Clinical and Radiographic Evaluation of Osseointegration of Dental Implants Treated with two types of Surface Treatment

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ABSTRACT

Introduction: The use of implants is growing today, and ongoing research into improving implant surface treatment is being done to increase implant success and shorten healing time. This study aimed to evaluate implant osseointegration with two different surface treatments: hydroxyapatite (HA) with calcium phosphate and sandblasted rough acid (SLA) etched surface. **Patients and methods:** This prospective clinical study included the placement of sixteen dental implants with split-mouth technique in eight patients who missing two lower posterior teeth bilaterally. The 16 implant were divided randomly into two groups; group A having implant with surface treated by SLA etched ,and group B having implant with surface treated by HA with calcium phosphate. Radiographic images were obtained in both pre-operative and follow-up phase.**Results:** Bone density values around implant showed a significant difference between groups using independent T-test at P value<0.05 under different time intervals, where SLA implant (group A) gave the highest change within first 5 month after implantation than HA calcium phosphate coated surface implant (group B). The rate of bone density improvement by time in both groups has significant difference, but neither age nor gender has significant difference in the obtained results.**Conclusion:** Successful osseointegration was achieved in both HA with calcium phosphate and SLA surface treatments in dental implants, while SLA method has the superior outcomes within first 5 months.

Keywords: Dental Implants; Osseointegration; hydroxyapatite; sandblasted acid

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INTRODUCTION

A medical implant is device which is fabricated from one or more materials inserted within the body and has no action with the tissue. The first implants used to replace missing teeth probably date back to pharos modern implants appeared when Brånemark gave rise to the concept of Osseointegration. (1) As Osseointegration is defined as a direct structural and functional connection between ordered,living bone and the surface of aload carrying implant.(2,3) Nowadays, dental implants has become asuitable treatment in oral rehabilitation of partially or fully edentulous patients.there are several types of implant as endosseous,frame,disk. Endosseous implants are now most famousand reliable for dental restoration. (4)

There are several factors govern success of Osseointegration of dental implant . The most important one of them is the surface of dental implant. Many modification to the surface has been appeared after initial presentation of Brånemark. Implant which was mainly titanium without any treatment. (5,6) Several materials are used to the surface of the implant to increase power of Osseointegration life (Hydroxyapatite,Sol gel coated ,Sandblasted acid etched ,Oxidized ,Plasma sprayed). [7,8]

Therefore this study was directed to evaluate two types of implants with two different surface treatments, clinically and radiographically of Osseointegration; the first is treated by hydroxyapatite with calciumphosphate, and the second is treated with sandblasted rough acid etched surface in posterior mandibular edentulous region.

PATIENTS AND METHODS

The study was included patients with missing mandibular posterior teeth from Suez University and Misr University for science and technology. All patients signed an informed consent after detailed discussion of the procedures and follow up visits. Approval of the Research Ethical Committee of the Faculty of Dentistry, Suez Canal University **(6/2021)** was obtained before starting the study.

Inclusion criteria:

Patients with bilateral missing posterior of both gender. Mandibular teeth (molars) with good oral hygiene. Adequate bone height above the inferior alveolar and mental nerves. All selected patients were free from any systemic disorders.

3-Exclusion criteria:

Presence of infection or advanced periodontal disease. Inadequate interocclusal space. Patients with local factors or medically compromising diseases who are contraindicated to implant placement affecting the clinical procedure as uncontrolled diabetes, osteoporosis. Patients with history of chemotherapy or radiotherapy for malignancies in the head and neck region. Parafunctional habits as bruxism and clenching.

