HYDROSSEO

SCIENTIFIC EVIDENCE

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HYDROPHILIC IMPLANTS IN DENTAL REHABILITATION

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Dental implants can have a major impact on quality of life in patients suffering from tooth and bone loss [1]

Titanium dental implants have higher success rates in healthy patients, restoring both functionality and aesthetics [2]. Yet patient and clinical variability affect case-by-case implantation outcomes [3].

Osseointegration survival rates vary widely, and are affected by certain high-risk conditions such as diabetes, immunosuppression, and smoking. Long-term success rates are also affected by the biomechanical properties of the rehabilitation, such as the support area, span length, implant angulation, materials used, and occlusal loading conditions [1,2].

Moreover, patients with certain comorbidities are at increased risk of peri-implantitis, with one meta-analysis reporting a 50% higher risk in diabetic patients compared to non-diabetic patients.[4].

Improving treatment for compromised patients requires technologies which can create implant surface properties that benefit implant longevity and reduce secondary complications such as implant failures due to mechanical overload, insufficient osseointegration, or peri-implantitis [1,4].

Successful osseointegration is a key factor for the clinical success of dental implant treatments [5]

Successful osseointegration depends on establishing direct bone-to-implant contact (BIC) without the interposition of connective tissue [6]. Interaction between the tissues and the implant surfaces begins immediately after the placement of the biomaterial in the body [7]. During early healing, proteins, blood, immune cells, and osteoprogenitor cells interact with the biomaterial [Fig. 1] – ultimately affecting implant osseointegration [8].

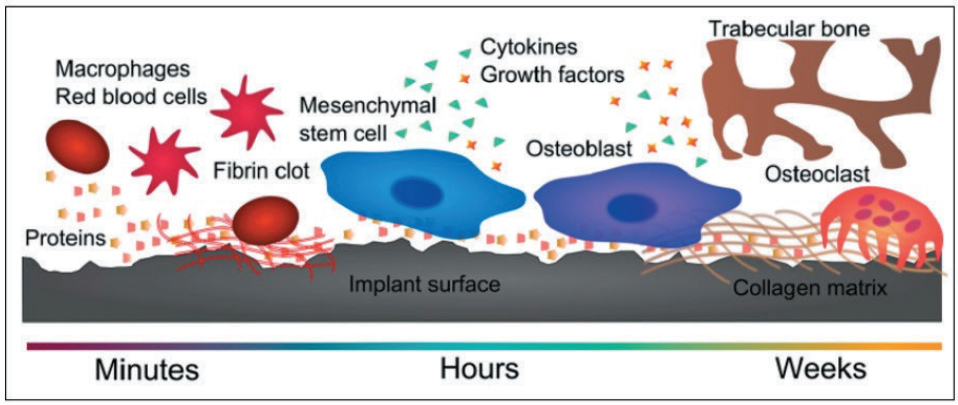

Figure 1. Timeline of biological response on the implant surface. These interactions are surface-dependent and can affect osteoblastic differentiation, maturation, and local factor production and, ultimately, matrix formation and implant osseointegration (adapted from Boyan et al [8]).

Implant surface properties play key roles in implant-tissue interaction and the success rate and quality of osseointegration [7]

Implant surface modification involves physical and topographical features at the micro and nano scales, such as coating, roughness, porosity, patterning, and fractal architecture [9]. Manipulating chemical and physical parameters can alter the biological response by optimizing the surface towards increased cell attachment, osteoblast differentiation, and ultimately osseointegration with surrounding and new bone formation [1,9].

DBD plasma technology

DBD (Dielectric Barrier Discharge) plasma treatment alters the implant surface in two key aspects:

HYDROPHILICITY

Plasma - the fourth state of matter after solid, liquid, and gas - is a gas mixture consisting of neutral and electrically charged particles. Plasma chemically modifies the **surface energy** of any material it is applied to, and has an additional antibacterial effect [9,10].

The surface of dental implants is typically hydrophobic at manufacture, covered with hydrocarbon molecules that impede osseointegration [1,2,11]. Plasma treatment clears these hydrocarbons, thus making the surface hydrophilic and improving implant osseointegration, healing, and survival rate potential [1,2,10,11,13,14].

