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"Optical Properties and Translucency of Implant-Supported PEEK Crowns: Spectrophotometric Evaluation"

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Abstract
***AIM-** To evaluate the difference in optical properties and translucency parameters of implant supported PEEK crowns at different time intervals.*
***MATERIAL AND METHODS:** Optical properties and translucency parameters of implant supported PEEK crowns were assessed in 35 patients using spectrophotometer*
***RESULT:** Results revealed noticeable changes in translucency parameters and optical properties of implant supported PEEK crowns at 3 months.*
***CONCLUSION-** Our study on 35 patients on implant-supported PEEK crowns revealed that glazing improves surface roughness and opalescence, enhancing aesthetic appeal. Although, oral fluids containing intrinsic and extrinsic factors still adversely affect PEEK's color stability and surface quality*
***Keywords-** Translucency parameters, Optical properties, spectrophotometer, PEEK crowns.*

I. Introduction

Thermoplastic high-performance polymers (HPP) like polyetheretherketone (PEEK), polyetherketoneketone (PEKK), and aryl ketone polymer (AKP) are gaining traction in dentistry for their robust mechanical properties and biocompatibility. PEEK, introduced in the late 20th century, offers excellent strength and resistance to chemicals, making it ideal for applications such as implant-supported restorations and prosthetic frameworks. Its similarity in elasticity to bone helps reduce stress on implants, enhancing long-term stability. Despite its advantages, PEEK's inherent opacity necessitates veneering for aesthetic purposes, and its bonding strength with resin cements can be limited due to low surface energy.

PEKK, another member of the PAEK family, differs from PEEK in its molecular structure with varying proportions of ether and keto groups. It shares similar strengths in biocompatibility and mechanical properties, making it suitable for dental applications requiring resilience and longevity. AKP, although less commonly discussed, also shows promise in dental materials for its chemical resistance and versatility in processing. While these HPPs offer significant advantages in dental care, challenges such as material opacity and processing requirements underscore ongoing research to optimize their use and expand their applications in restorative dentistry.

II. Material And Method

A study conducted at NIMS Dental College and Hospital in Jaipur involved 35 patients who received implant-supported PEEK crowns. The study utilized a spectrophotometer to measure the optical properties and translucency of these crowns, with data subsequently analyzed statistically to evaluate their performance.

Patient Selection and Initial Assessment

The study conducted on 35 patients from the Department of Prosthodontics at NIMS Dental College who required tooth replacement due to missing teeth. Out of 40 initially screened patients, 35 met the study's inclusion criteria and provided written consent. Comprehensive initial assessments included intraoral photographs for a

detailed oral examination, supplemented by intraoral periapical (IOPA) and orthopantomogram (OPG) images to assess bone density and evaluate the optimal placement of implants. These assessments were crucial for determining the feasibility and strategic planning of the subsequent implant procedures.

Treatment and Prosthesis Preparation

Following the initial assessment, treatment planning proceeded with diagnostic impressions to facilitate precise implant placement. Implant length and diameter were selected based on the findings from diagnostic tools and images. Surgical procedures were meticulously carried out to prepare the implant sites and place the implants. After a healing period of 3-4 months, a second-stage surgery was performed to expose the implant sites and place healing abutments. Final impressions were then taken using an open tray impression technique with addition silicone impression material to ensure accurate molding for the fabrication of implant-supported PEEK prostheses.

