

A group of scientists in white lab coats are gathered around a large, illuminated digital display in a dark laboratory. They are pointing at the screen, which shows a complex, glowing blue and white molecular or cellular structure. The scene is dimly lit, with the primary light source being the display itself, creating a focused and professional atmosphere.

# Research Highlights

# \*Research Highlights



First Author: **Dr. Christian Makary**  
 Corresponding Author: **Dr. Tonino Traini**  
 Clinical trial with histologic study at 4 week  
 Publication in 2024



## Bone-to-Implant Contact in Implants with Plasma-Treated Nanostructured Calcium-Incorporated Surface (XPEEDActive) Compared to Non-Plasma-Treated Implants (XPEED): A Human Histologic Study at 4 Weeks

Christian Makary<sup>1</sup>, Abdallah Menhall<sup>1</sup>, Pierre Lahoud<sup>1</sup>, Kyung Ran Yang<sup>2</sup>, Kwang Bum Park<sup>3</sup>, Dainius Razukevicius<sup>4</sup> and Tonino Traini<sup>5,\*</sup>

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**Abstract:** Titanium implants undergo an aging process through surface hydrocarbon deposition, resulting in decreased wettability and bioactivity. Plasma treatment was shown to significantly reduce surface hydrocarbons, thus improving implant hydrophilicity and enhancing the osseointegration process. This study investigates the effect of plasma surface treatment on bone-to-implant contact (BIC) of implants presenting a nanostructured calcium-incorporated surface (XPEED®). Following a Randomized Controlled Trial (RCT) design, patients undergoing implant surgery in the posterior maxilla received additional plasma-treated (n = 7) or -untreated (n = 5) 3.5 × 8 mm implants that were retrieved after a 4-week healing period for histological examination. Histomorphometric analysis showed that plasma-treated implants exhibited a 38.7% BIC rate compared to 22.4% of untreated implants (p = 0.002), indicating enhanced osseointegration potential. Histological images also revealed increased bone formation and active osteoblastic activity around plasma-treated implants when compared to untreated specimens. The findings suggest that plasma treatment improves surface hydrophilicity and biological response, facilitating early bone formation around titanium implants. This study underscores the importance of surface modifications in optimizing implant integration and supports the use of plasma treatment to enhance osseointegration, thereby improving clinical outcomes in implant dentistry and offering benefits for immediate and early loading protocols, particularly in soft bone conditions.

**Keywords:** titanium implants; plasma surface treatment; osseointegration; implantology; bone-to-implant contact; surface modification; immediate loading

**1. Introduction**  
 Titanium (Ti) fixtures are currently a quintessential part of modern dentistry [1]. They offer restorative solutions that would have otherwise been impossible [2]. With the fast evolution of all medical fields and the rise of the digital era, there is a continuous need for better, faster, and easier treatment modalities [3]. The modern dental implant has received

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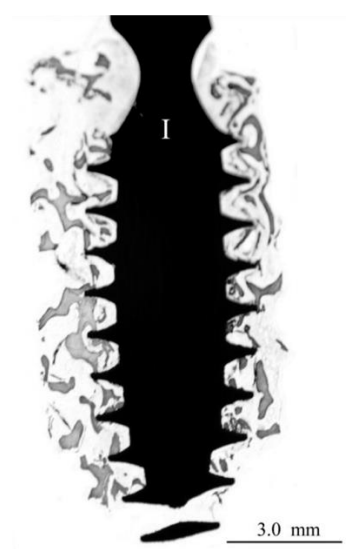
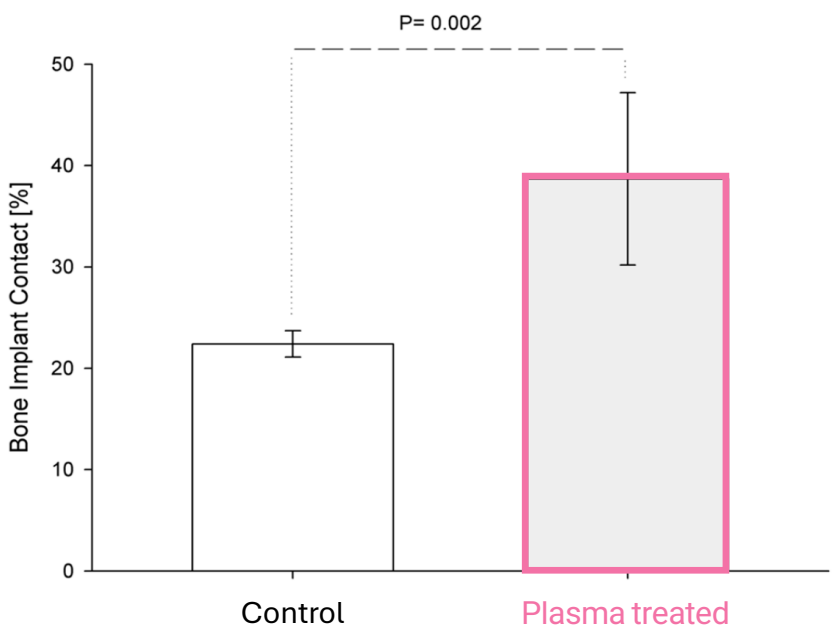
### Clinical Benefit