Preoperative preparation

The preoperative data was collected and recorded in full details. Clinical examination of the entire oral and para-oral tissues was done to ensure right patient selection. Evaluation of the implant site and the interocclusal space was done.Radiographic examination was obtained by Intra oral paralleling periapical direct digital radiographic using Trident (Brescia, Italia, vatech) and cone beam computed tomographic radiographs using the Planmeca (Promax 3D Classic, Helsinki, Finland) imaging system using a CMOS flat panel detector with isotropic voxel size is 0.35 µm in the regular resolution mode using amorphous silicon flat panel detector, the x-ray tube used to scan the patients possess a current intensity 10 mA, 90 KVp and a focal spot size 0.5mm **(Figure 1)**.

Operative phase

All Patients was operated under local anesthesia[*].Crestal incision was done using no.15 scalpel[**], blade handle[***], and elevation of muco-periosteal flap using periosteal elevator to expose bone. Pilot drill[****] was used for creating initial osteotomy, drills was used to complete osteoeomy and creat the site for inserting the implant. Patients were divided into (Group I) used hydroxyapatite with calcium phosphate surface and (Group II) used a sandblasted rough acid etched surfacethat inserted into the osteotomy site and threaded according to the manufacturer's instructions **(Figure 2,3)**.

Post-operative phase

All patients were informed to expect some redness, blood ooze or swelling. To minimize swelling ice backs were kept over the cheek at the area of surgery for 10 minute every half an hour for 12 hours after surgery. Soft diet should be eaten at the day of surgery with no hot food and drinks. Avoid rinsing and spitting the day of surgery for 24 hours after surgery. Avoid smoking for two weeks after surgery.

Figure 1: Preoperative photo of the edentulous area illustrate the (buccolingual width , mesiodistal width ,length and relation to mandibular canal).

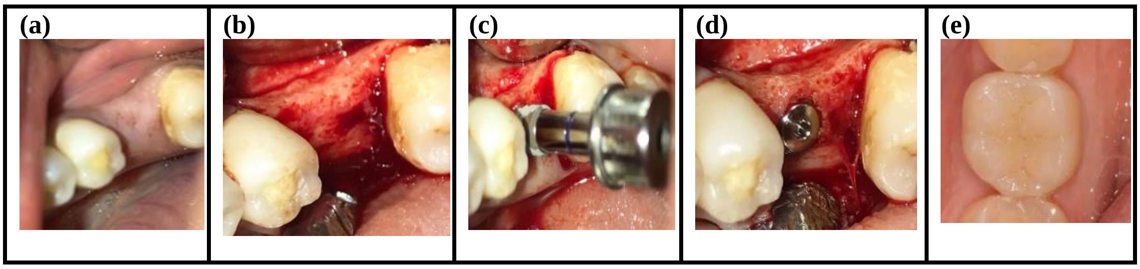

Figure (1): Surgical technique Group (A) showing (a) missing lower right first molar ; (b) crestal flap and bone exposure; (c) implant insertion treated by sandblasted acid etch; (d) the final placement of healing cap of implant treated by sandblasted acid etch; and (e) the final crown of implant treated by sandblasted acid etch.

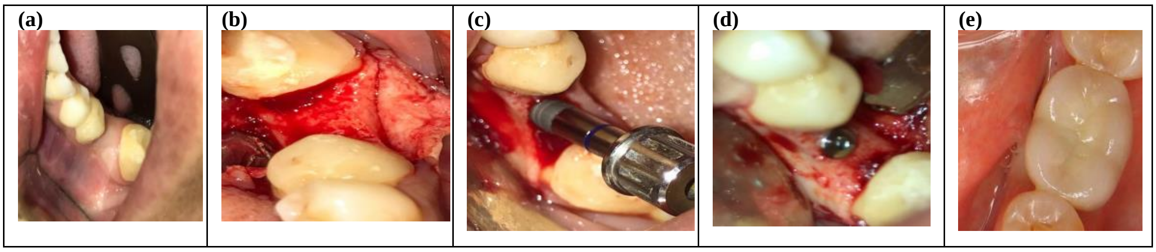

Figure (1): Surgical technique in Group (B) showing: (a) missing lower left first molar; (b) crestal flap and bone exposure; (c) implant insertion treated by hydroxyapatite with calcium phosphate; (d) the final placement of healing cap of implant treated by hydroxyapatite with calcium phosphate; and (e) the final crown of implant treated by hydroxyapatite with calcium

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** surgical blades, china.
***sedra dent, Pakistan.
**** Densah, Pakistan.

