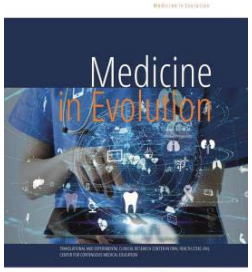
Effect of glycerin on the optical proprieties of PEEK



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Abstract

The aim of this study is to evaluate the optical proprieties of PEEK and the influence of a coupling medium (G-glycerin), by testing the hypothesis that glycerin can influence translucency. Eight standardized specimens were fabricated from CopraPeek (WhitePeaks Dental Solution, Germany) Medium A2 dentine 10 mm x 15 mm polished to 1.0 in thickness and Nexco Paste Dentine veneer material shade A3, with thicknesses of 0.5, 1.0 and 1.5 mm. Color and CIELAB coordinates were evaluated using Vita 0.5, 1.0 and 1.5 mm. Color and CIELAB coordinates were evaluated using Vita Easyshade.

All evaluations were repeated using glycerin and the values were recorded. Translucency is the relative amount of light that passes through a unit thickness of a material. Translucency parameter (TP) and contrast ratio (CR) were calculated. Also the value of color change (ΔE*) was calculated and statistical analysis was performed [1].

Expected results: The mean TP values of the studied samples were in the range of 1.22-3.81, which is lower than those reported for natural teeth [2][3][4]. The OP values of PEEK were recorded in the range of 0.78–3.11, also lower than those of natural teeth. Although mean translucency values were significantly different for each method (TP and CR), they were highly correlated (r2=0.70), even when G was used (r2=0.56).

Conclusion: The coupling medium significantly influenced the mean values of ΔE and translucency. Clinical assessment of perceptibility and acceptability thresholds of translucency is needed

Keywords: PEEK, glycerin, optical proprieties

INTRODUCTION

PEEK belongs to the PAEK family and is a biocompatible and chemically stable material for most organic and inorganic substances. Due to its excellent biological and physical properties, this material is used both in general medicine and in dentistry. However, there are also some aesthetic disadvantages that limit the use of PEEK as a monolithic element. The optical properties of PEEK include low translucency and a gray color [1][3][4]. Therefore an additional layer of composite resin is required for plating. This presents a challenge in achieving adequate strength between the RDC and PEEK physiologic component [6][7].

Conditioning the polymer surface with sulfuric acid or pirahna solution increases the adhesion strength. However, given the risks of using these materials in the oral cavity, their applicability is limited. Other studies have evaluated the degree of strength of the bond between PEEK and material intended for plating being a resin intended for provisional restorations, applying various surface treatments (mechanical etching by sandblasting or a chemical conditioning), respectively various primers used for conditioning [5][8][9][10].

Only one study tested the adhesion between the PEEK surface and RDC physiognomic components. In that study, the surfaces were etched, but no adhesives were used.

Aim and objectives

The aim of this study is to evaluate the color and translucency of polyetheretherketone (PEEK) and the influence of the binding medium (glycerin) on the optical properties, testing the hypothesis that glycerin influences the optical properties regardless of the evaluation method.

MATERIAL AND METHOD

A CopraPEEK disc (WhitePeaks Dental Solution, Essen, Germany) was used for this study. There were 6 lots of 8 plates each, having the following dimensions 10x15x1mm thick. The plates were polished using 450-2000 micron grit silicon carbide paper, the final gloss being achieved with a brush and a universal polishing paste (Ivoclar Vivadent). The final thickness of each pad was measured using a caliper. The first 3 batches were conditioned by sandblasting with 110 micron aluminum oxide sandblasting, then VisioLink primer was applied according to the manufacturer's instructions. Afterwards the plates were coated with Nexco color A2 photopolymerizable composite resin in layers of 0.5; 1 and 1.5 mm. The following batches were also conditioned by sandblasting with Al2O3, application of VisioLink primer, a layer of Nexco opaquer in one brush and later plated with Nexco light-curing composite resin in layers of 0.5, 1 and 1.5 mm.

Color and CIELAB coordinates were evaluated using a Vita Easyshade spectrophotometer on a white background and a black background [11][12][13]

All evaluations were repeated using glycerin as the binding medium and the values were recorded [3][14][15]

Translucency is the relative amount of light that passes through a unit thickness of a material.

The translucency parameter (TP) was calculated using the following formula

TP=[(L*b - L*w)2 + (a*b - b*w)2 + (b*b - b*w)2]1/2 and the contrast ratio (CR) was calculated using the following formula [4][9][21][22]

If the material is completely opaque, the TP value is zero. As the TP value increases, the translucency of the material increases [15][16][17].