Even implants that are marketed sterile (by Gamma irradiation, autoclave, or UV light) can reach greater hydrophilicity through plasma treatment [12]. However, this effect fades within days of plasma activation [1,2,11]. To overcome this degradation, applying plasma **immediately** before implantation maintains the improved hydrophilicity of the implant surface, with all the associated benefits [1,2].

CLEANLINESS

Plasma treatment removes surface contaminants and biofilm from the implant surface[10], creating a safer and more sterile implant environment[10].

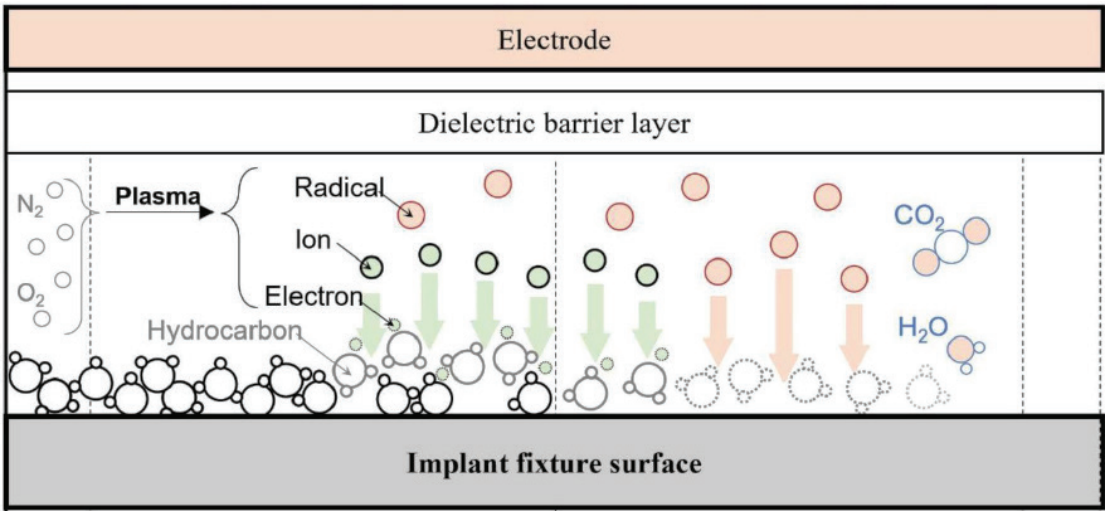

Figure 2 (From Lee et al [11])

DBD Plasma treatment may improve associated cell growth and osseointegration

Plasma treatment increases surface hydrophilicity and removes hydrocarbons, thereby increasing the recruitment, attachment, retention, proliferation, and overall phenotype of osteogenic cells [1,2,5] – improving cellular compatibility, bone formation, and clinical outcomes [4].

In animal studies, osteoblast attachment to chemically cleaned and super-hydrophilic titanium surfaces was shown to improve with plasma treatment, potentially increasing the spread, attachment, proliferation, and differentiation of blood cells related to osseointegration [4,16].

The importance of hydrophilicity in dental implants – with a focus on plasma technology

Changes in the microenvironment of implant surfaces may influence the cellular crosstalk and adhesion patterns of dental implant materials. To this end, cold plasma technology has been described to have an effect on cells, tissues, and biomaterials [7,10].

Adjunctive treatment of titanium surfaces with cold atmospheric plasma (CAP) may enhance healing capacity and osseointegration of dental implants[10] in difficult clinical scenarios with poor bone quality and quantity [9].

Plasma applied directly to tissues or cells can alter cellular activities, and control and manipulate the key biological processes of biofilm formation and tissue regeneration [10]. CAP may stimulate the re-osseointegration of affected implants by enhancing their wettability. In addition, CAP may enhance the elimination of bacterial plaque from implant surfaces, in inaccessible pockets, or during open-flap debridement [10].

In-vitro studies have demonstrated CAP's potential to enhance surface colonization and osteoblast activity and to accelerate mineralization, as well as to determine a clean surface with cell growth comparable to the sterile control on titanium surface [10].

In comparative studies with laser, air abrasion, and chlorhexidine, the combination of mechanical treatments and CAP resulted in synergistic antimicrobial effects and surface improvement, indicating CAP's potential role in surface rejuvenation and as a treatment for peri-implantitis [10].

