ORIGINAL RESEARCH

Platelet-rich Fibrin Attachment on Dental Implant Surfaces: Comparative *In Vitro* Evaluation of Sandblasting/Acid Etching and Plasma Spraying Treatments

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Abstract

Aim: This study assessed the effectiveness of platelet-rich fibrin (PRF) attachment on implant surfaces following various surface treatments.

Materials and methods: In this *in vitro* investigation, 45 dental implants with dimensions of 16 mm in length and 5 mm in diameter were used. Based on the surface treatment used, the samples were divided into three groups of 15 implants each randomly: group A: control, group B: surface treatment with sandblasted and acid-etching method, and group C: surface treatment with plasma spraying method. To obtain the PRF clots, blood samples were taken. After this procedure, the fibrin clot that was connected to the implants was carefully removed. PRF attachment effectiveness was evaluated using scanning electron microscopy.

Results: The maximum PRF attachment was found in the sandblasted and acid-etching method group with a mean of 2.56 ± 0.26 (CI: 1.84–3.44), followed by the plasma spraying method group with a mean of 2.24 ± 0.70 (CI: 1.98–2.68), and the control group with a mean of 1.02 ± 0.18 (CI: 0.70–1.36). A statistically significant difference was obtained between the three groups ($p = 0.0002$).

Conclusion: The current study concluded that the groups using the sandblasting and acid-etching methods had the highest PRF attachment, followed by the groups using the plasma spraying method and the control group.

Clinical significance: Successful PRF attachment in implant treatment may enhance early implant durability by promoting immediate peri-implant soft tissue integration and establishing a physiologically advantageous interface that facilitates later osseointegration. Blood clot formation is significantly influenced by the physical and chemical properties of an implant surface.

Keywords: Dental implants, Osseointegration, Plasma spraying, Platelet-rich fibrin, Sandblasted and acid-etching, Surface treatment.

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Introduction

The initial progression toward a dental implant's long-term stability and longevity is successful osseointegration. The need for quicker treatment times has grown along with advancements in the field of oral implantology. Osseointegration time is a significant factor that influences the overall duration between implant implantation and prosthesis delivery. Implant manufacturers alter the surface to enhance the bone-implant contact (BIC) and reduce the amount of time required for complete osseointegration before the implant may be loaded. The complex process of the entire osseointegration cascade is controlled by a variety of growth factors and inflammatory mediators.[1]

It is widely known that platelet concentrates play a significant part in the regeneration of both the hard and soft tissues that support teeth. Therefore, during the past 10 years, there has been an increased focus on platelet concentrates, such as platelet-rich fibrin (PRF) and its derivatives, to create an environment that is conducive to the osseointegration of dental implants, which has resulted in a high degree of success and survival. It is interesting to note that because platelet concentrates contain a variety of growth factors, such as transforming growth factor-β (TGF-β), vascular endothelial growth factor (VEGF), and platelet-derived growth factor (PDGF), they have been shown to have a more noticeable effect on soft tissue wound healing than hard tissues.[2] According to recent research, platelet concentrates such as PRF and comparable materials can be used in combination with immediate implants to preserve the peri-implant soft tissue condition and marginal bone structure.[3]

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In implant dentistry, sandblasting and acid-etching (SLA) is a frequently used technique to increase the material's rigidity. An SLA surface is produced by sandblasting the turned surface with large-grit alumina particles. After that, an acid is used to chemically change the surface. To enhance the contact surface for osseointegration, the SLA surface topographically produces a roughness with large depressions, sharp edges, and small micropits.[4] Another technique is the plasma spraying coating procedure, which involves spraying thermally melted materials onto implant substrates. Due to its favorable mechanical and biocompatibility properties, there has been considerable interest in the combination of hydroxyapatite (HA) coating with Ti alloy substrate. By encouraging soft tissue thickening around an implant, PRF can increase peri-implant tissue stability and decrease marginal bone loss.[5] Since there is currently a lack of comparative data on PRF adhesion across these different surface technologies, SLA and plasma-sprayed surfaces were specifically selected to fill a gap in the literature. Hence, the present study was conducted to assess the effectiveness of PRF attachment on implant surfaces following various surface treatments.

Materials and Methods

The present *in vitro* study was conducted in the Department of Oral and Maxillofacial Surgery, Kalinga Institute of Dental Sciences, Bhubaneswar, India. In this *in vitro* investigation, 45 dental implants with dimensions of 16 mm in length and 5 mm in diameter were used.

