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Research Article

Short-Term Clinical and Radiological Outcomes of Argon-Plasma Cleaned SLA Implants: A Retrospective Study

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Abstract

Background The aim of this retrospective study was to evaluate cumulative survival rate and bone loss around argon-plasma treated SLA implants followed for one year after functional loading. Materials and methods A total of two hundred nine implants placed in fifty-three patients from 2021 to 2022 were investigated with several identified risk factors (sex, systemic disease, smoking, length, implant recipient site, the type of superconstruction) Clinical examination (mobility, percussion, screw loosening, discomfort, etc.) and radiographic examination data were collected from patient records including all problems during follow-up period according to protocols described earlier. Results Two of 209 implants were failed. Both were inserted in the anterior mandible and the failure occurred three and seven months after functional loading, respectively. The 1-year implant cumulative survival rate was 99.19%. The bone loss > 2mm observed in 7.18% (n:15) of the patients. The regression analysis showed no significant predictive association between systemic disease, smoking and prosthodontic design with neither overall CSR nor bone loss. The screw/ abutment related mechanical complications were not seen. Conclusion Despite its limitations regarding the follow-up period and sample size of the current data, argon-plasma treated SLA implants (Dentcon® Ankara-Turkey) presented promising clinical results without showing mechanical failures.

Keywords: *argon-plasma; bone loss; survival; titanium*

Introduction

Within the past decades, endosseous dental implants have fundamentally altered the process of replacing missing or partially missing teeth. The success of implant-supported restorations as a method for oral rehabilitation has been shown by the high survival rates reported for both single and multiple missing tooth replacements [1]. However, certain implant patients run the risk of experiencing failure, peri-implantary infection related substantial bone loss, infections and mechanical complications.

It is well known that multiple variables could be responsible for implant failure. Some of the statistically analyzed factors associated with implant failure include; age and sex, smoking, systemic disorders, the implant site, quantity and quality of bone and implant surface treatments and features [2]. Implant failure has been categorized as early and late losses in various studies according to different intervals [3]. Several studies have proposed the first year after functional loading of the implants as a cutoff time point and determined the failures during this phase as "early failures" [4,5]. The implant failures within the one year after functional loading has been proclaimed to be associated with insufficient primary stability, infections, host immunity, genetic, immunological, and immunological factors[6].

Surface treatment by argon plasma has been initially used as the last step of the manufacturing process of titanium implant fixtures before their sterilization by gamma rays[7]. Based on encouraging results, the use of this technology for the decontamination of infected rough implant surfaces has been widened. Moreover, after chair-side use was available, plasma applications opened new possible strategies in the field of peri-implantitis therapy thanks to their positively effects on the response of soft and hard peri-implant tissues and biofilm management.

Dental clinicians are unfortunately particularly able to give patients seeking dental implant treatment specific answers to their questions due to conflicting data from studies [8]. It is crucial that the clinical results combined with the animal studies are reported in scientific publications when new implant systems are commercially released. Even though dental implants are developing more rapidly, there aren't many clinical studies that show how well they work for the local population. Therefore, the purpose of this study was to identify the risk factors for implant failure and to assess the short-term clinical outcome of the argon-plasma treated SLA implants.

Materials and Methods

Study design

The study was approved by the Ethics Review Committee of Istanbul Yeni Yüzyil University (21.11.2022/37). Data of the patients who underwent implant supported prosthetic rehabilitation between April 2021 and May 2022 at the university clinic of Yeni Yüzyil University, Faculty of Dentistry were screened for participation retrospectively.

Inclusion criteria were [9].:

- Natural dentition or tooth/implant supported fixed dentures of the opposing jaw
- Absence of medical contraindications for oral surgical procedures (ASA I and II)
- Ability to maintain personal oral hygiene.

