OPEN ACCESS

Saudi Journal of Oral and Dental Research
Abbreviated Key Title: Saudi J Oral Dent Res
ISSN 2518-1300 (Print) | ISSN 2518-1297 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article | **Periodontology**

Evaluation of Two Differently Surface-Treated Dental Implants: A Clinico-Radiographic Study

Kirtika Verma[1]*, Mukesh Kumar[2], Rajan Gupta[3], Parveen Dahiya[4], Sunita R. Melwani[5]

[1]Post Graduate Student, Department of Periodontology, Himachal Institute of Dental Sciences, Paonta Sahib, Himachal Pradesh, India
[2]B.D.S, M.D.S, Professor, Department of Periodontology, Himachal Institute of Dental Sciences, Paonta Sahib, Himachal Pradesh, India
[3]B.D.S, M.D.S, Head of Department and Professor, Department of Periodontology, Himachal Institute of Dental Sciences, Paonta Sahib, Himachal Pradesh, India
[4]B.D.S, M.D.S, Professor, Department of Periodontology, Himachal Institute of Dental Sciences, Paonta Sahib, Himachal Pradesh, India
[5]B.D.S, M.D.S, Reader, Department of Periodontology, Himachal Institute of Dental Sciences, Paonta Sahib, Himachal Pradesh, India

DOI: https://doi.org/10.36348/sjodr.2025.v10i05.003 | **Received:** 10.04.2025 | **Accepted:** 16.05.2025 | **Published:** 22.05.2025

***Corresponding author:** Kirtika Verma
Post Graduate Student, Department of Periodontology, Himachal Institute of Dental Sciences, Paonta Sahib, Himachal Pradesh, India

Abstract

Contemporary advancements in clinical dental implant replacement of teeth emphasize the modification of titanium surfaces to enhance osseointegration. These modifications employ both additive techniques, such as bioactive coatings, and subtractive processes, including acid etching and grit-blasting. ***Objective*:** The present clinic-radiographic study was conducted to evaluate clinical and radiological parameters around a conventional SLA coated and a CaP-coated sandblasted, large-grit, acid-etched (SLA) surface implants during the first year after placement. ***Materials and Methods*:** The clinical study was conducted on 20 patients who were randomly assigned to one of two groups: a control group and a test group. In the test group, dental implants coated with calcium phosphate nanocrystals were placed in the prepared osteotomy site. In contrast, the control group received standard implants without any coating, which were placed similarly. The patients' soft tissue and hard tissue health were evaluated and recorded at regular intervals - 1 month, 3 months, 6 months, and 1 year post-implant placement. A statistical analysis was then performed. ***Results:*** Plaque Index, Gingival Index, and Modified Sulcular Bleeding Index Crestal bone level were evaluated and showed no statistically significant result when observed on the mesial and distal aspects at 1-year but a statistically significant difference was found in pocket probing depth and densitometric analysis to assess the bone density (mesial, distal and apical) 1-year post implant placement. ***Conclusion*:** While the calcium phosphate-coated implants showed a notable reduction in crestal bone loss compared to the control group, this difference didn't reach statistical significance. However, a statistically significant difference was observed in the densitometric analysis, which showed an increased bone density (mesial, distal, and apical end) around Calcium Phosphate Coated Implants.

Keywords: Calcium Phosphate, Dental Implant, Crestal Bone Loss, Tissue Parameters, Osteotomy Site, Acid-Etched, Osteointegration.

INTRODUCTION

For over 50 years, dental implants have revolutionized restorative dentistry, providing reliable solutions for missing teeth with high success rates. Their introduction marked a revolutionary shift in dental care, enabling patients to regain function and aesthetics with remarkable success rates [1]. Osseointegration, a concept defined by Brånemark, refers to "a direct structural and functional connection between ordered, living bone and the surface of a load-bearing implant." [2].