To increase success rate for soft bone conditions such as the posterior maxilla (Clinical trial, n= 14)

The bone implant contact rate (BIC mean ±SD) for the treated group was 38.7 ± 8.5 %, while for the control group was 22.4% (±1.3) in which the difference of 16.3% was statistically significant (p=0.002).

The plasma treatment improve outcomes, especially with respect to implants having the highest risk of failure, thus creating an unmet clinical need as in the following cases:

- Clinical cases necessitating **immediate or early loading protocols**.
- Clinical cases with **soft (type 4) bone conditions** in the posterior maxilla where sufficient stability and osseointegration could be difficult to attain



Control



Plasma treated

**This clinical study demonstrates that the vacuum plasma treatment can enhance bone-to-implant contact, and it enables early loading particularly in soft bone conditions**



First Author: **Dr. Myron Nevins**  
 Corresponding Author: **Dr. David Kim**  
 Preclinical In vivo test using Canine model  
 Publication in 2023



## Gas Plasma Treatment Improves Titanium Dental Implant Osseointegration—A Preclinical In Vivo Experimental Study

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**Abstract:** Recent technological advancements led to the development of various plasma-based technologies for post-packaging modifications. The purpose of the present preclinical in vivo study was to assess the safety and efficacy of a novel chairside nonthermal gas plasma treatment for enhancing osseointegration of titanium implants. Six male mixed foxhounds underwent extraction of mandibular premolars and first molars, and the sockets healed for 42 days. Canine mandibles were randomized to receive either plasma-treated (test) or non-plasma-treated (control) dental implants. A total of 36 implants were placed in six animals, and they were sacrificed at 2 weeks (two animals), 4 weeks (two animals), and 6 weeks (two animals) after the implant surgery. When the radiographic analysis was performed, the changes in bone level were not statistically significant between the two groups at 2 weeks and 4 weeks. The difference became significant at 6 weeks ( $p = 0.016$ ), indicating more bone loss from baseline to 6 weeks for the control group. The bone-to-implant contact (BIC) appeared to be higher for the test groups at all time points, and the BIC was significantly higher for the test group at 4 weeks ( $p = 0.046$ ). In conclusion, this study underscored the potential of nonthermal plasma treatment in enhancing implant osseointegration.

**Keywords:** plasma treatment; dental implant; osseointegration; bone-to-implant contact; sandblasted large grit acid-etched surface; histology; histomorphometric analysis

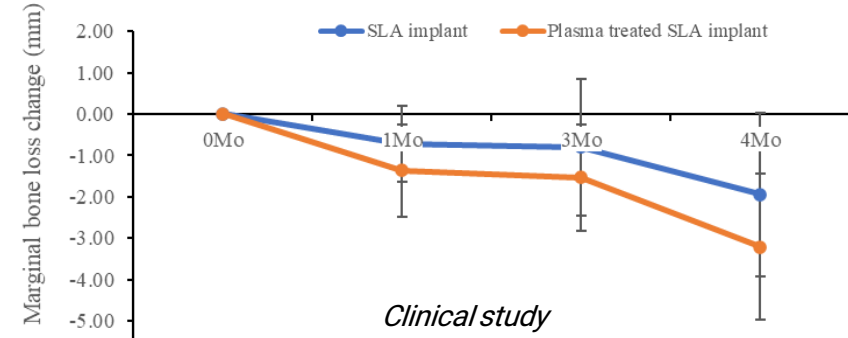
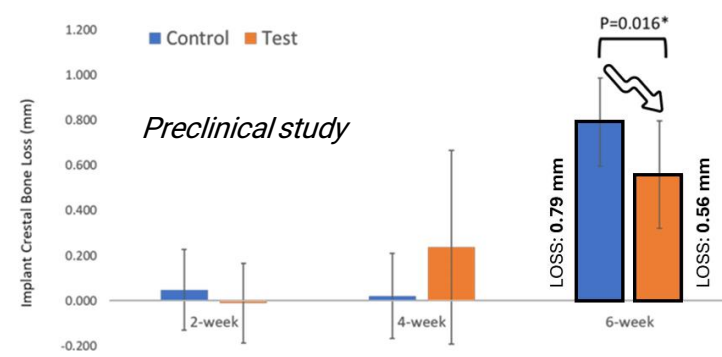
### 1. Introduction