Postoperative medication included Co-amoxiclav Tab[*]once daily / 5 days, Metronidazole[**]every 8 hours/5 days and Profinal Tab[***] every 12 hours for 5 days. All patients have been instructed to rinse their mouth using antiseptic mouth wash [****] 3 times / day. Sutures was removed seven days post-operatively.

Follow up phase:

Clinical evaluation: All Patients was evaluated daily for the 1st week then weekly for 1st month regarding post-operative pain, edema and any complications. Implant stability measurement: was measured before placement of healing cap and f after 6 months from the surgery using Implant Stability Quotient (ISQ) scale to compare changes in stability. Immediately after implant insertion, a smartpeg was placed over the implant and the initial stability of the implant was measured using Osstel ISQ system* in Implant Stability Quotient (ISQ) value in both buccolingual and mesodistal direction with the average between the two reading being recorded.

a) Post-operative Radiographic evaluation: using indirect standardized digital radiographs was achieved using Ez Sensor HD 1.5, and the Rinn extension cone paralleling (XCP) periapical film holder. Processing was started after the end of the exposure using Scan eXam™ One unit then the image appears on the screen then the image will be processed with built in software clininview. All patients were evaluated using this technique after one, three and five months postoperatively.

Statistical analysis

The analysis employed IBM SPSS Statistics, v. 19 (IBM, New York, NY). Continuous variables were expressed as mean ± standard error (SE). Two-way repeated measures analysis of variance (ANOVA) followed by paired sample t-test. To verify normal distribution of data the Kolmogorov-Smirnov and Shapiro-Wilk normality test was used. All statistical tests were performed at 0.05 levels. A p-value less than 0.05 was considered statistically significant and a confidence interval was estimated at 95%.

RESULTS

The present study showed the mean age in groups A and B was 37.13 because the implant placed was done at the same patient. Three implants were placed in male patient with ratio 37.5 % and 5 were placed in female patient with ratio 62.5 %. For both groups B **(Table 1)**.

The comparison between groups for bone density around implant, statistical analysis showed a significant difference between groups using independent T-test at P value<0.05 under different time intervals. Group A gave the highest change compared with first month than group B under different times with **(Figure 4)**.

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*Augmentin 1gm ,Manufactured by GlaxoSmithKline.
** Flagyl 500mg , Manufactured by Sanofi Aventis.
***Ibuprofen 600mg , Manufactured by Julphar, Ras Al Khaimah , U.A.E.
****Hexitol (chlorhexidine HCL 0.12%), Manufactured by A.D.C.O , A.R.E.

A significant difference between the first, third and fifth months of implant bone density in the two groups under study. The values of implant stability increased with increasing period from first month to five months in both groups **(Table 2)**. In a group

A receiving Sandblasted acid etch(Switzerland), the mean bone density around the implant initially after placing the implant was 79.33 and finally after five months was 81.92 giving increasing in the mean bone density about 7.10 with ratio 8.94% of the initial bone density which was significant change. On the other side, the group II receiving hydroxyapatite calcium phosphate(turkey) the mean bone density initially after placing the implant was 86.43 and finally after five months was 88.41 giving increasing in the mean bone density 6.49 with ratio 7.92% of the initial bone density which was also significant change. Generally, the group I gave more change than group II **(Figure 5)**.

There are significant difference between bone level between groups using independent sample T test at $P<0.05$ ($p<0.001$) for all variables, however the values of group A were lower than group B for all studied variables. Also, the comparision between time interval at the same groups showed significant difference between 1month, 3 months and 5 months, and the variables were increased significantly with increasing time from 1 Month to 5 months **(Table 3)**.