Dental implant innovations are flourishing alongside the demand for cosmetic dentistry, with osseointegration being key to biomechanical stability. Research highlights rough-surfaced implants as pivotal for enhancing bone anchoring and ensuring long-term stability, bolstering clinical outcomes [2]. The success of dental implants relies significantly on the availability of adequate bone to support them. A sufficient amount of bone ensures the stability and longevity of the implant as well as favourable osseointegration. However, vertical bone volume—a crucial factor in dental implant placement and successful osseointegration—is often inadequate. This deficiency may result from inflammation, trauma, or the rapid bone loss commonly following tooth extraction [3].

Implant stability is a cornerstone of successful implant dentistry, significantly affecting long-term outcomes. Key factors influencing treatment success include implant design, precise alveolar placement, surgical accuracy, the patient's health, and prosthesis type. Each element is vital for optimal integration, stability, and functionality [4].

Surface modifications of endosseous implants are increasingly recognized for their potential to enhance osseointegration, particularly in complex clinical scenarios. Deposits on implant surfaces, such as calcium or hydroxyapatite coatings, have been shown to accelerate early peri-implant bone healing by stimulating platelet activation. This is especially beneficial in challenging cases, including immediate implant placement, loading, or insertion into poor-quality bone [5].

Dual acid-etched (DAE) surfaces with calcium or hydroxyapatite coatings show comparable clinical success. These coatings release calcium phosphate ions upon implantation, forming biological hydroxyapatite enriched with proteins. This layer supports osteogenic cell attachment and proliferation, fostering strong bone integration [5]. The modified calcium-phosphate surface incorporates an advanced geometry meticulously engineered to complement the natural architecture of the bone. This design ensures optimal primary stability, preserves surrounding bone structures, and enhances overall esthetics, making it a comprehensive solution for modern implantology [6]. Furthermore, the introduction of a positive-angle platform switching fosters seamless soft tissue adaptation. This supports the formation of a stable peri-implant seal [6]. Its surface topography combines macro-roughness, created via a precise physical process, with microporosity, achieved through a specialized chemical treatment [7].

Incorporating calcium and phosphorus into the titanium oxide layer transforms the surface into an osteoconductive platform, actively encouraging bone growth. This enhancement bolsters osseointegration, ensuring superior implant stability and optimal long-term performance [7].

MATERIALS AND METHODS

A randomized clinico-radiographic trial was conducted at the Himachal Institute of Dental Sciences, Paonta Sahib, involving 20 patients with maxillary or mandibular tooth loss. Inclusion criteria required good oral hygiene, non-smoking status, sufficient bone for implant placement, and bilateral mandibular edentulous space. Exclusion criteria included poor oral hygiene, bruxism, or low platelet counts.

GROUPING OF PARTICIPANTS

Participants Were Randomly Divided into Two Groups:

- **Control group:** Received conventional SLA implants after osteotomy.
- **Test group:** Received calcium phosphate-coated implants (CaP) after osteotomy.

Calcium phosphate coatings are recognized for their bioactivity, enhancing cell adhesion, proliferation, and differentiation. Their biocompatibility and bone-like composition promote contact osteogenesis, expediting early osseointegration [8].

Surgical Procedure

Following local anesthesia, a crestal incision and full-thickness flap were performed. Osteotomy sites were prepared and irrigated with sterile saline. Implants-either conventional SLA (Adin Toureg-S) or CaP-coated (Adin Closefit Osseofix)-were placed under aseptic conditions with primary stability, and cover screws were attached. Flaps were repositioned and sutured using 3.0 braided silk. Postoperative instructions included avoiding brushing at the surgical site and rinsing with chlorhexidine gluconate. Sutures were removed after 7–10 days.

Second-stage surgery was performed at three months, involving mid-crestal incision, flap reflection, cover screw removal, and placement of a gingival former for 15 days, followed by abutment connection and cementation of a porcelain-fused metal crown. Follow-up assessments were conducted at 1, 3, 6, and 12 months.