Titanium dental implants are considered one of the most preferred and predictable treatment options for patients with missing teeth and occlusal rehabilitation [1]. The short- and long-term success of titanium dental implants is attributed to their ability to establish osseointegration, defined as the direct structural and functional connection between the living bone and the surface of a load-bearing implant [2]. A myriad of factors, such as implant design, surface composition, surface chemistry, surface roughness, surgical techniques, and the host-immune response, play a significant role in whether the titanium implant will achieve osseointegration or fibrointegration [3,4]. The dental implant's primary stability depends on the shape and surface morphology, and the secondary stability depends mainly on the implant surface [4].

The implant surface characteristics, particularly surface roughness and hydrophilicity, are regarded as one of the most critical factors in achieving a high bone-to-implant contact (BIC) [5,6]. With enhanced surface energy and wettability, a hydrophilic surface has been

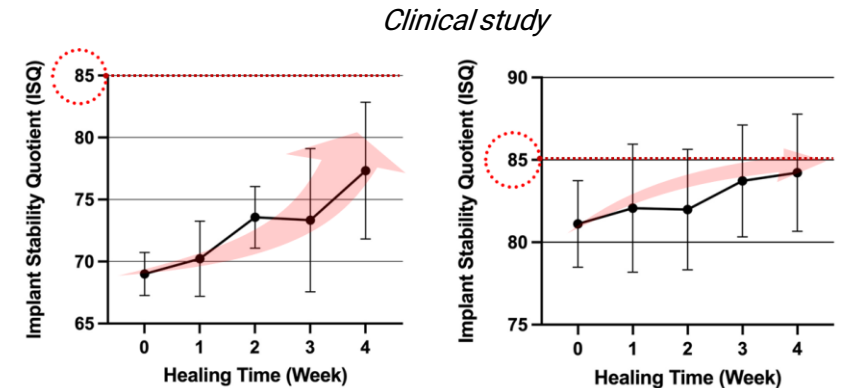
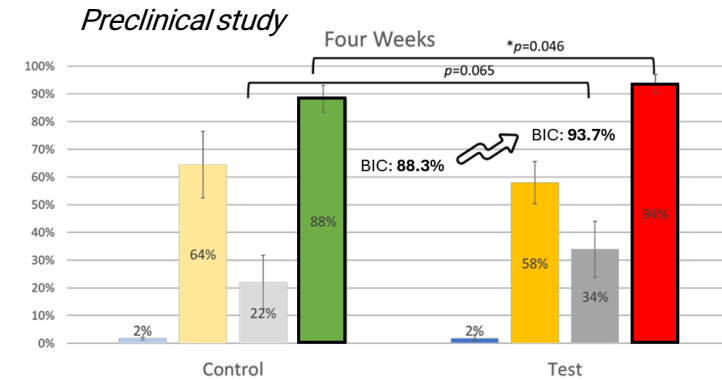
### Clinical Benefit #01 To reduce marginal bone loss by improving osseointegration

- Patient Population: Normal patient
- Indication for use: ACTILINK is used to treat short SLA-type implant fixture for improving success rate



### Clinical Benefit #02 To increase ISQ (Early Restoration)

- Patient Population: Normal patient (Who needs or wants immediate loading)
- Indication for use: ACTILINK is used to treat any SLA-type implant fixture for immediate loading with improved success rate



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 Citation: Nevins, M.; Chen, C.-Y.; Parma-Benfenati, S.; Kim, D.M. Gas Plasma Treatment Improves Titanium Dental Implant Osseointegration—A Preclinical In Vivo Experimental Study. *Bioengineering* **2023**, *10*, 1181. <https://doi.org/10.3390/bioengineering10101181>  
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**This preclinical study demonstrates that the vacuum plasma treatment can reduce marginal bone loss, and it enables shorter healing time for early loading**



First Author: **Dr. Myron Nevins**  
 Corresponding Author: **Dr. David Kim**  
 Preclinical In vivo test using Canine model  
 Publication in 2023



**A** (Clean surface) + **B** (Hydrophilicity) = **C** (Enhanced osteoblast cell activity)  
 It implies enhanced BIC leading to improved performance