Exclusion criteria were [9]:

- Patients with uncontrolled systemic diseases and/or having possible contraindications for implant surgery which could jeopardize the osseointegration (uncontrolled diabetes, osteoporosis, psychiatric disorders, pregnancy, etc.; (>ASAII)
- Medication potentially influencing the osseointegration process
- Formerly neighboring neoplasms or inflammatory processes at the implant recipient site
- Radiotherapy to the head and neck region in the last 24 months
- Bruxism
- Poor oral hygiene and/or compliance
- The existence of a cantilever by the superstructure
- The need for simultaneous bone augmentation including sinus lift.

The risk factors that could affect an implant survival rate were grouped into the following categories [10].:

- The patient's age and gender at time of implant placement
- Health-status: ASA I vs. ASA II
- Implant variables: implant size, recipient site and number of implants
- Prosthetic variables: grouped according to prosthesis type and prosthetic design (single, fixed, removable, etc)

Surgical procedure

All procedures were performed under local anesthesia. All of the patients received argon-plasma treated (Figure 1) SLA implants (Dentcon® Ankara-Turkey) according to the two-staged protocol determined by the manufacturer.

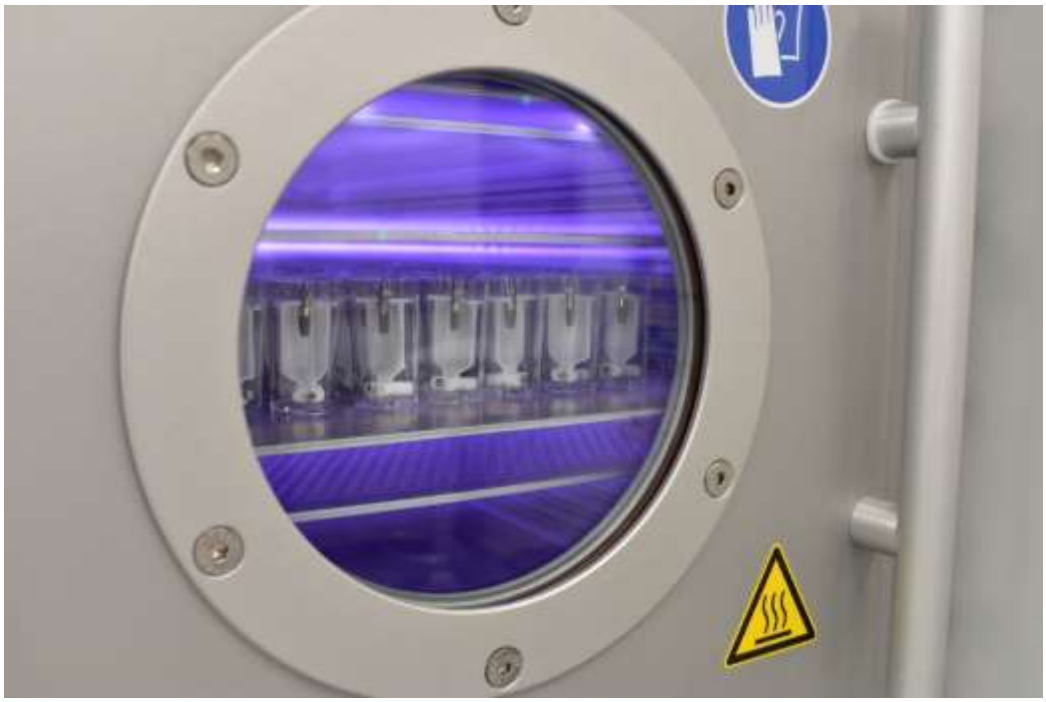

Figure 1. Prior to gamma sterilization, all implants were treated with argon for 10 minutes under 120 mBar. (Nano-low-pressure-plasma-systems- Plasmacleaner, Ebhausen, Germany)

Implant sizes ranged between 6 to 13 mm in length and 3,50 to 5, 0 mm in diameter. Briefly, a mucoperiosteal flap was raised at the ridge crest with relieving incisions on the buccal aspect and the implant cavities were prepared according to the manufacturer's guidelines. The insertion of the implants followed by a single experienced surgeon according to standard procedures, with achieving a peak insertion torque of at least 25 N/cm. Primary closure and suturing of the flap was performed with 3–0 non-resorbable sutures. A single shot antibiotic (Amoxicillin 875 mg/clavulanic acid 125 mg) were given 1 h prior to surgery. Healing caps were mounted 3 months postoperatively.