Clinical and Radiographic Assessment

Soft and hard tissue parameters-including Mombelli plaque index, modified sulcular bleeding index (Mombelli), simplified gingival index (Apse *et al*.,), probing pocket depth after 3,6 and 12 months, crestal bone loss (mesial and distal), and densitometric bone analysis-were recorded at 1,3,6 and 12 months follow-up.

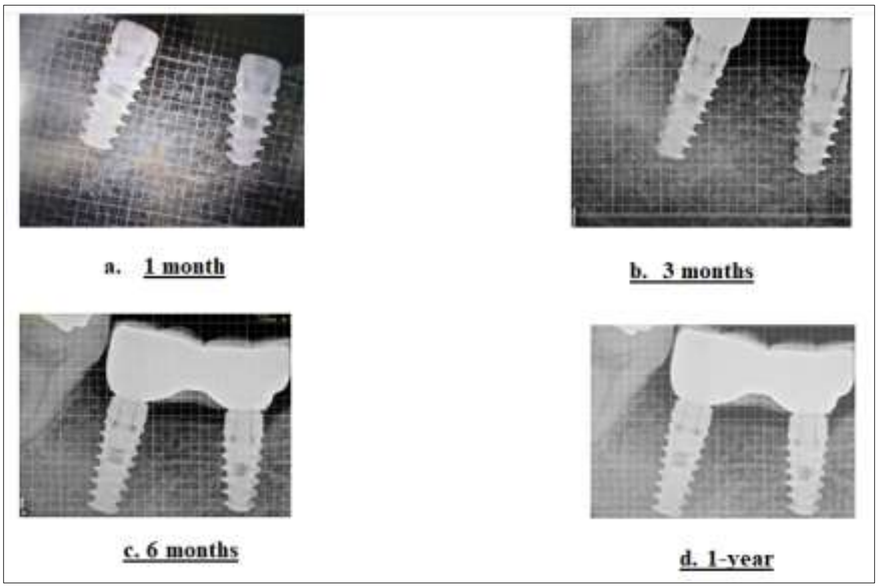

Figure 1: Radiographic Findings around Implants at Various Time Intervals

Statistical Analysis

Data were analyzed using Jamovi (Version 2.6.26). Descriptive statistics (mean, standard deviation) were calculated, and independent t-tests were used for group comparisons. Statistical significance was set at P < 0.05.

RESULTS

The study groups' plaque index, gingival index, and modified sulcular bleeding were compared using an independent t-test, which showed no statistically significant difference in plaque index between the two groups (Table 1). The comparison of the gingival index showed that there was no statistically significant difference in the gingival index between the two groups at 3 months (P=0.174), at 6 months (P=0.556), and at 1 year (P=0.628) (Table 2). Comparison of sulcular bleeding index, which showed that there was no statistically significant difference in bleeding index between the two groups at 3 months (P=1.000), at 6 months (P=0.135), and at 1 year (P=0.081) (Table 3).

Probing pocket depth did not differ significantly at 3 months (p=1.000), but significant differences emerged at 6 months (P=0.004) and 12 months (P=0.012), with the control group exhibiting greater depths in the control group than the test group. (Table 4)

The comparison of bone loss (mesial and distal) between the study groups at various periods. Statistical analysis was done using independent t-test which showed that there was no statistically significant difference in bone loss (mesial and distal) between the two groups (mesial) at 1 month (P=0.058), at 3 months (P=0.637), at 6 months (P=1.000), and at 1-year(P=0.898)(Table 5) and (distal) at 1 month (P=0.222), at 3 months (P=0.900) and at 6 months (P=0.834) (Table 5).

