ejbps, 2021, Volume 8, Issue 7, 497-504. **Research Article** **SJIF Impact Factor 6.044**

EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES

http://www.ejbps.com

ISSN 2349-8870
Volume: 8
Issue: 7
497-504
Year: 2021

TO EVALUATE SUCCESS RATE OF OSSEOINTEGRATION OF UV-PHOTOFUNCTIONALIZED SHORT DENTAL IMPLANTS: AN IN-VIVO STUDY

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Article Received on 19/05/2021 **Article Revised on 09/06/2021** **Article Accepted on 30/06/2021**

ABSTRACT

There can be a loss of biological activity after dental implants are made, which can be reactivated by exposing them to ultraviolet (UV) radiation, a process known as photofunctionalization. UV radiation is used to condition the titanium surface. This imparts a slight positive surface energy and hydrophilicity to the titanium dental implant surface. This conditioning renews biological activity lost after a shelf life of as little as two weeks time. The objective of this study was to determine whether UV treatment of titanium implants could enhance the osseointegration of short length tapered dental implants in humans in comparison to short tapered dental implants without pre-treatment.

KEYWORDS: Photofunctionalization, Short dental implants, UV-Ultraviolet rays, Dental implants, BIC Bone implant contact, Implant stability, RFA.

INTRODUCTION

Dental implants are today successfully used in dentistry for oral rehabilitation supporting mobile or fixed prosthesis.[1] In spite of recent advancement in implant dentistry, clinical challenges still remain in terms of reducing the healing time required for osseointegration to reduce patient morbidity and to fulfil the growing demands of modern implant therapy.[2-5]

Successful osseointegration of dental implants depends on the amount of bone directly contacting the titanium surface without soft tissue intervention.[6] Incomplete or destructive changes at the bone-implant contact area (BIC) can lead to implant failure.[6-8] For conventional implant procedures without any implant surface modification the BIC is estimated to be (45□16)%.[9] With surface modifications such as acid etching, fluoride apposition, or carbon-oxygen applications, BIC values between 50% and 75% can be achieved.[10-12] However, this is still much lower than a BIC of 100% as expected.

One recent problem associated with a reduced BIC is the shelf life of implants after production. It is assumed that the biological characteristics and the resulting ability of titanium implant surfaces to bond to bone remains stable over time. In recent reports, four-week old titanium surfaces needed twice the healing time to achieve similar osseointegration levels and exhibited less BIC than newly prepared titanium surfaces.[13]

Ultraviolet (UV) light treatment of titanium immediately prior to use, or Photofunctionalization (PF), has been found to counteract the biologic aging of titanium by regenerating hydrophilicity and removing hydrocarbon impurities.[6]

Indeed, the BIC of Photofunctionalized implants is increased from 53% to nearly 100% in animal models.[6,13,14] Photofunctionalized surfaces show increased protein adsorption and increased migration, attachment, and proliferation of osteogenic cells (two- to fivefold) in vitro.[15,16] The biomechanical strength of photofunctionalized implants is threefold higher than that of untreated implants at the early healing stage in animal modeling in vivo. This enhanced osseointegration persists, even in late healing stages, and is associated with 98.2% BIC around photofunctionalized implants, compared to less than 55% around untreated implant.

Several clinical studies have indicated that photofunctionalization may accelerate and enhance osseointegration of dental implants.[17-20] However, the efficacy of photofunctionalization in cases with short length implant has not been tested.

The present in vivo study aims to assess the success rate of Osseointegration of UV photofunctionalized short dental implants in human subject in comparison to standard short length tapered root form implant without pre-treatment.

MATERIALS AND METHODS

The study was conducted in Department of Prosthodontics, Crown and Bridge, Dr. Ziauddin Ahmed Dental college and Hospital, Aligarh. Cases were selected from outdoor patients, and written consent was obtained from patients before commencing surgical and prosthetic procedures. Ethical committee acceptance was obtained from the institutional ethical board before taking up the clinical study and was done according to ethical standards.

Fully edentulous or partially edentulous subjects above the age of 18 years who were able to give consent were included in the study. Presence of healthy periodontium in adjacent area was strictly evaluated.

Exclusion criteria included Tobacco user, uncontrolled periodontal disease, caries, or clinical or radiographic signs of infection. Patients with parafunctional habits, any history of systemic disease or medication that interfere with wound and bone healing were also excluded from the study.

Study was conducted on total of 20 patients who wanted dental implants and the implant length were of short length (less than 10 mm). Subjects were divided into two groups: Control group in which standard tapered dental implant were placed and case group in which adjunct pre-treatment of implants with UV-rays (photofunctionalization) (By UV-Makers, Palghar, Maharashtra, India) (Fig.1) was given.