Article  
**Gas Plasma Treatment Improves Titanium Dental Implant Osseointegration—A Preclinical In Vivo Experimental Study**

Myron Nevins <sup>1</sup>, Chia-Yu Chen <sup>1</sup>, Stephano Parma-Benfenati <sup>2</sup> and David M. Kim <sup>1,\*</sup>

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<sup>2</sup> Independent Researcher, Corso della Giovecca, 155, 44121 Ferrara, Italy; info@studioparmabenfenati.it  
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**Abstract:** Recent technological advancements led to the development of various plasma-based technologies for post-packaging modifications. The purpose of the present preclinical in vivo study was to assess the safety and efficacy of a novel chairside nonthermal gas plasma treatment for enhancing osseointegration of titanium implants. Six male mixed foxhounds underwent extraction of mandibular premolars and first molars, and the sockets healed for 42 days. Canine mandibles were randomized to receive either plasma-treated (test) or non-plasma-treated (control) dental implants. A total of 36 implants were placed in six animals, and they were sacrificed at 2 weeks (two animals), 4 weeks (two animals), and 6 weeks (two animals) after the implant surgery. When the radiographic analysis was performed, the changes in bone level were not statistically significant between the two groups at 2 weeks and 4 weeks. The difference became significant at 6 weeks ( $p = 0.016$ ), indicating more bone loss from baseline to 6 weeks for the control group. The bone-to-implant contact (BIC) appeared to be higher for the test groups at all time points, and the BIC was significantly higher for the test group at 4 weeks ( $p = 0.046$ ). In conclusion, this study underscored the potential of nonthermal plasma treatment in enhancing implant osseointegration.

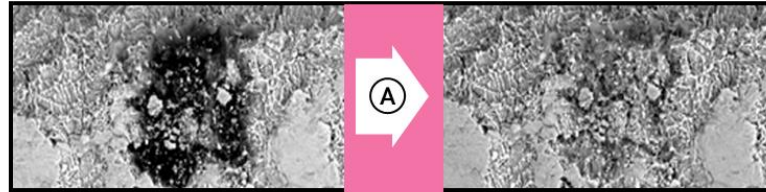
**Keywords:** plasma treatment; dental implant; osseointegration; bone-to-implant contact; sandblasted large grit acid-etched surface; histology; histomorphometric analysis

**1. Introduction**

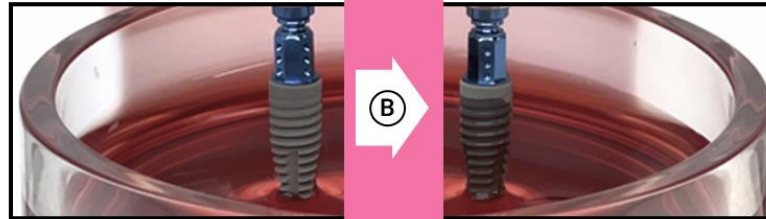
Titanium dental implants are considered one of the most preferred and predictable treatment options for patients with missing teeth and occlusal rehabilitation [1]. The short- and long-term success of titanium dental implants is attributed to their ability to establish osseointegration, defined as the direct structural and functional connection between the living bone and the surface of a load-bearing implant [2]. A myriad of factors, such as implant design, surface composition, surface chemistry, surface roughness, surgical techniques, and the host-immune response, play a significant role in whether the titanium implant will achieve osseointegration or fibrointegration [3,4]. The dental implant's primary stability depends on the shape and surface morphology, and the secondary stability depends mainly on the implant surface [4].

The implant surface characteristics, particularly surface roughness and hydrophilicity, are regarded as one of the most critical factors in achieving a high bone-to-implant contact (BIC) [5,6]. With enhanced surface energy and wettability, a hydrophilic surface has been

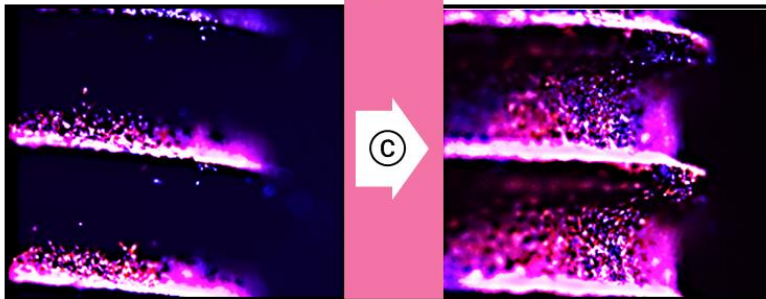
**A. Reduced hydrocarbon impurities to obtain clean surface**



**B. Increased surface energy to obtain hydrophilic property**



**C. Enhanced osteoblast cell activity with increased actin and nucleus**



**Table 1.** Statistical analysis demonstrating a significant difference in BIC between control and test implants at week 4.