The comparison of densitometric analysis in Hounsfield Units (mesial, distal, and apical end) between the study groups at various periods. Statistical analysis was done using independent t-test which showed that there was a statistically significant difference in bone loss (mesial, distal and apical) between the two groups (mesial) at 1 month (P=0.002), at 3 months (P=0.002), at 6 months (P=0.009), and at 1-year(P=0.008)(Table 6),(distal) at 1 month (P=0.054), at 3 months (P=0.005), at 6 months (P=0.006) and at 1-year(P=0.001) (Table 6)

After 1 month post-implant placement, there was no statistically significant difference in apical bone density between test and control groups (p=0.041). However, significant differences emerged at 3 months (p=0.002), 6 months (p=0.003), and 1 year (p=0.005)(Table 7).

Table 1: Comparison of Mombelli's plaque index scores at various time periods

	Group	N	Mean	SD	p-value
Mombelli's Plaque Index 3 Months	**Control Group**	10	0.80	0.63	0.331
	Case Group	10	1.00	0.00	
Mombelli's Plaque Index 6 Months	**Control Group**	10	0.70	0.48	1.000
	Case Group	10	0.70	0.48	
Mombelli's Plaque Index 1 Year	**Control Group**	10	0.70	0.48	0.660
	Case Group	10	0.60	0.51	

Table 2: Intergroup Comparison of gingival index scores at various time periods

	Group	N	Mean	SD	p-value
Gingival Index 3 Months	**Control Group**	10	1.10	0.32	0.174
	Case Group	10	0.90	0.32	
Gingival Index 6 Months	**Control Group**	10	0.80	0.42	0.556
	Case Group	10	0.90	0.32	
Gingival Index 1 Year	**Control Group**	10	0.70	0.48	0.628
	Case Group	10	0.80	0.42	

Table 3: Intergroup Comparison of Modified Sulcular Bleeding Index Scores at Various Time Periods

	Group	N	Mean	SD	p-value
MSBI 3 Months	**Control Group**	10	0.80	0.63	1.000
	Case Group	10	0.80	0.42	
MSBI 6 Months	**Control Group**	10	0.90	0.32	0.135
	Case Group	10	0.60	0.52	
MSBI 1 Year	**Control Group**	10	0.70	0.48	0.081
	Case Group	10	0.30	0.48	

Table 4: Comparison of probing pocket depth at various time periods

	Group	N	Mean	SD	P-value
Probing Depth 3 Months	**Control Group**	10	1.75	0.42	0.189
	Case Group	10	2.05	0.55	
Probing Depth 6 Months	**Control Group**	10	1.65	0.34	0.004*
	Case Group	10	1.15	0.34	
Probing Depth 1 Year	**Control Group**	10	1.75	0.59	0.012*
	Case Group	10	1.15	0.34	

*Statistically significant (p<0.05, Independent t-test)

Table 5: Comparison of radiographic bone loss (mesial and distal) at various time periods(N=10)

	Group	Mean± SD(Mesial)	Mean±SD(Distal)	p-value (mesial)	p-value (distal)
Bone Loss 1 Month	**Control Group**	11.00±0.75	10.81±0.90	0.058	0.222
	Case Group	10.40±0.57	10.35±0.71		
Bone Loss 3 Months	**Control Group**	10.11±0.84	10.05±1.04	0.637	0.900
	Case Group	9.95±0.64	10.00±0.67		
Bone Loss 6 Months	**Control Group**	10.00±1.29	10.00±1.33	1.000	0.918
	Case Group	10.00±0.67	10.05±0.72		
Bone Loss 1 Year	**Control Group**	9.95±1.01	9.95±1.30	0.898	0.834
	Case Group	10.00±0.67	10.05±0.72		

Table 6: Comparison of bone density (mesial and distal) at various time periods (N=10)