CAP operates at room temperature utilizing simple, portable equipment. Thus, plasma treatment is a promising and affordable option to use during surgery - immediately prior to implant placement, or in peri-implantitis treatment [9]. !

* This white paper brought to you by AB Dental Devices, in the interest of furthering education around hydrophilic dental implants.!

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Hydrophilic implants generated using a low-cost dielectric barrier discharge plasma device at the time of placement exhibit increased osseointegration in an animal pre clinical study: An effect that is sex-dependent

Michael B. Berger, D. Joshua Cohen, Michael M. Levit, Jennifer L. Puetzer, Barbara D. Boyan, Zvi Schwartz

Dental Materials, Volume 38, Issue 4, April 2022, Pages 632-645

Abstract

Objectives

Increased wettability of titanium and titanium alloy surfaces due to processing and storage methods increases osteoprogenitor cell differentiation and osseointegration compared to microroughness alone. Implants that are exposed to air have a hydrophobic surface due to adsorption of atmospheric hydrocarbons, which can limit overall implant success. Dielectric barrier discharge plasma (DBD) is one method to increase surface hydrophilicity. Although current DBD methods yield a hydrophilic surface, adsorbed hydrocarbons rapidly restore hydrophobicity. We demonstrated that application of DBD to implants previously packaged in a vacuum, generates a hydrophilic surface that supports osteoblastic differentiation in vitro and this can be done immediately prior to use. In the present study, we tested the hypothesis that DBD treatment to alter surface wettability at the time of implant placement will improve osseointegration in vivo.

Materials and methods

Twenty male and sixteen female rabbits were used in a preclinical trans-axial femur model of osseointegration. Control and DBD treatment implants were inserted randomized per hind limb in each rabbit (1 implant/hind-limb). At 6 weeks post-surgery, bone-to-implant contact, adjacent bone volume, and torque to failure were assessed by micro-CT, calcified histology, and mechanical testing.

Results

DBD plasma treatment of vacuum-sealed implants increased surface wettability and did not change surface chemistry or roughness. Peak torque and torsional energy, and bone to-implant contact increased with DBD treatment in males. In contrast, female rabbits showed increased osseointegration equal to DBD treated male implants regardless of DBD plasma treatment.

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Conclusion

DBD treatment is an effective method to enhance osseointegration by increasing surface wettability; however, this response is sex dependent. In healthy female patients, DBD treatment may not be necessary but in older patients or patients with compromised bone, this treatment could be an effective measure to ensure implant success.

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Benchtop plasma treatment of titanium surfaces enhances cell response

Michael B. Berger, Kyla B. Bosh, D. Joshua Cohen, Barbara D. Boyan, Zvi Schwartz

Dental Materials, Volume 37, Issue 4, April 2021, Pages 690-700

Abstract

Objective

Modifications to implant surface properties, including topography, chemistry, and wettability, alter immune response, osteoblast differentiation of bone marrow stromal cells (MSCs), and implant integration in vivo. Dielectric barrier discharge (DBD) plasma treatment has been used to sterilize surfaces and remove adsorbed carbon, improving wettability. However, unless it is used immediately prior to placement, ambient atmospheric hydrocarbons rapidly adhere to the surface, thereby reducing its hydrophilicity. Moreover, this method is not practical in many clinical settings. The aim of this study was to evaluate the effectiveness of an on-site benchtop modification technique for implants at time of placement, consisting of a DBD plasma that is used to sterilize implants that are pre-packaged in a vacuum. Effects of the plasma-treatment on implant surface properties and cellular response of MSCs and osteoblasts were assessed in vitro.

Methods

Titanium-aluminum-vanadium implant surfaces were grit-blasted (GB) or grit-blasted and acid-etched (AE), and packaged under vacuum. AE surfaces were also plasma treated using the benchtop device (GB + AE) and then removed from the vacuum. GB surface morphology was altered with AE but AE microroughness was not changed with the plasma-treatment. Plasma-treatment increased the surface wettability, but did not alter surface atomic concentrations of titanium, oxygen, or carbon.

