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OPTICAL PROPERTIES OF COMPOSITES

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ABSTRACT

It is a challenge for every aesthetic dentist to replicate the appearance and colour of teeth to its closest sense and form. Hence the demand for aesthetic restorations have increased in last two decades and scientific research in the field of dentistry has lead to introduction of composites with high strength, optical properties and decreased polymerization shrinkage. Dental resin based composites are composed of Resin Matrix e.g BisGMA (bisphenol A glycerolate dimethacrylate) UDMA (Urethane dimethacrylate) TEGDMA (triethylene glycol dimethacrylate), Filler e.g Macrofillers, Microfillers, Nanofillers and Coupling Agents e.g. Titanates, Zirconates, Organosilane. Since aesthetic properties of composites are very important, this article concentrates on optical properties of composites a) Translucency b) Opacity c) Fluorescence d) Opalscence and factors affecting them.

Key Words:- Optical Properties, Composite, Translucency, Opacity, Fluorescence, Opalscence.

INTRODUCTION

The use of composite resins as aesthetic restoration in restorative dentistry has become an important reality. Further improvements in its aesthetic properties, has led to its popularity among the most popular aesthetic restorative materials in dental clinical practice (Silvia TF *et al*., 2009). One of the most important goal in aesthetic restorative dentistry is to produce restorations which have the optical properties similar to that of natural tooth (Joiner, 2004). The optical properties of aesthetic material include translucency, opacity, fluorescence and opalescence (Raquel P *et al*., 2008).

Factors Influencing The Optical Properties of Composites

Translucency

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Translucency is the property of a substance that permits the passage of light but disperses the light so that objects cannot be seen through the material (Raquel P *et al*., 2008). It can be also described as a state between complete opacity and transparency (Yu B, Lee YK, 2008). It may be hardest to quantify in natural dentition as it varies from person to person and many times even within the same person (Villarroel M *et al*., 2011). Enamel is significantly more translucent than dentine, attenuating its saturation and able to transmit light to the underlying dentine (Raquel P *et al*., 2008). When refractive indices of fillers and resin matrix are nearly matched, highest translucency is obtained (Lee YK *et al*., 2006).

Parameters Affecting the Translucency

Thickness, Filler particles, Resin matrix composition, Flowability, Light curing, Aging.

Thickness

The limit between translucency and opacity is determined by the thickness of composite resins (Raquel P *et al*., 2008). When the thickness of resin composite is

more than 1 mm, translucency decreases significantly and opalescence increases significantly (Arimoto A *et al*., 2010) Thickness of enamel decreases from incisal to cervical region. Thickness of enamel is 1-2.1mm in the incisal area, 0.5 – 0.8 mm in the middle third and 0.2 – 0.3 mm in the cervical region. Hence the translucency is less in the cervical area than the incisal area, which in turn affects the translucency of composite.

Filler Particles

With the increase in the amount of filler, translucency decreased almost linearly. (Lee YK, 2007) concluded that the size and volume fractions of fillers should be controlled for the best colour reproduction for dental resin composite, as they are responsible for the scattering and absorption characteristics on which the translucency property is dependent (Yong KL, 2007). This is in accordance with the results by Ruyter *et al*., (1982) and Kawaguchi *et al*., (1994) who reported that the scattering of light in composite resins is dependent on the filler particle size (Ivar ER and Harry O, 1982; Hiroyuki A *et al*., 1998). According to Sturdevant et al the fillers are responsible to produce light dispersion similarly in enamel Suzuki H *et al*., 1991).

Resin Matrix Composition

The BisGMA (bisphenol A glycerolate dimethacrylate) based resin composite was significantly more translucent than the UDMA (urethane dimethacrylate) and TEGDMA (triethylene glycol dimethacrylate) based composites (Azzopardi N *et al*., 2009). If the filler content is constant, addition of BisGMA has a direct effect on translucency of composite material (Azzopardi N *et al*., 2009). BisGMA and UDMA could not hold the filler particles incorporated in them for longer time periods, leading to voids and surface defects which in turn affect the translucency of the composite resins (Patodiya A, Hegde MN, 2012).

