Overcome the Limitation in Surface Processing of Implant! UV Irradiation

Ⅰ. Literature review on UV irradiated implant / Ⅱ. Clinical difference between SLA surface finishing and UV irradiated implant / Ⅲ. Utilization of UV irradiated implant in difficult case / Ⅳ. Utilization of UV implant in guide procedure

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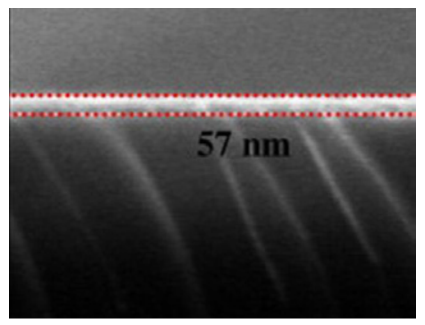
Ⅰ. Literature review on UV irradiated implant

A wide range of researches and developments for surface processing had been carried out to increase the success range of implant including shortening of the healing time for osseointegration, fortification of resistance against inflammation around the implant and application for difficult cases (lack of insufficient initial bone contact area between the aged bone or bone and implant, etc.). In particular, interest on appropriate surface finishing of implant for elderlies with poor osseous tissues due to rapid aging of population in Korean society and covering of the cost of implant under the National Health Insurance Plan, thereby reducing the financial burden individuals have to bear.

Recently, sandblasted with large grit and acid etched (SLA) surface finishing that not only increased the mechanical surface but also optimized the biological stability of the implant surface appears to be recognized as the most generalized surface finishing.

However, even the SLA surface finishing evaluated to have most stable surface roughness for the implant and bi-friendly displayed manifestation of biologic aging that interfere with integration of bone and implant due to adhesion of organic matters such as hydrocarbon in the air as time passes after surface processing. In order to resolve this issue, UV irradiated implant has been introduced. This is a fact that has been researched in diversified formats and proven since several years ago by professor Ogawa of UCLA, USA. It has been reported that reforming change for the implant surface through UV irradiation can achieve the following: 1) implant surface changes from hydrophobic to superhydrophilic, 2) increase the BIC ratio to ideal level, 3) induce osseointegration strength of the short implants with relatively small surface area to the surface area equivalent or higher than that of the ordinary sized implant, 4) shorten the time taken for healing of implant, and 5) effects on suppression of inflammation around implant, etc. These effects are collectively referred to as the UV Photofunctionalization. As such, this study reviews the clinical application of UV irradiated implant as a means of overcoming the limitations of implant surface processing by beginning with theoretical and literatures reviews.

Ⅰ. Literature review on UV irradiated implant



Biologic Aging
Unlike the Resorbable Blasting Media (RBM) that widens the mechanical implant surface area by pressurized spraying of hydroxyapatite powder, implant surface that has been SLA surface processed in order to increase the mechanical surface area through pressurized spraying of alumina (Al2O3) powder and maximize the bio-friendliness through etching by strong acid at high temperature is equipped with stable formation of TiO_2 oxidation membrane, thereby establishing the conditions capable of accelerating osteogenesis. (Fig. 1)

Fig. 1 TiO_2 layer formed at the outer boundary of SLA surface finish _ Martin Anderson, Department of Chemical and Biological Engineering, Applied Chemistry, Chalmers University of Technology, Gothenburg, Sweden

However, according to the research results, it was confirmed that hydrocarbon that exists in the air covers approximately 60~75% of the entire surface area after about 1 month, thereby resulting in the manifestation of biologic aging that interferes with the osseointegration between the implant and bone.

UV [UV Photofunctionalization]
Implant surface becomes hydrophobic due to organic matters such as hydrocarbon and the ability to pull factors that form bones such as protein, etc. gets degraded. However, it was possible to observe that irradiation of the implant surface with UV ray exposed TiO_2 layer on the surface through removal of organic matters such as hydrocarbon, thereby maximizing bio-friendliness.