	Control (Mean ± SD)	Test (Mean ± SD)	p-Value
<b>Osteoid (%)</b>			
2 weeks	2.2 ± 1.0%	3.6 ± 0.5%	0.366
4 weeks	1.7 ± 0.5%	1.8 ± 1.1%	0.853
6 weeks	1.8 ± 1.0%	1.1 ± 0.2%	0.224
<b>New bone (%)</b>			
2 weeks	57.7 ± 7.7%	62.8 ± 8.3%	0.316
4 weeks	64.4 ± 12%	58.0 ± 7.6%	0.292
6 weeks	71.4 ± 10.1%	73.4 ± 5.3%	0.914
<b>Old bone (%)</b>			
2 weeks	16.8 ± 10.8%	15.0 ± 7.7%	0.765
4 weeks	22.1 ± 9.7%	33.9 ± 10.1%	0.065
6 weeks	10.3 ± 4.7%	14.4 ± 6.8%	0.326
<b>BIC (%)</b>			
2 weeks	76.7 ± 11.0%	81.4 ± 6.9%	0.428
4 weeks	88.3 ± 4.8%	93.7 ± 3.3%	<b>0.046</b>
6 weeks	83.5 ± 10.2%	88.9 ± 4.8%	0.284



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# \*Research Highlights



First Author: Dr. Yoon-Kyung Kim  
 Corresponding Author: Prof. Dong-Seok Sohn  
 Clinical Trials to evaluate efficacy of plasma tech.  
 To be Published in 2025



## Article Impact of Plasma Surface Treatment on Implant Stability and Early Osseointegration: A Retrospective Cohort Study

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### Abstract

(1) Introduction: The clinical success of dental implants depends on rapid osseointegration, which can be impaired by hydrocarbon contamination and biological aging of titanium surfaces. Chairside plasma surface treatment has emerged as a practical method to restore surface hydrophilicity and enhance early bone-implant integration. (2) Materials and Methods: This retrospective cohort study evaluated 73 plasma-treated implants placed in 47 patients from June 2023 to October 2024. Non-thermal atmospheric pressure plasma was applied immediately before placement using the ACTILINK™ Reborn system. Implant stability was assessed baseline, weekly for the first four weeks, and again at week 8 using resonance frequency analysis (ISQ). Subgroup analyses were conducted according to initial ISQ, jaw location, implant length/diameter, and final insertion torque. (3) Results: All implants healed uneventfully without a stability dip. Mean ISQ increased from 78.97 ± 5.52 at placement to 83.74 ± 4.36 at week 8 ( $p < 0.001$ ). Implants with lower initial stability demonstrated the greatest relative gains, while those with very high initial stability showed minimal changes. Mandibular and shorter implants demonstrated higher stability gains compared to maxillary and longer fixtures. (4) Conclusions: Chairside plasma surface treatment was associated with progressive ISQ increases during the 8-week healing period. The greatest gains occurred in implants with lower initial stability, while very stable implants showed little change. Stability improvements were also greater in mandibular sites, shorter fixtures, and those with higher insertion torque. These findings are limited to short-term ISQ outcomes and require validation in prospective controlled trials with standardized protocols.

**Keywords:** plasma surface treatment; osseointegration; dental implant; hydrophilicity; resonance frequency analysis; implant stability quotient (ISQ); early loading



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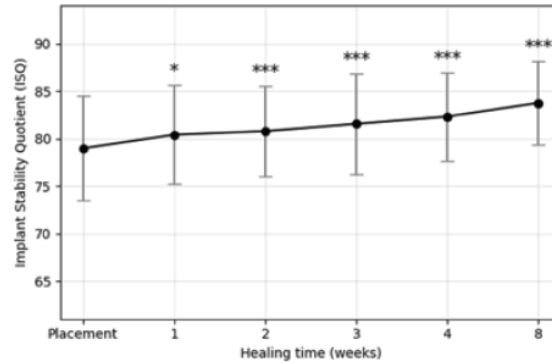
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## Clinical Benefit

