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COLOUR STABILITY AND FRACTURE RESISTANCE OF LITHIUM DI SILICATE, INDIRECT RESIN COMPOSITE AND ZIRCONIA BY USING TWO DUAL CURING RESIN CEMENTS

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Mohammed A.M. Badwan

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Lityum Disilikat Seramik, Indirek Kompozit Rezin ve Zirkonyum Materyallerinin Renk Stabilitesi ve Kırılma Direnci Incelenmesi iki Rezin Siman kullanarak

Name of the student: Dr Mohammed Abdulrahman Badwan
Mentor: Dr Erkut Kahramanoglu
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özet

Amaç: Bu çalışmanın amacı lityum disilikat seramik, indirek kompozit rezin ve zirkonyum materyallerinin renk stabilitesi ve kırılma direnci açısından incelenmesidir.

Gereç ve Yöntem: Çalışmada 180 örnek (3 grup, n=60) E-max, zirkonya ve indirek kompozit rezin materyallerinden (10 mm çap ve 1 mm kalınlık) disk şeklinde üretildi ve hazırlanan örnekler rezin siman ile simante edildi. Örneklere termal siklüs cihazı ile (5 °-55 ° C / bekleme süresi: 20 saniye), 168 saat süresince 10 000 döngü yaşlandırma işlemi uygulandı. Yaşlandırma işlemini takiben örnekler 7 gün boyunca boyama çözeltilerinde (kahve ve çay) bekletildi ve spektrofotometre yardımı ile ΔE değerleri belirlendikten sonra örnekler kırma testine sokuldu. İstatistiksel analiz için SPSS programı kullanıldı.

Bulgular:

Çalışma sonucunda simantasyon öncesi ve sonrası değerler ve termal siklüs öncesi ve sonrası değerler arasında istatistiksel olarak anlamlı bir fark bulunmuştur (P <0.05). Materyallerin eğilme dayanımları arasında fark bulunmuştur (P <0.05). Sonuç olarak, materyaller arasında termal siklüs öncesi ve sonrası ve simantasyon öncesi ve sonrası istatistiksel olarak farklar bulunmuştur. Kahve ve çay solüsyonlarının etkisi değerlendirildiğinde, zirkonya ve kompozit rezin materyalleri arasında istatistiksel olarak anlamlı bir fark gözlenmezken; zirkonya ve e-max ve e-max ve kompozit rezin.

Sonuç: Bu çalışmada, termal siklüs, simantasyon ve boyama çözeltilerinin 3 materyalin renk stabilitesi üzerinde etkili olduğu sonucuna varıldı. En yüksek renk stabilitesi e-max materyalinde görüldü. Materyallerin eğilme dayanımları arasında fark bulundu. E-max materyalinin eğilme dayanımı zirconia ve kompozit rezine göre daha yüksek bulundu.

Anahtar Sözcükler: Variolink, Nexus NX3, renk stabilitesi, kırılma direnci, termal siklüs.

COLOUR STABILITY AND FRACTURE RESISTANCE OF LITHIUM DI SILICATE, INDIRECT RESIN COMPOSITE AND ZIRCONIA BY USING TWO DUAL CURING RESIN CEMENTS

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SUMMARY

Aim: To examine the colour stability and fracture resistance of lithium di silicate, Indirect resin composite and Zirconia.

Material and Method: Three groups of 180 samples (n= 60) of E-max, zirconia and indirect resin composite (10mm diameter and 1mm thick). Discs were then fabricated and cemented with dual cured resin cements. Aging treatment was afterwards applied to the discs using thermal cycle machine (at 5°C to 55°C/dwell time: 20s), 10000 cycles for 168 hours. The samples were then emerged in staining solutions (coffee and tea) for 7 days to determine ΔE using spectrophotometer then fractured. Results were analysed using SPPS program.

Findings: The study results revealed a difference between before and after cementation and before and after thermal cycle ($P<0.05$). There was a difference between the flexural strength of the materials $P<0.05$). Results revealed a difference between the materials before and after thermal cycle and a difference between before and after cementation in the majority of the variables ($P<0.05$). In regard to coffee and tea the results showed a difference between Zirconia and E-max as well as a difference between E-max and Gradia but no difference between Zirconia and Gradia.

Results: In the limitation of the current study it can be concluded that Thermal cycle, cementation and staining solutions had an impact on the colour stability of the three materials. E-max had the highest colour stability. There is a difference between flexural strength of the three materials, Zirconia has ~~a~~ better flexural strength when compared to E-max and Gradia.

Key Words: Variolink, Nexus Third Generation NX 3, Colour stability measurements, Fracture resistance test, Thermal cycle machine.

List of Abbreviations

Abbreviations	**Full form**
CAD/CAM	Computer-aided design/computer-aided manufacturing
Zr	Zirconium
Ti	Titanium
MPa	Megapascal
N	Newton
kN	Kilonewton
NX3	Nexus 3rd generation
G	Gram
°C	Degrees Celsius
µm	Micrometre
Mm	Millimetre
M	Meter
mL	Millilitre
ISO	International Organization for Standardization
S	Sample
C	Control
CAT	Control after thermal cycle
BC	Before cementation
AC	After cementation
AT	After thermal cycle

1. Introduction

The strength and aging of intra-oral restoration are associated with the achievement of three measures strength, fit and esthetic (Singh et al, 2015; de Oliveira and Botta, 2014). According to Harryparsad (2014) the main factors for selecting restorative material include patients' aesthetic demands and expectations and manufacturing techniques. Other researchers found that factors such as the discoloration that may happen over time when exposed to different food and drinks such as tea, coffee, coca-cola, chlorohexidine or bleaching agent (Rosentritt et al, 2014; Khaledi et al, 2014; Malekipour et al, 2012). Colour stability is one of the main elements that a patient desire to maintain. Most studies indicate that composite resins are susceptible to colour changes over time (Singh et al, 2015). According to several research there are many factors that affect the colour stability of restorative materials, this includes smoothness of the surface, brand and shade of the material, exposure to food and drinks and the finishing techniques (Singh et al, 2015; Stawarczyk et al, 2012). Several studies have reported that staining of resin-based materials by coloured solutions such as tea, coffee and cola (Wilson et al, 1997; Schulze at al, 2003; Scotti et al 1997). For instance, Scotti et al (1997) simulated the oral condition by dipping specimens in synthetic saliva mixed with chlorhexidine, coffee or tea in a dark environment at 37 °C. According to their study synthetic saliva and coffee produced the most darkening. Similarly, Stober et al (2001) found that red wine and coffee caused discoloration. Moreover, Lazzetti et al (2000) examined the colour satiability of fluoride- releasing materials by mixing them in cranberry juice, coffee and tea. Their study results revealed that the hydrophobic materials were more colour stable and stain resistance than the hydrophilic materials. Um and Ruyter (1999) reported that discoloration by coffee was mainly due to the absorption of colorants by the tested materials. Another important characteristic of dental materials is fracture resistance as it depends on material resistance to crack from its internal defects. Such cracks may lead to microscopic fractures of the restoration margins and/ or the bulk fracture of the filling (Bonilla et al, 2001). According to (Freitas et al, 2002) indirect composites offer greater resistance to fractures compared with direct composite materials. Ceramic materials are known for their good esthetic, excellent fracture resistance, bonding durability and simplified fabrication techniques using CAD/CAM, therefore, there is a growing interest in them (Hooshmand et al, 2008).

Glass ceramics are classified the best materials in offering the best esthetic characteristics as they have high translucency, light transmission and natural tooth look restorations (de Oliveira and Botta, 2014). Lithium disilicate glass ceramic is one of the glass ceramic materials that has improved in performance in the last years; it is known for its high flexural strength and appealing translucency (Topcu et al, 2009). The success of the dental restoration is relied on different factors such as mechanical properties, type of material, surface texture, translucency and colour. The most popular aesthetic restorative material used in crowns and bridges work are porcelain fused to metal (PFM); zirconia, Lithium disilicate and Indirect Resin Composite as they are thought to have excellent mechanical properties. Thus, they have been widely used by clinician because of their excellent aesthetic properties. The choice of different ceramic materials should be selected carefully as the final aesthetic outcome varies depending on the thickness, colour, translucency, surface, shape, texture and brand of the material. Colour Stability and Fracture Resistance are the most essential aspects for a successful aesthetic dental restoration.

Zirconia, lithium disilicate and Indirect composite are the most popular glass ceramic used (Christensen, 2003). Zirconia has been widely used for industrial purposes in the last years. It is known for its exceptionally durable and 100% biocompatible. Therefore, it is mainly used in crowns, bridges and implants (Christensen, 2003). The strength of zirconia is due to the crystalline phase transformation system which gives the material high mechanical strength and reliability (DeanyI,1996). Additionally, zirconia is used as a framework in all ceramic crowns and fixed dental prostheses which provides patients with sufficient strength and esthetic outcome (Shenoy and Shenoy, 2010; Bachhav and Aras, 2011). The main advantage of zirconia is that it limited the amounts of defects due to fabrication with CAD/CAM techniques which has significantly reduced time and cost and has sufficient strength of the reconstruction and space for veneering (Seghi et al, 1995). Land and Hopp (2010) found that lithium disilicate crowns for posterior teeth with reduced thickness showed much more fatigue failures than the zirconia. However, lithium disilicate also known as E-max crowns is also one of the most widely used glass ceramic (Denry, 1996). Lithium disilicate is known for its longer lasting, high aesthetic qualities and attractive appearance (Sorensen et al, 1999). In addition, it is considered a great option for poor quality, stained and damaged teeth. Thus, it is less likely to break compared to zirconia crowns (Sorensen et al, 1999). Indirect composite material is also popular as it is considered to exhibit better stress distribution, lower cost, easy to use and can be used in daily clinical practice (Souza et al, 2010; Cetin and Unlu, 2009; Hickel and Manhart, 2001). However, indirect composite has less long-term characteristics such as roughness and are more likely to change in colour (Nandini, 2010).

In the current study we used Dual cure resin cements NX3 Nexus Third Generation, Variolink N and Multilink N since it has been reported that such cements allow the transmission of light through the ceramics even if it is too thick or too opaque. On the other hand, it is argued that the chemically polymerized resin cements do not offer a selection of shade and translucency (Vrochari et al, 2009). Moreover, the self-adhesive resin cements such as Rely X Unicem Self-Adhesive Universal Cement (3M ESPE), SmartCem 2 (Dentsply, York, Pa.) and SpeedCEM (Ivoclar Vivadent) are reported to bond to enamel and dentin less than dual cure resin cements (Lürhs et al, 2010; Radovic et al, 2008). Whilst, according to several studies (Noie, 1995; Nathanson and Banasr, 2002) the light cure resin cements such as Rely X Veneer Cement (3M ESPE, St. Paul, Minn.), Variolink Veneer (Ivoclar, Vivadent, Amherst, N.Y.) and Choice 2 Light Cured Veneer Cement (Bisco, Schaumburg, Ill) has lower mean colour (ΔE) change compared to the dual cure resin cements. Which indicates that the dual cure resin cements have more ageing induced colour change than the light cure resin cements (Nathanson and Banasr, 2002).

Both colour stability and fracture resistance are essential for the success of crowns and bridges veneering. The colour stability and fracture resistance of lithium disilicate, Indirect resin composite and Zirconia has been intensively studied. However, there is lack of research on the difference between the materials and which is better in terms of strength and colour maintenance.

Thus, this study involves an examination of three esthetic materials, which are considered the most popular esthetic materials used in the field of dentistry. The study will also explore the difference between dual cure cements which include Variolink (N), Multilink N cements and Nexus3 Third Generation NX3 Cement. The spectrophotometer (colour meter), vita easy shade "V" device (latest version) will find out the colour measurements of the three materials we motioned earlier.

1.1. Aim

The aim of this study is to examine the colour stability and fracture resistance of lithium disilicate (E-max), Indirect resin composite (Gradia) and Zirconia by using dual cure resin cements.

1.2. Objectives

1. To assess the colour stability difference between E-max, Gradia and Zirconia before and after cementation and after thermal cycle
2. To determine the colour stability difference between materials; before and after cementation and after thermal cycle
3. To assess the changes that will occur to the colour of E-max, Gradia and Zirconia discs after coffee and tea
4. To determine the difference of flexural strength between the materials (Zirconia, E-max and Gradia).
5. To examine the difference between flexural strength of the three materials (control groups) and (control group after thermal cycle).
6. To identify the best esthetic material among E-max, Gradia and Zirconia
7. To assess the difference between cements (Variolink, Multilink and Nexus 3rd generation) on the colour of the materials.

8. To assess the difference between cements (Variolink, Multilink and Nexus 3rd generation) on the flexural strength of the materials.

1.3. Null Hypothesis

H1: There is no statistically significant difference between E-max, Gradia and Zirconia before and after cementation and after thermal cycle in colour stability.

H2: There is no statistically significant difference between materials; before and after cementation among all materials in colour stability.

H3: There is no statistical significance difference between cements (Variolink, Multilink and Nexus 3rd generation) on the colour of the materials.

H4: There is no statistical significance difference between E-max, Gradia and Zirconia after coffee and tea.

H5: There is no difference of flexural strength between the materials (Zirconia, E-max and Gradia).

H6: There is no statistical significance difference between cements (Variolink, Multilink and Nexus 3rd generation) on the flexural strength of the materials.