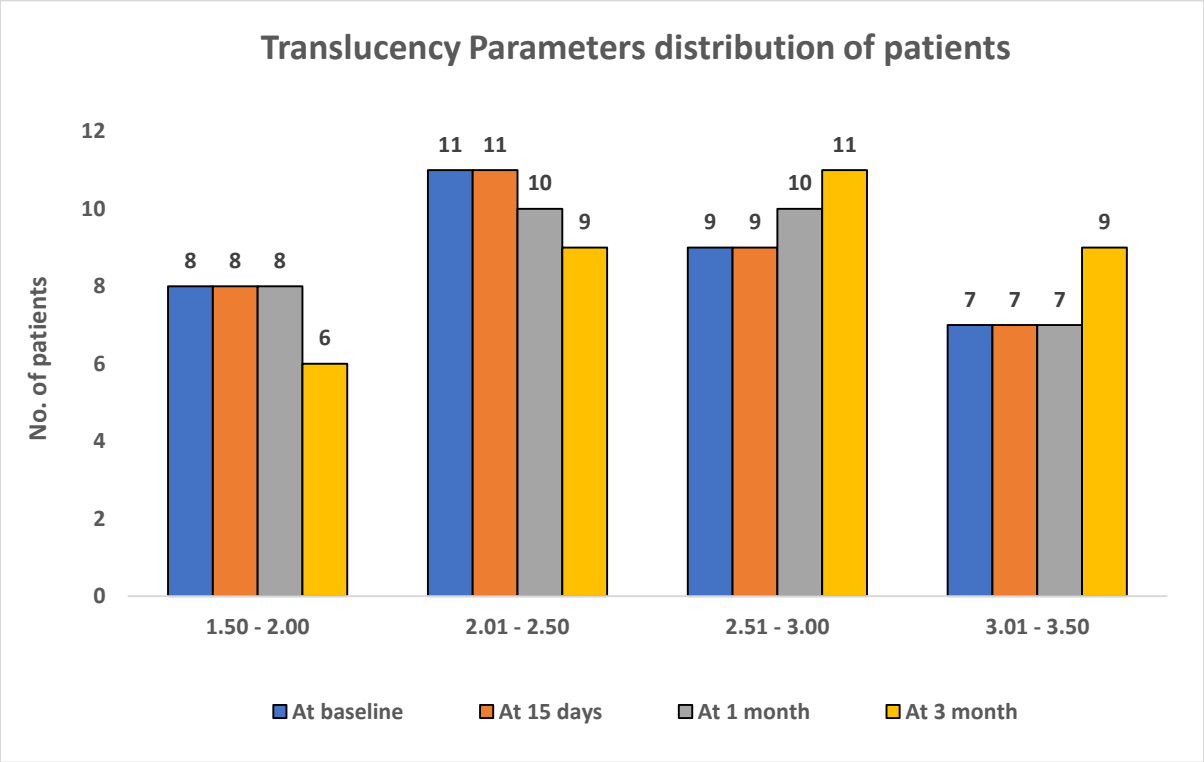
Testing, Loading, and Follow-up Evaluation

The optical properties and translucency parameters of the customized PEEK prostheses were evaluated using a spectrophotometer before and after loading into the patients' oral cavities. This testing phase aimed to assess the initial performance and aesthetic qualities of the prostheses. Follow-up evaluations were conducted at regular intervals (15 days, 1 month, and 3 months) to monitor any changes in optical properties and translucency over time. Results obtained from these evaluations were compared with baseline measurements to determine the prostheses' optical stability.