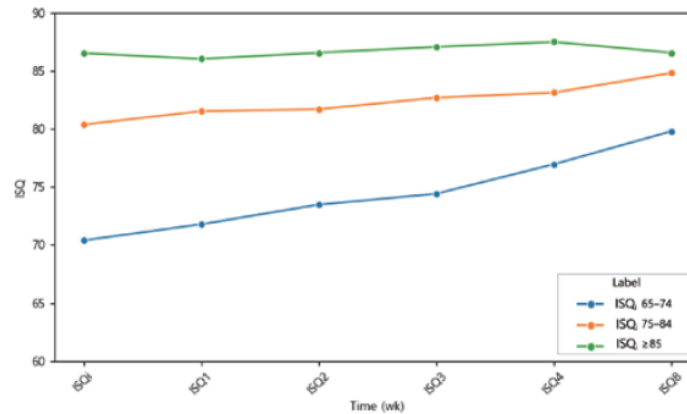
All implants healed successfully with no stability dip during the 8-week period

### Continuous ISQ Increase over 8 Weeks



Plasma-treated implants exhibited a steady rise in ISQ from 78.97 ± 5.52 to 83.74 ± 4.36 ( $p < 0.001$ ) with no transient stability dip. This pattern demonstrates faster and more consistent early osseointegration compared with typical healing responses.

### Subgroup Analysis by Jaw and Implant Dimensions



All subgroups showed progressive ISQ increases, but greater gains were observed in the mandible and in shorter ( $\leq 10$  mm) or narrower ( $\leq 4.0$  mm) implants. These findings suggest that plasma activation benefits various implant types regardless of bone quality.

**This clinical study demonstrates that the vacuum plasma treatment can enhance early implant stability, and it enables safe early or immediate loading**

# \*Research Highlights



First Author: Dr. Jin Seon Kwon  
 Corresponding Author: Prof. Jung Bo Huh  
 Clinical Trials to evaluate efficacy of plasma tech.  
 To be Published in 2024



Article

## Prospective Randomized Controlled Clinical Trial to Evaluate the Safety and Efficacy of ACTLINK Plasma Treatment for Promoting Osseointegration and Bone Regeneration in Dental Implants

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**Abstract:** Recent studies have explored surface treatments, such as increasing the hydrophilicity of implant fixtures, to enhance the osseointegration of implants. This prospective clinical study aimed to assess the clinical stability and efficacy of plasma treatment applied to implants with sandblast–acid etching (SLA) surfaces before placement. Twenty-eight patients requiring implant placement provided consent and were assigned randomly to either the SLA group without plasma treatment or the SLA/plasma group with plasma treatment. Recall checks were conducted one and three months after the first-stage surgery, followed by a second surgery at four months. Although no significant differences in buccal bone defects or implant stability were observed between the groups, the SLA/plasma group showed significant increases in marginal bone changes on the mesial and distal sides, as assessed using periapical radiographs. This study underscores the potential of pre-implantation plasma treatment to enhance bone regeneration around implants.

**Keywords:** plasma treatment; implant surface modification; osseointegration; marginal bone change

### 1. Introduction

Osseointegration, introduced by Per–Ingvar Brånemark, refers to the direct structural and functional connection between the surface of the dental implant and the living bone [1]. Research on the surface characteristics to enhance the osseointegration of implants is ongoing [2]. The surface treatment of fixtures through sandblasting and acid etching (SLA) is common practice [3]. On the other hand, such titanium surfaces undergo biological aging, meaning that their hydrophilicity and biological properties diminish over time [4–6]. There-

**check for updates**  
 Citation: Kwon, J.-S.; Cho, W.-T.; Lee, J.-H.; Joo, J.-Y.; Lee, J.-Y.; Lim, Y.; Jeon, H.-J.; Huh, J.-B. Prospective Randomized Controlled Clinical Trial to Evaluate the Safety and Efficacy of ACTLINK Plasma Treatment for Promoting Osseointegration and Bone Regeneration in Dental Implants. *Bioengineering* 2024, 11, 980. <https://doi.org/10.3390/bioengineering1110980>