2. General Information

2.1. Types of glass ceramics

2.1.1. Lithium disilicate glass ceramic IPS E-Max press

Many dentists believe that Lithium disilicate is considered a highly esthetic and a very strong material that can be easily cemented (Fabianelli et al, 2006). It is also believed that Lithium disilicate offers a unique mix which offers a full contour restoration and can be used in all areas of the mouth (Fabianelli et al, 2006). There are two main types of Lithium disilicate used in restorative dentistry, this includes IPS E-max (Ivoclar Vivadent) lithium disilicate which is composed of quartz, lithium dioxide, phosphor oxide, alumina, potassium oxide, and other components (Deany, 1996). Such ingredients are thought to yield a high thermal shock resistant glass ceramic. The second type of lithium disilicate is IPS E-max Press Ivoclar Vivadent, this is the pressed version of the E-max and is made of two different crystals that are thought to prevent the formation of defects such as pores and pigments. Furthermore, polyvalent ions that are dissolved in the ceramic glass are used to provide the preferred colour to the lithium disilicate.

According to several studies' lithium disilicate achieved better mechanical properties when compared to other dental glass ceramics (Iqbal et al, 1998; Soares, 2003; Holand and Apel, 2006). Ohashi et al (2017) evaluated and compared the characteristics (biaxial flexural strength, wear resistance, and acid resistance) of three pressable lithium disilicate glass ceramic materials (GC Initial LiSi Press, IPS e-max Press (e-max; Ivoclar Vivadent), and Vintage LD Press (LD; Shofu). In terms of wear resistance their study found that IPS E-max Press damaged surfaces was much less than the other lithium disilicate materials. Additionally, in relation to the acid resistance they found that LiSi Press in acid performed the lowest, while there was no significant difference between IPS E-max Press and Vintage LD Press. Furthermore, in relation to the biaxial flexural the study reported no significant difference between LiSi and E-max and that the LD was much lower which indicates that LiSi and E-max ceramics have a better physical property, stronger fracture resistance and better density. However, the biaxial flexural strengths were not significantly different between the materials after the thermal cycle test. The study concluded that the three lithium disilicate materials have different physical properties; LiSi and E-max have a better physical and chemical stability than the Vintage LD Press.

2.1.2. Zirconia (ZrO2)

Zirconia was first identified in 1789 by a German chemist Klaproth (Babic et al, 2005). Zirconia is considered a strong metal and is commonly used in implant dentistry (Kobayashi et al, 1995). There are three main types of zirconia used in restorative dentistry, these include Zirconia dispersion toughened ceramics, partially stabilized zirconia and tetragonal zirconia polycrystals (Garvie et al, 1975). As mentioned earlier zirconia is known for its optimal properties, it is tough, strong and fatigue resistant, in addition it has excellent wear properties. In dental implant dentistry there are two main zirconia metals: Zirconium (Zr) and titanium (Ti). Both metals are considered strong with similar chemical and physical properties and they do not inhibit the bone forming cells (Kobayashi et al, 1995). The mechanical properties of zirconia were proven in many studies, for instance according to (Vagkopoulou, 2009) the fracture toughness of zirconia is between 6 and 10 MPa m1/2 which is twice as stronger than the aluminium oxide ceramics. Additionally, the flexural strength is between 900–1200MPa and a compression resistance id 2000MPa (Vagkopoulou, 2009). Moreover, the fracture load ranges between 706N, 2000N and 4100N, this is a higher fracture load than lithium disilicate (Vagkopoulou, 2009). In relation to the biocompatibility, most vitro and vivo studies have confirmed high mean values in both Zirconium (Zr) and titanium (Ti) (Vagkopoulou, 2009; Piconi and Maccauro, 1999); Manicone et al, 2007). Furthermore, in relation to the aging of zirconia, it is proven that aging or low temperature degradation is slow and thus has slow transformation (Chevalier, 2006).

2.1.3. Indirect resin composite (Gradia)

Indirect composite inlay technique was introduced in Germany by Mormann (1982) and in France by Touati and Pissis (1984). The inlay technique offered the easy fabrication, reduced marginal shrinking as well as efficiency in building the proximal contacts and contours. Fruits et al (2006) found that indirect resin restoration is associated with less microleakage than the direct resin groups. Additionally, Lutz et al (1984), found improvements in wear resistance of heat cured formulation and chemically cured formulations.

In addition, several studies were conducted to observe the efficacy and longevity of the indirect composite materials. For instance, Wendt et al (1987) studied the clinical performance heat treated composite by comparing the difference between direct and indirect methods. According to their study, there was no difference between the materials. Moreover, Wendt (1987) revealed that there is an increase in the diametral tensile strength and hardness and no decrease in the compressive strength when the light cured composites were exposed to heat treatment for 10 minutes at 100°C to 200°C. Similarly, Cook and Johnson (1987) found an increase in diametral tensile strength as well as flexural strength and fracture toughness in composites post cured at 100°C for 24 hours. Similarly, Bartlett and Sunderam (2006) three-years randomised clinical study found no significance difference between the indirect and direct composite in terms of the wear. Other researchers believe that indirect composite materials are in more favour than the direct composite since they are thought to be stronger and less likely to fracture than the direct composite resin (Burke, 1994). For instance, Kaytan et al (2005) found that indirect resin composite has a much better colour stability than the composite resin. Moreover, Thordrup et al (2006) ten-year prospective study on indirect and direct composite revealed that indirect composite showed higher survival rate and was less likely to fracture. As mentioned earlier colour stability is a vital property for the longevity for teeth restoration (Wilson et al. 1997). According to a vitro study that was conducted by (Stober et al 2001, Villalta, 2006) resin-based composite are prone to staining. Moreover, Setz et al (1997) double blinded study compared two types of composites used in veneering found significant discoloration after one year. On the other hand, Wilson et al (1997) found that the colour can change under various chemical and physical conditions such as thermal changes and humidity. Other researchers identified an interaction between staining the degree of conversion (Villalta, 2006; Cook and Chong, 1985; DeGee, 1984). Additionally, the indirect composite can be stained by other factors such as coffee, tea and other beverages (Satou et al, 1989).

Several clinical studies explored the earlier version of indirect resin composite also known as first generation indirect composites. These composites were micro-filled with flexural strength ranging from 60 MPa to 80 MPa (Touati and Aidan, 1997; Kakaboura et al, 2003). (Touati and Aidan, 1997) found that the flexural strength of composites ranged between 120 MPa to 160 MPa.

The characteristics of the two second-generation composites (Belleglass HP and Symphony) was examined by (Kakaboura et al, 2003). They evaluated the degree of conversion, microhardness, roughness, flexural strength and polymerization shrinkage. According to their study results the two materials differed in composition and process of curing where Belleglass HP displayed higher degree of conversion, surface microhardness, flexural strength and increased roughness. Mandikos et al, (2001) on the other hand compared the wear resistance and toughness of the first-generation indirect composite to the second-generation. Their results revealed that the first-generation had higher wear resistance and toughness than the second-generation indirect composite resin.

2.2. Types of cements

2.2.1. Variolink N Cement

Variolink is a highly esthetic luting material which have been on the market since 1997 and is considered successful in fulfilling the requirements of the adhesive cementation used in restorative dentistry. In 2014 a new Variolink esthetic was introduced which is considered a colour stable adhesive luting system for permanent luting of glass ceramic material such as lithium disilicate and composites. There are two types of Variolink esthetic: purely light-curing Variolink LC and the dual-curing Variolink Esthetic DC. The Variolink LC is used for restorations and offers an adequate degree of translucency, while the Variolink Esthetic DC is used for opaque restorations. Both Variolink LC and Variolink Esthetic DC feature the same formulation, the only difference between them is the additives on the DC version which includes a self-curing initiator that are not needed in the LC version (Sasseville, 2012). Thus, both the DC and LC versions perform the same handling properties and physical properties. Another popular Variolink used on the market is the Variolink N, this is the standard version of the Variolink (Fay et al, 2001). The luting system of the Variolink N is recommended for the combination of the glass ceramic restorations including (IPS Empress System, IPS E-max lithium disilicate). There are many advantages for using Variolink N in esthetic dentistry, the first advantage is the selection of shades and translucency which means the shade is selected according to the teeth of the patients (Bookhan et al, 2005). Another advantage of Variolink N is its sensitivity to light without affecting other properties such as long-term stability and curing depth, thus Variolink N veneers are purely light curing materials. Polish ability is another advantage of Variolink N as the particle size of the glass filler is 1.0 µm and the maximum particle size is 3 µm which means higher polish ability (Sorensen et al, 2001).

2.2.2. Multilink N Auto-mix Cement

The Multilink N self-adhesive resin cement is mainly used for the cementation for all IPS E-max, IPS empress restoration and indirect restorations and for cementation of indirect restorations (inlays, onlays, crowns, bridges, endodontic posts).

Its main features include high bond strength, dual, self-curing, universal as well as long-lasting, outstanding and well-balanced adhesion of the restoration. Multilink N performs a high initial bonding values on IPS E-max lithium disilicate glass-ceramics even after the aging through thermal cycle machine (Kern and Lehmann, 2013). Thus, the Multilink N Cement self-adhesive generates an excellent bond to glass ceramics. According to several clinical studies Multilink N achieved good results in terms of survival rate. The survival rate of restoration in terms of adhesion was proven in 9 studies (Aziman et al, 2012). Beuer et al (2011) study on fifteen full contour IPS E-max CAD lithium disilicate was cemented with Multilink N for four years, the results showed that none of the monitored restorations had come loose and survival rate was 100%. Similarly, Fasbinder et al. (2001) studied twenty-three IPS E-max lithium disilicate crowns that were cemented with Multilink N for four years, the results showed that none of the restorations failed and the survival rate was 97%.

2.2.3. Nexus Third Generation NX3 - Nexus3 Cement

Nexus Third Generation NX3 is a permanent resin cement system used for all indirect applications. It has many features such as innovative chemistry for unmatched aesthetics, super adhesion and great versatility. The delivery system choices of the Nexus Third Generation NX3 include an auto-mix syringe for dual cure cement which can be used for all indirect applications including veneers. The NX3 is the first colour stable adhesive cement, it has an optimised resin matrix and its known for its exclusive amine free initiator system. Furthermore, the NX3 has simplified superior bonding, it obtains a high bond strength, it is an excellent adhesion to dentin, enamel, CAD/CAM blocks, ceramic, porcelain, resin and metal. Moreover, it has a superior colour stability and a long-term aesthetics for both light cure and dual cure cements. (Heintze and Rousson, 2011).

2.3. Studies on Fracture Resistance

Fracture resistance is described as the stress that tend to fracture or break. The main factors that limit the resistance of fracture includes size, division of load and fracture toughness. Fracture resistance is a helpful element in evaluating the fracture resistance of ceramic materials (Lopes et al, 1991). Several methods are used in measuring the strength of dental ceramics, the most popular methods include bars, discs, rods, cylinders and crown shaped specimens (Cohert et al, 2001).

According to (Juntavee and Millstein, 1992) many ceramic materials have a critical strain fracture ranging from 0.05 to 0.2%, thus in order to improve the strength of ceramics the modulus should be amended. Batchelor (1960) found that the strength and modulus of elasticity of the mixtures increases with the proportion of the crystalline phase after introduction into glass of the crystalline grains of high strength and elasticity. (O'Brien, 1984) found that the strength of dental ceramics is influenced by the presence of residual stresses. According to Guazzato et al (2004) among a variety of zirconia offer enhanced mechanical properties when compared to other ceramic materials. On the other hand, Nawafleh (2015) investigated the impact of core/veneer thickness ratio on the fracture strength of E-max crowns. Her study results revealed E-max is more fracture resistant and capable to survive.

Johansson et al (2014) compared fracture resistance of monolithic zirconia and monolithic lithium disilicate (IPS E-max press) after thermal cycle. Since Zirconia has higher flexural strength (1000 MPa) than lithium disilicate (400 MPa) while the Indirect Gradia have a volume percentage of inorganic ceramic fillers of approximately 66%

which result into improved mechanical properties with a flexural strength between 120 and 160 MPa. It has been demonstrated that flexural strength of zirconia decreases when subjected to such aging treatments (Cotes et al, 2014; Flinn et al, 2012). Kohorest et al (2008) demonstrated that thermal cycles between 5°C to 55°C significantly decreased the fracture resistance of zirconia-based FDPs. On the other hand, the flexural strength of lithium disilicate restorations is different regarding to the technique of production there are two types one for press technique and the other for CAD/CAM (e.g. IPS E-max press and IPS E-max CAD). Since IPS E-max press possesses higher flexural strength (400 ± 40 MPa) than IPS E-max CAD (360 ± 60 MPa) (Moncke et al, 2017).

