International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

Comparative Analysis of Light Interaction Characteristics of Peek Using Different Surface Finishing Methods - An Invitro Study

Dr. Lambodharan R[1], Dr. Ezhisaivallabi S[2], Dr. Kowsalya S[3]

Abstract: ***Background**: Polyetheretherketone (PEEK) is increasingly used as a scan body material in digital implant dentistry owing to its favourable mechanical and optical properties. Surface finishing may influence its interaction with light during light scanning. **Aim**: To evaluate the effect of surface finishing on the optical properties of PEEK. Materials and **Methods**: Twenty-four CAD/CAM- milled PEEK specimens were allocated into three groups (n=8): as-milled, glazed, and polished. Reflectance and absorbance were assessed using UV-Vis-NIR spectrophotometry, while refractive index and extinction coefficient were evaluated using spectroscopic ellipsometry. **Results**: Polished PEEK demonstrated significantly lower reflectance and higher absorbance than the as-milled and glazed groups ($p < 0.05$). No significant difference was observed in refractive index, whereas the extinction coefficient was significantly higher in polished PEEK ($p < 0.001$). **Conclusion**: Surface finishing significantly influences the optical properties of PEEK and may affect its performance as a scan body material in digital implant workflows.*

Keywords: Polyetheretherketone, Scan body, Surface finishing, Reflectance, Absorbance, Spectroscopic ellipsometry, Digital dentistry

1. Introduction

Digital dentistry has transformed prosthodontic practice by enabling accurate virtual workflows for implant rehabilitation. The accuracy of digital implant impressions depends heavily on the optical properties of scan body materials, which serve as reference markers for transferring implant position to digital software platforms. Consequently, how light interacts with scan body materials significantly influences scanning efficiency and data acquisition accuracy. Polyetheretherketone (PEEK), a semi-crystalline high-performance polymer of the PAEK family, has gained wide acceptance in implant dentistry due to its biocompatibility, favourable elastic modulus, chemical stability, wear resistance, radiolucency, and CAD/CAM machinability[1–3]. Its elastic modulus (3–4 GPa) closely approximates cortical bone, promoting favourable stress distribution around implant-supported restorations[4]. PEEK is increasingly used for implant scan bodies owing to its dimensional stability and reduced intraoral reflection compared with metallic alternatives. However, surface modifications such as polishing and glazing alter surface roughness and topography, potentially affecting light reflection, absorption, and scattering during intraoral scanning. Optical parameters-reflectance, absorbance, refractive index, and extinction coefficient- determine scanner detection efficiency and image acquisition quality[5]. Prior studies using ellipsometry and spectroscopy have shown that surface finishing influences PEEK's optical and translucency characteristics[6–8].Despite this, no study has comprehensively compared reflectance, absorbance, refractive index, and extinction coefficient among as-milled, polished, and glazed PEEK scan body surfaces using both UV–Vis–NIR spectrophotometry and ellipsometry. This gap limits understanding of how surface finishing affects digital scanning accuracy. Therefore, this in vitro study evaluated and compared the light interaction characteristics of PEEK scan bodies under different surface finishing protocols, providing foundational data for optimizing digital implant workflows.

2. Materials and Methods

Study Design

The present in vitro experimental study was conducted to evaluate and compare the light interaction characteristics of PEEK specimens subjected to different surface finishing methods. The optical properties assessed included reflectance, absorbance, refractive index, and extinction coefficient.

Materials Used

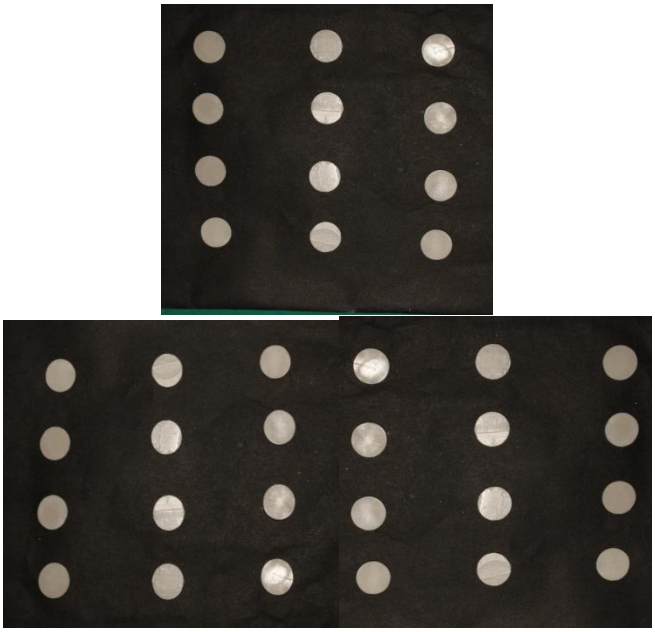
PEEK Material [PEEK Blank: Manufacturer Batch/Lot Number]
Glazing Material [Material Name Manufacturer Batch/Lot Number]
Polishing System [Polishing Kit/Material Manufacturer Batch]