	Group	Mean± SD (Mesial)	Mean± SD (Distal)	p-value (Mesial)	p-value (Distal)
Bone Density 1 Month	**Control Group**	92.30±14.78	99.20±18.72	0.002*	0.054
	Case Group	115.40±12.84	116.60±18.95		
Bone Density 3 Months	**Control Group**	102.00±18.00	100.70±14.64	0.002*	0.005*
	Case Group	136.10±23.84	132.60±28.16		
Bone Density 6 Months	**Control Group**	115.50±14.95	114.20±17.60	0.009*	0.006*
	Case Group	141.50±23.63	144.40±24.69		
Bone Density 1 Year	**Control Group**	118.10±18.48	114.10±14.60	0.008*	0.001*
	Case Group	146.20±23.43	149.40±25.80		

*Statistically significant (p<0.05, Independent t-test)

Table 7: Comparison of bone density (apical) at various time periods (In Hounsfeild Units)

	Group	N	Mean	SD	p-value
Bone Density 1 Month	**Control Group**	10	96.90	22.37	0.041*
	Case Group	10	116.70	17.62	
Bone Density 3 Months	**Control Group**	10	100.00	16.42	0.002*

	Case Group	10	135.90	25.71	
Bone Density 6 Months	**Control Group**	10	111.50	14.78	0.003*
	Case Group	10	142.80	24.78	
Bone Density 1 Year	**Control Group**	10	117.20	16.12	0.005*
	Case Group	10	145.90	23.82	

DISCUSSION

The evolution of implant surface treatments has made dental implantation a routine clinical procedure, with a focus on enhancing stability and alveolar bone integration. Bioactive coatings such as hydroxyapatite, calcium phosphate, and bioactive glass have been shown to significantly improve the osteogenic properties of dental implants. Preclinical studies consistently demonstrate that textured surfaces increase bone-to-implant contact, particularly during the critical early healing phase [8].

Surface enhancement strategies employ a variety of physical, mechanical, chemical, biological, and nanotechnology-based approaches. Physical modifications, such as titanium plasma spraying, create macro-textures for robust bone attachment, while mechanical techniques like grit blasting increase roughness for improved mechanical interlock. Chemical treatments, including acid etching and anodization, further enhance micro- and nano-scale features to promote cellular adhesion and biocompatibility [9].

Biological and nanotechnology-based coatings stimulate osteogenesis and mimic extracellular matrix structures, respectively, to optimize bone integration.

In this study, mechanical additive methods utilizing calcium phosphate media were employed to achieve the desired surface roughness for optimal osseointegration. The findings align with those of Camille Pierre *et al.*, [9], who demonstrated that advanced titanium surface treatments-combining sandblasting, acid etching, and precise deposition of bioactive calcium phosphate coatings-boost bioactivity and accelerate early osseointegration.

The study involved 20 patients divided into two groups: Group I (Control Group) with SLA surface implants (mean age 45±2 years) and Group II (Test Group) with calcium phosphate-coated implants (mean age 35±2 years). Each group received 10 implants, with the test group utilizing nanocrystal-coated implants (Osseofix surface). Both groups in the present study achieved a 100% cumulative survival rate at one year.

The evaluation encompassed both hard and soft tissue parameters for the test and control groups. Hard tissue analysis focused on crestal bone loss and bone density development in the peri-implant region, assessed using RVG and an XCP tool to maintain precise paralleling. Bhardwaj I *et al.*, [10], employed a radiographic grid for objective evaluation of mesial and distal bone levels at 1, 3, 6, and 1-year post-implant placement. No significant difference in mesial (1 month(p=0.058), at 3 months(p=0.637), at 6 months (p=1.000) and 1-year(p=0.898) post-implant placement) (Table no.5) or distal bone loss(1 month (p-0.222), at 3 months (p-0.900), at 6 months (p-0.918) and 1-year(p-0.834)(Table no.5) post-implant placement was observed between the control (SLA surface) and test (Calcium Phosphate-coated) groups across all time points. However, densitometric analysis revealed significantly higher mesial bone density in the test group compared to the control group at all intervals (1 month: p=0.002; 3 months: p=0.002; 6 months: p=0.009; 1-year: p=0.008), highlighting the enhanced osteogenic performance of Calcium Phosphate-coated implants (Table no. 6).The improved bone density around CaP-coated implants is likely attributable to the bioactive properties of the coating, which promote osteoblast differentiation and facilitate biochemical bonding between the implant and bone. These findings are supported by Ko *et al.*, [7], who observed similar trends in bone density and integration.