2.4. Studies on Colour Stability

Staining resistance is an essential property for the longevity of removable fixed dentures, crowns and direct restoration in esthetic areas (Wilson et al, 1997). Several in-vitro studies found that resin-based composites are prone to staining (Stober at al, 2001, Villalta et al, 2006). A double-blind pilot study was conducted by Setz and Engel (1997) which aimed at comparing two composites used in veneering telescopic dentures, the study results revealed significance discolouration after one year. Rosentritt et al (1998) examined the colour stability of laboratory-made composite veneers and found that the discoloration of the material was clinically unacceptable. Discoloration of dental composite restorations can be caused by both exogenous or endogenous reasons (Kolbeck and Rosentritt et al, 2006). The endogenous reasons include the discolouration of resin matrix and the link of resin matrix and fillers (Wilson et al, 1997). Endogenous usually occur when the materials are aged under various chemical and physical conditions, this includes for example thermal changes and humidity (Stober et al 2001, Cook and Chong, 1987). De Gee et al (1984) examined the correlation between staining and the degree of conversion and found that inadequate staining favours the absorption of some colours such as visible and ultra violet irradiation may change the colour of composite materials. In relation to the exogenous reasons it included the adsorption and absorption of stains (Satou et al, 1989). Numerous studies investigated the staining of composites by coffee, tea and other beverages. For instance, Um and Ruyter (1991) evaluated the colour stability of resin based veneering materials using boiled coffee and tea at 50°C. Their study results indicated that discolouration of materials occurred by the sorption of the colourants into the organic phase of the veneering materials. Similarly, Dietshci et al (1994) 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 thermocycling post curing and polished before staining. The study results revealed that erythrosine had the most colour changed. Moreover, 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 was investigated by Scotti et al (1997). It was concluded that the synthetic saliva and coffee had the greatest colour change. The maintenance of ceramic characteristics is vital from an aesthetic point of view especially that restorations that mimic the shape and colour of adjacent teeth are can be noticed easily and may therefore, lead to failure in treatments (Nogueira and Della Bona (2013) Assunção et al (2009), ten Bosch and Coops (1995). There are three main types of composite resin discolorations, the first type is extrinsic discoloration which is caused by the build-up of plaque; 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 as well as by the reaction of the staining agents on the inner side of the superficial composite resin layer (Dietschi et al, (1994); Asmussen (1983)). The colour stability is essential throughout its functional lifetime mainly for the durability of treatments and for cosmetic reasons (Prashanthi and Madhyastha, 2015).

3. Materials and Methods

In vitro study was used to to examine the colour stability and fracture resistance of lithium di silicate (E-max), Indirect resin composite (Gradia) and Zirconia by using dual cure resin cements. This section provides a detailed explanation of the research methodology adopted for the fulfilment of the study's research objectives.

3.1. Samples and groups

3.1.1. Preparing sample materials

A total of 180 (10mm diameter, 1mm thick) (Muench et al, 2005; Turgut and Bagis, 2013; Turgut and Bagis, 2011; Dikicier, 2014; Almansour, 2018; Ozer et al 2018, Bagheri et al, 2015; Alabdulwahab et al, 2015) ceramic discs material of Zirconia (Zirkonzahn n=60/each: Zirkonzahn, Gais, Italy). Lithium disilicate (IPS e-max press n=60/each: Ivoclar Vivadent, Sachaan, Liechtenstein). Indirect Resin Composite (Gradia, GC Europe N.V: Leuven, Belgium) was divided into two main groups which include colour stability and fracture resistance; (n=60) for each material and each cement has a total of 30 discs (Table 1). The colour stability samples were divided into two groups control group (A) before and after thermal cycle without cementation and group (C) was divided into Variolink N and Nexus 3rd generation resin cements for E-max and Gradia materials, while the zirconia material was cemented Multilink N and Nexus 3rd generation resin cements as according to the manufacture company it cannot be cemented with Variolink N resin cements. The samples were sub-grouped as (1- Variolink N before cementation and Nexus 3 before cementation; 2- Variolink N after cementation and Nexus3 after cementation; 3- Variolink N after thermal cycle and Nexus 3rd after thermal cycle; 4- Variolink N after thermal cycle with coffee and Nexus3 after thermal cycle with coffee; 5- Variolink N after thermal cycle with tea and Nexus3 after thermal cycle with tea). In terms of fracture resistance, the sample materials were grouped as (control group (A) fracture resistance, control group (A) after thermal cycle, group (B) Variolink N after cementation and group (B) Nexus 3 after cementation, group (C) Variolink N after thermal cycle and group (C) Nexus 3 after thermal cycle. The control groups were not cemented (figure 1). After organising the main groups (colour stability and fracture resistance) we then subdivided them into three groups (A, B and C) (Tables 1 and 2).

Table 1: Chemical composition and manufactures of the materials used in this study

Material	**Composition**	**Manufacturer**
Lithium disilicate glass ceramic IPS E-Max 	57-80%SiO2,11-19%Li2O, k2O, MgO,Al2O3,P2O5 and other oxides	Ivoclar Vivadent AG Schaan, Liechtenstein
Zirconia 	Higher than 90% ZrO2 and Glass infiltrated ceramics (+HfO2) Y2O3 Al2O3 SiO2 Fe2O3 Na2O Density	Zirkonzahn, Gais, Italy
Indirect Resin Composite Gradia 	Urethane dimethacrylate (UDMA) as a matrix + Silica Powder, Silica Glass Powder and Prepolymerized as a filler.	GC Europe N.V: Leuven, Belgium
Total etch Variolink N adhesive resin cement ‘’0’’ transparent shade 	Dimethacrylates, Inorganic fillers, Ytterbium trifluoride, Catalysts and stabilizers, Pigments.	Ivoclar Vivadent AG Schaan, Liechtenstein
Nexus Third Generation NX3 - Nexus3 ‘’Clear’’ shade 	Composition not available	SDS Kerr California, USA
Multilink N transparent shade 	Dimethacrylates and HEMA Ytterbium trifluoride, Mixed oxide; highly dispersed silicon dioxide, Barium glass filler, Ba-Al-Fluoro silicate glass, Initiators and stabilizers Pigments	Ivoclar Vivadent AG Schaan, Liechtenstein

Table 2: Sample grouping

Groups	Materials	Working methods
Group A: total (n=60) Control group (no cementation)	E-Max (n=20) / Zirconia (n=20) / Gradia (n=20)	1- Control group thermal cycle (n=30) Colour measured + thermal cycle + staining coffee and tea + colour measured + fracture 2- Control group fracture (n=30)
Group B: total (n=60) Divided into: Variolink N + Multilink N auto-mix (n=30) Nexus 3rd (n=30)	E-Max (n=20) / Zirconia (n=20) / Gradia (n=20)	Cementation + fracture + no thermal cycle.
Group C: total (n=60) Divided into: Variolink N + Multilink auto-mix (n=30) Nexus 3 (n=30)	E-Max (n=20) / Zirconia (n=20) / Gradia (n=20)	Colour measured + cementation + colour measured + thermal cycle + colour measured + staining coffee and tea + colour measured + fracture.

Note: Total number (Samples = 180)

Colour stability Samples

Zirconia (n=40)
A-control group before and after thermal cycle (20)
C group:
1-Multilink N (10)
- before cementation
- after cementation
- after thermal cycle
- after thermal cycle with coffee
- after thermal cycle with tea

2-Nexus 3rd G (10)
- before cementation
- after cementation
- after thermal cycle
- after thermal cycle with coffee
- after thermal cycle with tea

E-max (n=40)
A-control group before and after thermal cycle (20)
C group:
1-Variolink (10)
- before cementation
- after cementation
- after thermal cycle
- after thermal cycle with coffee
- after thermal cycle with tea

2-Nexus 3rd G (10)
- before cementation
- after cementation
- after thermal cycle
- after thermal cycle with coffee
- after thermal cycle with tea

Gradia (n=40)
A-control group before and after thermal cycle (20)
C group:
1-Variolink (10)
- before cementation
- after cementation
- after thermal cycle
- after thermal cycle with coffee
- after thermal cycle with tea

2-Nexus 3rd G (10)
- before cementation
- after cementation
- after thermal cycle
- after thermal cycle with coffee
- after thermal cycle with tea

Fracture resistance Samples

Zirconia (n=60)
A-control group fracture resistance (10)
A-control group thermal cycle (10)
B-Variolink after cementation (10)
B-nexus after cementation (10)
C-Variolink after thermal cycle (10)
C-nexus after thermal cycle (10)

E-max (n=60)
A-control group fracture resistance (10)
A-control group thermal cycle (10)
B-Variolink after cementation (10)
B-nexus after cementation (10)
C-Variolink after thermal cycle (10)
C-nexus after thermal cycle (10)

Gradia (n=60)
A-control group fracture resistance (10)
A-control group thermal cycle (10)
B-Variolink after cementation (10)
B-nexus after cementation (10)
C-Variolink after thermal cycle (10) C-nexus after thermal cycle (10)

Figure1: Colour stability and fracture resistance samples

3.1.2. Fabrication of samples (technician part)

E-max, zirconia and indirect resin composite materials were fabricated in the laboratory according to the manufacturer's instructions.

For the E-max fabrication lost-wax and heat-pressed techniques (IPS E-max press Programat EP3000 press furnace, Ivoclar Vivadent, Schaan, Liechtenstein) was used for one shade of a lithium disilicate glass-ceramic material (IPS e.max Press HT and LT, A1 shade, n=60/each; Ivoclar Vivadent, Schaan, Liechtenstein). All samples were fabricated at 10mm diameter and 1mm thick by using the CAD/CAM Ceramill Motion2 (AMANNGIRRBACH, Koblach, Austria) with 5-axis technology wet-grinding and dry-milling in one compact unit. In order to achieve the accurate dimension of the wax block as shown in (figures 1 and 2) every sample takes 10 min milling.

Before

After

Figure 2: Before and after using the CAD/CAM milling machine to shape the wax disc

Thickness

Diameter

Figure 3: Inserting the dimensions of wax disc by using CAD software before starting the CAD/CAM milling machine

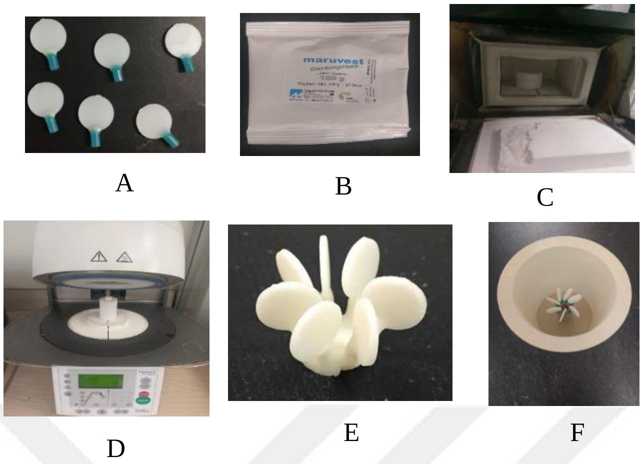


Figure 4: Steps of E-max discs fabrication: A) Discs with sprues B) Investment. C) furnace. D) Press furnace. E) Discs F) Ring

Thickness Diameter

Figure 5: Final dimensions of E-max disc

Figure 6: Final shape of E-max disc

After that wax was removed from the CAD/CAM machine and attached to a special sprue ring. Later on, investment powder100g (Maruvest investment, Cerampress, Megadental, Germany) was poured and mixed with water using vacuum mixing unit (Renfert, Hilzingen, Gemany) then placed inside 850°C furnace (burnout furnace, Renfert Magma, Hilzingen, Germany) for 45 minutes. After furnace, it was ready for Programat EP3000 press furnace. After pressing the ring was separated using Sandblast unit (Renfert, Hilzingen, Germany) then removed the sprues using a diamond disc (Horico, Berlin, Germany) (figure 3). Then the disc was removed by using airborne particle abrasion unit (Toptec-Bego, Bremen, Germany) with 50-mm glass beads at a pressure of 4 to 2 bars. The level of the pressure was decreased when it became closer to the ceramic material's surface. Both surfaces of the specimens were successively wet-ground to the desired dimensions with 220-, 320-, 500-, 600-, and 800-grade silicon carbide papers mounted on a surface grinder and polisher machine (MetaServ Grinder-Polisher; Buehler UK, Coventry, UK). The final step was to clean and wash the specimens under water. These are the steps of creating E-max samples to reach the accurate dimension required which is 10 mm diameter and 1mm thick (figures 4 and 5).
Zirkonzahn (Zirkonzahn, Gais, Italy) translucent blank was used for 60 fabricated samples of zirconia. The zirconia was manufactured in the CAD/CAM Ceramill Motion2 (AMANNGIRRBACH, Koblach, Austria) with 5-axis technology wet-grinding and dry-milling in one compact unit by using CAD/CAM software and inserted the samples of 10mm diameter and 1mm thickness, after that the CAD/CAM milling machine started to mill the specimen for 10 minutes for each sample (figures 6 and 7).
After milling the specimen, a low speed hand piece (NSK ultimate xl, Shimohinata, Japan) was used with a fine bur to remove the disc from the blank. After that, using a rubber finishing bur to soften the edges of the disc and scrubbed with a small brush. Then immersed the disc inside A1 water-based (Zirkonzahn, Gais, Italy) colour liquid to achieve the desired A1 shade discs and placed them into the sand until dried (figure 8).
The zirconia specimens were sintered at 1500°C after they were made (figures 9 and 10).