Also, the total color change value ΔE* was calculated and statistical analyzes were performed (t-test, Pearson correlation test).

To quantify color change levels to a clinical standard, ΔE* values were converted to NBS units according to the following formula [4][18][19][22].

NBS = ΔE* × 0.92

RESULTS

The mean TP values of the study samples were in the range of 1.22-3.8, which is lower than the values reported for natural teeth. Average TP values for 1mm thickness of human enamel and dentin are 14.7; 15.2; 18.7; 16.4.

The OP values of the samples were recorded in the range of 0.78-3.11, being also lower than the values of natural teeth, which recorded a value of 4.8.

Samples that had an intermediate layer of opaquer tended to be more opaque compared to those without an opaquer. A possible reason could be the opaquer layer that intensifies the yellowish color of the samples.

Other statistical analyzes are:

TP-TPg = The value of r2, the correlation coefficient, is 0.5281. This is a moderate positive correlation, meaning that there is a tendency for high scores on variable X to go with high scores on variable Y (and vice versa).

OP-OPg = The value of R2, the correlation coefficient, is 0.0669. Although technically a positive correlation, the relationship between the variables is weak (nb. the closer the value is to zero, the weaker the relationship).

CR-CRg = The value of R2, the correlation coefficient, is 0.2464. Although technically a positive correlation, the relationship between the variables is weak (n.b. the closer the value is to zero, the weaker

TP-TPg = The P-Value is < .00001. The result is significant at p values < .01 (P Value from Pearson (R) Calculator)

OP-OPg = The P-Value is .086579. The result is significant at values p < .10 (P Value from Pearson (R) Calculator)

CR-CRg = The P-Value is .000408. The result is significant at p values < .01 (P Value from Pearson (R) Calculator)

Figure 1. Mean TP, CR, OP values for all groups

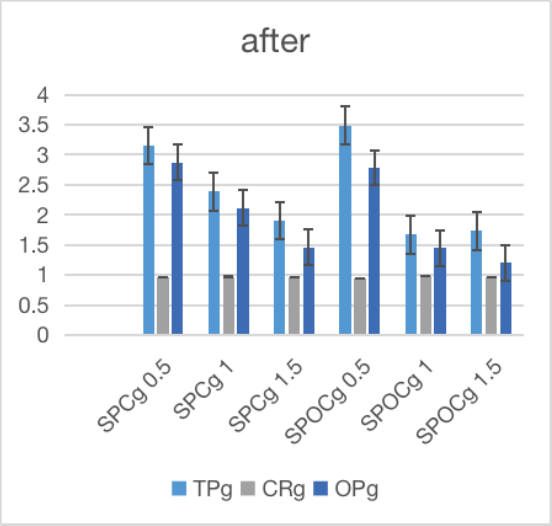

Figure 2. Mean TP, CR, OP values for all groups with binding medium

E recorded increased values in batches with a thickness of 0.5mm SPC and 1mm SPOC.

The lowest values were recorded in the 1.5 SPOC and 1.5 SPOCg thick batches.

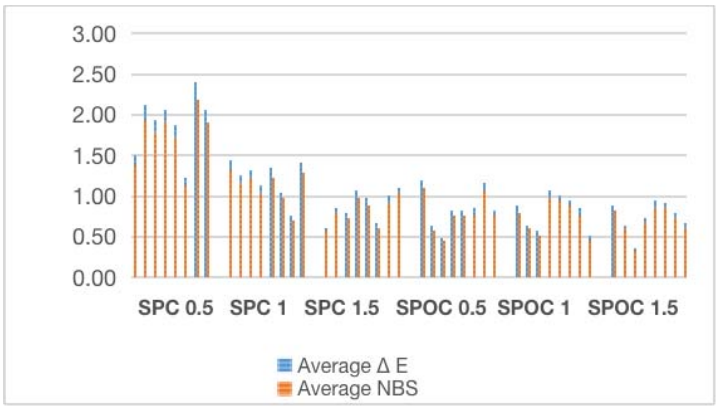

Figure 3. Mean values of ΔE and Translucency

DISCUSSIONS

The use of glycerin as a binding medium significantly influenced the mean values of ΔE and translucency. The groups where glycerin was used had higher values of the parameters compared to the control groups.