Equipment Used

1) UV–Vis–NIR Spectrophotometer
2) Spectroscopic Ellipsometer
3) CAD Software
4) CAD/CAM Milling Unit
5) Finishing and Polishing Instruments

Specimen preparation

PEEK specimens simulating scan body surfaces were designed using CAD software and standardized to dimensions of 10 mm diameter and 1.3 mm thickness. The designed specimens were milled from PEEK blanks using a CAD/CAM milling machine according to the manufacturer's recommendations. A total of 24 specimens were fabricated.



Specimen grouping
The specimens were randomly allocated into three groups (n = 8):
Group I – As-Milled PEEK-Specimens received no additional surface treatment after milling.
Group II – Glazed PEEK-specimens subjected to glazing procedures.
Group III – Polished PEEK-Specimens subjected to polishing procedures.

The primer and glazing liquid were applied uniformly over the specimen surface according to the manufacturer's instructions. The specimens were then allowed to polymerize under light curing unit.

The specimens were polished sequentially according to the manufacturer's protocol until a smooth surface was achieved.

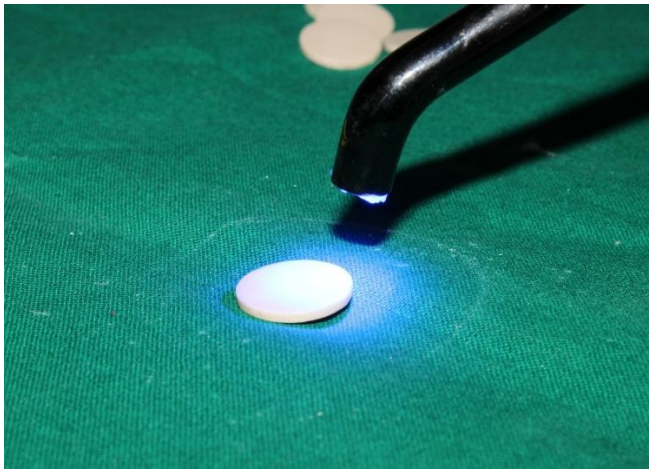


Figure: Glazing Procedute

Optical Evaluation

UV–VIS–NIR Spectrophotometric Analysis
Reflectance and absorbance measurements were performed using a UV–Vis–NIR spectrophotometer employing the diffuse reflectance spectroscopy technique.

The optical response of each specimen was recorded over a wavelength range of 400–565 nm.
Parameters evaluated:
Reflectance (%)
Absorbance

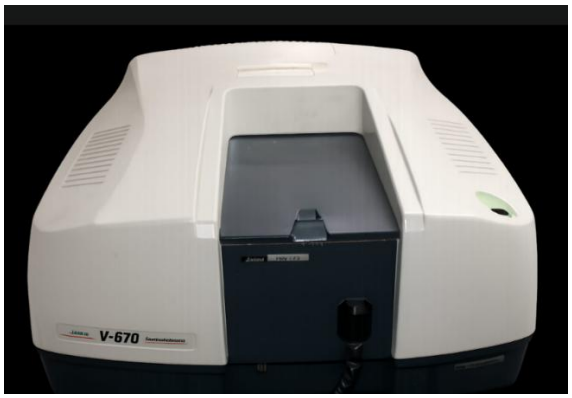


Figure: UV–VIS–NIR Spectrophotometer

Spectroscopic Ellipsometric Analysis
Refractive index (n) and extinction coefficient (k) were measured using a spectroscopic ellipsometer. Ellipsometric measurements were performed under standardized laboratory conditions. The acquired data were analyzed using the instrument software to determine wavelength-dependent optical constants.