FIG. 1a: UV chamber (By UV Makers).

FIG. 1b: UV chamber (by UV makers).

The effectiveness of UV ray were confirmed by placing a drop of water before UV treatment in which bleb of water is seen on implant surface (Fig.2). After UV treatment the implant became hydrophilic and water drop was fully spread on treated implant (Fig.3).

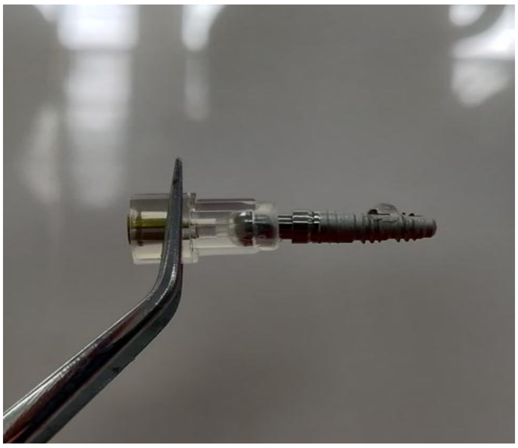


Fig. 2: Implant before UV treatment showing bleb of water on implant.

Fig. 3: Implant after UV treatment showing increased hydrophilicity.

The implant stability was checked with Resonance frequency analysis (RFA) (Penguin)(Fig.4)

Fig. 4: Showing RFA with transducer and its elements.

Before the implantation procedure, presurgical evaluation such as hemogram, bleeding time, clotting time, blood sugar (Fasting and post prandial), premedication, and radiographic evaluation of the edentulous site using periapical and panoramic radiograph was done.

At the site of implant placement a full thickness crestal incision was given with no. 15 surgical blade. Surgical placement of implant was done using physiodispenser and surgical implant kit. As per manufacturer's instructions under adequate irrigation, osteotomy site was prepared using sequential drills of increasing diameter.

For photofunctionalization implants were removed from the container(Fig.5) and placed in UV chamber for 20 minutes at wavelength of 253.7 nm (Fig.6). To check for photofunctionalization a drop of saline was injected onto treated implant surface (Fig.7). After confirming the hydrophilicity the implant was placed in osteotomy site.

Fig.5: Implant removed from container to be placed inside UV chamber.

Fig.6a: UV light treatment for 15 minutes.

Fig.6b: UV light treatment for 15 minutes.

Fig.7: Demonstration of photofunctionalization.

Follow up examinations were made on the day of implant placement, 2, 6 and 12 months interval(Fig.8).

Measurement of Implant Stability Using Resonance Frequency Analysis (RFA)

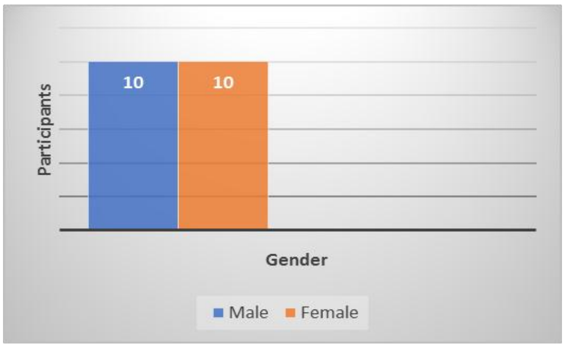
Resonance Frequency Analysis is a non-invasive diagnostic technique that evaluates implant stability at different time intervals by using vibration and a principle of structural analysis. RFA uses a small L-shaped transducer which is tighten up to the implant or to the abutment by using a screw. The transducer consists of two elements comprised of ceramic, one of which vibrates by a sinusoidal signal in the frequency range of 5–15 kHz while the second element serves as a receptor. Directly to the implant body the transducer is screwed and implant is shaked at a constant input and amplitude, starting from a low frequency and then gradually increasing pitch until the resonation in the implant starts. High frequency resonation gives an indication of a stronger bone-implant interface.

Resonance Frequency Analysis is extensively used for clinically assessing osseointegration, as well as for prognostic assessment. Implant stability quotient is the measurement unit (ISQ of 0 to 100).

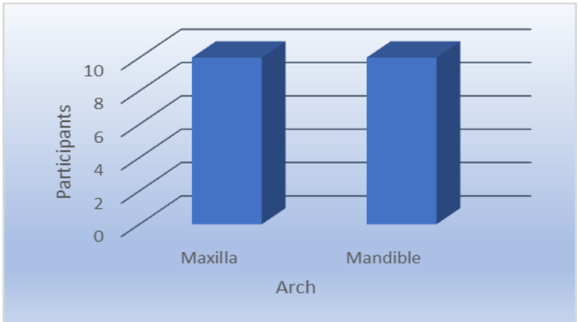
Fig. 8: RFA readings at different interval of time.