Densitometric analysis revealed no significant difference in distal bone density between test and control groups after 1 month (p=0.054), but a significant increase in the test group at 3 months (p=0.005), 6 months (p=0.006), and 1 year (p=0.001) post-implant placement. (Table no. 6) McGlumphy *et al.*, [11], conducted a 7-year study on hydroxyapatite (HA)-coated implants, showing enhanced stability and accelerated healing due to increased bone density. HA nanocrystals, similar to calcium phosphate coatings, supported osteogenesis by mimicking natural bone minerals, optimizing osteoblast attachment and activity.

Densitometric analysis revealed no significant difference in apical bone density between test and control groups after 1 month (p=0.041), but a significant increase in the test group at 3 months (p=0.002), 6 months (p=0.003), and 1 year (p=0.005) post-implant placement. (Table no. 7). A crucial advantage of calcium ions within these coatings is their role in forming a biochemical bond between the implant and the surrounding bone. The findings of ***Poulos et al.***, [12], provide valuable histologic evidence reinforcing the enhanced bone density observed around calcium phosphate-coated implants, highlighting their potential in optimizing implant success.

After 3 months post-implant placement, no statistically significant difference in mean probing depth was observed between the test and control groups (p=0.189). However, significant differences emerged at 6 months (p=0.004) and 1 year (p=0.012) (Table no.4), indicating a reduction in probing depth over time. This could be possibly since titanium surfaces modified with calcium ions (Ca^{2+}) enhance platelet adhesion, activation, and provisional matrix formation [13].

For soft tissue parameters, the Plaque Index, Gingival Index, and Sulcular Bleeding Index were evaluated in the patient at regular time intervals of 3 months, 6 months, and 1 year for both the test group and the control group. Plaque Index between test and control groups depicted no statistically significant difference at 3 months (p-0.331), 6 months (p-1.000), and at 1-year (p-0.660) (Table no.1) after implant placement was seen. The gingival index recorded at 3 months, at 6 months, and at 1-year between the two groups showed no statistically significant result at 3 months (P-0.174), at 6 months (P-0.556), and at 1-year (p-0.628) (Table 2). ***Victor Palarie et al.,*** [14], found no significant difference in the gingival healing index 1-year post-implant placement for calcium phosphate-coated implants. Similarly, the Modified Sulcular Bleeding Index showed no statistical difference between groups at 3 months (p=1.000), 6 months (p=0.135), and 1-year (p=0.081) (Table no.3). ***Rajpal J et al.,*** [15], conducted a clinico-radiographic study on 10 implants across seven patients, evaluating soft tissue health indicators over six months. Their results matched the current study, showing no significant clinical parameter changes from baseline to six months.

Within the limitations of this study, both CaP-coated and uncoated SLA implants demonstrated excellent survival and minimal bone loss during the first year post-placement. CaP-coated SLA implants exhibited clinical viability, low complication rates, and stable marginal bone levels, supporting their suitability for routine clinical use. Further studies are warranted to confirm their long-term benefits [7].

CONCLUSIONS

Within the limitations of the present study, the following conclusions can be made:

- All 20 implants in both groups achieved a 100% survival rate at one year.
- No statistically significant differences were found in crestal bone level reduction, plaque score, gingival score, or sulcus bleeding score between groups.
- A significant reduction in probing pocket depth was observed in the test group at 6 and 12 months.
- Densitometric analysis revealed statistically significant increases in bone density at the mesial, distal, and apical ends in the CaP-coated group at all intervals.

These results support the clinical utility of calcium phosphate-coated implants in promoting implant stability and osseointegration.