Parameters evaluated:
• Refractive Index (n)
• Extinction Coefficient (k)

Figure: Ellipsometer

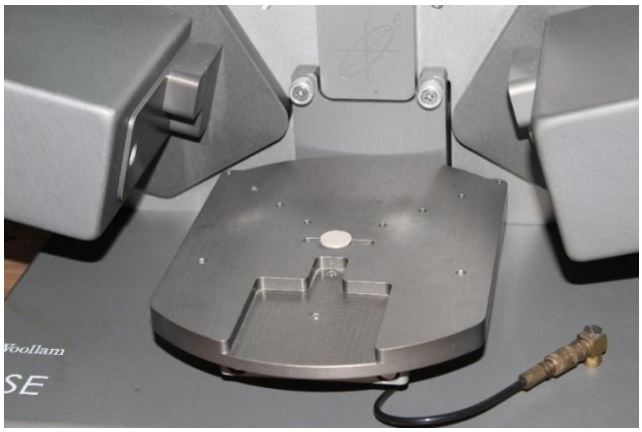


Figure: Specimen Positioning For Ellipsometry

Outcome Measures

The following optical parameters were evaluated:

1) Reflectance
2) Absorbance
3) Refractive Index
4) Extinction Coefficient

Statistical Analysis

The obtained data were tabulated and subjected to statistical analysis.

[Statistical software used: Level of significance: $p < 0.05$ Tests employed:]

The mean and standard deviation values were calculated for all study groups. Intergroup comparisons were performed to identify statistically significant differences among the surface finishing methods.

Table 1: Comparison of Reflectance among As-milled, Glazed and Polished PEEK

Comparison of Reflectance and Absorbance As-Milled, Glazed and Polished PEEK using One-Way ANOVA and Games- Howell Post Hoc Analysis

Parameter	Groups	Mean ± SD	P-value
Reflectance	As-Milled Peek	0.376± 0.010	0.002
	Glazed PEEK	0.377± 0.288	
	Polished PEEK	0.345± 0.004	

Parameter	Groups (I)	Groups (J)	Mean Difference	P-value
Reflectance	1	2	-0.001	0.994
	1	3	0.031	<0.001*
	2	3	0.032	0.036

The mean reflectance values were 0.376 ± 0.010 for the As-milled PEEK group, 0.377 ± 0.028 for the Glazed PEEK group and 0.345 ± 0.004 for the Polished peek group. One – way ANOVA demonstrated a statistically significant difference in reflectance among the three groups ($p = 0.002$). Games-Howell post hoc analysis revealed no statistically significant difference between the As-milled and Glazed PEEK groups (mean difference = -0.001; $p = 0.994$). However, statistically significant differences were observed between the As-milled and Polished PEEK groups (mean difference = 0.031; $p < 0.001$) and between the Glazed and Polished PEEK groups (mean difference = 0.032; $p = 0.036$). Polished PEEK exhibited significantly lower reflectance than both As-milled and Glazed PEEK.

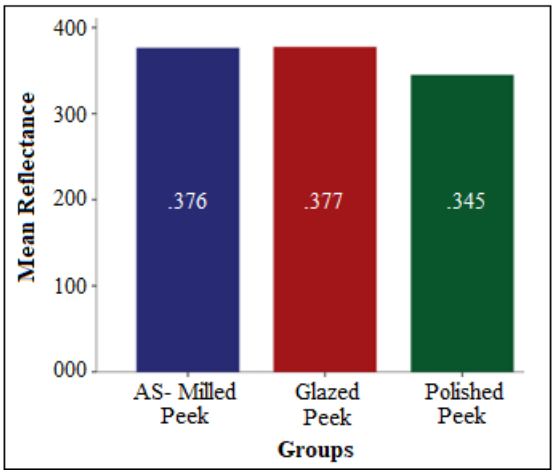


Table 2

Parameter	Groups	Mean ± SD	P-value
Absorbance	As-Milled Peek	41.33± 1.056	0.002
	Glazed PEEK	42.50 ± 2.146	
	Polished PEEK	45.24± 0.462	

Parameter	Groups (I)	Groups (J)	Mean Difference	P-value
Absorbance	1	2	-1.168	0.385
	1	3	-3.912	<0.001*
	2	3	-2.744	0.020

The mean absorbance values were 41.33 ± 1.06 for the As-milled PEEK froup, 42.50 ± 2.15 for the Glazed PEEK group and 45.24 ± 0.46 for the Polished peek group. One –way ANOVA demonstrated a statistically significant difference in absorbance among the three groups ($p < 0.001$). One –way ANOVA demonstrated a statistically difference in absorbance among the three groups ($p < 0.001$).

Games –Howell post hoc analysis revealed no statistically significant difference between the As-milled and Glazed PEEK groups (mean difference = -1.168; $p = 0.385$). However, statistically significant differences were observed between the As-milled and Polished PEEK groups (mean difference = - 3.912; $p < 0.001$) and between the Glazed and Polished PEEK groups (mean difference = -2.744; $p = 0.020$). Polished PEEK exhibited significantly higher absorbance than both As-milled and Glazed PEEK.