Prosthetic procedure

All final prostheses were delivered 7-10 one week after the second surgery by a single dental dental prosthodontist. (Figure 2) The laboratory phases were performed by the same dental technician at the same dental laboratory. The definitive crowns consisted of a standard titanium abutment (Dentcon® Ankara-Turkey), with a metal-supported ceramic veneer suprastructure. For removable prosthesis, patients were assigned to subgroups according to their own preference of the connection type.

Outcome parameters

Implant survival, radiological bone loss, prosthetic complications and oral-heath-related quality of life were documented for each implant immediately after functional loading and with 6-month intervals during a period of one year.

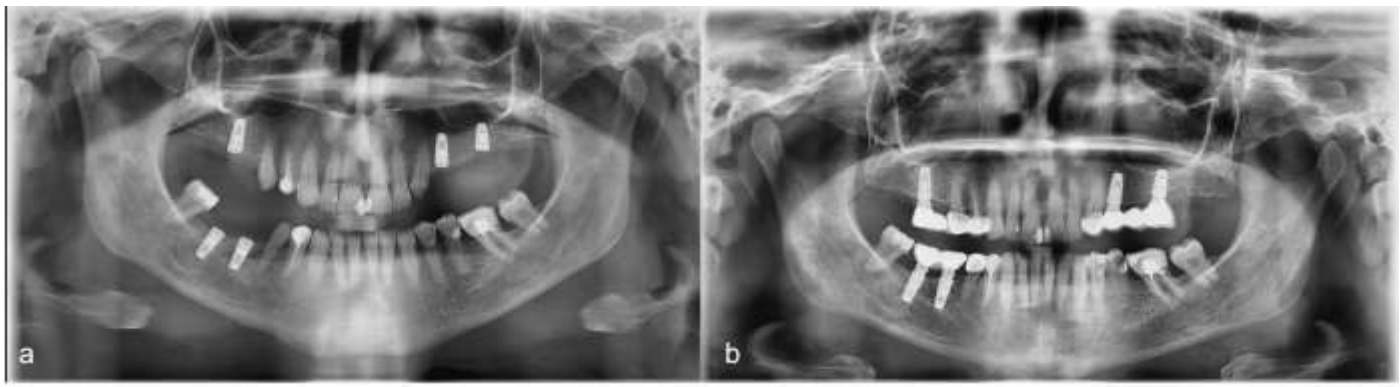

Figure 2. The radiographic visualization of the rehabilitation of a patient. Immediately after implant insertion (left), one year after prosthetic rehabilitation (right). Please note the crestal bone stability.

Bone resorption was evaluated by measuring the bone crest levels around the implants via standard right-angle parallel technique with single digital radiographs as described by Brägger [11]. The radiographs were scanned at 600 dpi (Trophy RVG UI USB Sensor, KODAK 5.0 software, Carestream, Stuttgart, Germany) and a special image analysis software was used to assess bone level (IC Measure, The Imaging Source Europe GmbH, Bremen, Germany) (Figure 3) [12].