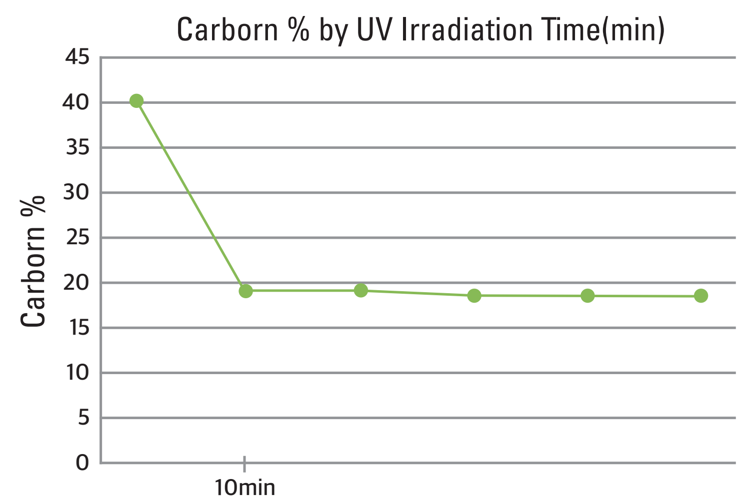


Fig. 2 Source of data: DIO R&D Institute

1) Removal of organic matters such as hydrocarbon
Hydrocarbon that covered 60~75% of the implant surface prior to UV irradiation dropped to 20% level after 10 minutes of UV irradiation with no change even if the duration of UV irradiation is increased. (Fig. 2) (Ultraviolet Photofunctionalization of Titanium Implants / Takahiro Ogawa, 2014).

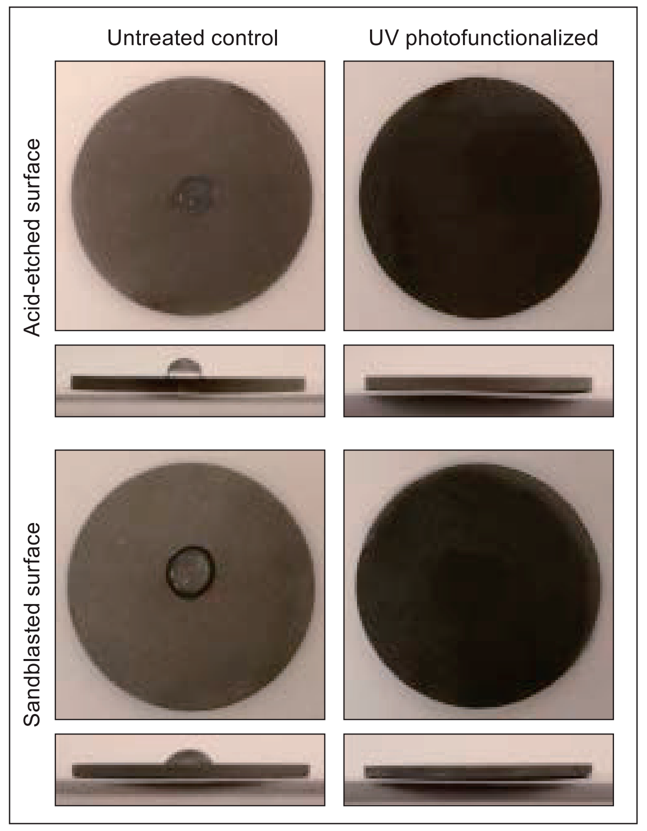


Fig. 3-1 Conversion from hydrophobic to hydrophilic surfaces of titanium by UV treatment. Top and side view images are shown of 10μL of water on acid-etched and sandblasted titanium disks before and after UV treatment.