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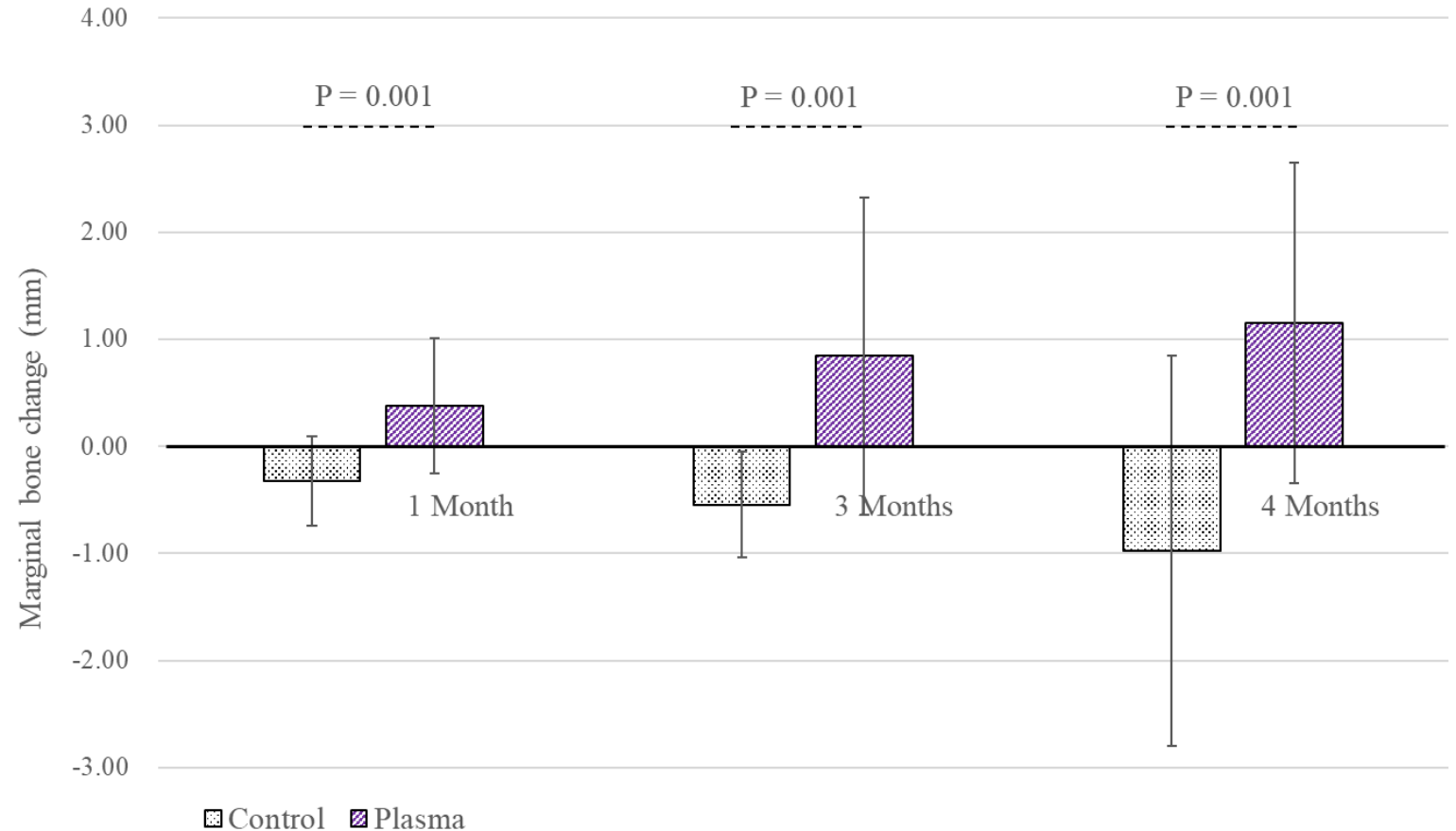
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## Clinical Benefit

To increase success rate of “Short implant” by reducing marginal bone loss (Clinical trial, n=28)



**This clinical study demonstrates that the vacuum plasma treatment can reduce marginal bone loss, and it improves peri-implant bone healing**

# \*Research Highlights



First Author: **Dr. Luigi Canullo**  
 Preclinical In vitro test using fibroblast cells  
 Publication in 2024

Clinical Benefit  
 To increase soft tissue integration of abutment

Further implication  
 To increase soft tissue integration of crown



## Article Vacuum Plasma Treatment Device for Enhancing Fibroblast Activity on Machined and Rough Titanium Surfaces

Luigi Canullo <sup>1</sup>, Tullio Genova <sup>2</sup>, Giorgia Chinigò <sup>2</sup>, Roberta Iacono <sup>3</sup>, Paolo Pesce <sup>1,\*</sup>, Maria Menini <sup>1</sup> and Federico Mussano <sup>4</sup>

