ERD European Journal of Research in Dentistry

ORIGINAL ARTICLE / ARAŞTIRMA MAKALESİ

Comparison of Colour Stability of Lithium Disilicate, Indirect Resin Composite and Zirconia: An In Vitro Study

Lityum Disilikat, İndirekt Rezin Kompozit ve Zirkonyanın Renk Stabilitesinin Karşılaştırılması: İn Vitro Çalışma

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Article History

Submitted	12.08.2024
Revised	16.08.2024
Accepted	20.08.2024
Published	29.08.2024

ABSTRACT

Objectives: The study was aimed to examine the colour stability of lithium disilicate, indirect resin composite and zirconia.
Materials and Methods: One hundred and twenty samples were split into three groups (n=40) of materials lithium disilicate, indirect resin composite and zirconia (10 mm diameter and 1mm thick discs). Discs were cemented with three different dual cured resin cements. Thermocycling of 10000 cycles for 168 hours was applied to 20 specimens from each group. The samples then emerged in staining solutions (coffee and tea) for 7 days. Colour changes were measured at four different stages to determine ΔE using spectrophotometer.
Results: The study results revealed a statistically significant difference between the materials before and after cementation and thermal cycle ($p<0.05$). Regarding staining solutions, the results also showed a statistically significant difference between three materials ($p<0.05$). No statistically significant difference was found between coffee and tea in terms of colour changing effects ($p<0.05$).
Conclusions: It was observed that the thermal cycle, cementation process and staining solutions influenced the color stability of all materials. The material with the highest color stability was determined to be IPS e.max. Colour stability is one of the main elements for the success of a dental treatment. Thus, staining resistance is an essential property for the longevity of aesthetic restorations.
Keywords: Lithium disilicate, Indirect resin composite, Zirconia, Colour stability, Staining.

ÖZ

Amaç: Çalışmanın amacı lityum disilikat, indirekt rezin kompozit ve zirkonyanın renk stabilitesini incelemektir.
Gereç ve Yöntemler: Yüz yirmi örnek, lityum disilikat, indirekt rezin kompozit ve zirkonya (10 mm çap ve 1 mm kalınlığında diskler) materyallerinden oluşan üç gruba (n=40) ayrıldı. Diskler üç farklı dual cure rezin simanıyla simante edildi. Her gruptan 20 örneğe 168 saat boyunca 10000 döngülük termal siklüs uygulandı. Daha sonra örnekler 7 gün boyunca boyama solüsyonlarında (kahve ve çay) ortaya çıktı. Renk değişimleri spektrofotometre kullanılarak ΔE'yi belirlemek için dört farklı aşamada ölçüldü
Bulgular: Çalışma sonuçları, simantasyon öncesi ve sonrası materyaller ile termal siklus arasında istatistiksel olarak anlamlı bir fark olduğunu ortaya koydu ($p<0.05$). Boyama solüsyonlarına ilişkin sonuçlar, üç malzeme arasında istatistiksel olarak anlamlı bir fark olduğunu da gösterdi ($p<0,05$). Kahve ve çay arasında renk değiştirme etkileri açısından istatistiksel olarak anlamlı bir fark bulunmamıştır ($p<0,05$)
Sonuç: Termal siklus, simantasyon işlemi ve boyama solüsyonlarının tüm materyallerin renk stabilitesi üzerinde etkisi olduğu görüldü. Materyaller arasında en yüksek renk stabilitesine sahip materyal IPS e.max olarak tespit edildi. Renk stabilitesi, bir diş tedavisinin başarısı için ana unsurlardan biridir. Bu nedenle, renklenmeye karşı direnç estetik restorasyonların uzun ömürlülüğü için önemli bir özelliktir.
Anahtar Kelimeler: Lityum disilikat, dolaylı reçine kompozit, zirkonya, renk stabilitesi, leke oluşumu

How to cite this article: Kahramanoglu, E., Badwan, M. Comparison of Colour Stability of Lithium Disilicate, Indirect Resin Composite and Zirconia: An In Vitro Study. European Journal of Research in Dentistry, 2024;8(2): 66-71. DOI: http://dx.doi.org/10.29228/erd.73

INTRODUCTION

The colour stability throughout the materials functional lifetime is essential mainly for the durability of treatment and cosmetic reasons (Prashanthi et al., 2015). Staining resistance is an essential property for the longevity of removable fixed dentures, crowns and direct restorations in aesthetic areas (Wilson et al., 1997).