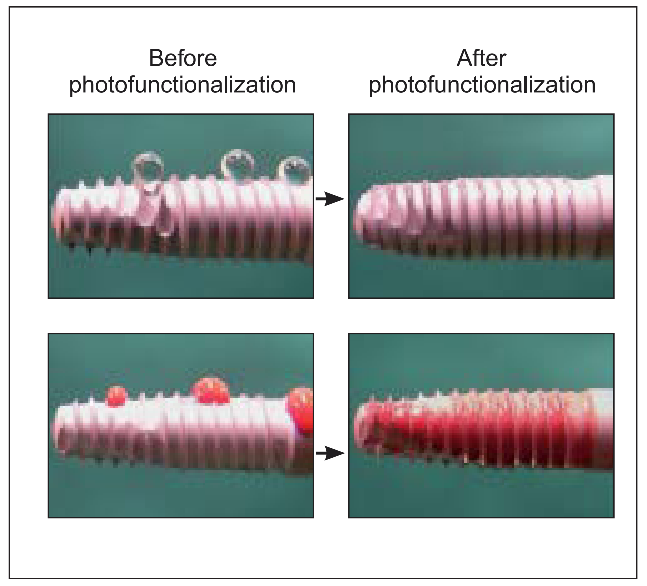


Fig. 3-2 Superhydrophilic and superhemophilic surfaces of den-tal implants after photofunctionalization. Images show droplets of 3L of double-distilled water and rat blood placed on implant surfaces (left) before and (right) after photofunctionalization. After photofunctionalization, 9μL of double-distilled water or blood (three droplets of 3μL each) was sufficient to spread and cover the entire surface of a dental implant.

2) Superhydrophilicity
Implant surface after more than 1 month of surface processing becomes hydrophobic. That is, the contact angle of water on the implant surface is above 60o and, as illustrated in the figures (Fig. 3-1 and 3-2), water dropped onto this surface does not get absorbed but forms droplets. On the other hand, if such surface is irradiated with UV for more than 10 minutes, it becomes superhydrophilic and the contact angle becomes close to 0o at which it is possible to observe that water dropped on the surface is absorbed immediately into the surface. This signifies that, at the time of embedding the implant, it is possible to induce quick and firm osseointegration by increasing adsorption of protein involved in osteogenesis by absorbing blood quickly even if bone graft is necessary due to large defect in the area of embedding of implant as well as quick wetting of blood. (Ultraviolet Photofunctionalization of Titanium Implants / Takahiro Ogawa, 2014)

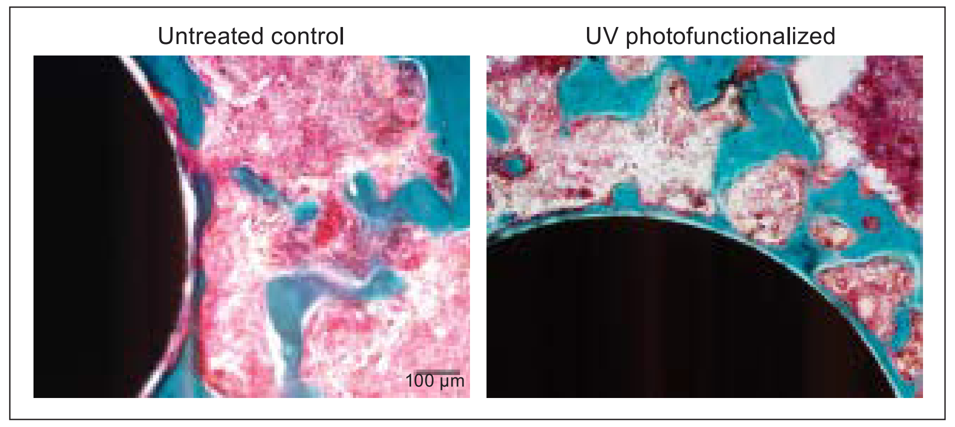


Fig.4 Evidence of increased peri-implant bone generation promoted by UV function-alization. These histologic images show peri-implant tissue at 2 weeks postimplan-tation in a rat femur model with and without UV treatment (Goldner trichrome).