III. Results

Table 1: Frequency distribution of TP of patients at different time interval

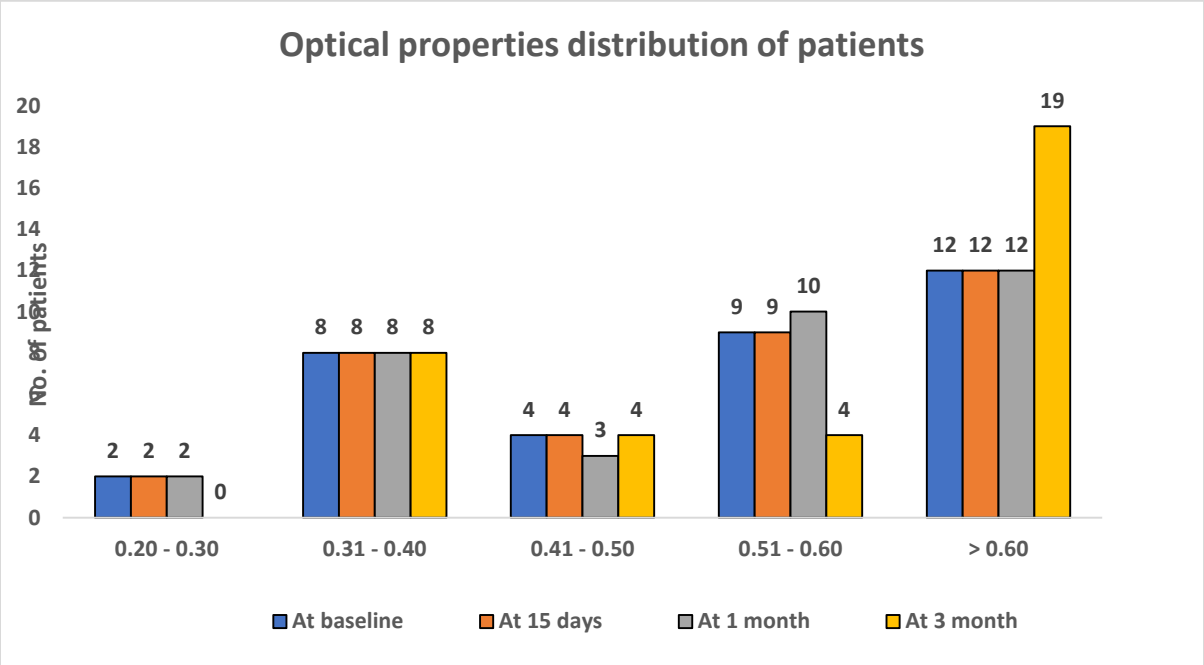
Translucency Parameters	At Baseline	At 15 Days	At 1 Month	At 3 Months
1.50 - 2.00	8 (22.86%)	8 (22.86%)	8 (22.86%)	6 (17.14%)
2.01 - 2.50	11 (31.43%)	11 (31.43%)	10 (28.57%)	9 (25.71%)
2.51 - 3.00	9 (25.71%)	9 (25.71%)	10 (28.57%)	11 (31.43%)
3.01 - 3.50	7 (20%)	7 (20%)	7 (20%)	9 (25.71%)



In the frequency distribution of translucency parameters, the data suggests that maximum change in the translucency parameters were observed in 11 patients, with a range of 2.51-3.00. Minimum change was observed in 6 patients, which was in the range of 1.50-2.00. In the range of 2.51-3.00 most of the patients fall, suggesting that majority of patients have values in this range.

Table 2: Frequency distribution of OP of patients at different time interval

Optical Properties	At Baseline	At 15 Days	At 1 Month	At 3 Months
0.20 - 0.30	2 (5.71%)	2 (5.71%)	2 (5.71%)	0
0.31 - 0.40	8 (22.86%)	8 (22.86%)	8 (22.86%)	8 (22.86%)
0.41 - 0.50	4 (11.43%)	4 (11.43%)	3 (8.57%)	4 (11.43%)
0.51 - 0.60	9 (25.71%)	9 (25.71%)	10 (28.57%)	4 (11.43%)
> 0.60	12 (34.29%)	12 (34.29%)	12 (34.29%)	19 (54.29%)



In the frequency distribution of optical properties, maximum change in the optical properties were observed in 19 patients, with a range of >.60. Minimum change was observed in 2 patients, which was in the range of 0.20-0.30. In the range of >0.60 most of the patients fall, suggesting that a significant portion of patients have values in this range.

Table 3: Descriptive statistics of age, TP and OP at baseline, at 15 days, at 1 month and at 3 months.