Discoloration of dental composite restorations can be caused by both exogenous and endogenous reasons (Kolbeck et al., 2006). The endogenous reasons include the discoloration of resin matrix and the link between resin matrix and fillers (Wilson et al., 1997). They usually occur when the materials are aged under various chemical and physical conditions including thermal changes and humidity (Cook et al., 1987).

There are three main types of composite resin discolorations. The first type is extrinsic discoloration which is caused by the build-up of plaque (Satou et al., 1989); the second type is intrinsic discoloration which is caused by the aging of the material and third type is the alteration of the surface colour which is caused by the superficial degradation, the reaction of the staining agents on the inner side of the superficial composite resin layer (Turgut & Bagis, 2011).

Numerous studies investigated the staining of composites by coffee, tea and other beverages. Um and Ruyter evaluated the colour stability of resin based veneering materials using boiled coffee and tea at 50°C (Um & Ruyter, 1991). Their study indicated that discoloration of materials occurred by the absorption of the colourants into the organic phase of the veneering materials. Similarly, Dietschi et al. compared the colour stability of 10 new generation light cured composites by using numerous colouring solutions including coffee, E1010 food dye, vinegar and erythrosine. Their specimens were exposed to post curing thermocycling and polished before staining procedures. The study revealed that erythrosine caused the most colour change (Dietschi et al., 1994). Moreover, Scotti et al. investigated the colour stability of acrylic resins by simulating the oral condition through mixing the specimens in synthetic saliva combined with coffee, tea or chlorhexidine at 37°C and concluded that the synthetic saliva and coffee caused more colour change (Scotti et al., 1997).

In the current literature, there is a wide range of studies examining rhe colour stability of different restorative materials. Yet, limited number of studies are available that compares those materials after exposed to different procedures. The purpose of this study is to examine the colour stability of lithium disilicate (IPS e.max), indirect resin composite (Gradia) and zirconia by using dual cure resin cements. The null hypothesis is that there is no statistically significant difference in colour stability between these materials after exposed to different procedures (before and after cementation, after thermal cycle, after processed with staining solutions).

MATERIALS AND METHODS

One hundred and twenty samples were split into three groups (n=40) of materials lithium disilicate, indirect resin composite and zirconia. All samples were fabricated as mentioned in Turgut & Bagis (2011, 2013), Alabdulwahhab et al., (2015) as discs of 10 mm diameter and 1mm thickness (Fig. 1)

Figure 1: The final shape of the disc materials (Zirconia, E-max and Gradia)

Heat-pressed method was preferred by using IPS e.max press Programat EP3000 press furnace (Ivoclar Vivadent, Schaan, Liechtenstein) for the fabrication of lithium disilicate glass-ceramic material (IPS e.max Press HT and LT, A1 shade, Ivoclar Vivadent, Schaan, Liechtenstein). Zirkonzahn translucent blocks (Zirkonzahn, der Ahr, Gais, Italy) were used for fabrication zirconia samples. The zirconia samples were manufactured with 5-axis wet-grinding and dry-milling technology in one compact unit by using CAD/CAM Ceramill Motion2 (Amanngirrbach, Koblach, Austria). Indirect resin composite samples of Gradia (GC Europe NV, Leuven, Belgium) were manufactured by placing into metal ring between two glass slides and fixed with an elastic band. Then samples were stapled with a stapler machine for 15 minutes to achieve the accurate dimension and inserted inside the light-cured machine (Lumamat100, Ivoclar Vivadent, Schaan, Liechtenstein) for 12 minutes to polymerise the discs.

Before cementation one surface of all discs were sandblasted from 10 mm distance for 15 seconds with 30 μm alumina sands (Al_2O_3) by a sandblasting unit (Renfert, Hilzingen, Germany). IPS e.max and Gradia samples were cemented with dual cure resin cements (Variolink N (Ivoclar Vivadent AG Schaan, Liechtenstein) of transparent "0" shade and Nexus Third Generation NX 3 - Nexus 3 (SDS Kerr, California, USA) of ''clear" shade. Zirconia samples were cemented with dual cure resin cements Multilink N (Ivoclar Vivadent AG Schaan, Liechtenstein) of transparent shade and Nexus Third Generation NX 3 - Nexus 3 (SDS Kerr, California, USA) of ''clear" shade. All disc-shaped specimens were placed over the glass slab to create a cement layer with approximately 100πm thick underneath the ceramic disc (Hernandes et al., 2016.).

