twice daily, and as many as 60% subjects in all groups were performing interproximal flossing at least once a day. Our clinical and radiological investigations support the self-reported DOHM information as minimal sites of plaque accumulation, gingival bleeding and pocketing were observed in all patients. In a prospective four-year follow-up study Corbella et al²⁰ investigated the effect DOHM protocols on implant survival in patients having undergone full-mouth rehabilitation using dental implants. All patients in the Corbella study²⁰ received professional dental hygiene treatment (PDHT) and oral hygiene instructions every six months. At 48 months of follow-up, Corbella and associates²⁰ concluded that adoption of a systematic oral hygiene maintenance protocol is effective in minimizing the risk of plaque accumulation around implants; thus, reducing the risk of complications or peri-implant diseases. We agree with the results of Corbella study²⁰. In our investigation, all participants received PDHT and regular oral examinations/instructions every six months at a dental facility (DF). Since DOHM and PDHT can keep dental implants clinically and radiologically stable up to at least 4 years in completely edentulous individuals²⁰, authors of the present investigation propose that these protocols can also benefit partially edentulous individuals (such as those included in our study) regardless of type of method used for abutment disinfection method used at PL.

Education and socioeconomic status (SES) are important factors that influence oral health²¹⁻²⁴.

Regrettably, the questionnaire used in the current investigation did not assess income and literacy status of the target population. Nevertheless, it is perceived that all patients were health literate and understood the importance of oral hygiene maintenance. Moreover, from a financial perspective, it is also speculated that all patients had a stable income status that possibly influenced them to visit their oral health care providers every six months and attain professional dental prophylaxis. It should also be emphasized that all participants that were assessed in the current investigation had a history of periodontal disease. It is possible that their DOHM protocols were initially compromised; and were educated about the significance of DOHM at the time of implant placement and/or PL, which most likely compelled them to improve their brushing and flossing habits and to visit their oral healthcare providers routinely for periodic examinations. The authors therefore suggest that there is not benefit of performing abutment disinfection prior to PL using AP or 0.2% CHX gel in individuals that are non-compliant towards routine dental visits. Thus, patient education and periodic oral evaluations should be recommended to all patients.

Stagnation or accumulation of plaque in the subgingival areas facilitates the growth of pathogenic bacteria including *Porphyromonas gingivalis*, *Escherichia coli* and *Treponema denticola* at the IAI and microleakage of their toxins through micro-gaps at the IAI is linked with the initiation and progression of peri-implant diseases²⁵. Similarly, the peri-implant sulcular fluid (PISF) volume and its cytokine profile are altered in patients with inflamed peri-implant soft and osseous tissues^{23,26,27}.

Limitations

Due to limitations in funding sources, objectives and span of the present study could not be expanded to incorporate microbiologic and immunologic investigations. In other words, subgingival plaque samples were not collected for

microbial in all groups. Moreover, tobacco-product users and patients with immunocompromised health statuses were not sought as these factors are independent risk factors of peri-implantitis irrespective of the type of abutment disinfection protocol used prior to PL^{3,23}. We hypothesize that DOHM in addition to routine visits to medical and dental healthcare providers can help minimize the risk of peri-implant infections in vulnerable populations and this is independent of the type of abutment disinfection protocol used before PL. Further studies are needed to these this hypothesis.

Conclusions

Decontamination of implant abutments directly before PL can be performed using AP or 0.2% CHX gel. Regular dental visits and DOHM significantly contribute towards maintaining peri-implant health after PL.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Funding

The authors are grateful to the Researchers supporting project at King Saud University for funding through Researchers supporting project (RSP2023R44), Riyadh, Saudi Arabia.

Ethics Approval

Ethical approval was granted by Ethics Committee, Center for Dental Practice and Clinical Research, Saudi Arabia (SDPRC/051D-06OR).

Informed Consent

All participants were required to read and sign an informed consent form. The right to withdraw without penalty was granted and a written information sheet about the objectives of this study was given to all patients.