Variables		Minimum	Maximum	Median (IQR)	Mean ± SD
At Baseline	**TP**	1.583	3.429	2.476 (2.143-2.903)	2.511 ± 0.514
	OP	0.286	0.704	0.554 (0.35-0.648)	0.516 ± 0.141
At 15 Days	**TP**	1.583	3.431	2.476 (2.143-2.903)	2.512 ± 0.514
	OP	0.286	0.704	0.557 (0.353-0.649)	0.518 ± 0.141
At 1 Month	**TP**	1.604	3.44	2.491 (2.158-2.911)	2.524 ± 0.513
	OP	0.29	0.71	0.564 (0.364-0.658)	0.525 ± 0.141
At 3 Month	**TP**	1.654	3.608	2.59 (2.182-3.082)	2.572 ± 0.524
	OP	0.352	0.805	0.681 (0.503-0.71)	0.63 ± 0.153

TP: Translucency Parameters; OP: Optical Properties; IQR: Inter-quartile range; SD: Standard deviation
Comparing TP and OP values at baseline with TP and OP values at 15 days, 1 month and 3 months suggests noticeable changes.

IV. Discussion

In recent years, the field of dental biomaterials has seen a surge in innovation, with Poly-Ether-Ether-Ketone (PEEK) emerging as a notable candidate for various dental applications, particularly in fixed prosthodontics. Praised for its strength and biocompatibility, PEEK offers a compelling alternative to traditional materials due to its ability to closely mimic the appearance of natural teeth. However, one of its primary drawbacks lies in its inherent low translucency and coloration, which can detract from achieving optimal aesthetic outcomes without additional intervention such as veneering or composite resin layers (Alsilani, 2021; Morsi, 2023).

Research has extensively evaluated the optical properties and translucency of PEEK over time, utilizing spectrophotometry to assess changes in response to environmental factors, including oral fluid interactions and surface roughness development (Saleh, 2020; Sulayain, 2016). These studies underscore the complex interplay between intrinsic factors like resin matrix alterations and extrinsic factors such as dietary habits, both of which can significantly influence the long-term color stability and appearance of PEEK restorations (Ahmed, 2020; Fahmy, 2020).

Moreover, the choice of veneering materials has been identified as crucial in enhancing the aesthetic performance of PEEK restorations. Studies highlight that the type and thickness of veneers can significantly impact color stability and overall aesthetic outcomes (Ferracane et al., 2021; Saleh, 2020). The hydrophilic nature of certain composite veneers and the incorporation of nano-ceramic fillers have shown promise in reducing color changes over time, thereby improving the longevity and visual appeal of PEEK restorations (Abdulmaguied, 2020; Hahnel et al., 2021).

The interaction of dental materials with common beverages like coffee and their staining potential poses additional challenges. Research indicates that acidic beverages and tannin-rich substances can exacerbate staining and contribute to surface degradation, compromising both the aesthetic integrity and mechanical properties of dental restorations (Gürgan et al., 2021; Hamdy, 2020). Clinicians must consider these factors when selecting materials and advising patients on oral hygiene practices to mitigate potential long-term effects on PEEK restorations (Badran et al., 2020; Raafat, 2020).

The ongoing refinement of PEEK formulations and veneering techniques remains a focal point of research efforts aimed at overcoming these challenges. Advances in material science seek to improve PEEK's translucency and color-matching capabilities while maintaining its inherent strength and biocompatibility (Ziada and Beleidi, 2021). These advancements are critical in expanding the application of PEEK in dental prosthetics, ensuring that it meets both functional requirements and patient expectations for natural-looking dental restorations (Aydin et al., 2020; Rasetto et al., 2019).

In conclusion, while PEEK presents substantial advantages as a dental biomaterial, including its durability and biocompatibility, its aesthetic limitations necessitate strategic approaches in clinical practice. By understanding the complex factors influencing PEEK's optical properties and leveraging advancements in veneering techniques and material science, clinicians can optimize the aesthetic outcomes of PEEK restorations and enhance patient satisfaction in dental care settings

V. Conclusion

The study on implant-supported PEEK crowns revealed that glazing improves surface roughness and opalescence, enhancing aesthetic appeal. However, oral fluids containing intrinsic and extrinsic factors still adversely affect PEEK's color stability and surface quality, independent of glazing. These findings emphasize ongoing challenges in maintaining PEEK's performance as a dental material despite surface treatment advancements.

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