Thickness

Diameter

Figure 7: Inserting the dimensions of Zirconia disc by using CAD/CAM software before starting the CAD/CAM milling machine

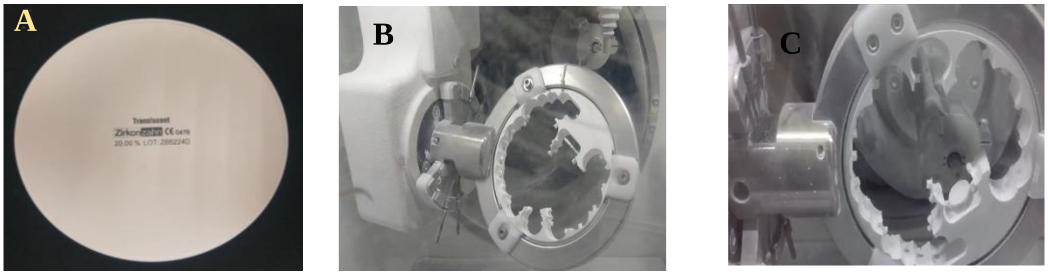


Figure 8: (A) Zirconia translucent blank before milling CAD/CAM milling machine (B and C)start milling the blank to shape it as discs.

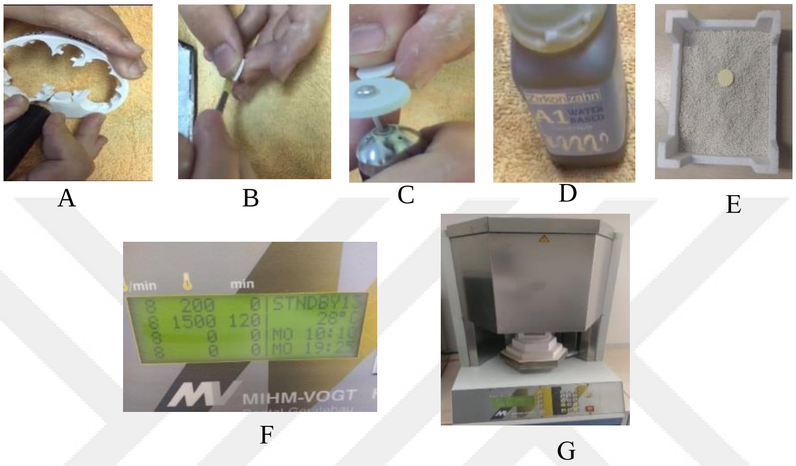


Figure 9: Steps of Zirconia disc fabrication: A) remove the disc from the blank.
B) Brush to clean. C) Rubber disc. D) colour liquid. E) Sand. F) Furnace temperature
G) Furnace

Figure 10: Thickness of the Zirconia disc

Figure 11: Final shape of Zirconia disc

For indirect resin composite fabrication 60 samples of Gradia (GC Europe N.V: Leuven, Belgium) were manufactured into A1 shade by filling a metal ring of 10mm diameter and 1mm thick by using a tube of indirect resin composite Gradia manufactured from (GC Europe N.V, Leuven, Belgium). After filling the metal ring by the composite, the material was pressed between two glass slides and fixed with an elastic band, then was stapled with a stapler machine for 15 minutes to achieve the accurate dimension (figure 11). After that it was inserted inside the light-cured machine (lumamat100, Ivoclar Vivadent, Schaan, Liechtenstein) for 12 minutes to polymerise the discs (figures 12 and 13).

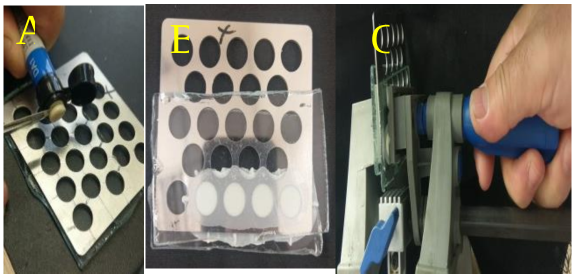


Figure 12: (A and B) Pressing the Gradia specimens for 15 min by using (C) stapler machine to staple the specimens to fit the accurate dimensions

Figure 13: Light-cured machine twelve minutes to polymerize the specimens

Figure 14: The final shape of Gradia Disc

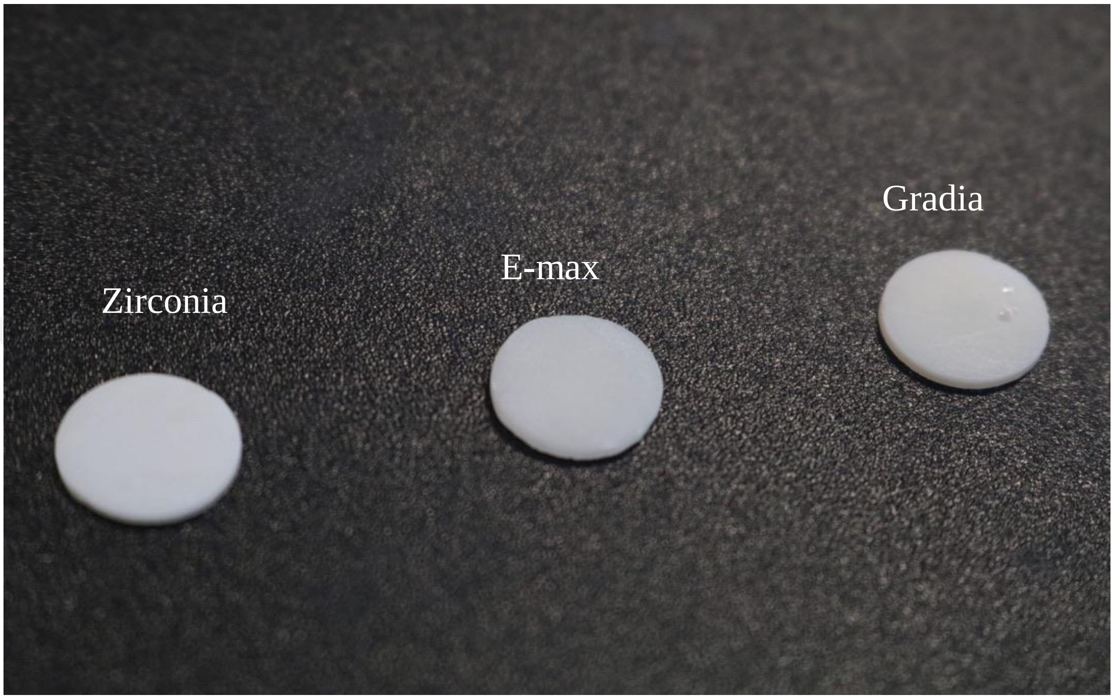


Figure 15: The final shape of the disc materials (Zirconia, E-max and Gradia)

3.2. Cementation

The materials sample Zirconia, E-max and Gradia (figure 14) were colour measured before the cementation process. However, before cementing the materials one surface of the disc was sandblasted by a suitable sandblasting unit with alumina sand from a distance of 10 mm for 15 seconds each (Renfert, Hilzingen, Germany, 30 µm, 0.28MP). These steps were applied with different types of pressure according to the bonds manufacture. These steps were applied with different types of pressure according to the bonds manufacture (figures 15 and 16).

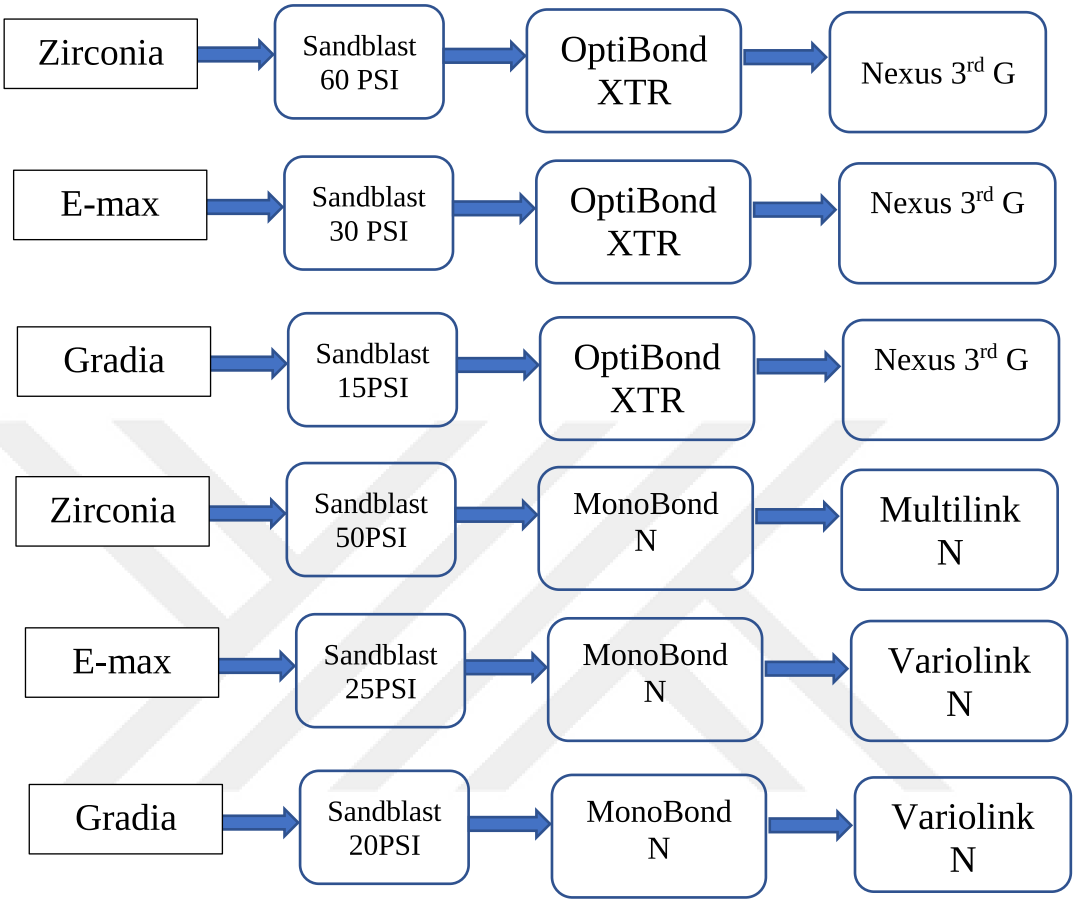


Figure 16: Different sandblast pressure applied according to the type of the material

A B

Figure 17: Sandblasting unit: A and B) Before and after sandblasting

The three materials were then cemented with Dual Cured Resin Cements: Variolink N Resin Cement System Base (shade “0” transparent), and catalyst “0” transparent shade (Ivoclar Vivadent AG Schaan, Liechtenstein). Multilink N transparent shade (Ivoclar Vivadent AG Schaan, Liechtenstein) and Nexus Third Generation NX 3 - Nexus3 ‘’clear’’ shade (SDS Kerr California, USA) (figure123).

Cementation was prepared using (Hernandes et al, 2016)"Mylar strip technique" (figure 17). The Mylar strip was placed over a glass slab and two adhesive tape strips (4M) were placed over the Mylar strip to act as spacer to ensure the standard thickness for all cements and prevent it from moving (figure 20).

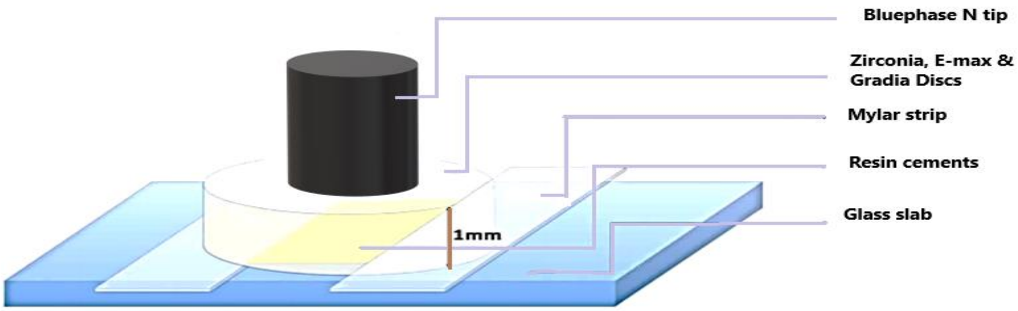
The Resin Cement Variolink N, Base (shade “0” transparent), and catalyst “0” transparent shade, respectively: (Ivoclar Vivadent, Schaan, Liechtenstein) was used for Gradia samples by first painting the samples with a special brush from the Variolink N kit with Monobond N and waited for one minute then mixed the (shade “0” transparent) base and catalyst together on a mixing paper pad with a spatula then applied on the disc by using a plastic instrument and placed on the glass slab. Additionally, the same procedure has been done for the E-max samples but first used hydrofluoric acid on each disc before applying the Monobond N (figures 18,19,21,22 and 24).

Multilink N transparent shade (Ivoclar Vivadent AG Schaan, Liechtenstein) was used only for Zirconia by applying Monobond N with a special brush from the Multilink N kit. A dual-cured cement (base/catalyst) and a single-syringe with small tube on each disc were then placed on the glass slab (figures 18,19,21 and 23).

Nexus Third Generation NX 3 - Nexus3 ‘’Clear’’ shade (Kerr California, USA) was used for all materials (E-max, Zirconia and Gradia) by using a special brush from the kit to apply the Optibond XTR then waited for one minute before auto-mix. After that a dual-cured cement (single-syringe base/catalyst) was applied to the disc then placed on the glass slab (figures 18,19,21 and 23).