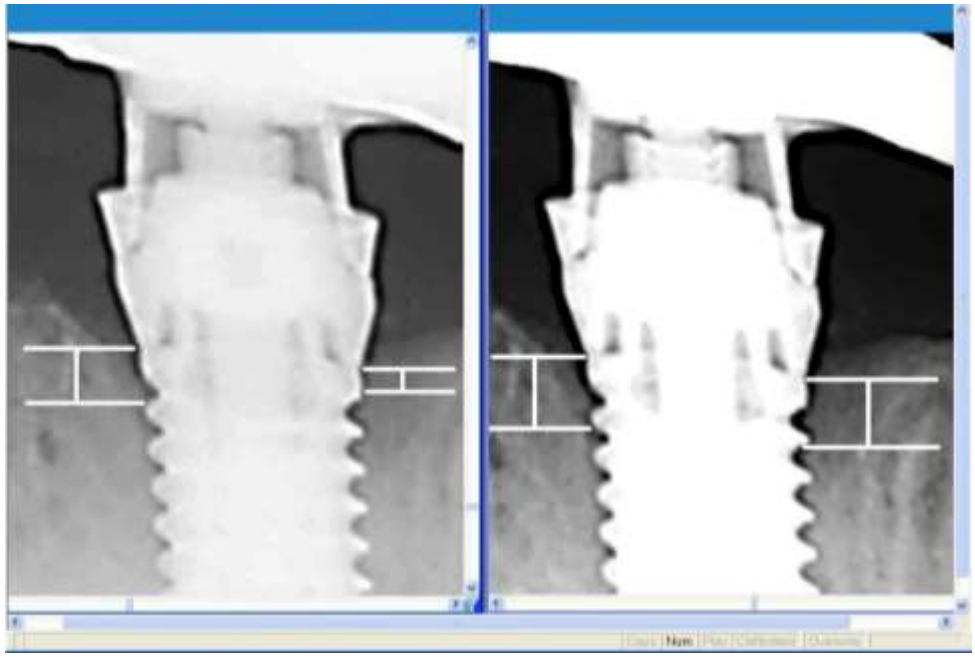

Figure 3. For the assessment of the bone loss, radiographs were scanned at 600 dpi (Trophy RVG UI USB Sensor, KODAK 5.0 software, Carestream, Stuttgart, Germany) and a special image analysis software was used to assess bone level (IC Measure, The Imaging Source Europe GmbH, Bremen, Germany)

Patients' satisfaction and the impact of the reconstruction on the quality of life was assessed by using the Turkish version of OHIP11- 16, which considers 14 metrics in seven domains using a five-point verbal rating scale ranging from "never" (coded 0) to "very often" (coded 4) [13]. Preoperative OHIP measurement was taken as reference. Low point scores represent a high quality of life.

In addition to the above-mentioned parameters, prosthetic complications were also documented during the examination period.

Statistical analysis

The demographic characteristics of the individuals included in the study were assessed by frequency analysis. Comparative assessment of bone loss was examined on the basis of the demographic findings of the individuals and correlation analyzes were made considering the expected values of the observations of the nxr-shaped cross tables. Logistic regression analysis was performed on the basis of demographic characteristics that were found to be significant on the bone loss groups.

Then, the variables that were not significant on the logistic regression were removed from the model and a reduced logistic regression model was created. The reduced logistic regression analysis was obtained using the Backward (Wald) method. The margin of error was taken as 5% in the evaluation of statistical hypothesis tests. Findings on hypothesis testing were obtained using the IBM SPSS 26 program.

Results

The data of 53 patients (21 men and 32 women aged ranged between 20 and 69 (mean: 51 ± 4.59 years) were included. Totally, 209 implants were inserted. The results of the demographic findings and the systemic diseases and smoking status of the individuals included in the study are given in Table 1.

	n	**%**
Gender		
Male	21	39,62
Female	32	60,37
ASA		
ASA 1	21	39,62
ASA 2	32	60,37
Smoking status		
-	37	69,81
+	16	30,18

Table 1. The results of the demographic findings of the individuals and risk factors. According to the ASA variable, the rate of disease-free individuals is 39,62% and the rate of individuals included in ASA II classification is 60,37%. The rate of individuals who do not smoke was 69,81%.

During the examination period of 12 months after functional loading, two implant losses have been observed. Both losses were the implants placed in the anterior mandible and have occurred after three and seven months of loading, respectively. No implant losses were detected prior to prosthetic treatment. However, the statistical examination of odds-ratio revealed no significance.