Light cure device of the wavelength range of 385 to 515 nm (Bluephase N; Ivoclar Vivadent AG Schaan, Liechtenstein) was applied for 1 minute for every sample of each material to achieve optimum polymerization (Fig. 2).

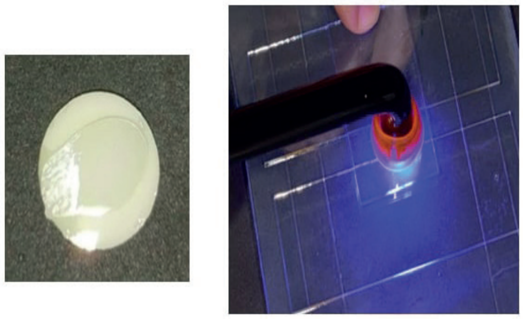

Figure 2: Mylar Strip technique

Thermocycling (SD Mechatronik Thermocycler, Feldkirchen-Westerham, Germany) was applied to 20 specimens from each group of 10000 cycles for 168 hours (7 days). The procedure was performed with temperature switching from 5°C to 55°C with dwell time of 20 seconds. Three groups containing 5 specimens from each material were immersed in 200 mL of black tea and coffee for 7 days. The specimens were then left in the solution until the temperature reached 37°C and then they were placed in paper cups. This process was repeated every 24 hours to prevent any possible chemical changes.

The colour stability was checked with the spectrophotometer (Vita Easy Shade, Vita Zahnfabrik, Bad Sackingen, Germany) in four stages: Before and after cementation, after thermocycling and after staining (Fig. 3). All colour measurements were performed three times for each specimen and the average of the three readings were calculated. The total colour difference (ΔE*) was calculated using the standart equation. Descriptive statistics was performed by using SPSS (Statistical Package for Social Sciences) for Windows 21.0 program. T-test and One-way ANOVA test were used to compare the quantitative data between groups, as the data showed normal distribution, and the Tukey HDS test was used to identify the groups causing the statistical differences. The results were evaluated at the significance level of $p<0.05$.

Figure 3: Spectrophotometer (VITA Easyshade V) measurement

RESULTS

Table 1 shows the results of the colour measurements for control group, table 2 shows the colour measurements before and after cementation and after thermal cycle and table 3 shows the colour measurements after staining. One-way ANOVA test was used to determine the difference between IPS e.max, Gradia and Zirconia before and after cementation and after thermal cycle (Table 4). Before thermal cycle the study results revealed a statistically significant difference between IPS e.max and Zirconia or Gradia ($p<0.001$). Moreover, after thermal cycle there were also a statistically significant difference between IPS e.max and Zirconia or Gradia ($p<0.001$). After staining solutions, the results showed another statistically significant difference between IPS e.max and Zirconia or Gradia ($p<0.001$). Lastly, the t-test was used to determine the difference between coffee and tea, and no statistically significant difference was found ($p>0.05$).

Table 1. Colour measurements for control group before and after thermal cycles

	Zirconia (n=10)		E-max (n=10)		Gradia (n=10)	
	BT	AT	BT	AT	BT	AT
S1	1.6	0.6	2.1	3.4	2.6	0.9
S2	1.6	0.5	2.4	3.8	2.4	0.2
S3	1.6	0.9	1.5	3.0	2.6	0.6
S4	2.0	1.5	2.6	2.8	2.0	0.7
S5	1.7	1.4	2.0	2.9	2.1	0.5
S6	1.7	1.3	2.2	2.7	2.4	1.3
S7	1.9	0.3	2.6	3.4	2.2	0.8
S8	1.7	1.0	2.3	2.6	2.3	1.3
S9	1.8	0.5	2.9	2.7	2.4	0.4
S10	1.8	1.1	2.8	3.4	2.3	1.9
Mean	1.7	0.9	2.3	3.1	2.3	0.9

S: Sample, BT: Before thermal cycle, AT: After thermal cycle

Table 2. Colour measurements before and after cementation and after thermal cycle