Table (1): frequency distribution of the studied subjects according to theirpersonal data (N=16):

Variable		Group A (n=8)		Group B (n=8)		P-value
		No.	%	No.	%	
Age	Mean ± SD	37.13 ± 5.74		37.13 ± 5.74		00.1[ns]
	Min - Max	28.0- 45.0		28.0- 45.0		
Gender	Male	3	37.5%	3	37.5%	1.00[ns]
	Female	5	62.5%	5	62.5%	

(ns) Not statistically significant

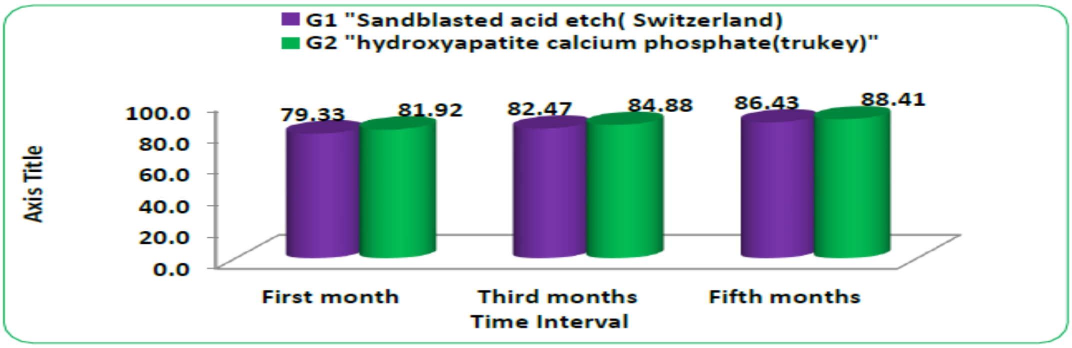

Figure (4): graphical representation showing the different between two groups for bone density around the implant.

Table (2) comparison between time interval at different groups

Time interval	GA "Sandblastedacid etch(Switzerland)	GB"hydroxyapatite calcium phosphate(trukey)"
First month	79.33±3.00[c]	81.92±2.57[c]
Third month	82.47±2.98[b]	84.88±2.68[b]
Fifth month	86.43±2.85[a]	88.41±2.77[a]

F-test	**11.68**	**11.77**
P values <0.05	**0.001**	**0.001**

*****,ab; means significant difference between time interval using one way ANOVA test at P<0.05***

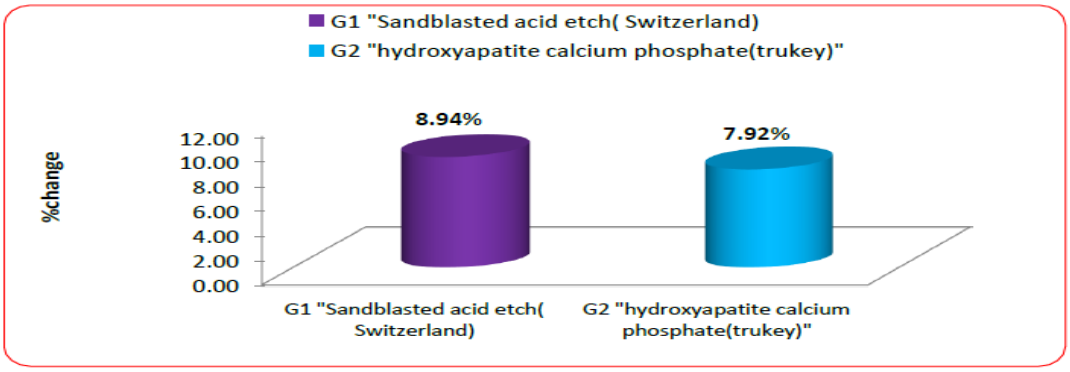

Figure (5): Graphical representation showing the different change between initial and final mean bone density in each group