Results

MSCs and osteoblast-like cells (MG63 s) produced increased concentrations of osteocalcin, osteopontin, and osteoprotegerin after plasma-treatment of AE surfaces compared to non-plasma-treated AE surfaces; production of IL6 was reduced and IL10 was. Aging GB + AE surfaces for 7 days after plasma-treatment but still in the vacuum environment reduced the effectiveness of plasma on cellular response.

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Significance

Overall, these data suggest that application of benchtop plasma at the time of implant placement can alter the surface free energy of an implant surface without modifying surface chemical composition and enhance the differentiation and activity of MSCs and osteoblasts that are in contact with these implant surfaces.

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Premium Hydrophilic Implant Package

Frequently Asked Questions

1. **What makes AB Dental's solution to hydrophilic implants unique?**
   AB Dental's Hydrophilic package gives dentists a unique opportunity to provide an improved hydrophilic implant to patients whenever needed, wherever needed. This solution offers the dentists two main benefits:
   1. The freedom to operate by removing the dependence on implant availability (distributor stock or manufacturer's stock)
   2. The ability to improve implantation success by converting any AB Dental implant into a hydrophilic one in the clinic immediately prior to the implantation, and that way - avoid deterioration of the hydrophilicity that occurs in other similar solutions

2. **Can any AB Dental implant be transformed into a hydrophilic implant?**
   Yes, all AB Dental implants can be activated to hydrophilicity – all diameters and all lengths.

3. **Does AB Dental's hydrophilic solution work as well as ready-made hydrophilic implants?**
   Numerous studies found that hydrophilicity has a limited shelf life, and its effectivity deteriorates over time (sometimes as soon as one-week post-manufacturing). AB Dental's hydrophilic implants have the advantage of real-time activation, showing the adherence of water to the implant once it's activated and removing the shelf-life expiration limitation. AB Dental's solution ensures optimum hydrophilicity as well as surface cleanliness and reduced organic impurities.

4. **Is there any downside to using hydrophilic implants as a standard of care?**
   Absolutely no. Hydrophilic implants have been shown to potentially improve osseointegration and hence can be leveraged for use in all implantation procedures. Moreover, plasma activation of implants has been shown to reduce organic impurities and return implants to manufacturing standards. The plasma process does not impair the implant surface roughness or its composition in any way.

5. **Hydrophilic activation of implants adds steps to the implant process and may create a cumbersome process**
   The plasma activation process is done using a table-top device. It takes 60 seconds and can be done almost hands-free with one click on the device while preparing the patient for the treatment.

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6. **What are the advantages of using a hydrophilic implant?**
   - Accelerates osteoblast proliferation and bone regeneration, potentially leading to an enhanced osseointegration process and shorter recovery time
   - Increases bone-to-implant contact (BIC)
   - Promotes a sterile implant surface by eliminating harmful contaminants
   - Improves success of immediate loading of the restoration
   - Improve overall implantation success, especially in compromised bone patients

7. **When is it most recommended to use hydrophilic implants?**
   Hydrophilic implants can be used as a standard of care in all implantation processes, especially in the following cases:
   - Elderly patients with weak or insufficient bone
   - Patients with a relevant challenging medical history (diabetic)
   - Patients with a relevant challenging background (smokers)
   - Immediate loading or large post-extraction socket bony defect cases

8. **What clinical evidence is available?**
   Over the past 20 years, many clinical reports have been published supporting the advantages of hydrophilic implants. These reports are available online.
   AB Dental has been and still investing many resources into clinical trials to provide further clinical evidence of the advantages of hydrophilic implants and the plasma device in particular.

9. **Can the Hydrophilic activator be sold as a stand-alone device?**
   No, the device is part of a premium kit and acts as the enabler, transforming any standard AB Dental implant into a hydrophilic one.

10. **Can the plasma activator be used with other implant brands?**
    The plasma activator is intended only for AB Dental implants. Using any other type of implant will cancel the warranty on the device provided by the company.

11. **The implants are sold sterile. Why do they need further decontamination?**
    Even implants that are marketed sterile by Gamma irradiation, Autoclave, or UV light can reach a higher level of cleanliness and hydrophilicity by plasma treatment and thus increase their potential for optimal osseointegration.

DMS 32699 , Rev A 1223

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