	Zirconia (n=60)						E-max (n=60)						Gradia (n=60)					
	Multilink N (30)			Nexus 3rd (30)			Variolink N (30)			Nexus 3rd (30)			Variolink N (30)			Nexus 3rd (30)		
	BC (10)	AC (10)	AT (10)	BC (10)	AC (10)	AT (10)	BC (10)	AC (10)	AT (10)	BC (10)	AC (10)	AT (10)	BC (10)	AC (10)	AT (10)	BC (10)	AC (10)	AT (10)
S1	1.8	2.0	0.8	1.9	2.9	2.4	2.7	3.6	3.5	3.0	3.9	4.2	2.1	2.1	2.3	2.4	1.5	1.5
S2	2.1	2.1	2.1	2.2	3.0	0.8	2.6	1.8	2.7	2.9	4.0	3.7	1.8	2.6	0.8	2.0	1.6	0.9
S3	1.8	2.3	1.4	2.1	2.9	0.3	3.3	3.1	3.5	2.7	4.4	4.1	2.0	2.0	0.9	1.6	1.5	2.7
S4	1.8	2.6	0.9	1.9	2.1	1.4	2.9	2.2	2.3	2.9	4.5	2.3	1.8	2.5	1.0	2.3	1.1	1.0
S5	1.8	2.0	1.3	2.3	2.7	2.9	2.9	2.4	2.8	2.2	4.8	3.9	1.5	2.2	2.3	2.3	1.6	2.6
S6	2.1	2.5	0.5	2.0	3.6	2.9	2.4	3.9	2.4	3.0	6.0	2.8	2.1	2.5	1.3	1.8	1.0	2.1
S7	1.9	1.6	1.9	1.8	2.8	2.0	2.6	2.2	3.6	3.8	4.0	2.8	2.1	2.1	2.2	2.1	1.6	1.0
S8	1.7	1.4	1.7	1.9	3.0	2.8	2.9	1.3	2.3	2.8	4.8	3.7	1.8	2.5	2.3	1.9	1.6	2.9
S9	2.2	2.0	0.9	1.8	2.8	1.7	3.3	0.9	3.3	2.2	4.4	3.4	2.2	2.0	0.8	2.2	3.1	1.6
S10	2.0	2.3	0.2	2.3	2.7	2.9	3.0	1.8	2.8	1.6	4.9	4.7	2.0	2.2	0.7	2.3	3.2	2.1
Mean	1.9	2.1	1.2	2.2	2.9	2.0	2.9	2.3	2.9	2.7	4.6	3.6	1.9	2.3	1.5	2.1	1.8	1.8

S: Sample, BC: Before Cementation, AC: After Cementation, AT: After Thermal cycle

Table 3. Colour measurements after staining

	Zirconia (n=30)						E-max (n=30)						Gradia (n=30)					
	Control Group		Multilink Group		Nexus Group		Control Group		Variolink Group		Nexus Group		Control Group		Variolink Group		Nexus Group	
	cof	TE	cof	TE	cof	TE	cof	TE	cof	TE	cof	TE	cof	TE	cof	TE	cof	TE
S1	2.2	1.2	1.7	1.0	1.9	1.9	1.9	3.0	1.9	1.8	1.6	1.2	2.4	1.2	2.3	2.1	1.5	1.6
S2	2.1	1.7	1.8	1.6	2.0	2.3	0.3	1.7	1.4	1.8	2.4	2.4	5.6	0.8	1.8	1.4	1.4	2.1
S3	2.2	1.3	2.8	1.2	1.0	1.4	2.4	2.5	2.0	1.9	1.9	1.4	4.1	1.3	2.1	1.6	2.1	2.5
S4	2.0	2.2	2.5	2.6	1.8	1.7	1.6	2.6	1.9	1.8	1.6	2.3	3.4	1.1	2.1	0.5	1.0	2.0
S5	2.1	0.4	1.9	1.8	2.1	2.3	1.8	2.5	0.6	1.6	1.9	2.7	3.9	2.5	1.6	1.6	1.3	2.0
Mean	2.1	1.4	2.1	1.6	1.8	1.9	1.6	2.5	1.6	1.8	1.9	2.0	3.9	1.4	2.0	1.4	1.5	2.0