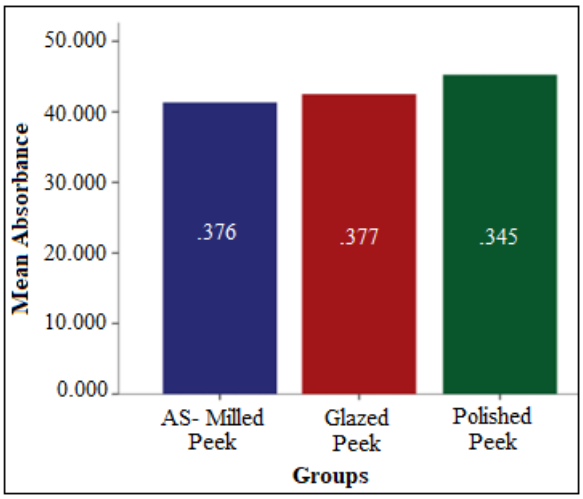


Table 3: Comparison of Refractive index (n) between Glazed and Polished PEEK

N:

Group	Glazed	Polished	MD+ SD Difference	Test Statistics	p Value
Mean ± SD	1.509± 0.007	1.52± 0.046	-0.018+ 0.002	1.584	.113
Median (IQR)	1.5109 (1.5106-1.5127)	1.5572 (1.4791-1.5697)			
Mean Rank	340.97	365.27			

MD: Mean Difference; SD: Standard Deviation

The mean refractive index of the Glazed PEEK group was 1.509 ± 0.007, while that of the Polished PEEK group was 1.527 ± 0.046. The polished group showed a higher mean value; however, the difference between the groups was not statistically significant (Mann-Whitney U test statistic = 1.584, p = 0.113). Thus, no significant difference in refractive index was observed between the glazed and Polished PEEK Groups.

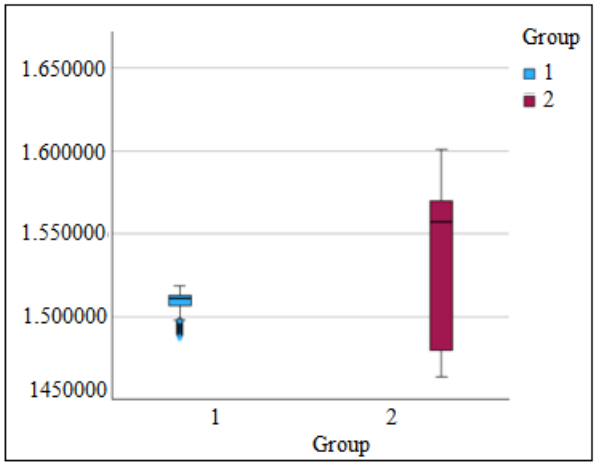
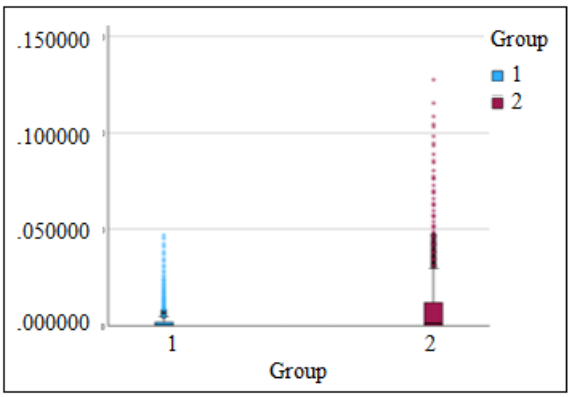


Table 4: Comparison of Absorption Coefficient (k) between Glazed and Polished PEEK

K

Group	Glazed	Polished	MD+ SD Difference	Test Statistics	p Value
Mean ± SD	0.003± 0.008	0.013± 0.023	-0.009± 0.001	0.987	<.001*
Median (IQR)	0.0001 (0.0000-0.0020)	0.0014 (0.0002-0.0123)			
Mean Rank	284.75	422.62			

The mean extinction coefficient of the Glazed PEEK group was 0.003 ± 0.008, whereas the Polished PEEK group demonstrated a mean value of 0.013 ± 0.023. Mann Whitney U test revealed a highly statistically significant difference between the two groups (test statistic = 8.987, p < 0.001). The polished PEEK specimens exhibited a significantly higher extinction coefficient than the glazed PEEK specimens.



3. Discussion

The present study evaluated the influence of different surface finishing methods on the light interaction characteristics of PEEK specimens by assessing reflectance, absorbance, refractive index, and extinction coefficient. With the increasing application of PEEK as a scan body material in digital implant dentistry, understanding the influence of surface modifications on optical behaviour has become clinically relevant. The findings demonstrated that surface finishing procedures significantly influenced the interaction of light with PEEK surfaces.