All disk-shaped specimens were placed over the glass slab to create a Resin Cement layer with approximately 100πm thick underneath the ceramic disc (Hernandes et al, 2016). After that light cured device was applied for 1 minute for every sample of each material Ivoclar Vivadent. Ivoclar Vivadent Bluephase Style User Manual.Available: http://www.manualsdir.com/manuals/773892/ivoclar-vivadent-bluephase-style.html?page=88&original=1. 2013; Last accessed 14th Feb 2019.

to achieve optimum polymerization for each disc. The Bluephase N light cured device (figure 25) was used as it has a high-quality medical device with (polywave) broadband spectrum and it is suitable for the polymerization of all light curing dental materials in the wavelength range of 385-515nm (Ivoclar Vivadent; 2013). This has been designed according to the latest standard of science and technology in compliance with the relevant industry standards. After the cementation process (figure 26) the spectrophotometer Vita easy shade was used to check the colour of the samples.



Hernandes et al, 2016

Figure 18: Mylar Strip technique

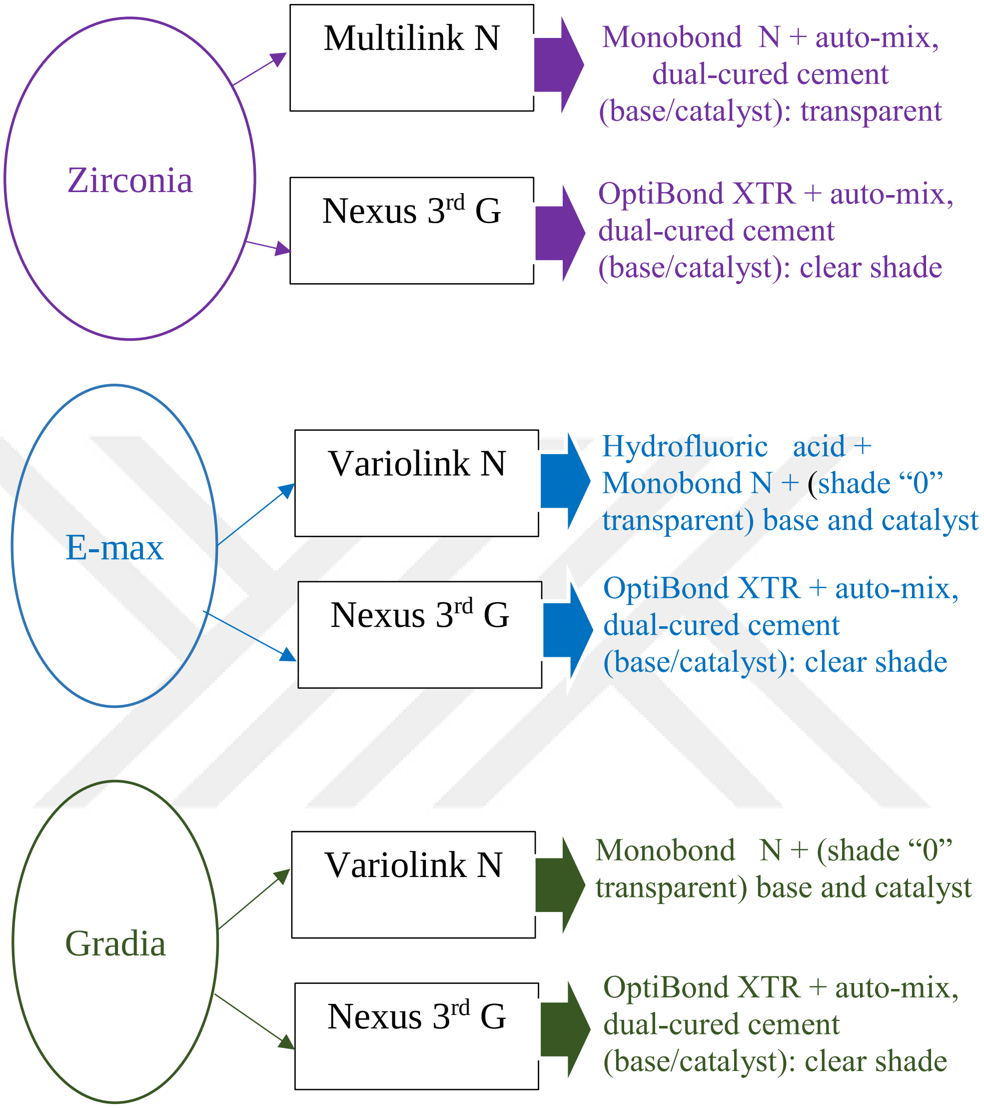


Figure 19: The procedures that has been used to cement each material with its cements

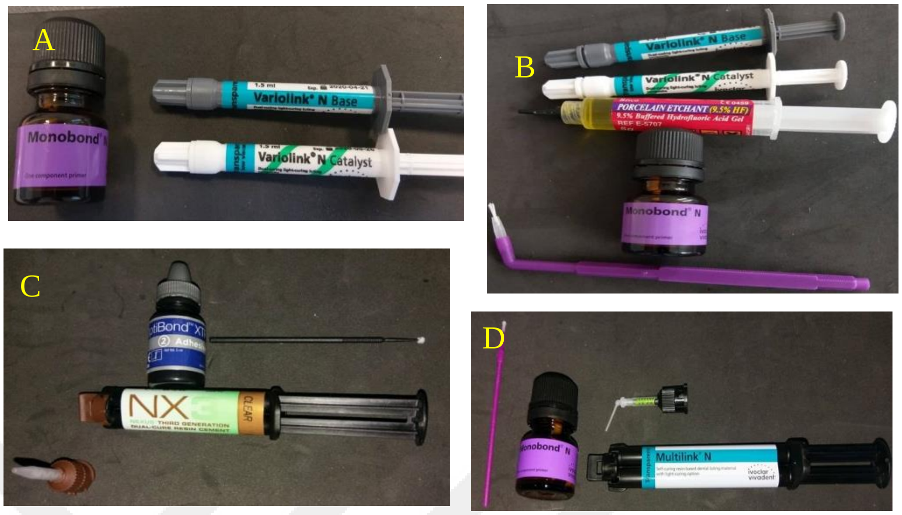


Figure 20: A, B, C and D Resin Cements (A and B) Variolink N shade “0” transparent kit, (C) Nexus Third Generation NX 3 - Nexus3‘’Clear’’ shade kit and (D) Multilink N transparent shade kit

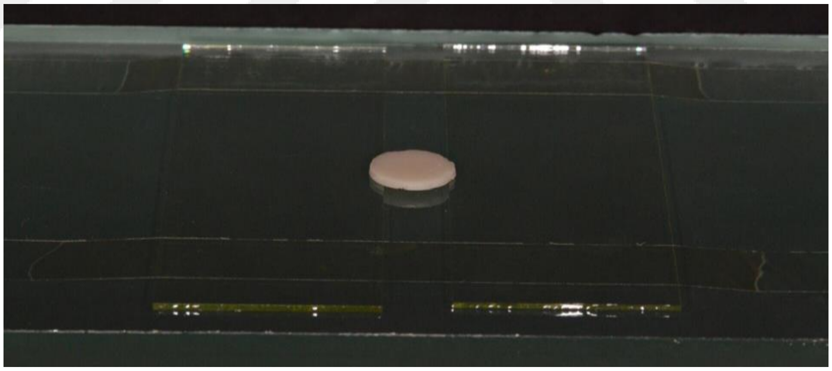


Figure 21: Glass slab with Mylar Strip and one of the samples

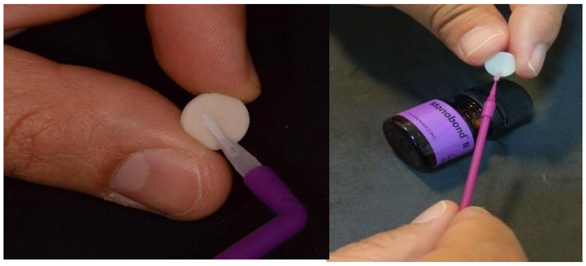


Figure 22: Monobond and Optibond XTR applying on the disc material

Figure 23: Hydrofluoric acid application used specially for E-max discs

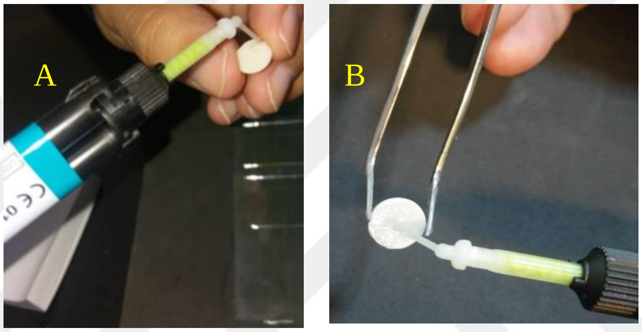


Figure 24: (A) Applying the resin cements on the disc material by using Multilink N cement and in picture (B) applying the resin cements on the disc material by using Nexus3 cement

Before mixing

After mixing

Figure 25: Mixing the Variolink N, Base (shade “0” transparent), and catalyst “0” transparent shade on paper pad with spatula

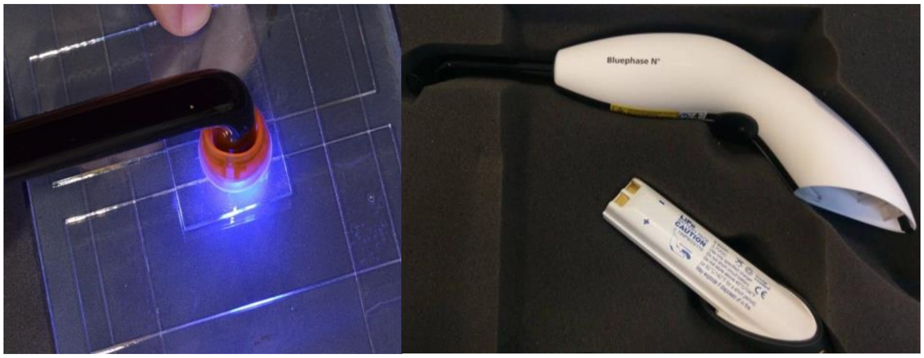


Figure 26: The Bluephase N light cured device

Figure 27: The final results of cementation different types of resin cements and material

3.3. Aging process

Thermocycling with temperature switching from (5°C to 55°C/dwell time: 20s SD Mechatronik machine, JULABO, model no: ED V.2, Germany) was performed; 10,000 cycles for 168 hours (7 days) (Kiomarsi, et al 2017; Lahiji, et al 2018). After thermocycling, the specimens were washed in water and dried in absorbent paper before the colour measurements were made. According to (Palmer et al, 1992) who reported minimum and maximum temperatures intraorally between 1.0°C and 58.5°C and suggested a range of 0°C to 67°C for the thermocycling tests of dental materials. (Gary et al, 2004) stated that, postoperative cracks are reported as a possible cause of fracture and a crack can start from a defect, growing very slowly under further load until fails.

Before we used the thermal cycle machine, we organized the samples by using highspeed handpiece with a (BR-31C) bur by engraving each disc corner site a number and a letter to distinguish between the groups (figure 28). Then we placed each group of each material in a small see through tulle bag (figure 29) in order to be in a suitable environment for the thermal cycle machine (figure 27). After thermocycling, the discs specimens were washed in tap water and dried by using absorbent paper before using the spectrophotometer Vita easy shade V device to check the colour.

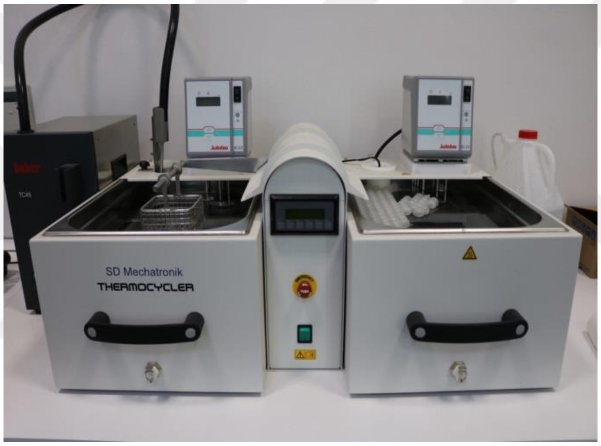


Figure 28: Thermal cycle machine

Figure 29: Engraving each disc corner with a letter and number

Figure 30: Placing the disc materials in small see through tulle bag to fit the environment of the thermal cycle machine

3.4. Staining in coffee and tea

Three groups of each material, each containing 5 specimens were immersed in 200 mL of, black tea and coffee at 37°C for 7 days as 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 (Al-Shalawi et al, 2017; Borges et al, 2011). In both tea and coffee groups, the selected disc specimens were dipped in either tea or a coffee solution. For the tea group the solution was prepared by placing five Lipton tea bags in boiling distilled water (boiled 10 times). The specimens were then left in the tea solution until the temperature reached 37°C and then they were placed in paper cups. This process was repeated every 24 hours in order to prevent any possible chemical changes. After 7 days the samples were then taken out from the solution and washed for 30 seconds with tap water and dried by using absorbent napkin. For the coffee group the discs specimens were dipped in Turkish coffee. The solution was prepared by adding 5 tablespoons of coffee in 200 mL of water and left until the solution temperature reached 37°C and then were placed in paper cups. This process was repeated every 24 hours in order to prevent any possible chemical changes. After 7 days the samples were then taken out from the solution and washed for 30 seconds with tap water and dried by using absorbent napkin. After the Staining process has been completed for all the discs, the spectrophotometer Vita easy shade was used in order to check the colour of the samples.