S: Sample, TE: Tea, cof: Coffee

Table 4. Statistical differences between the materials

			Difference of mean	P value	95% Confidence Interval	
					Lower limit	Upper limit
BC	Zirconia	E-max	-0.81500	.000	-1.0589	-0.5711
		Gradia	-0.04500	.897	-0.2889	0.1989
	E-max	Zirconia	0.81500	.000	0.5711	1.0589
		Gradia	0.77000	.000	0.5711	1.0139
	Gradia	Zirconia	0.04500	.897	-1.989	0.2889
		E-max	-0.77000	.000	1.0139	-0.5261
AC	Zirconia	E-max	-0.97500	.004	-1.6779	-0.2721
		Gradia	0.44500	.288	-0.2579	1.1479
	E-max	Zirconia	0.97500	.004	0.2721	1.6779
		Gradia	1.42000	.000	0.7171	2.1229
	Gradia	Zirconia	-0.44500	.288	-1.1479	0.2579
		E-max	1.42000	.000	-2.1229	-0.7171
AT	Zirconia	E-max	-1.65000	.000	-2.2442	-1.0558
		Gradia	-0.65000	968	-0.6542	0.5342
	E-max	Zirconia	-0.6000	.000	10.558	2.2442
		Gradia	1.59000	.000	0.9958	2.1842
	Gradia	Zirconia	0.06000	.968	-0.5342	0.6542
		E-max	-1.59000	.000	-2.1842	-0.9958

BC: Before cementation, AC: After cementation, AT: After thermal cycle

DISCUSSION

The main factors for selecting restorative materials include patients' esthetical demands, expectations, and manufacturing techniques (Harryparsad et al., 2014). The null hypothesis of our study was rejected. The study results revealed a statistically significant difference between materials after exposed to different procedures. IPS e.max showed more stable values before and after cementation, after thermal cycle and after staining solutions. Acar et al., (2016) found that lithium disilicate (IPS E-max) was the most colour stable material compared to hybrid nano-ceramic and nanocomposite. Sayed also found that IPS e.max veneers exhibited the best colour stability when compared with nano hybrid and Vita Enamic veneers (Sayed et al., 2016). Lee and Choi (2018) found high translucency of lithium disilicate ceramics exhibited greater colour changes after aging. On contrary, Hamza et al., (2018)found that the colour stability of IPS e.max and IPS Empress were not affected by aging process. They also found that resin cement systems also influence the colour change of prosthetic restorations. Moreover, other studies found that thermocycling is associated with volumetric contraction and expansion of materials which can cause degradation (Gürdal et al., 2002; Shimizu et al., 2008).

However, colour may also be affected by the other factors such as water or material ageing (Shimizu et al., 2008). Papadopoulos found that indirect resin composites (Adoro, HFO, Gradia) showed a yellow shift after accelerated aging and indirect resin composites (Gradia, Solidex) demonstrated a colour change after water immersion (Wagner et al., 1995; Gürdal et al., 2002; Nakamura et al., 2002; Papadopoulos et al., 2010). Several researchers found that the factors such as discoloration that may happen over time when exposed to different foods and drinks such as tea, coffee, cola, chlorohexidine or bleaching agent (Malekipour et al., 2012; Khaledi et al., 2014; Rosentritt et al., 2015). The current study also found that cementing the materials with different resin cements had an impact on the colour stability of the ceramic materials.

It has been reported that a 7-day conditioning period of ceramic materials will take up a significant staining within the first week of exposure to solutions (Borges et al., 2011; Al-Shalawi et al., 2017). Many studies also found that different beverages have varying degrees of staining on different types of materials (Reis et al., 2003; Lamba et al., 2012; Nikzad et al., 2012). According to Kelly and Benetti (2011), IPS e.max ceramics are more translucent, thus less likely to stain. This study also evaluated the impact effect of coffee and tea on the colour stability. According to the study results, IPS e.max was the most colour stable material. However, there was no statistically significant difference between Zirconia and Gradia in colour change after staining.

Sayed et al., (2016) found that coffee had the highest impact on the colour change of restorative materials. This may be explained by the easier absorption of the coffee into the material (Al Kheraif et al., 2013). Similarly, Raeisosadat et al., (2016) assessed the colour stability of three commonly used resin-based materials and revealed that all the materials were more significantly affected by the coffee when compared to the tea. Bagheri et al. (2005) argued that coffee includes a yellow colour which causes the materials with low polarity to easily stain. In this study there was no statistically significant difference between coffee and tea in terms of colour changing effects.

CONCLUSION

Within the limitations of this study the following conclusions may be drawn:

IPS e.max has the best colour stability after cementation and thermal cycle.

IPS e.max has the best colour stability after exposed to staining solutions.

There is no difference between coffee and tea in terms of colour changing effects.

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