The bone loss around 91,9% of the implants remained well within the limits for ‘success, as defined by the 2007 Pisa consensus over the time (>2 mm) [14]. Marginal bone loss was pronounced around 7,14% of the implants however, no correlation could be observed regarding the age, gender, ASA and smoking status and prosthetic suprastructure type (Table 2).

Variable		n	%
Bone loss			
	-	192	91,9
	>2mm	15	7,14
	Fail	2	0,95
Region			
	Anterior mandible	22	10,95
	Anterior maxilla	27	12,86
	Posterior mandible	71	33,81
	Posterior maxilla	89	42,38
Implant length (mm)			
	6	11	5,24
	8	43	20,48
	10	41	19,52
	11,5	90	42,86
	13	24	11,90
Implant diameter (mm)			
	3,5	36	17,62
	4	139	66,19
	4,5	27	12,86
	5	7	3,33
Distribution regarding the suprastructure type			
	Fixed suprastructures	98	47,59
	Removable suprastructures	18	8,65
	Crown (single implant)	90	43,75

Table 2. Logistic regression result regarding the implant failures and bone loss revealed that, none of the variables have a significant effect ($p>0.05$).

There was a pronounced subjective improvement, as assessed by the Oral Health Impact Profile (OHIP) score which includes 14 items in seven domains (functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap) with a five-point verbal rating scale ranging from “never” (coded 0) to “very often” (coded 4) (Figure 4).

The survival rates for final prostheses were 100%. No loosening or fracture of the abutment screw was observed. Overall, no further mechanical complications were registered during the observation period.

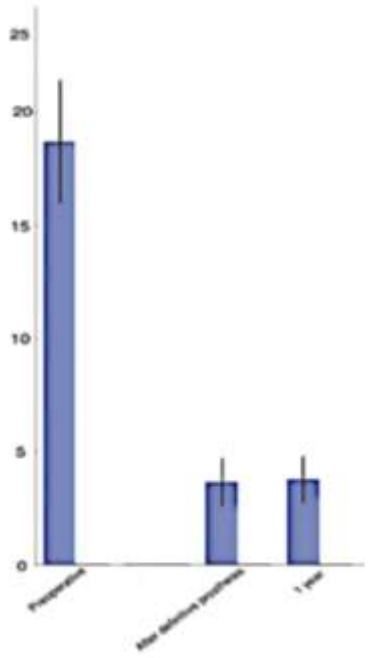

Figure 4. There was a pronounced subjective improvement, as assessed by the Oral Health Impact Profile (OHIP) score which includes 14 items in seven domains (functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap) with a five-point verbal rating scale ranging from "never" (coded 0) to "very often" (coded 4).

Discussion

Titanium or titanium alloys are mostly used biomaterials in dental implantology and alterations in their surface can modify the cellular functional response to improve the osteointegrative properties [15]. It is well known that an argon plasma treatment could generate a surface with improved mechanical proprieties without modifying its chemical composition. It could also reduce the oxidative stress, which is considered one of the major causes of dental implant failure [16]. Despite scientifically proven implant designs and surfaces with high survival rates, implant failure can occur. Finding and diagnosing the pitfalls from the scientific perspective via clinical studies is the first step in post market surveillance. Therefore, the current study aims to evaluate the short-term clinical and radiological outcomes of the argon-plasma treated SLA implants (Dentcon® Ankara-Turkey).

Implant surface treatments via plasma of Argon have been studied over the years in order to decontaminate the surface, increase wettability and enhance cell adhesion [17]. Ex-vivo studies showed the activation of surfaces, which leads to increasing cell proliferation [18,19]. The main advantage of these effects is, that they could be achieved without changing the surface topography [20]. In vivo studies also showed clinical benefits influencing hard and soft tissue levels and cell adhesion, especially in biofilm management. Recently, Flörke et al. showed that, cols atmospheric plasma combined with mechanical debridement could be a feasible treatment modality in the management of peri-implantitis due to the antimicrobial effects of cold atmospheric plasma [21].