3.5. Colour measurement

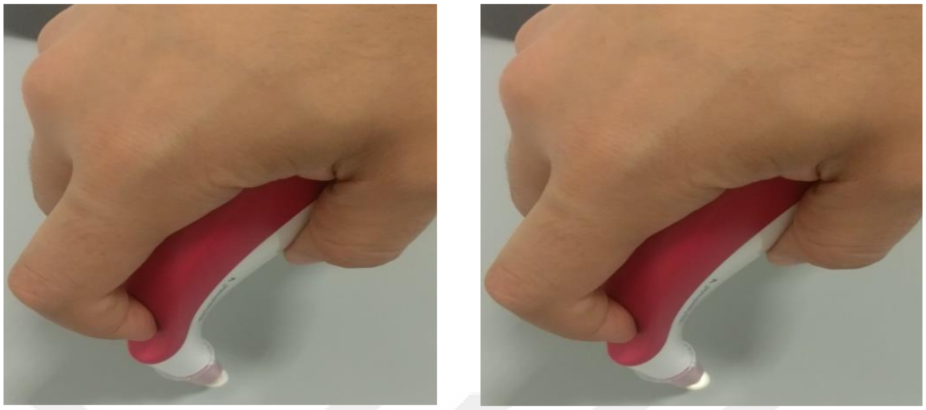
3.5.1. Colour stability measurements

The colour stability was checked in four stages before and after cementation and after thermal cycle machine for each material. Furthermore, the samples were checked again after being placed in coffee and Tea. Spectrophotometer device (Vita easy shade V) was used to check the first stage before samples cementation. There are several devices that work similar to the Vita easy shade device such as vita easy shade, Xrite Shade-X and the Crystaleye (Olympus America). All of these devices and systems are suitable for calibrating the shade, however, the vita easy shade V device is the easiest to use and more accurate in taking the colour shade with more advanced system than the other devices (McLaren and Chang, 2006). Colour measurements was made using an Easy shade (V) (figure 30) Vita probe spectrophotometer (Vita Easy Shade, Vita, Germany).

Figure 31: Vita easy shade V device (latest version)

The Vita easy shade V device has five different systems (purple, light pink, dark pink, light green and dark green) and according to the manufacture instructions the fifth system (dark green) was used to determine the shade of the crown analogue for base shade determination (figure 31). This will allow us to obtain the measurement results in VITA classical A1-D4 and VITA SYSTEM 3D-MASTER. The light indicates the precision of the measured shade in comparison to the standard shade of the respective shade system. A grey background was used as a neutral background according to (Li et al, 2009) under the discs that we measured using the vita easy shade V device by placing the measuring tip flush in the centre of the discs in 90-degree angle and pressed on the measurement button to calibrate the shade of the disc (figure 32) using the CIELAB scale and L*, a*, b*. After the measurement was taken, the measurement details appeared on the device screen to obtain more detailed information on the measured VITA classical A1–D4 or VITA SYSTEM 3D-MASTER shades. In order to get the measurement, we pressed on the device screen for more detailed information of disc shade for either one of the three materials (zirconia, e-max or Gradia). (figures 33,34 and 35) explains the process.

Figure 32: The vita easy shade V device has five different systems



Before

After

Figure 33: Shows the using vita easy shade V device over the grey background at 90-degrees to calibrate the shade of the disc before and after

Every disc of each material (E-max, Zirconia and Gradia) has been organised in a small plastic bag with labelled stickers to distinguish each material disc from the other. This has been conducted according to the group and type of cement (Variolink N, Multilink N and Nexus 3rd G) that we used. The Vita device screen displayed the shade of the disc such as Gradia sample (number 2 group C, before Variolink cement applied). The device in (figure 33) then showed the reading on the screen 1M2 and A1 with a yellow line underneath them. The device in (figure 34) also gives the readings for the Zirconia sample disc on its screen 1M2 and A1 with a yellow line underneath them as well as for E-max reading 0M3 and B1 with a yellow line underneath them (figure 35). The yellow line indicates that the shade is average; there are three types of lines (yellow, red and green). As mentioned earlier the yellow line is average which means that there is a recognisable but still an acceptable difference between the base shade of the restoration and the target shade it is compared to. However, it might be insufficient for the interior tooth restoration under certain circumstances. The green line means a good colour shade which mean there is a little or no difference between the base shade of the restoration and the target shade that is compared with. The red line means adjust which indicates there is a recognisable difference between the base shade of the restoration and the target

shade it was compared to, thus the restoration should be reworked in order to achieve an acceptable shade match. The coloured lines are not useful in our study because we are not comparing the tooth shade with shade of the restoration. The (1M2) is one shade of the Vita system 3d-master shades (M, L and R) the numbers before and after the M shade (1M2) means that a perfect match can be achieved for aesthetically suitable solution in each case. More information regarding this are found in the device manual (VITA Zahnfabrik dental company. Vita easy shade V Operating Instructions Manual.Available).
Https://www.manualslib.com/manual/1235503/Vita-Easyshade-V.html?fbclid=IwAR3IsBJzhW1IM92gduoaeTyZUAwLG3ZSol5wpwQi3rXBimTuM_LV2TWT4EQ#manual. 2011; Last accessed 14th Feb 2019). In relation to the (A1) result shows the shade of the material disc. For more details of A1 shade, we clicked on A1 touch screen to show the following information for Gradia disc (number 2, group C, before Variolink cement applied:

ΔE: 1.8, ΔL +/-: +0.6, ΔC: +/-: +1.4, Δh +/-: +3.5

Readings stand for the vita easy shade V device:

ΔE: The overall shade deviation of the tooth

ΔL +/-: The lightness of the tooth is higher (+) /lower (-) than the VITA classical A1–D4 shade. ΔC: +/-: Chroma: The tooth is higher (+) /lower (-) than the VITA classical A1–D4 shade. Δh +/-: The hue of the tooth is yellower (+) / redder (-) than the VITA classical A1–D4 shade

The total colour difference (ΔE*) was calculated using the following equation:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Values of ΔE < 1: regarded as invisible to the naked eye.

Values 1 < ΔE < 3.3 considered perceptible by skilled operators but considered clinically acceptable.

Values ΔE > 3.3: considered perceptible by non-skilled persons as well and for that reason are clinically unacceptable.

All colour measurements were performed three times for each specimen and the average of the three readings were calculated. All the colour measurement procedures were done by the same steps. All shades readings can be shown in (Tables 3,4 and 5) for all discs.

Figure 34: Spectrophotometer measurement screen shows the results of the Gradia sample

Figure 35: Spectrophotometer measurement screen shows the results of the Zirconia sample

Figure 36: Spectrophotometer measurement screen shows the results of the E-max sample

Table 3: Shades of coffee and tea groups (A and C)

	E-MAX (N= 30)						ZIRCONIA (N= 30)						GRADIA (N= 30)					
	Control (A)group (n=10)		**Variolink (C)group (n=10)**		**Nexus (C)group (n=10)**		**Control (A)group (n=10)**		**Multilink (C)group (n=10)**		**Nexus (C)group (n=10)**		**Control (A)group (n=10)**		**Variolink (C)group (n=10)**		**Nexus (C)group (n=10)**	
S	**cof**	**Tea**	**cof**	**Tea**	**cof**	**Tea**	**cof**	**Tea**	**cof**	**Tea**	**cof**	**Tea**	**cof**	**Tea**	**cof**	**Tea**	**cof**	**Tea**
S1	A3.5	C3	C1	C3	A1	A3.5	A1	D4	A1	B2	A1	B2	B2	A2	A2	D4	A3	C2
S2	B1	C4	C1	C3	D2	C3	A1	D3	B1	D2	C1	A1	D4	A3	B2	C3	D4	D2
S3	C1	C4	A1	C4	A3	A4	B2	C1	B2	B2	B1	D2	B2	B4	C1	D3	D3	C2
S4	A1	C4	A1	D3	A1	C3	A1	C1	C1	D2	D2	C1	B2	A3	B2	D3	B2	C2
S5	B1	C3	D2	C3	A1	C4	B1	C1	A1	D3	A1	A1	B2	A2	D4	D3	D3	C1

S = Sample
Cof = Coffee
Tea = Tea

Table 4: Shades of control group (A)

	E-max Control Group (n=10)		Zirconia Control Group (n=10)		Gradia Control Group (n=10)	
S	**C**	**CAT**	**C**	**CAT**	**C**	**CAT**
S1	B1	B1	A1	B1	A1	A1
S2	B1	B1	A1	B1	A1	A1
S3	B1	B1	A1	B1	A1	A1
S4	B1	B1	A1	B1	A1	A1
S5	B1	B1	A1	B1	A1	A1
S6	B1	B1	A1	B1	A1	A1
S7	B1	B1	A1	B1	A1	A1
S8	B1	B1	A1	B1	A1	A1
S9	B1	B1	A1	B1	A1	A1
S10	B1	B1	A1	B1	A1	A1

S: Sample
C: Control Group
CAT: control group after thermal cycle

Table 5: Shades of group (C)

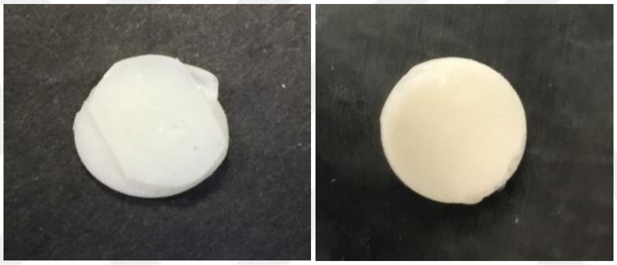
	E-max (n= 20)						Zirconia (n= 20)						Gradia (n= 20)					
	Variolink (n=10)			**Nexus (n=10)**			**Multilink (n=10)**			**Nexus (n=10)**			**Variolink (n=10)**			**Nexus (n=10)**		
S	**BC**	**AC**	**AT**	**BC**	**AC**	**AT**	**BC**	**AC**	**AT**	**BC**	**AC**	**AT**	**BC**	**AC**	**AT**	**BC**	**AC**	**AT**
S1	B1	D2	B1	B1	B1	B1	A1	C1	B1	A1	B1	B1	A1	A1	A1	A1	C1	B1
S2	B1	D2	B1	B1	B1	B1	A1	C1	B1	A1	B1	B1	A1	A1	B1	A1	C1	B1
S3	B1	D2	B1	B1	B1	B1	A1	B1	B1	A1	C1	B1	A1	A1	B1	A1	C1	A1
S4	B1	D2	B1	B1	B1	B1	A1	C1	B1	A1	B1	B1	A1	A1	B1	A1	B1	B1
S5	B1	D2	B1	B1	D2	B1	A1	C1	A1	A1	B1	B1	A1	A1	A1	A1	B1	A1
S6	B1	D2	B1	B1	B1	B1	A1	B1	B1	A1	B1	B1	A1	A1	B1	A1	C1	A1
S7	B1	D2	B1	B1	B1	B1	A1	C1	A1	A1	B1	B1	A1	A1	A1	A1	B1	B1
S8	B1	C2	B1	B1	B1	B1	A1	C1	A1	A1	B1	B1	A1	A1	A1	A1	B1	A1
S9	B1	C2	B1	B1	B1	B1	A1	C1	A1	A1	C1	B1	A1	A1	B1	A1	A1	A1
S10	B1	D2	B1	B1	B1	B1	A1	B1	B1	A1	B1	B1	A1	A1	B1	A1	A1	A1

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

3.6. Fracture resistance testing

3.6.1. Biaxial flexure test

Before starting the fracture test, cements were added to the samples to fill the spaces on the empty edges that were already cemented before with same types of cement (figures 19 and 36) because the mechanism of the fracture machine is affected by any mobility of the sample during the fracture test. Thus, the additional cement will let the samples more stable on the manufactured base that is attached to lower part of the machine while fracture test is working.