RESULTS

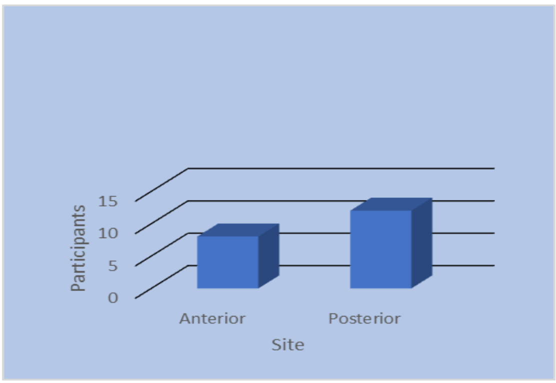
Twenty patients 10 male [50%] and 10 female [50%] above 18 years participated in study. 10(50%) implants were placed in maxillary and 10(50%) in mandibular arches with 8(40%) in anterior site and 12(60%) posterior site were placed in the participant included in study (Graph1-3).



Graph 1: Frequency distribution of male and female.



Graph 2: Frequency distribution of maxillary and mandibular arch.



Graph 3: Frequency distribution of anterior and posterior group.

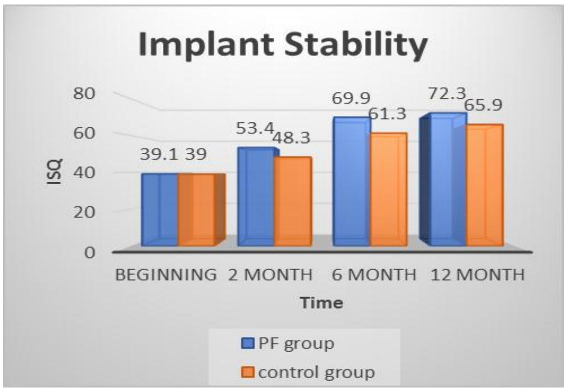
PATIENT	*GENDER*	*ARCH*	*SITE*	*AGE*	*RFA Readings PLACEMENT*	*2ND*	*6TH*	*12TH*
1.	M	MAND	POST	>50	40	53	73	74
2.	F	MAX	ANT	>30	37	52	67	69
3.	M	MAX	ANT	>30	38	54	68	70
4.	M	MAND	POST	>50	41	55	73	74
5.	M	MAND	POST	>30	40	53	67	73
6.	F	MAND	POST	<30	41	55	69	75
7.	F	MAX	ANT	<30	37	53	68	71
8.	M	MAND	POST	>50	40	51	73	74
9.	F	MAX	ANT	<30	39	53	70	71
10.	F	MAX	ANT	<30	38	55	71	72
11.	M	MAND	POST	>30	40	50	65	66
12.	F	MAND	POST	>50	40	51	63	67
13.	F	MAND	POST	>50	40	51	63	67
14.	F	MAX	POST	>30	37	44	58	63
15.	M	MAX	ANT	>30	38	46	59	64
16.	M	MAX	ANT	<30	39	48	60	65
17.	M	MAND	POST	<30	41	53	64	70
18.	F	MAND	POST	<30	40	49	62	68
19.	F	MAX	POST	>30	37	45	59	64
20.	M	MAX	ANT	>30	38	46	60	65

Master chart depicting all RFA values at different interval of time. Number 1 to 10 denotes patients who received implants treated with UV rays(photofunctionalization) and 11 to 20 are patients without pre-treated implants

Independent sample t-test was conducted to find out implant stability difference in PF group and Control group at different time period.