Authors' Contributions

T. Abduljabbar was involved in conception and design, development of the method, data collection and analysis, manuscript writing and final approval of manuscript. T. Abduljabbar, F. Vohra, A. Alsahhaf, M. Alrabiah, K Ali were involved in manuscript correction, assistance with writing of the manuscript and final approval of the manuscript. A. Alsahhaf was involved in manuscript correction, assistance with writing of the manuscript and final approval of the manuscript.

Availability of Data and Materials

Data is available from the corresponding author on reasonable request.

ORCID ID

A. Alsahhaf: 0000-0002-3391-9027

M. Alrabiah: 0000-0003-0665-3734

Khalid Ali: 0000-0002-8222-1362

F. Vohra: 0000-0002-6204-7985

T. Abduljabbar: 0000-0001-7266-5886

References

- 1) Al Amri MD, Kellesarian SV, Al-Kheraif AA, Malmstrom H, Javed F, Romanos GE. Effect of oral hygiene maintenance on HbA1c levels and peri-implant parameters around immediately loaded dental implants placed in type-2 diabetic patients: 2 years follow-up. *Clin Oral Implants Res* 2016; 27: 1439-1443.
- 2) Al Amri MD, Kellesarian SV, Abduljabbar TS, Al Rifaiy MQ, Al Baker AM, Al-Kheraif AA. Comparison of Peri-Implant Soft Tissue Parameters and Crestal Bone Loss Around Immediately Loaded and Delayed Loaded Implants in Smokers and Non-Smokers: 5-Year Follow-Up Results. *J Periodontol* 2017; 88: 3-9.
- 3) Javed F, Romanos GE. Chronic hyperglycemia as a risk factor in implant therapy. *Periodontol* 2000 2019; 81: 57-63.
- 4) Canullo L, Micarelli C, Lembo-Fazio L, Iannello G, Clementini M. Microscopical and microbiologic characterization of customized titanium abutments after different cleaning procedures. *Clin Oral Implants Res* 2014; 25: 328-336.
- 5) Jansen VK, Conrads G, Richter EJ. Microbial leakage and marginal fit of the implant-abutment interface. *Int J Oral Maxillofac Implants* 1997; 12: 527-540.
- 6) King GN, Hermann JS, Schoolfield JD, Buser D, Cochran DL. Influence of the size of the microgap on crestal bone levels in non-submerged dental implants: a radiographic study in the canine mandible. *J Periodontol* 2002; 73: 1111-1117.
- 7) Harder S, Dimaczek B, Açil Y, Terheyden H, Freitag-Wolf S, Kern M. Molecular leakage at implant-abutment connection--in vitro investigation of tightness of internal conical implant-abutment connections against endotoxin penetration. *Clin Oral Investig* 2010; 14: 427-432.
- 8) Assenza B, Tripodi D, Scarano A, Perrotti V, Piattelli A, Iezzi G, D'Ercole S. Bacterial leakage in implants with different implant-abutment connections: an in vitro study. *J Periodontol* 2012; 83: 491-497.
- 9) Kim S, Choi C, Cha Y, Chang JS. The efficacy of convenient cleaning methods applicable for cus-