4) Enhancement of usefulness of short implants
Short implant has excellent level of utilization since it can lower the risks of complications following the minimally invasive procedure and surgery, and since it is possible to anticipate reduction in treatment period and cost by avoiding the need for treatment prior to the implant procedure such as maxillary sinus augmentation and bone augmentation, etc. However, there is limitation in clinical application due to the limitations in the strength of integration between the implant and bone due to its small surface area. However, it had been reported that short implant irradiated with UV displayed synostosis strength equivalent to that of the ordinary implant (with length of more than 10mm) 4 and 8 weeks after irradiation. (Success Rate, Healing Time, and Implant Stability of Photofunctionalized Dental Implants_Akiyoshi Funato, etc., 2013)

5) Overcome the limitation of the cases of immediate embedding after tooth extraction
In the case of embedding the implant immediately after tooth extraction, it is very difficult to embed implant and generating bones while there is no bone simultaneously. According to experiments, the bone contact rate was at about 1/3 of the rate for general case if implant is embedded immediately after tooth extraction. However, in the case of UV irradiated implant, it displayed osseointegration strength equivalent to that of general case, thereby displaying results of healing that is 2~3 folds greater than that for implant without UV irradiation. (Success Rate, Healing Time, and Implant Stability of Photofunctionalized Dental Implants_Akiyoshi Funato, etc., 2013)

6) Shortening the healing time
According to experiments, implant irradiated with UV ray for 15 minutes not only displayed enhancement of its hydrophilicity and bio-friendliness but also reduction in the atomic mass of hydrocarbon on the surface. Moreover, in spite of the fact that more than 90% of the all the cases were difficult cases needing stepwise or simultaneous surgery, photofunctinalized implant through UV irradiation displayed high success rate of 97.6%. The time taken for loading was 3.2 months, which is a substantial reduction in comparison to that of the control group at 6.5 months (Fig. 5).
(Success Rate, Healing Time, and Implant Stability of Photofunctionalized Dental Implants_Akiyoshi Funato, etc., 2013)

7) Suppression of inflammation around the implant
Although implant has established itself as a predictable and successful treatment method to solve the loss of tooth, complications due to aesthetic, biological and technical factors have been reported. Among

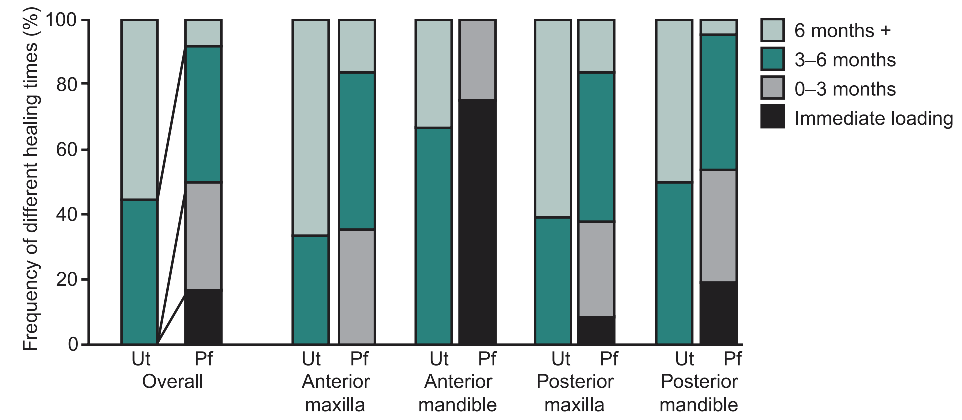


Fig.5 The distribution of specific healing times before functional loading of untreated and photofunctionalized implants. Ut: Untreated implants, Pf: photofunctionalized implants.