Flowability

Flowable resin composites have 20-25% less filler content than traditional composites (Nuray A *et al*., 2003). This contributes to their higher viscosity and polymerization shrinkage, but lower rigidity and flexural strength as compared to the traditional composites (Nuray A *et al*., 2003).. Their translucency is also higher than traditional resin composite (Yu B and Lee YK, 2008).

Light Curing

Changes in colour during light curing were still in the range of unacceptable colour change. For a precise shade match of composite material, cured material should be used (Sidhu SK *et al*., 2006). Translucency increased in indirect composite resins and decreased in direct composite resins after curing (Si TW *et al*., 2008).

Aging

Significant colour change is seen after accelerated aging. The light-curing materials were significantly more colour stable than the chemically-curing materials (Karen AS *et al*., 2003).

Clinical Significance of Translucency

Composite resin with less translucency should be used for dentin, whereas with more translucency should be used for enamel (Villarroel M *et al*., 2011). Elizabeth-Ann Ryan, Laura E. Tam, Dorothy McComb concluded that the "opaque" or "dentin" composites had relatively low translucency, the "universal" or "body" composites had medium translucency, and the "enamel" composites had relatively high translucency (Elizabeth AR *et al*., 2010), it is in accordance to the results by Ikeda et al who demonstrated that translucency of opaque shade was less than body shades (Ikeda T *et al*., 2005). Even Homan Naeimi Akbar et al, concluded that dentin shades had lowest total and diffused translucency as compared to enamel shades which had the highest translucency values (Homan NA *et al*., 2012). This is consistent with the findings of Kamishima *et al*., (2005) who reported that the opaque shades of composite resins were less translucent than other shades. Similarly, who reported that composites with darker shades are less translucent (Yu B, Lee Y-K, 2008). Raquel Pachaly *et al*. conducted a two stage study and revealed that there are differences in the degree of translucency of different composite resins, due to variations in their composition which is in accordance to the conclusion by Jardim (2002); Villarroel; Hirata; Souza (2005). With the increase in wavelength of the light, the transmittance of Micro-filled composite increases but the transmittance of Hybrid Composite remains the same. Nano- Composites have higher translucency than micro-filled composites and physical properties and wear resistance similar to Hybrid composites (Mitra BS *et al*., 2003).

The silorane composite exhibited better polymerization-dependent chromatic stability, and lower translucency compared to universal dimethacrylate – based composites (Perez MM *et al*., 2010). Mithra *et al*., evaluated the clinical efficiency of posterior composites to conclude that with the introduction of double translucency shade system, there is improvement in the optical properties of restoration which enables better color matching (Hegde MN & Pardal D, 2009).

Opacity

It is the property that does not allow the passage of light; i.e. opaque structures have higher intensity of light dispersion (Raquel P *et al*., 2008). In general opacity can be considered as the inverse of translucency (Vichi A *et al*., 2004). Choosing artificial dentin and enamel composites of proper opacities and correct thickness of each layer is very important. Resin composites with more than 3% nanofiller had significantly low opacity. The composites with 6 wt % nanofiller had 34-65% lower opacity than the composite that did not contain nanofiller (Kim JJ *et al*., 2007).

Parameters Affecting Opacity

Thickness, Water Aging, Surface Roughness, Refraction of light at matrix particle interface, U.V Light Aging.

Thickness

Opacity of composite resin increases with the increase in thickness of material to be layered during the application of composites (Villarroel M *et al*., 2011).

Water Aging

Opacity in composites is influenced by water aging. Smaller the dimension of the filler particles, lower the water aging susceptibility and lower the change in opacity (Vichi A *et al*., 2004). Change in opacity due to water aging was markedly seen in chemically cured resin composites and it was negligible in light cured resin composite (Inokoshi S *et al*., 1996).