PEEK is a high-performance thermoplastic polymer belonging to the polyaryletherketone (PAEK) family and has gained considerable attention in dentistry due to its favourable biomechanical properties, chemical stability, biocompatibility, and ease of CAD/CAM processing. Previous investigations by Schwitalla and Müller[1] and Najeeb et al[2] highlighted the potential of PEEK as a promising biomaterial for implant and prosthodontic applications because of its elastic modulus, which closely resembles that of cortical bone.

In the present study, glazed PEEK specimens demonstrated higher reflectance values compared with polished and as-milled specimens. This observation may be attributed to the smoother surface morphology produced by glazing, resulting in greater specular reflection and reduced diffuse scattering. Similar findings were reported by Shah et al[3], who observed

that surface finishing procedures improved the optical properties and translucency characteristics of implant-supported PEEK restorations. A smoother surface facilitates uniform reflection of incident light and improves optical performance.

Conversely, as-milled specimens exhibited lower reflectance values and increased light scattering. The surface irregularities created during CAD/CAM milling generate microscopic grooves that disperse incident light in multiple directions. According to Anusavice et al[4], surface roughness plays a critical role in determining the optical behaviour of dental materials by influencing reflection, transmission, and scattering phenomena. Increased surface roughness generally results in diffuse reflection and reduced optical efficiency.

The absorbance values recorded in the present investigation were highest in the as-milled group and lowest in the glazed specimens. This may be explained by the presence of surface defects and irregularities that facilitate multiple internal reflections and light trapping. Polishing and glazing procedures reduce these surface imperfections and thereby decrease optical absorption. Similar observations regarding the influence of surface finishing on optical characteristics have been reported in studies evaluating aesthetic restorative materials and PEEK-based restorations[3],[5].

The refractive index values obtained in this study showed only minor variations among the experimental groups. Refractive index is considered an intrinsic optical property determined primarily by molecular structure and chemical composition rather than surface morphology. Katsifis et al[6] utilized spectroscopic ellipsometry to evaluate the optical properties of PEEK and reported refractive index values within the range of 1.65–1.70 for untreated PEEK. The findings of the present study are consistent with their observations and suggest that surface finishing procedures do not substantially alter the fundamental optical constants of the material.

Similarly, minimal differences were observed in the extinction coefficient among the study groups. Katsifis et al[6] demonstrated that extinction coefficient values are primarily associated with intrinsic electronic and optical characteristics of PEEK and are influenced only minimally by superficial modifications. The present findings support this concept and indicate that polishing and glazing predominantly affect surface optical interactions rather than bulk material properties.

An important aspect of the present investigation is its relevance to digital implant workflows. The success of intraoral scanning depends on the ability of scan body surfaces to reflect projected light in a predictable manner. Excessive surface roughness may increase light scattering and reduce scanner recognition efficiency, whereas optimized surface finishing may improve image acquisition and digital impression accuracy. Mangano et al[7] reported that optical characteristics of scanned surfaces influence the trueness and precision of digital impressions obtained with intraoral scanners. Therefore, modifications that enhance controlled reflection of light may contribute to improved scan body performance.

A noteworthy finding of the present study is that surface finishing altered reflectance and absorbance more significantly than refractive index and extinction coefficient. This indicates that optical behaviour relevant to scanner performance is governed predominantly by surface topography rather than changes in the intrinsic material structure. Such findings are clinically relevant because surface modification procedures can be performed chairside or during laboratory fabrication without affecting the bulk properties of PEEK.

To the best of current knowledge, no previous study has comprehensively investigated the influence of glazing and polishing procedures on reflectance, absorbance, refractive index, and extinction coefficient of PEEK specifically in relation to scan body applications. Most published studies have focused on mechanical properties, bonding characteristics, surface roughness, and restorative applications of PEEK. Therefore, the present investigation provides novel information regarding the optical behaviour of surface-modified PEEK and establishes a scientific basis for future studies evaluating the relationship between optical properties and scan body accuracy.

4. Limitations

1) The study was conducted under in vitro conditions and may not fully replicate the oral environment.
2) Saliva, blood contamination, and repeated clinical scanning procedures were not simulated.
3) Only one PEEK material system was evaluated.
4) Direct assessment of intraoral scanner accuracy was not performed.

5. Future Recommendations

Future investigations should evaluate the influence of surface finishing methods on the trueness and precision of digital implant impressions using different intraoral scanners. Correlation between optical parameters and scan accuracy should also be investigated under simulated clinical conditions.