Table (3): Means significant difference between the bone levels between groups in differentchange using indep. T-Testat P<0.05

Groups	1 M	3 M	5 M	ANOVAs P values
Group A	**0.00**	**0.00**	**0.00**	**<0.001****
Group B	**0.53**	**0.58**	**0.83**	**<0.001****
T test Pvalue	**<0.001****	**<0.001****	**<0.001****	
Group A	**0.58**	**0.50**	**0.31**	**<0.001****
Group B	**0.10**	**0.38**	**0.94**	**<0.001****
T test Pvalue	**<0.001****	**<0.001****	**<0.001****	
Group A	**0.10**	**0.49**	**0.08**	**<0.001****
Group B	**0.53**	**0.11**	**0.18**	**<0.001****
T test Pvalue	**<0.001****	**<0.001****	**<0.001****	
Group A	**0.62**	**0.75**	**0.36**	**<0.001****
Group B	**0.65**	**0.83**	**0.58**	**<0.001****
T test Pvalue	**<0.001****	**<0.001****	**<0.001****	
Group A	**0.51**	**0.65**	**0.22**	**<0.001****
Group B	**0.30**	**0.45**	**0.20**	**<0.001****
T test Pvalue	**<0.001****	**<0.001****	**<0.001****	
Group A	**0.63**	**0.65**	**0.22**	**<0.001****
Group B	**0.41**	**0.86**	**0.96**	**<0.001****
T test P value	**<0.001****	**<0.001****	**<0.001****	
Group A	**0.52**	**0.59**	**0.30**	**<0.001****

Group B	**0.20**	**0.43**	**0.12**	**<0.001****
T test Pvalue	**<0.001****	**<0.001****	**<0.001****	
Group A	**0.70**	**0.20**	**0.85**	**<0.001****
Group B	**0.07**	**0.40**	**0.82**	**<0.001****
T test Pvalue	**<0.001****	**<0.001****	**<0.001****	

Discussion:

Implant surface treatment plays a vital biological function in the osseointegration process, improving the pace of osseointegration, the percentage of bone-to-implant contact (BIC), and, as a result, implant stability. [(9,10)] Constant research for improving implant surface treatment has been conducted in order to improve implant success and reduce healing time. [(11)]

This study was conducted to compare the effect of two methods of surface treatment; hydroxyapatite with calcium phosphate and sandblasted rough acid etched surface treatment on implant treatment success in healthy middle- aged patients of both sexes. Gender, age, and other demographic characteristics are thought to play a role in determining the overall therapy outcome. [(12)]

The patients in this study were divided into two groups: right side act as implant with surface treated by sandblasted acid etch, and left side act as implant with surface treated by hydroxyapatite with calcium phosphate. The patients were two males and six females, ranging in age from 35 to 42 years old. The current study found that treated patients had a lower male contribution of 37.5 percent and a higher female contribution of 62.5 percent. As a result, females outnumber males in both groups; nonetheless, this has no bearing on the results. [(13)] This minor rise in females was explained in this study as they are more worried about dental and oral health and pay more attention to their aesthetic appearance. And researchers looked at the impact of risk variables on implant survival one month after implantation on treatment and prognosis, and discovered no significant gender differences between failed and successful implants. [(14)]

The link between probable risk factors and early implant failure, on the other hand. Male sex was discovered to be one of the characteristics that were strongly connected with early implant failure, and the study also revealed that males have the greatest rate of implant failure. This could be related to inadequate dental hygiene, habits, or systemic disorders, among other things. [(15)]

In terms of age, the majority of patients in our study are under the age of 40, with only two patients over 40. There is neither significant age difference between the study's two groups, nor between their outcomes. The majority of prior research found no link between age and gender and early implant failure. [(15)]