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**Abstract:** This study was conducted to compare the effects of an innovative plasma surface treatment device that does not need a gas supply for titanium disks with two different surface topographies: the prototypical machined surface (MAC) and one of the most diffused roughened ones (SL) obtained through grit blasting and acid etching. A total of 200-MAC and 200-SL titanium disks were used. Each group of disks was divided into four sub-groups of 40 samples each that were subjected to five different tests. Among these, 150-MAC and 150-SL were considered the test group, and they were treated with plasma for 15, 30, and 60 s after being removed from the sterile packaging. On the other hand, 50-MAC and 50-SL were considered the control group, and they were only removed from sterile plastic vials. The samples were analyzed to evaluate the capability of the plasma treatment in influencing protein adsorption, cell adhesion, proliferation, and microbial growth on the test group disks when compared to the untreated disks. Protein adsorption was significantly enhanced after 20 min of plasma treatment for 15 and 30 s on the MAC and SL disks. Plasma treatment for 15 and 30 s significantly increased the level of adhesion in both treated samples after 30 min. Furthermore, the MAC samples showed a significant increase in cell adhesion 4 h after plasma treatment for 15 s. The SEM analysis highlighted that, on the treated samples (especially on the MAC disks), the cells with a polygonal and flat shape prevailed, while the fusiform- and globular-shaped cells were rare. The encouraging results obtained further confirm the effectiveness of plasma treatments on cell adhesion and fibroblast activity.

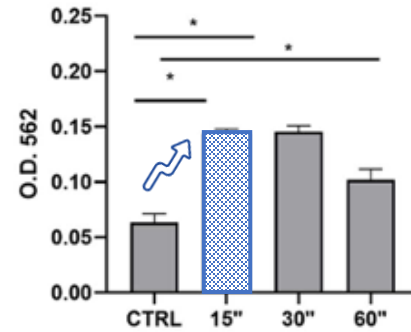
**Keywords:** plasma; titanium; cell adhesion; bioactivation; fibroblast

### 1. Introduction

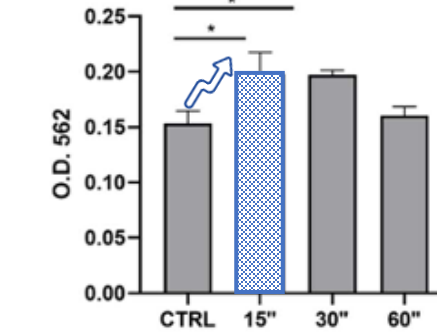
After implant placement, whatever the planned loading protocol, the insertion of the abutment is an important phase of the rehabilitation. It becomes a real surgical act when the abutment is inserted on a submerged implant fixture that is already osseointegrated [1]. It necessarily produces peri-implant stress and trauma, and, in these circumstances, there is temporary exposure of the implant to the oral environment. Furthermore, as demonstrated by Hermann et al., bone remodeling may occur in the hard tissues around the implant [2].

Some strategies were tested in terms of enhancing abutment integration, as well as in limiting peri-implant soft tissue disruption and marginal bone resorption. Several authors have suggested that, by reducing the number of interventions such as abutment detachments and reattachments, peri-implant resorption can be minimized. In fact, one-time definitive abutment placement has shown a biological and clinical advantage by preserving peri-implant tissues [3–5].

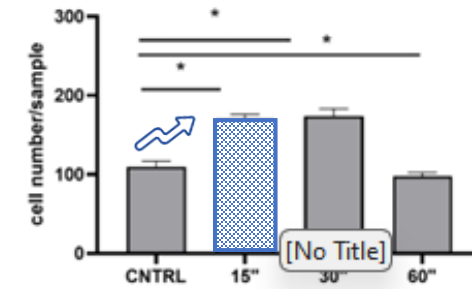
**A** Protein Adsorption MAC 20 min



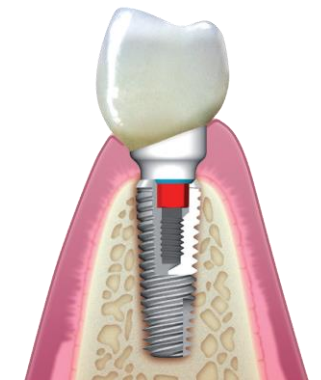
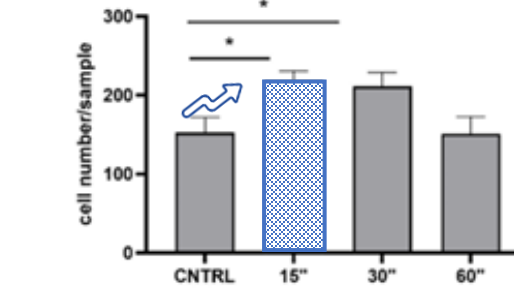
**B** Protein Adsorption SL 20 min



**A** Adhesion MAC 30 min



**B** Adhesion SL 30 min



Soft tissue integration with abutment and crown

This in vitro study demonstrates that the vacuum plasma treatment can be used for the abutment to enhance soft tissue integration, and it can reduce peri-implantitis