Before After

Figure 37: Before and after addition of the cements

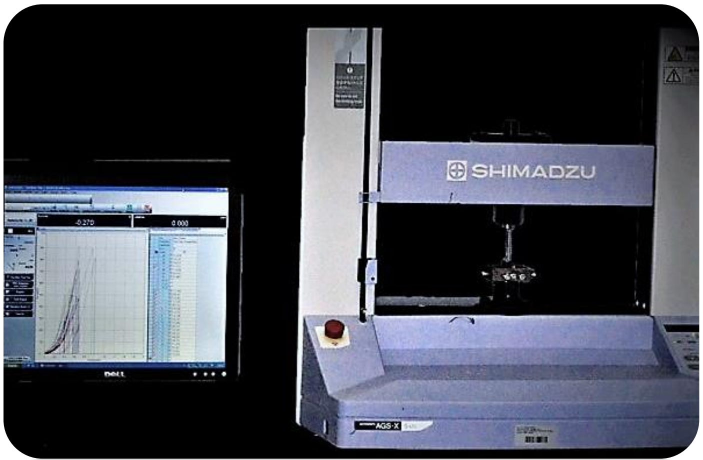


Figure 38: Universal machine (SHIMADZU machine)

All samples were individually mounted on a computer controlled universal testing machine (figure 37) (SHIMADZU, model no:133064800195, Kyoto, Japan) with a loadcell of 5kN and data was recorded using computer software (Trapezius X SHIMADZU Software). The test was done by compressive mode of load using a metallic rod with a flat end tip (1.4mm radius) as recommended in ISO 6872. This metallic rod is attached to the upper movable compartment of testing machine traveling at cross- head speed of 1mm/min. The lower immobile base was fixed with screws (figure 38). The piston on three balls test was used to determine the biaxial flexure strength of the 180 discs (10mm diameter 1mm thick) of the three materials. The disc specimens were supported on three steel balls (2.38mm diameter) positioned 120 distances between each other on a circle (7.44-mm radius). The force was applied to the middle of the specimen. The recorded fracture load in (N) was then inserted into the following equation to give the flexural strength value in (MPa):

$$S = -0.2387\, P(X - Y)/d^2$$

S is the flexure strength in (MPa), P is the total load-causing fracture in (N), and d is the specimen thickness at the fracture origin. X and Y were determined as follows

$$X = (1 + v)\ \ln (r_2 \,/\, r_3)^{\,2} + [(1 - v)/2](r_2/r_3)^{\,2}$$

$$Y = (1 + v)[1 + \ln(r_1/r_3)^{\,2}] + (1 - v)(r_1/r_3)^{\,2}$$

The equation translated in (figure 38) as r_1 is the radius of the support Circle in (mm), r_2 is the radius of the loaded area or the tip of the piston in (mm), and r_3 is the radius of the specimen in (mm) and (v) is Poisson’s ratio and it is noticed to be changed from material to another. According to the material market instructions the Poisson’s ratio for Zirconia is (0.342), (0.23) for lithium disilicate (AlBakry et al, 2003) and (0.31) for Gradia (Chung et al, 2004).

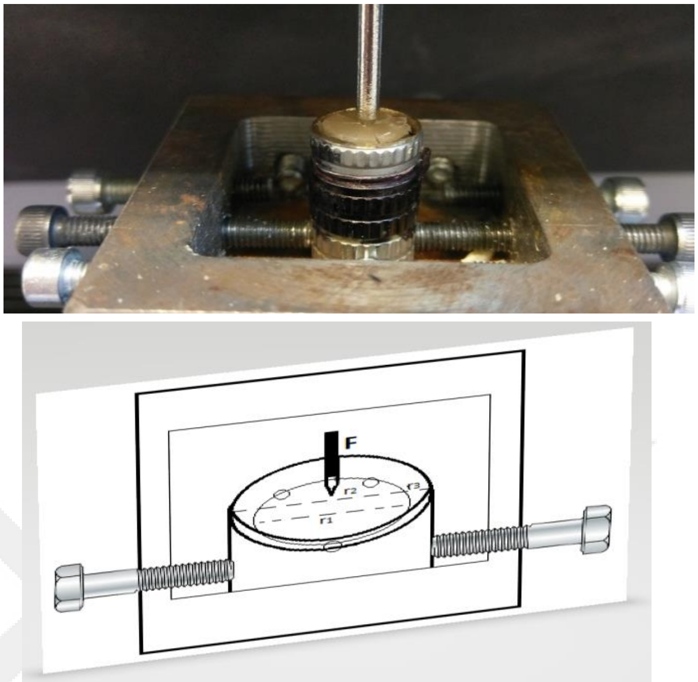


Figure 39: Fracture resistance test

3.7. Statistical analysis

In general, descriptive statistics and inferential statistic techniques were used for data analysis. The first step was to enter the data in the questionnaires into SPSS. The data was described using descriptive statistical methods such as frequencies, mean, standard deviation and cross-tabulation. The main purpose of descriptive analysis was to understand the variables in the data and then identify the dependent and independent variables. However, two inferential statistical methods were used: t-test and analysis of variance and One-way ANOVA (post hoc) followed by Tukey. The main aim of employing these two methods was to examine the differences between different types of materials and cements. T-test was used to explore the differences between two groups while analysis of variance was used to examine the differences between three groups and more. Significant difference ($P<0.05$).

4. Findings

4.1. Colour measurement

The aim of this study was to examine the colour stability and fracture resistance of E-max, Gradia and Zirconia by using dual cure resin cements. This section presents the descriptive statistics results for colour measurements, colour measurement for staining from coffee and tea and colour measurement before and after thermal cycle.

Table 6 shows the results for the colour measurements for group (C) of all the disc materials before and after cementation and after thermal cycle. The mean value for Zirconia Multilink is 1.9 for before cementation, 2.1 for after cementation and 1.2 for after thermal cycle (AT). The mean value for Zirconia Nexus is 2.2 for before cementation, 2.9 for after cementation and 2.0 for after thermal cycle. Moreover, the mean value for E-max Variolink is 2.9 for before cementation, 2.3 for after cementation and 2.9 for after thermal cycle. The mean value for E-max Nexus is 2.7 for before cementation, 4.6 for after cementation and 3.6 for after thermal cycle. Furthermore, the mean value for Gradia Variolink is 1.9 for before cementation, 2.3 for after cementation and 1.5 for after thermal cycle. The mean value for Gradia Nexus is 2.1 for before cementation, 1.8 for after the cementation and 1.8 for after thermal cycle.

Table 6: Colour measurements for group (C) of all the disc materials before and after cementation and After thermal cycle

	Zirconia (n=60)						**E-max (n=60)**						**Gradia (n=60)**					
	Multilink N (30) Group (C)			Nexus 3^{rd} (30) Group (C)			Variolink N (30) Group (C)			Nexus 3^{rd} (30) Group (C)			Variolink N (30) Group (C)			Nexus 3^{rd} (30) Group (C)		
	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

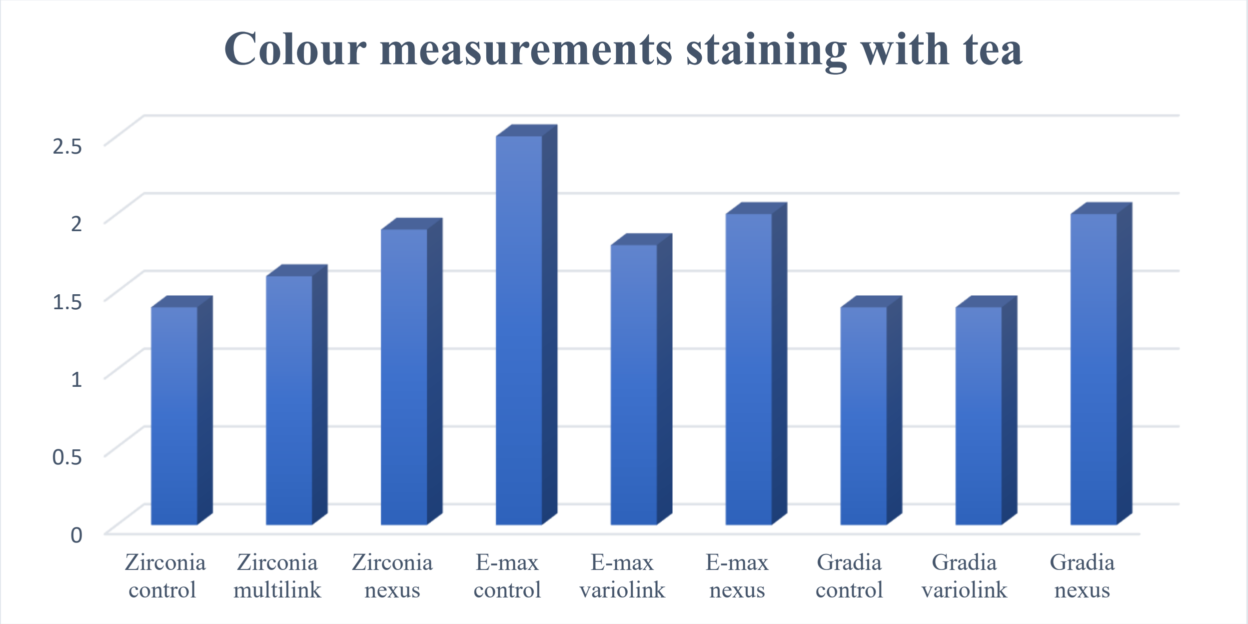
S: Sample
BC: Before Cementation
AC: After Cementation
AT: After Thermal cycle

Table 7 presents the results of the colour measurements for staining (Coffee and Tea), group (A) and (C) for all the materials. For Zirconia Multilink the mean values for (coffee and tea) are 2.1 and 1.6 respectively. Whilst, for Zirconia Nexus the mean values for (coffee and tea) are 1.8 and 1.9 respectively. In relation to E-max Variolink the mean values for (coffee and tea are 1.6 and 1.8 respectively. Moreover, in relation to E-max Nexus the mean values for (coffee and tea are 1.9 and 2.0 respectively. In addition, for Gradia Variolink the mean values for (coffee and tea) are 2.0 and 1.4 respectively. For Gradia Nexus the mean values for (coffee and tea) are 1.5 and 2.0 respectively. See Table 7 for control groups mean values. Graph 1 illustrates the colour measurement staining with tea for all materials and graph 2 illustrates the colour measurement staining with coffee for all materials.

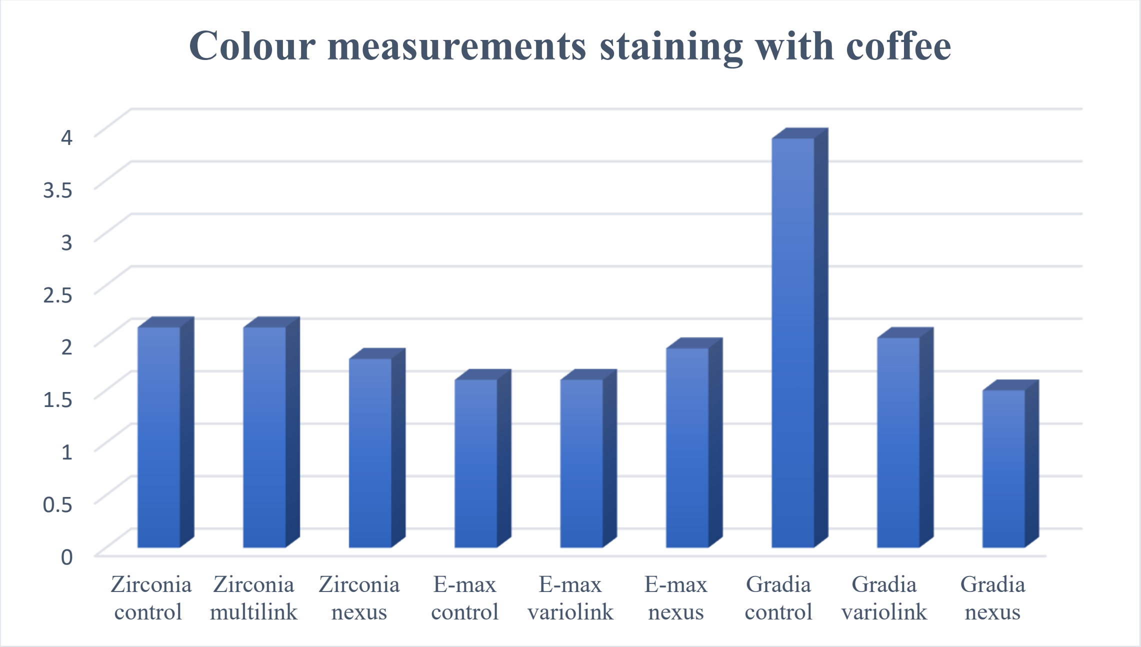
Table 7: Colour measurements for staining (Coffee and Tea), group (A) and (C) for all the materials

	Zirconia (n=30)						E-max (n=30)						Gradia (n=30)					
	Control (10) Group (A)		Multilink N (10) Group (C)		Nexus (10) Group (C)		Control (10) Group (A)		Variolink (10) Group (C)		Nexus (10) Group (C)		Control (10) Group (A)		Variolink (10) Group (C)		Nexus (10) Group (C)	
	AT cof (5)	AT TE (5)	AT cof (5)	AT TE (5)	AT cof (5)	AT TE (5)	AT cof (5)	AT TE (5)	AT cof (5)	AT TE (5)	AT cof (5)	AT TE (5)	AT cof (5)	AT TE (5)	AT cof (5)	AT TE (5)	AT cof (5)	AT TE (5)
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

AT cof: After thermal cycle then emerged in a coffee.
AT TE: After thermal cycle then emerged in a tea.



Graph 1: Colour measurements for staining with tea groups (A) and (C) for all the materials.



Graph 2: Colour measurements for staining with coffee groups (A) and (C) for all the materials.

Table 8 shows results of the colour measurements for control Group (A) before and after thermal cycles for all the materials. The mean values for Zirconia, E-max and Gradia control are 1.7, 2.3 and 2.3 respectively. Whilst the mean values for Zirconia, E-max and Gradia control after thermal cycle are 0.9, 3.1 and 0.9 respectively.