I. Comparison of implant stability at beginning, 2nd, 6th and 12 month in PF Group V/s Control Group

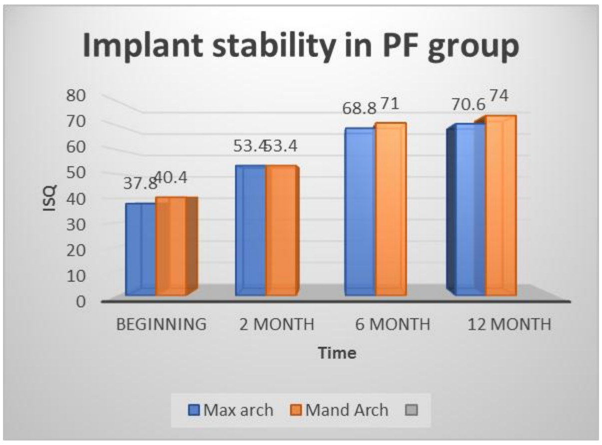
There was a significant difference of implant stability in PF group (M=53.40, 69, 72.30 SD = 1.350, 2.470, 2.003) and Control group (M=48.30, 61.30, 65.90 SD = 2.983, 2.406, 2.132); t(8) = 4.925, 7.887, 6.919, p <.001**, <.001**, <.001** at 2nd, 6th and 12 month respectively. There was no significant difference of implant stability at the beginning in PF group (M=39, SD=1.524) and Control group(M=39, SD=1.414);t(8)= 0.152, p .881. The mean indicates PF group have higher implant stability compared to Control group.



Graph 1: Comparison of Implant stability in PF and Control group at different interval of time.

II. Comparison of implant stability in maxillary and mandibular arch of PF group at different interval of time

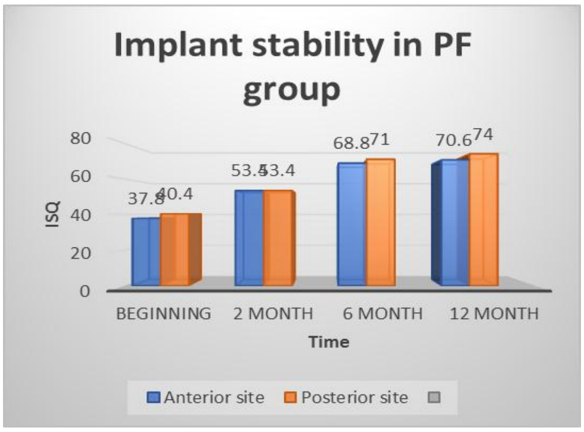
Independent sample t-test was conducted to find out implant stability difference in PF group of Maxillary and Mandibular arch at different time period. There was a significant difference of implant stability in maxillary (M=37.80,70.60 SD = .837,1.140) and mandibular arch (M=40.40,74 SD =.548,.707);t(8)= -5.814,-5.667, p <.001**,<.001** at beginning and 12 month respectively. The mean indicates mandibular arch have higher implant stability compared to maxillary arch.



Graph 2: Comparison of implant stability in maxillary and mandibular arch of PF group at different interval of time.

III. Comparison of implant stability at beginning,2nd,6th and 12 month between Anterior and Posterior site in PF group

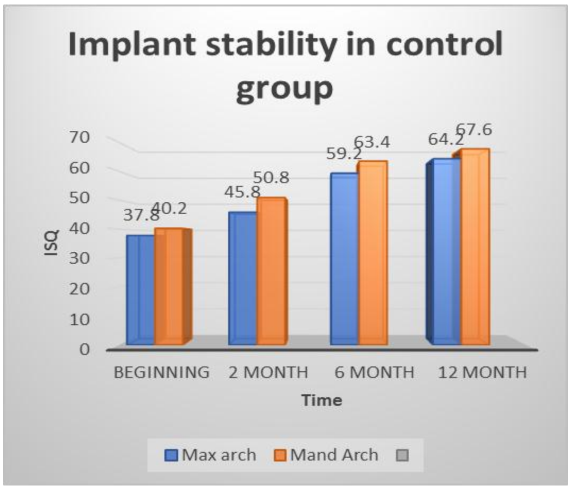
Independent sample t-test was conducted to find out implant stability difference in PF group of anterior and posterior region at different time period. There was a significant difference of implant stability in anterior region (M=37.80,70.60 SD =. 837, 1.140) and posterior region (M=40.40,74, SD = .548,.707);t(8)= -5.814,-5.667 p <.001**,<.001** at beginning and 12 month respectively. The mean indicates posterior region have higher implant stability compared to anterior region.



Graph 3: Comparison of implant stability in anterior and posterior site of PF group at different interval of time.

IV. Comparison of implant stability at beginning,2nd,6th and 12 month between Maxillary and Mandibular Arch in Control group