The study concluded that age and gender made no significant difference between the two groups. [(16)] While it was discovered that the age group above 60 years had the highest number of implant failures, and males were higher than females in this age range. It was determined that one of the patient-related factors is age. Patients' failure rates have tended to rise as they get older, possibly due to their increased risk of co-morbidities, decreased bone density, and poor oral hygiene. [18,19]

In contrast to popular belief, a recent study found that there were more elderly female implant patients than male implant patients, and that improvement in implant stability was more noticeable in female patients than male patients; additionally, female patients tend to maintain their original ISQ value during the healing period than male patients. Both male and female patients' ISQ scores increased during the bone healing period. [20]

We enlisted 8 patients in this trial, and 16 delayed implants were used to replace missing bilateral mandibular posterior teeth. Our finding reveal that both (SLA) and HA calcium phosphate coated surface implants achieved good osseointegration and clinical success throughout the early healing period. Later, an acid, such as sulfuric, hydrochloric, or nitric acid, is used to chemically treat the surface. The SLA surface is roughened topographically with big dips, sharp edges, and microscopic micro pits to improve contact surface for osseointegration. [21] The biological properties of the SLA surface have been demonstrated. SLA enhances platelet apposition and causes cell migration and differentiation, according to experimental designs. In reality, the SLA surface creates a favourable biological environment for cell adhesion, causing human osteoblasts to proliferate and expand. [22]

The current study found that sandblasted-etched surface implants had considerable stability that increased with time from the first month to the fifth month; the mean bone density around the implant was 79.33 after the first month and 81.92 after five months. In a related investigation, 54 patients who had been followed-up were evaluated five-year radiographic follow-up results of the Korean sandblasting with big grit, and acid etching (SLA)-treated implant system. [23] A total of 176 implant placements were completed. Before the initial surgery, shortly after the first and second surgeries, immediately after the final prosthesis installation, and every year after that, radiographs were taken. They concluded that implants with the SLA surface have a much higher survival probability in bone environments like the maxilla with an overall survival of 96.6%. They concluded that implants with the SLA surface have a very superior survival rate in relatively poor bone environments such as the maxilla.

Supported our findings; reported higher BIC in SLA implants (82.7%) than in RBM implants (78.3%) 12 weeks after implant placement in adult mutts ,as well as,compared the survival rate of RBM surface implants with that of SLA surface implants, reported that the former was 95.2% and the latter 99.1%, with a higher survival rate observed in SLA surface implants. [23] They reported that SLA surface implants produced better results in the posterior maxilla with poor bone.

In addition, there was a comparison of osseointegration between laser- treated and acid-etched titanium implants surfaces and revealed that both exhibited good osseointegration. There were no significant differences found between both. Also, they observed good osseointegration in both acid etched and laser surface implant with no significant differences in the bone to implant contact percentage comparing acid-etched and laser-treated surface implants. [24]

Other type of implant used in the current study is hydroxyapatite calcium phosphate; Synthetic HA is a calcium phosphate ceramic that is chemically similar to the HA that forms naturally in the human body. After implantation, it has been reported that calcium phosphate from the implant surface is released into the peri-implant region, which increases the saturation of body fluids and results in the precipitation of a biological apatite layer on the implant surface. [25] Other researchers have reported increased adhesion and proliferation of bone- forming cells at the bone–HA interface in both animal and human models, which results in accelerated bone formation, maturation, and union between HA- coated implants and the surrounding bone. [26]

In the present study, a significant stability that increased with increasing period in hydroxyapatite calcium phosphate group; the mean bone density initially after placing the implant was 86.43 and finally after five months was 88.4, in agreement with study ,whose investigation was undertaken to determine if multithreaded implants partially coated with hydroxyapatite (HA) with calcium phosphate could be effectively loaded earlier than 3-6 months after placement.[117] After 2 years in function, implants partially coated with plasma- sprayed and hydrothermally treated HA were clinically predictable when restored in occlusion immediately after or within 3 weeks of implant placement.