Based on the surface treatment used, the samples were divided into 3 groups of 15 implants each randomly:

Group A: Control: A cotton pellet soaked in regular saline was used to burnish and polish the surface for 1 minute.

Group B: Surface treatment with sandblasted and acid-etching method: The surfaces were polished with 3 µm diamond paste and then roughened with 150 µm Al_2O_3 grain size under 6 bar pressure. After that, a 38–40% hydrochloric acid (HCl) solution was used to acid-etch the surfaces for 10 seconds. All the samples were allowed to air-dry after being ultrasonically cleaned for 5 minutes using double-distilled water.

Group C: Surface treatment with plasma spraying method: A 2 mm thick layer of commercial-grade, 150 µm-sized hydroxyapatite powder was applied under 1500°C temperature at a distance of 120 mm. Before being coated, implants were ultrasonically cleaned in deionized water to remove any organic impurities.

Procedure for Platelet-rich Fibrin Preparation

To obtain the PRF clots, 9 cL of blood was collected in vacuum tubes. The tubes were removed after 3 minutes of centrifugation at 2,700 rpm.[5] The liquid fibrinogen was then quickly transferred into Eppendorf tubes after being aspirated at the maximum point of the white cap tubes using a sterile needle to prevent red blood cells. Next, liquid fibrinogen was poured into 3 different containers. Each group's 15 samples were placed in 3 different containers and immersed at room temperature for a total of 60 minutes. After this procedure, the fibrin clot that was connected to the implants was carefully removed.

Evaluation of Platelet-rich Fibrin Attachment on Implant Surface

The samples were kept in saline buffered with 1% formaldehyde phosphate for 15 minutes. The samples were submerged in gradually diluted ethanol solutions (25, 50, 75, 95, and 100%) for approximately 10 minutes to make them less hydrated. The samples were then dried in a critical point dryer using liquid carbon dioxide. The dehydrated samples were mounted on metallic stubs, desiccated at room temperature, and plated with gold. Scanning photomicrographs were generated at 15 kV and 5000× magnification using an SEM. The amount of fibrin clot attachment to the implant surface was calculated using the mean of the following ratings:[6]

Score 0: There were no blood cells or fibrin network.
Score 1: Low blood cells and/or fibrin network.
Score 2: A moderate blood cell count and fibrin network.
Score 3: Trapped blood cells and a thick fibrin network.

Statistical Analysis

In this study, a descriptive statistical technique was used. Results are presented as mean ± standard deviation for continuous metrics. The significance was evaluated at the 5% level of significance. The Kruskal–Wallis test was used to evaluate differences between more than 2 independent groups. The Mann–Whitney *U* test was used for pairwise comparisons when a significant Kruskal–Wallis result was obtained.

Results

Table 1 shows the PRF attachment on implant surface after different surface treatments. The mean PRF attachment in the control group was 1.02 ± 0.18, the sandblasted and acid-etching method group was 2.56 ± 0.26, and the plasma spraying method group was 2.24 ± 0.70.

Comparison of the PRF attachment on implant surface after different surface treatments is depicted in Table 2. The highest PRF attachment was found in the sandblasted and acid-etching method group with a mean of 2.56 ± 0.26, followed by the plasma spraying method group with a mean of 2.24 ± 0.70, and the control group with a mean of 1.02 ± 0.18. A statistically significant difference was obtained between the three groups.

Pairwise comparative evaluation between the study groups is shown in Table 3. A significant difference was found between the control vs sandblasted and acid-etching method groups and the control vs plasma spraying method groups. There was no significant difference found between the sandblasted and acid-etching method vs plasma spraying method groups (p = 0.516, not significant).