REFERENCES

1. Warreth, A., Ibieyou, N., O'Leary, R. B., Cremonese, M., & Abdulrahim, M. (2017). Dental implants: An overview. *Dental Update*, *44*(7), 596–620.
2. Guéhennec, L. L., Soueidan, A., Layrolle, P., & Amouriq, Y. (2006). Surface treatments of titanium dental implants for rapid osseointegration. *Dental Materials*, *23*(7), 844–854
3. Bansal, A., Kumar, M., Ramandeep, F., Badalia, I., & Salil, F. (2017). Measuring Implants Stability—A Review. *Dental Journal of Advance Studies*, *5*(3), 105–111.
4. Chrcanovic, B. R., Albrektsson, T., & Wennerberg, A. (2014). Reasons for failures of oral implants. *Journal of Oral Rehabilitation*, *41*(6), 443–476.
5. Santander, S., Alcaine, C., Lyahyai, J., Pérez, M. A., Rodellar, C., Doblaré, M., & Ochoa, I. (2014). In vitro osteoinduction of human mesenchymal stem cells in biomimetic surface modified titanium alloy implants. *Dental Materials Journal*, *33*(3), 305–312.
6. Han T, Carranza FA Jr, Kenney EB. Calcium phosphate ceramics in dentistry: a review of the literature. *J West Soc Periodontol Periodontal Abstr*. 1984;32:88-108.
7. Ko, K., Kim, S., Choi, S., & Lee, J. (2019). Randomized controlled clinical trial on calcium phosphate coated and conventional SLA surface implants: 1-year study on survival rate and marginal bone level. *Clinical Implant Dentistry and Related Research*, *21*(5), 995–1001.
8. Drevet, R., Fauré, J., & Benhayoune, H. Bioactive Calcium Phosphate Coatings for Bone Implant Applications: A Review. *Coatings*, *13*(6)(2023), 1091.
9. Pierre, C., Bertrand, G., Rey, C., Benhamou, O., & Combes, C. (2018). Calcium phosphate coatings elaborated by the soaking process on titanium dental implants: Surface preparation, processing and physical–chemical characterization. *Dental Materials*, *35*(2), e25–e35.
10. Bhardwaj, I., Bhushan, A., Baiju, C. S., Bali, S., & Joshi, V. (2015). Evaluation of peri-implant soft tissue and bone levels around early loaded implant in restoring single missing tooth: A clinico-radiographic study. *Journal of Indian Society of Periodontology*, *20*(1), 36.
11. McGlumphy EA, Peterson LJ, Larsen PE, Jeffcoat MK. Prospective study of 429 hydroxyapatite-coated cylindric omniloc implants placed in 121 patients. *Int J Oral Maxillofac Implants* 2003;18:82-92.
12. Poulos NM, Rodriguez NA, Lee J, Rueggeberg FA, Schüpbach P, Hall J, et al. Evaluation of a novel calcium phosphate-coated titanium porous oxide implant surface: a study in rabbits. *Int J Oral Maxillofac Implants* 2011;26:731-738

13. Anitua, E., Prado, R., Orive, G., & Tejero, R. (2014). Effects of calcium-modified titanium implant surfaces on platelet activation, clot formation, and osseointegration. *Journal of Biomedical Materials Research Part A*, *103*(3), 969–980.
14. Palarie, V., Bicer, C., Lehmann, K. M., Zahalka, M., Draenert, F. G., & Kämmerer, P. W. (2011). Early outcome of an implant system with a resorbable adhesive calcium–phosphate coating—a prospective clinical study in partially dentate patients. *Clinical Oral Investigations*, *16*(4), 1039–1048
15. Rajpal, J., Gupta, K., Tandon, P., Srivastava, A., & Chandra, C. (2014). Assessment of hard and soft tissue changes around Implants: A clinico-radiographic in vivo study. *Journal of Dental Implants*, *4*(2), 126.