- tomized abutments: an in vitro study. *BMC Oral Health* 2021; 21: 78.
- 10) Coelho PG, Giro G, Teixeira HS, Marin C, Witek L, Thompson VP, Tovar N, Silva NR. Argon-based atmospheric pressure plasma enhances early bone response to rough titanium surfaces. *J Biomed Mater Res A* 2012; 100: 1901-1906.
 - 11) Sinjari B, D'Addazio G, De Tullio I, Traini T, Caputi S. Peri-Implant Bone Resorption during Healing Abutment Placement: The Effect of a 0.20% Chlorhexidine Gel vs. Placebo-A Randomized Double Blind Controlled Human Study. *Biomed Res Int* 2018; 2018: 5326340.
 - 12) Løe H. The Gingival Index, the Plaque Index and the Retention Index Systems. *J Periodontol* 1967; 38: Suppl: 610-616.
 - 13) Armitage GC, Svanberg GK, Loe H. Microscopic evaluation of clinical measurements of connective tissue attachment levels. *J Clin Periodontol* 1977; 4: 173-190.
 - 14) Updegrave WJ. The paralleling extension-cone technique in intraoral dental radiography. *Oral Surg Oral Med Oral Pathol* 1951; 4: 1250-1261.
 - 15) Khocht A, Janal M, Harasty L, Chang KM. Comparison of direct digital and conventional intraoral radiographs in detecting alveolar bone loss. *J Am Dent Assoc* 2003; 134: 1468-1475.
 - 16) Alahmari F, Javed F, Ahmed ZU, Romanos GE, Al-Kheraif AA. Soft tissue status and crestal bone loss around conventionally loaded dental implants placed in cigarette- and waterpipe (narghile) smokers: 8-years' follow-up results. *Clin Implant Dent Relat Res* 2019; 21: 873-878.
 - 17) Sasada Y, Cochran DL. Implant-Abutment Connections: A Review of Biologic Consequences and Peri-implantitis Implications. *Int J Oral Maxillofac Implants* 2017; 32: 1296-1307.
 - 18) Rösing CK, Fiorini T, Haas AN, Muniz F, Oppermann RV, Susin C. The impact of maintenance on peri-implant health. *Braz Oral Res* 2019; 33: e074.
 - 19) Vohra F, Al-Rifaiy MQ, Lillywhite G, Abu Hassan MI, Javed F. Efficacy of mechanical debridement with adjunct antimicrobial photodynamic therapy for the management of peri-implant diseases: a systematic review. *Photochem Photobiol Sci* 2014; 13: 1160-1168.
 - 20) Corbella S, Del Fabbro M, Taschieri S, De Siena F, Francetti L. Clinical evaluation of an implant maintenance protocol for the prevention of peri-implant diseases in patients treated with immediately loaded full-arch rehabilitations. *Int J Dent Hyg* 2011; 9: 216-222.
 - 21) Javed F, Näsström K, Benchimol D, Altamash M, Klinge B, Engström PE. Comparison of periodontal and socioeconomic status between subjects with type 2 diabetes mellitus and non-diabetic controls. *J Periodontol* 2007; 78: 2112-2119.
 - 22) ArRejaie AS, Al-Aali KA, Alrabiah M, Vohra F, Mokeem SA, Basunbul G, Alrahlah A, Abduljabbar T. Proinflammatory cytokine levels and peri-implant parameters among cigarette smokers, individuals vaping electronic cigarettes, and non-smokers. *J Periodontol* 2019; 90: 367-374.
 - 23) Javed F, Rahman I, Romanos GE. Tobacco-product usage as a risk factor for dental implants. *Periodontol* 2000 2019; 81: 48-56.
 - 24) Karaaslan F, Dikilitaş A, Yiğit U. The effects of vaping electronic cigarettes on periodontitis. *Aust Dent J* 2020; 65: 143-149.
 - 25) Baj A, Beltramini GA, Bolzoni A, Cura F, Palmieri A, Scarano A, Ottria L, Gianni AB. Bacterial colonization of the implant-abutment interface of conical connection with an internal octagon: an in vitro study using real-time PCR. *J Biol Regul Homeost Agents* 2017; 31: 163-168.
 - 26) Abduljabbar T, Al-Sahaly F, Kellesarian SV, Kellesarian TV, Al-Anazi M, Al-Khathami M, Javed F, Vohra F. Comparison of peri-implant clinical and radiographic inflammatory parameters and whole salivary destructive inflammatory cytokine profile among obese and non-obese men. *Cytokine* 2016; 88: 51-56.
 - 27) Javed F, Al-Hezaimi K, Salameh Z, Almas K, Romanos GE. Proinflammatory cytokines in the crevicular fluid of patients with peri-implantitis. *Cytokine* 2011; 53: 8-12.