Table 1: Evaluation of the PRF attachment on implant surface after different surface treatments

Study groups	*Sample size*	*Mean ± SD*	*95% CI for mean*	
			Lower	*Upper*
Group A: Control	15	1.02 ± 0.18	0.70	1.36
Group B: Sandblasted and acid-etching method	15	2.56 ± 0.26	1.84	3.44
Group C: Plasma spraying method	15	2.24 ± 0.70	1.98	2.68

Table 2: Comparison of the PRF attachment on implant surface after different surface treatments

Study groups	*Sample size*	*Mean ± SD*	*95% CI for mean*		*Mean rank*	*p-value*
			Lower	*Upper*		
Group A: Control	15	1.02 ± 0.18	0.70	1.36	11.08	0.0002
Group B: Sandblasted and acid-etching method	15	2.56 ± 0.26	1.84	3.44	21.16	
Group C: Plasma spraying method	15	2.24 ± 0.70	1.98	2.68	20.52	

Table 3: Pairwise comparative evaluation between the study groups

Study groups	*Mean difference*	*Significance*
Control vs sandblasted and acid-etching method	−1.54	0.001
Control vs plasma spraying method	−1.22	0.001
Sandblasted and acid-etching method vs plasma spraying method	0.32	0.516

Discussion

Early wound healing and subsequent osseointegration are significantly influenced by the interplay between PRF and implant surface properties. The impact of various surface treatments on PRF adhesion, which is crucial for physiologically driven implant integration, is demonstrated in this work. Protein adsorption and cellular adhesion are known to be influenced by implant surface topography and surface energy. When compared to clean, machined surfaces, roughened and chemically altered surfaces showed better PRF adhesion. Increased surface area and micro- or nanoscale imperfections that provide mechanical interlocking of the fibrin matrix are responsible for this. In contrast, machined surfaces showed poorer PRF retention and restricted fibrin anchoring, perhaps as a result of decreased surface energy and roughness. PRF is regarded as a healing biomaterial that is frequently utilized to improve soft tissue wound healing and bone regeneration during implant and reconstructive periodontal surgery treatments.[7]

PRF functions as an autologous biomaterial that is high in leukocytes, platelets, and growth factors, including vascular endothelial growth factor (VEGF), transforming growth factor-β (TGF-β), and platelet-derived growth factor (PDGF), all of which are critical for angiogenesis and bone regeneration. Thus, in order to preserve a physiologically active interface throughout the initial phases of healing, PRF adhesion and stability on the implant surface are essential.[8,9]

These findings are comparable to those of Gahlert et al.,[10] who demonstrated that surface roughness was enhanced by both acid etching and airborne particles. The surface topography may change in combination with changes in surface chemistry and physics. Surface roughness may be similar for both machined implant surfaces and surface modifiers such as sandblasting or acid etching.

According to Wennerberg and Albrektsson,[11] roughened surfaces with a thick and linked fibrin network, such as sandblasted and acid-etched (SLA) implants, demonstrated noticeably enhanced PRF adhesion. The micro-rough texture improves clot stability by increasing surface area and facilitating mechanical interlocking of the fibrin matrix. Sustained growth factor release, which is essential for osteoblast differentiation and new bone formation, is also encouraged by increased platelet activation on rough surfaces.

According to studies by Oncu and Erbeyoglu[12] and Priya et al.,[13] PRF enhances implant stability during the first healing period. Implant stability was enhanced by applying L-PRF to the implant surface. Because PRF-treated implants have a significantly greater bone level, quick insertion in conjunction with grafting may be accomplished successfully, and implantology can be carried out in place of a prolonged healing phase that causes significant bone loss. PRF therapy accelerates and increases the amount of new bone deposition in the early phases of recovery.

Due the formation of a fibrin attachment is crucial for promoting cell migration and differentiation during the osseointegration process, platelet concentrates may provide all the required components, including fibrin mesh, platelets, leukocytes, growth factors, and essential proteins such as fibronectin and vitronectin.[14,15]

SLA surfaces function better than plasma-sprayed surfaces due to their improved fibrin interlocking, regulated multiscale microtopography, and greater and more stable surface energy. These characteristics lead to faster and more reliable osseointegration without the mechanical hazards of plasma-sprayed coatings, improve protein adsorption, stabilize the blood clot, and encourage osteoblast development.

The limitation of the present study is that, since it was carried out in an *in vitro* setting, additional biological research is required, such as the use of osteoblast cell models to assess extracellular matrix formation, adhesion, and proliferation. To ascertain appropriate surface roughness, histological investigations focusing on the examination of cell attachment, development, and bone apposition on the implant would be helpful. *In vitro* PRF adhesion might not directly predict clinical osseointegration. Further studies using *in vivo* or osteoblast models are proposed.

Conclusion

The current study concluded that the groups using the sandblasting and acid-etching methods had the highest PRF attachment, followed by the groups using the plasma spraying method and the control group. SLA surfaces may benefit more when combined with PRF, but further clinical validation is required.

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