The literature survey shows that the effect of age on implant failure is controversial. Moy et al. [22] reported that the rate of implant failure was higher among patients aged >60 years, whereas Park et al. [23] reported a high survival rate in elderly people (older than 65 years) after appropriately controlling for systemic disease and carefully selecting the implant system. The present study similarly found no significant age-related differences in healthy individuals or patients with well-controlled systemic diseases.

The implant failures reported herein were those placed in the anterior mandible. This finding is inconsistent with several studies that the weighted odds ratio for early implant failure was unfavorable for posterior maxilla placement [24]. Higher failure rates in implants placed in the mandible have been also reported by Kang et al. [25] previously. Despite the limited sample size, we think that the higher risk of early implant failure in the mandible should not overlooked.

It is obvious that, there are many different aspects that contribute to early bone loss, regardless of the cause the overall amount of bone loss may affect clinical criteria of success to failure. Misch at al [14] have stated that the marginal bone loss for the quality of health scale should include the first year. Moreover, in addition to the subjective parameters such as: no pain observation with palpation, percussion, or function and no clinical implant mobility notification in any direction with loads less than 500 g, the observation of less than 2.0 mm of radiographically crestal bone loss compared with the implant insertion surgery represents “success” [14]. The results of the current study revealed an average crestal bone loss for 91,9% of the implants after one year of functional loading, which is in physiological limits as suggested by Pisa consensus conference. However, for the definitive assessment of marginal bone loss, the follow-up period should be at least 5 years to obtain reliable results, because shorter observation periods might lead to different conclusion [12].

The literature provides strong evidence for higher surface roughness and a greater affinity for biofilm formation, with the consequence of increased exudation in periodontal or peri-implant soft tissues for acrylic restorations [12,26]. In the current study, most of the implants (n: 12/15) with a bone loss of > 2 mm were of the patients who were treated with acrylic overdentures. Therefore, increased bone resorption around those implants could be pretty much attributed to the increased inflammatory changes during the whole examination period.

In the literature, a strong link between residual sub-mucosal cement and peri-implant diseases has been found [27]. Considering the fact that all fixed prosthetic superstructures included in the current study were cemented, it might be proclaimed that the implant system examined herein showed lower marginal bone loss despite the overwhelmingly use of cemented restorations (91,35%) in the study sample.

The fracture of an osseointegrated implant, which necessitates the removal of remaining implant parts-and in some cases including the surrounding bone-is one of the main challenges in the dental implantology [28]. Considering the results of the present study, no fracture of the implant could be observed, which allows us to proclaim that the system evaluated herein shows safe characteristics considering the fracture resistance. Additionally, it has been proclaimed that other mechanical failures of implant and supported prosthesis such as loosening or fracture of the screws have similar prevalence to biological and esthetic failures, and therefore need to be given due credence and the identification of specific factors contributing to such failures can help reduce incidence[29]. Within the results of the current study, no loosening/fracture of the retention elements could be observed. This fact might be attributed to the 2 mm diameter connection screws and precise connection. It should be also kept in mind that, the torque values determined by the manufacturer should be reached to avoid a possible complication regarding the connection elements.

It is obvious that, bruxism, uncontrolled systemic diseases, antiresorptive therapy, corticosteroid therapy and existing periodontal pathologies could negatively affect the osseointegration process and result in implant failures. In the current study, implant survival rate was determined as >99% and the marginal bone loss was nearly within physiological limits. The highly selected patient group in the present study with the exclusion of common risk factors for implant failures could also be seen as a limitation.

Conclusions

The extensive use of implants, which is expected to furtherly rise over the next years, means that dental practitioners have to learn how to deal with implant complications. Parallel to the developments in materials sciences, novel surface treatment strategies available, which might be confusing for the dental professionals. To avoid the possible problems, the pitfalls and potential future remedies should be assessed with clinical studies.

Despite the limitations regarding the follow-up period and sample size, it could be concluded that argon-plasma treated SLA implants presented promising clinical results in terms of both survival rates and bone loss without showing mechanical failures. Further studies with greater sample size focusing on additional peri-implantary health parameters are needed.

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