Surface Roughness

Opacity of composite resin is very sensitive to surface roughness, hence its aesthetic value depends on the finishing and polishing of the surface of the restoration (Hegde MN *et al*., 2008). Also with increase in the surface roughness, the opacity of the material also increases (Inokoshi S *et al*., 1996).

Refraction of light at matrix particle interface

Composite Resins are composed of numerous inorganic filler particles and a surrounding matrix. Higher the Refractive index between the particles and the matrix phase, greater is the opacity of material. This is moreover due to multiple reflections and refractions at the matrix-particle interfaces (Inokoshi S *et al*., 1996).

U.V Light Aging

Opacity of composite resin material increased after U.V Light aging, but it has less effect than water aging (Vichi A *et al*.,).

Fluorescence

Fluorescence is a type of photoluminescence, in which the ultraviolet radiant energy (UV) is absorbed by an object that later emits light energy within the visible spectrum (Raquel P *et al*., 2008). A strong blue fluorescence is emitted by natural teeth under the action of U.V light. Rare earth oxides (e.g. europium, cerium and ytterbium) are included in glass fillers as fluorescent additive, (Uo M *et al*., 2005) but according to Meller et al fluorescence is independent of filler material, size distribution, shape and volume.

Composites attain their maximum fluorescence when the combination of excitation and emission wavelengths was approximately about the same, but with varying intensities. METAMERISM is the phenomenon by which the visual appearance of two colour specimens with different spectral power distributions appears to match (Meller C and Klein C, 2012). Universal resin composites has more fluorescence than the flowable resin composite. The fluorescence properties significantly change with the age of the composite (Lee YK *et al*., 2006).

Opalescence

Opalescence is due to opalizing agents, which are made of a regular three dimensional array of equal-size spheres. The actual composition of spheres is amorphous silica (approximately 0.15 mm) cemented together with more amorphous silica, so that a difference in refractive index exists between the spheres which leads to dispersion of light within the tooth structure. This leads to an optical phenomenon called opalescence (Yong KL *et al*., 2005). Dental resin composites are composed of resin matrix and dispersing fillers, which have different refractive indices. Thus under reflected light it gives the material a bluish appearance and under transmitted light an orange/brown appearance (Yu B *et al*., 2010). It changes after accelerated aging (Lee YK *et al*., 2006). Opalescence contributes to the masking of background colour. It varies according to the material and shade of the resin composites (Yong KL *et al*., 2005). Micro-filled composite has lower opalescence than those of the hybrid and nano-filled composites (Yu B *et al*., 2010).

Other Factors Affecting Optical Properties of Composites

Optical Properties of composite resins can be affected by absorption of pigments when exposed to various staining medias like red wine, coffee, tea, cola, water (increasing order) (Ertas E *et al*., 2006). But Fontes et al concluded in his study that coffee does not result in change in colour of composite resins (Silvia TF *et al*., 2009). Smoking habits results in colour instability (Sidhu

SK, 2006). The surface roughness also influences the colour of the resin composites (Ghinea R *et al*., 2011). The photo-initiator system can not only influence the polymerization characteristics, but also have impact on the composite colour stability (Janda R *et al*., 2004). Light-curable composite materials have more resistance to colour changes after accelerated aging by light and water than chemically-cured composite materials (Sidhu SK, 2006).

CONCLUSION

To conclude optical properties of composites are very important for appropriate shade matching in Aesthetic Restorative Dentistry. If the thickness of composite is more than 1 mm translucency decreases and opalescence increases significantly. Fillers are responsible for change in translucency, opacity and opalescence but not for fluorescence in composite resins. Opalescence contributes to the masking of the background colour. Consumption of different drinks and habits like smoking in day to day life also affect the optical properties of the composite resins significantly.

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