these, there is particularly high rate of manifestation of inflammation around the implant. According to experiments, it has been reported that inflammation around the implant occurred in approximately 19~56% of the patients. In the experiment using fully grown dogs, the bone absorption rate around the UV irradiated implant was lower than the bone absorption rate around the implant not irradiated with UV as the results of measurement of bone absorption rate through clinical test, radiological imaging and CT after 90 and 180 days of implant embedding (Fig. 6). Moreover, when the tissue slices are observed histologically, implant without UV irradiation displayed failure in attachment of bones or partial destruction on the interface between the bone and implant. In contract, there was no observation of bone absorption in the top portion of the UV irradiated implant and it could be observed that interface between the bone and the implant was maintained. (Fig. 7)
Resultantly, UV irradiation appears to suppress the progress of inflammation around the implant. (Effect of Ultraviolet Irradiation of the Implant Surface on Progression of Periimplantitis-A Pilot Study in Dogs_Katsuhiko Kimoto, etc., 2016)

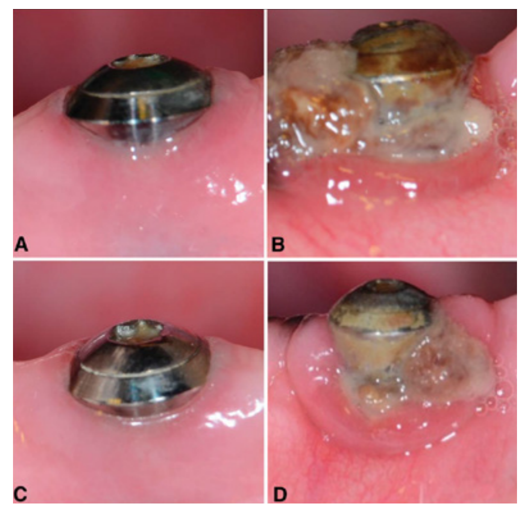


Fig.6 Intraoral photographs. A, Non-UV group after 90 days. (B) UV group after 90 days. (C) non-UV group after 180 days (90 days after dental floss application), and (D) UV group after 180 days (90 days after dental floss application).

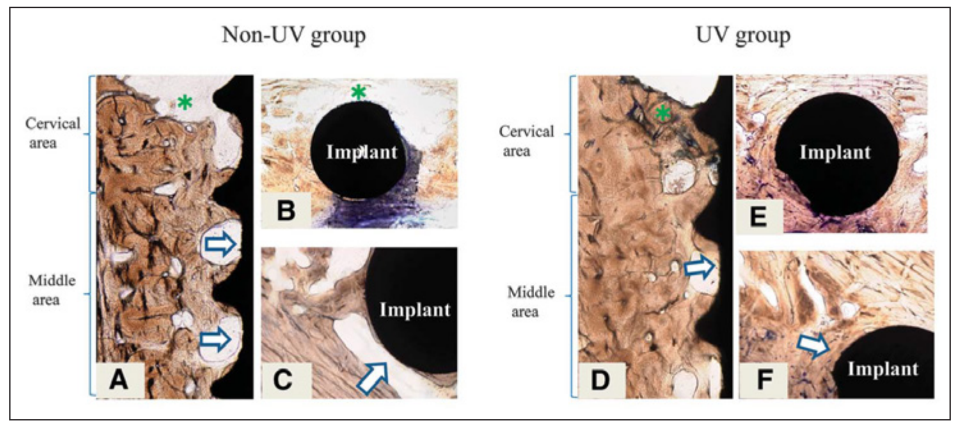


Fig.7 Light microscopic histological images (after 180 days). The grind samples were stained by methylene blue and examined under a light microscope. A, Cervical and middle areas of non-UV-irradiated implant at sagittal section. B, Cervical area of the non-UV-irradiated implant at horizontal section. C,Middle area ofthe non-UV-irradiated implant at horizontal section. D, Cervical and middle areas of UV-irradiated implant at sagittal section. E, Cervical area of the UV-irradiated implant at horizontal section. F, Middle area of the UV-irradiated implant at horizontal section.