In the same line; study comparing HA-coated Zimmer Tapered Screw-Vent Implant survival rates and marginal bone stability, when loaded immediately versus when loaded early in 3 weeks. [27] With this implant after 7 years in function, they found no significant loss of stability and with survival of 100% in Group A and 95.5% in Group B. The results from this study of 50 implants showed that HA-coated Zimmer Tapered Screw-Vent Implants were clinically effective, with an overall cumulative 7-year survival rate of 98.0%.

Study was conducted retrospectively for one year, targeting 41 patients whose treatment areas were the posterior maxilla and the mandible. [28] Osstem TS III HA (Osstem Implant Co., Busan, Korea) and Zimmer TSV-HA (Zimmer Dental, Carlsbad, CA, USA), which employ the new hydroxyapatite coating technique, were used. After one year of loading was measured using periapical radiography. For all patients as a single group, the survival rate of the implants was 100%, and the mean marginal bone loss was 0.26±0.59 mm.

Other previous study have shown that Ca-P coatings improve the biocompatibility and fixation of implants; for example, there was a study reported that Ca-P coatings are much more effective in stimulating the bone reaction than microroughness of surfaces, emphasizing that, in addition to the implant surface conditions, the bone reaction to an oral implant is determined by the local conditions at the implantation site, i.e., the presence of cortical or trabecular bone. [29,30]

By comparing both types sandblasted acid etch (Switzerland) implant surface has higher rate of acceleration of progression in bone density than hydroxyapatite calcium phosphate (turkey) coated surface implants. As the statistical analysis showed a significant difference between groups (P value<0.05). In disagreement with other studies as previous study aimed to evaluate the effectiveness of a calcium phosphate (CaPO4)-coated and anodized titanium surface in vitro and in vivo. As a turned surface was employed as a negative control. Surface characteristics were analyzed with field emission scanning electron microscopy, energy dispersive spectroscopy, and confocal laser scanning microscopy. [31] They concluded that A CaPO coating on an anodized surface may induce rapid osseointegration at the bone-implant interface and more bone formation near theimplant surface.

However, in a recent meta-analysis aimed to bring together preclinical studies in experimental animals to determine whether Ca-P-coated Ti implant surfaces possess increased osseointegration capability ; they found no statistical significance between implants coated with Ca-P and implants with conventional etched surfaces (SLA type) it can be concluded that Ca-P-coated Ti surfaces have a similar osseointegration power to conventional etched surfaces (SLA or similar). [32]

In this study, Densitometric analysis of radiographic images for osseointegration tracking around implants during follow-up months depends on the selected EZ Dent-i software. It is considered a cheaper available alternative to CBCT with similar accuracy in osseointegration follow-up. Moreover, study stated that EZ Dent-i software could be a dependable only way for assessing progression rate of osseointegration around dental implants through analysis of values of bone density through radiographic images. [33]

The limitation of this study is that, bone density value obtained by radiographic image analysis is the only used method to evaluate stability. Besides that, these obtained values before loading and actual functioning. Follow-up period was for 5 months only, missing comparison of long-term success between HA-coating and SLA surface treatment. In future study, various methods as static and dynamic biomechanical testing, Histomorphometric analysis and radiographical examinations evaluate for peri-implant osteogenesis and implant stability, in addition to implant surface treatment comparison when different surface modifications are used. [34]

CONCLUSION AND RECOMMENDATIONS

Successful osseointegration was achieved in both HA with calcium phosphate and SLA surface treatments in dental implants, while SLA method has the superior outcomes within first 5 months.

The study recommends a study of bone density after placing the implants. The study recommends making comparisons between the material used in this research (calcium phosphate hydroxyapatite) and another with a rough acid-etched surface embossed with sand. The study recommends a microscopic study to study the healing nature of this material around dental implants.

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