The thickness of the physiognomic component in the RDC also influenced the mean translucency and opalescence values. 0.5mm thick plates show higher TP values than 1.5mm thick plates. The highest OP values were recorded for the 0.5 mm thick lot and with an intermediate layer of opaquer.

CONCLUSIONS

It can be stated that the intermediate layer of opaquer influences the optical properties of the analyzed specimens.

The use of a binding medium (glycerin) will lead to perceptible optical changes, according to the recorded NBS values of 1.5-3.0 in batches with a thickness of 0.5 SPC and 0.5 mm SPOC, and in the rest of the batches barely perceptible changes were recorded.

REFERENCES

1. Chu SJ, Trushkowsky RD, Paravina RD. Dental color matching instruments and systems. Journal of Dentistry 2010;38S:e2–16
2. Paul S, Peter A, Pietrobon N, Ha¨mmerle CH. Visual and spectrophotometric shade analysis of human teeth.Journal of Dental Research 2002;81:578–82.
3. Nogueira AD, Della Bona A. The effect of a coupling medium on color and translucency of CAD-CAM ceramics. J Dent. 2013 Aug; 41 Suppl 3:e18-23.
4. L Porojan, FR Toma, RD Vasiliu, F Topală-Ionel, SD Porojan, A Matichescu. Optical Properties and Color
5. Stability of Dental PEEK Related to Artificial Ageing and Staining. Polymers. 2021, Vol.13, No.23, p.4102
6. Revilla-León M, Sadeghpour M, Özcan M. An update on applications of 3D printing technologies used for processing polymers used in implant dentistry. Odontology 2020;108(3):331–338

7. Alqurashi, H.; Khurshid, Z.; Syed, A.U.Y.; Habib, S.R.; Rokaya, D.; Zafar, M.S. Polyetherketoneketone (PEKK): An emerging biomaterial for oral implants and dental prostheses. J. Adv. Res. 2020, 28, 87–95.
8. Qin, L.; Yao, S. Review on Development and Dental Applications of Polyetheretherketone-Based Biomaterials and Restora-tions. Materials 2021, 14, 408.
9. Choi J-H, Park J-M, Ahn S-G, Jung J-Y, Lee M-H, Song K-Y, et al. Comparative study of visual and instrumental analyses of shade selection. Journal of Wuhan University of Technology – Materials Science Edition 2010;25:62–7
10. Chu SJ, Devigus A, Paravina R, Mieleszko A. Fundamentals of color: shade and communication in esthetic dentistry. Chicago: Quintessence; 2011
11. CIE Technical Report. Colorimetry. CIE Pub No. 15:2004. Vienna: CIE Central Bureau; 2004.
12. Ragain JR, Johnston WM. Color acceptance of direct dental restorative materials by human observers. Color Research & Application 2000;25:278–85.
13. Lee H-S, Lee Y-K, Lim B-S. Inffluence of thermocycling on the optical properties of laboratory resin composites and allceramic material. Journal of Materials Science Materials in Medicine 2004;15:1221–6.
14. Johnston WM, Ma T, Kienle BH. Translucency parameter of colorants for maxillofacial prostheses. The International Journal of Prosthodontics 1995;8:79–86.
15. Hu X, Johnston WM. Translucency estimation for thick pigment maxillofacial elastomer. Journal of Dentistry 2011;39s:e2–8.
16. Johnston WM, Reisbick MH. Color and translucency changes during and after curing of aesthetic restorative materials. Dental Materials 1997;13:89–97
17. Brainard DH. Color appearance and color difference specifification. In: Shevell SK, editor. The science of color. Oxford: Elsevier; 2003.
18. Shanda J. CIE colorimetry Colorimetry – understanding the CIE system, vol. 3. New Jersey: John Wiley & Sons, Inc.; 2007. p. 62.
19. Miyagawa Y, Powers JM, O'Brien WJ. Optical properties of direct restorative materials. Journal of Dental Research 1981;60:890–4
20. O'Brien WJ, Groh CL, Boenke KM. A new, small-colordifference equation for dental shades. Journal of Dental Research 1990;11:1762–4.
21. Douglas RD, Steinhauer TJ, Wee AG. Intraoral determination of the tolerance of dentists for perceptibility and acceptability of shade mismatch. Journal of Prosthetic Dentistry 2007;97:200–8.
22. Ruyter IE, Niler K, Moller B. Color stability of dental composite resin materials for crown and bridge veneers. Dental Materials 1987;3:246–51