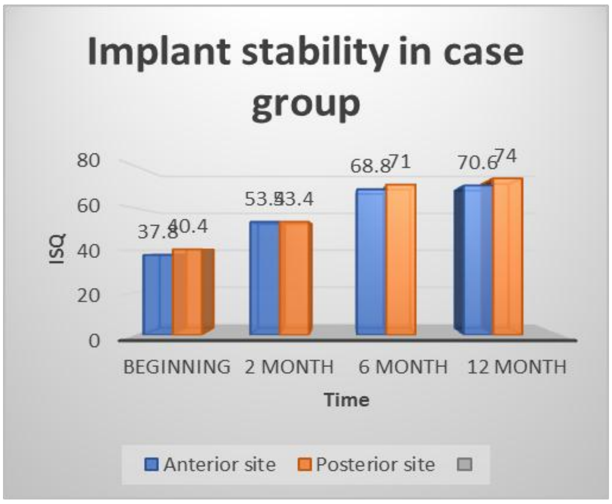
Independent sample t-test was conducted to find out implant stability difference in control group of Maxillary and Mandibular arch at different time period. There was a significant difference of implant stability in maxillary (M=37.80,45.80,59.20,64.20 SD = .837,1.483,.837,.837) and mandibular arch (M=40.20,50.80,63.40,67.60 SD =.447,1.483,1.140,1.517);t(8)=-5.657,-5.330,-6.641,-4.389, p<.001**,<.001**,<.001**,.002* at beginning, 2^{nd}, 6^{th}, and 12 month respectively. The mean indicates mandibular arch have higher implant stability compared to maxillary arch



Graph 4: Comparison of implant stability in maxillary and mandibular arch of Control group at different interval of time.

V. Comparison of implant stability at beginning,2nd,6th and 12 month between Anterior and Posterior site in Control group

Independent sample t-test was conducted to find out implant stability difference in control group of anterior and posterior region at different time period. There was no significant difference of implant stability in anterior region (M=38.33,46.67,59.67,64.67 SD = .577, 1.155, .577, .577) and posterior region (M=39.29,49,62,66.43 SD =1.604, 3.317, 2.582,2.370);t(8)= -0.973, -1.154, -1.500, -1.232, p .359, .282, .172, .253 at beginning,2^{nd},6^{th},and 12 month respectively. The mean indicates posterior region have higher implant stability compared to anterior region. However, the results may be misleading as the number of posterior cases in control group are less(N=7) compared to anterior (N=3).



Graph 5: Comparison of implant stability in anterior and posterior site of Control group at different interval of time.

DISCUSSION

The present study is a prospective study designed to help us understand the effect of surface modification on biologic outcome of dental implant in humans. Total of 20 patients were selected for the study and Implants placed were Standard Short Length Tapered Root Form Internal Implants.

In the present study, short implants were placed in various region and there implant stability was checked at different interval of time i.e. at beginning, 2nd, 6^{th} and 12th month. At initial phase i.e. at beginning (ISQ 39.10 and 39 for PF group and Control group respectively) none of the implant group shows better results than other group. At 2nd month when PF group and Control group were compared PF group implants shows significantly greater stability. The same significant results were found again when implants were compared for stability at 6th and 12th month.

In a study done by Ueno et.al[21] to determine whether UV light treatment of titanium implants could enhance osseointegration to sufficiently overcome the negative aspects of shorter implants in a rat femur model. He concluded that UV light pre-treatment substantially enhanced the osseointegration capacity of acid-etched titanium implants. The deficiencies of osseointegration in implants with a 40% shorter length were overcome by UV treatment in the rat model using miniature implants. However, as the study was conducted in animal model its true significance cannot be warranted.

In the present study, it is seen that the PF group short dental implants have higher implant stability compared to the control group after two months and later owing to increase in osseointegration capacity after UV pre-treatment.

Although the result of present study were different from that of Mehl et. al.[22] who conducted a study to evaluate the effect of UV photofunctionalization of dental titanium implants with exposure to the oral cavity on osseointegration in an animal model and observed that there was no significant difference in BIC or ISQ value between implants with and without exposure to UV photofunctionalization.

In the present study there is a strong correlation between implant stability and bone density at placement, however the values are not significant at later stages i.e. 2 months after. On the other hand, several studies have demonstrated no correlations between bone density and implant stability. A study done by Roze et.al[23] and Huwiler et al.[24] Found that there is no correlation between ISQ and histomorphometric parameters of trabecular bone analyzed by micro-CT. However in these studies only trabecular, not cortical, bone density was evaluated.

Limitations of the study

It should be noted that study was limited due to small sample size, and shorter duration of follow up. Future studies involving large cohort with longer duration of follow up and employment of advanced diagnostic modalities may overcome the limitations of the present study.

CONCLUSION

Within the limitations of the study, we can conclude that UV photofunctionalization improves implant stability.

1. The initial implant stability in the beginning shows no difference in PF and control group.
2. On follow up of 2, 6 & 12 months there was a significant difference in implant stability in PF group.
3. UV photofunctionalization is proven to be an adjunct in improving implant stability.
4. Through using UV photofunctionalization limitation of implant length could be overcome

ACKNOWLEDGEMENTS

The authors reported no conflicts of interest related to this study.

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