Table 8: Colour measurements for control Group (A) before and after thermal cycles for all the materials

	Zirconia (n=10)		**E-max (n=10)**		**Gradia (n=10)**	
	Control (A)Group (n=10)		Control (A)Group (n=10)		Control (A)Group (n=10)	
	C (10)	CAT (10)	C (10)	CAT (10)	C (10)	CAT (10)
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
C: Control Group
CAT: Control group after thermal cycle

The result shown in Table 9 present the colour measurements for Control Group (A) and Group (C) (Multilink N +Variolink N + Nexus 3rd) before and after thermal cycle. The mean values for the Zirconia Multilink before and after thermal cycle are 2.0 and 1.2 respectively. The mean values for the E-max Variolink before and after thermal cycle are 2.9 and 2.7 respectively. The mean values for the Gradia Variolink before and after thermal cycle are 1.9 and 1.5 respectively. In addition to Nexus cement, mean values for the Zirconia Nexus before and after thermal cycle are 2.0 and 2.0 respectively. The mean values for the E-max Nexus before and after thermal cycle are 2.7 and 3.6 respectively. Finally, the mean values for the Gradia Nexus before and after thermal cycle are 2.1 and 1.8 respectively. See Table 9 for control group (group A) mean values.

Table 9: Results of the Colour measurements for {Control Group (A)} and {Group (C) (Multilink N +Variolink N + Nexus 3rd)} before and after thermal cycle

	Zirconia (n=10)						E-max (n=10)						Gradia (n=10)					
	Control (A)Group (n=10)		(C) Group Multilink (n=10)		(C)Group Nexus3rd (n=10)		Control (A)Group (n=10)		(C) group Variolink (n=10		(C)Group Nexus3rd (n=10)		Control (A)Group (n=10)		(C)group Variolink (n=10		(C)Group Nexus3rd (n=10)	
	C	CAT	BC	AT	BC	AT	C	CAT	BC	AT	BC	AT	C	CAT	BC	AT	BC	AT
S1	1.6	0.6	2.1	0.8	1.9	2.4	2.1	3.4	2.7	3.5	3.0	4.2	2.6	0.9	2.1	2.3	2.4	1.5
S2	1.6	0.5	1.9	2.1	2.2	0.8	2.4	3.8	2.6	2.7	2.9	3.7	2.4	0.2	1.8	0.8	2.0	0.9
S3	1.6	0.9	1.8	1.4	2.1	0.3	1.5	3.0	3.3	3.5	2.7	4.1	2.6	0.6	2.0	0.9	1.6	2.7
S4	2.0	1.5	1.9	0.9	1.9	1.4	2.6	2.8	2.9	2.3	2.9	2.3	2.0	0.7	1.8	1.0	2.3	1.0
S5	1.7	1.4	1.9	1.3	2.3	2.9	2.0	2.9	2.9	2.8	2.2	3.9	2.1	0.5	1.5	2.3	2.3	2.6
S6	1.7	1.3	2.2	0.5	2.0	2.9	2.2	2.7	2.4	2.4	3.0	2.8	2.4	1.3	2.1	1.3	1.8	2.1
S7	1.9	0.3	1.6	1.9	1.8	2.0	2.6	3.4	2.6	3.6	3.8	2.8	2.2	0.8	2.1	2.2	2.1	1.0
S8	1.7	1.0	2.2	1.7	1.9	2.8	2.3	2.6	2.9	2.3	2.8	3.7	2.3	1.3	1.8	2.3	1.9	2.9
S9	1.8	0.5	2.1	0.9	1.8	1.7	2.9	2.7	3.3	3.3	2.2	3.4	2.4	0.4	2.2	0.8	2.2	1.6
S10	1.8	1.1	1.9	0.2	2.3	2.9	2.8	3.4	3.0	2.8	1.6	4.7	2.3	1.9	2.0	0.7	2.3	2.1
Mean	1.7	0.9	2.0	1.2	2.0	2.0	2.3	3.1	2.9	2.9	2.7	3.6	2.3	0.9	1.9	1.5	2.1	1.8

S: Sample
C: Control Group
CAT: control group after thermal cycle
BC: Before Cementation
AT: After Thermal cycle

Moreover, the results shown in table 10 present the results of the colour measurements differences between dual cure resin cements (after Cementation and after Thermal Cycle). The mean values for Zirconia Multilink after cementation and thermal cycle are 2.1 and 1.2 respectively. Additionally, the mean values for E-max Variolink after cementation and thermal cycle are 2.3 and 2.9 respectively and for Gradia Variolink after cementation and thermal cycle are 2.3 and 1.3 respectively. In addition, the mean values for Zirconia nexus after cementation and thermal cycle are 2.9 and 2.0 respectively. Besides, the mean values for E-max nexus after cementation and thermal cycle are 4.6 and 3.6 respectively. Finally, the mean values for Gradia nexus after cementation and thermal cycle are 1.8 and 1.8 respectively.

Table 10: Colour measurements Differences between dual cure resin cements (After Cementation and after Thermal Cycle)

	MULTILINK N CEMENT		VARIOLINK N CEMENT				NEXUS 3RD GENERTATION CEMENT					
	Zirconia		**E-max**		**Gradia**		**Zirconia**		**E-max**		**Gradia**	
	AC	**AT**	**AC**	**AT**	**AC**	**AT**	**AC**	**AT**	**AC**	**AT**	**AC**	**AT**
S1	2.0	0.8	3.6	3.5	2.1	2.3	2.9	2.4	3.9	4.2	1.5	1.5
S2	2.1	2.1	1.8	2.7	2.6	0.8	3.0	0.8	4.0	3.7	1.6	0.9
S3	2.3	1.4	3.1	3.5	2.0	0.9	2.9	0.3	4.4	4.1	1.5	2.7
S4	2.6	0.9	2.2	2.3	2.5	1.0	2.1	1.4	4.5	2.3	1.1	1.0
S5	2.0	1.3	2.4	2.8	2.2	2.3	2.7	2.9	4.8	3.9	1.6	2.6
S6	2.5	0.5	3.9	2.4	2.5	1.3	3.6	2.9	6.0	2.8	1.0	2.1
S7	1.6	1.9	2.2	3.6	2.1	2.2	2.8	2.0	4.0	2.8	1.6	1.0
S8	1.4	1.7	1.3	2.3	2.5	2.3	3.0	2.8	4.8	3.7	1.6	2.9
S9	2.0	0.9	0.9	3.3	2.0	0.8	2.8	1.7	4.4	3.4	3.1	1.6
S10	2.3	0.2	1.8	2.8	2.2	0.7	2.7	2.9	4.9	4.7	3.2	2.1
Mean	2.1	1.2	2.3	2.9	2.3	1.3	2.9	2.0	4.6	3.6	1.8	1.8

S: Sample
AC: After Cementation
AT: After thermal cycle

4.1.1. The difference between E-max, Gradia and Zirconia before and after cementation and after thermal cycle (group C)

One-way ANOVA (Tukey test) was used to determine the difference between E-max, Gradia and Zirconia before and after cementation and after thermal cycle (group C). In regard to before cementation the results presented Table 11 show a statistical significant difference between Zirconia and E-max (P=0.000) mean difference (-0.81500) and a difference between E-max and Gradia (P=0.000) mean difference (0.77000). However, no statistical significant difference between Zirconia and Gradia (P=0.879) mean difference (0.44500). Moreover, in relation to after cementation the results show a statistical significant difference between Zirconia and E-max (P=0.004) mean difference (-0.97500) and a difference between E-max and Gradia (P=0.000) mean difference (1.42000). However, no statistical significant difference between Zirconia and Gradia (P=0.288) mean difference (0.44500). Similarly, in relation to after thermal cycle the results revealed a statistical significant difference between Zirconia and E-max (P=0.000) mean difference (-1.65000) and a difference between E-max and Gradia (P=0.000) mean difference (1.59000). But, no statistical significant difference between Zirconia and Gradia (P=0.968) mean difference (-0.65000).

One-way ANOVA (post hoc test) was also used to assess the difference between E-max, Gradia and Zirconia before and after cementation and after thermal cycle according to cement used (group C). The study results presented in Table 12 show no statistical significant difference between Zirconia Multilink before and after cementation (P=0.410), however, there is a significant difference before cementation and after thermal cycle (P=0.001). Additionally, there was a significance difference between after cementation and after thermal cycle (P=0.000). In relation to Zirconia Nexus the study results show a statistical significant difference between before and after cementation (P=0.004), however, there is no significant difference before cementation and after thermal cycle (P=0.970). Additionally, there was a significance difference between after cementation and after thermal cycle (P=0.004). Moreover, in relation to E-max

Variolink the study results show no statistical significant difference between before and after cementation (P=0.076) and no significant difference before cementation and after thermal cycle (P=0.839). However, there was a significance difference between after cementation and after thermal cycle (P=0.050). Besides, in regard to E-max Nexus the study results show a statistical significant difference between before and after cementation (P=0.007), a significant difference before cementation and after thermal cycle (P=0.000) and a significance difference between after cementation and after thermal cycle (P=0.002). Furthermore, in regards Gradia Nexus the study results show no statistical significant difference between before and after cementation (P=0.115), however, there is a significant difference before cementation and after thermal cycle (P=0.000) as well as a significance difference between after cementation and after thermal cycle (P=0.025).

Table 11: Difference between the materials before and after cementation and after thermal cycle group (C)

			Difference of mean	P value	95% Confidence Interval	
					Lower limit	**Upper limit**
Before cementation	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
After cementation	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
After thermal cycle	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

Table 12: The difference between E-max, Gradia and Zirconia before and after cementation and after thermal cycle according to cement used

Material			Difference of mean	P value	95% Confidence Interval	
					Lowe limit	**Upper limit**
Zirconia Multilink	Before cementation	After cementation	-0.160	0.410	-0.552	0.232
		After thermal cycle	0.750	0.001	0.358	1.142
	After cementation	Before cementation	0.160	0.410	-0.232	0.552
		After thermal cycle	0.910	0.000	0.518	1.302
	After thermal cycle	Before cementation	-0.750	0.001	-1.142	-0.358
		After cementation	0.910	0.000	-1.302	-0.518
Zirconia Nexus	Before cementation	After cementation	-0.830	0.004	-1.376	-0.283
		After thermal cycle	0.100	0.970	-0.536	0.556
	After cementation	Before cementation	0.830	0.004	0.283	1.376
		After thermal cycle	0.840	0.004	0.293	1.386
	After thermal cycle	Before cementation	-0.010	0.970	-0.556	0.536
		After cementation	-0.840	0.004	-1.386	-0.293
E-max Variolink	Before cementation	After cementation	0.540	0.076	-0.060	1.140
		After thermal cycle	-0.060	0.839	-0.660	0.540
	After cementation	Before cementation	-0.540	0.076	-1.140	0.060
		After thermal cycle	-0.600	0.050	-1.200	0.000
	After thermal cycle	Before cementation	0.060	0.839	-0.540	0.660
		After cementation	0.600	0.050	-0.000	1.200
E-max Nexus	Before cementation	After cementation	-1.860	0.000	-2.460	-1.260
		After thermal cycle	-0.850	0.007	-1.440	-0.250
	After cementation	Before cementation	1.860	0.000	1.260	2.460
		After thermal cycle	1.010	0.002	0.410	1.610
	After thermal cycle	Before cementation	0.850	0.007	0.250	1.450
		After cementation	-1.010	0.002	-1.610	-0.410
Gradia Variolink	Before cementation	After cementation	-0.330	0.115	-0.746	0.086
		After thermal cycle	0.480	0.025	0.064	0.896
	After cementation	Before cementation	0.330	0.115	-0.086	0.746
		After thermal cycle	0.8100	0.000	0394	1.226
	After thermal cycle	Before cementation	-0.480	0.025	-0.896	-0.064
		After cementation	-0.810	0.000	-1.226	-0.394
Gradia Nexus	Before cementation	After cementation	0.3100	0.282	-0.270	0.890
		After thermal cycle	0.250	0.384	-0.330	0.830
	After cementation	Before cementation	-0.310	0.282	-.890	0.270
		After thermal cycle	-0.060	0.833	-0.640	0.520
	After thermal cycle	Before cementation	-0.250	0.384	-0.830	0.330
		After cementation	0.060	0.833	-0.520	0.640

Paired sample T-test was used to determine the difference between materials; before and after cementation and after thermal cycle (Table 13). According to the study results there is no significance difference between Zirconia Multilink and Zirconia Nexus before, after cementation and after thermal cycle (P=0.584, 0.666, 0.165) respectively. Likewise, the study results show no significance difference between E-max Variolink and E-max Nexus before, after cementation and after thermal cycle (P=0.154, 0.186, 0.334) respectively. Additionally, there is no significance difference between Zirconia Multilink and Gradia Variolink before, after cementation and after thermal cycle (P=0.511, 0.338, 0.241) respectively. Also, there is no significance difference between Zirconia Nexus and Gradia Nexus before, after cementation and after thermal cycle (P=0.351, 0.089, 0.488) respectively. Similarly, there is no significance difference between E-max Nexus and Gradia Nexus before, after cementation and after thermal cycle (P=0.113, 0.608, 0.755) respectively. In relation to the difference between Gradia Variolink and Gradia Nexus the results indicate no difference between before and after thermal cycle (P=0.472, 0.928) respectively. But, there was a significance difference after cementation (P=0.040). Similarly, in relation to the difference between Zirconia Multilink E-max Variolink and the results indicate no difference between before and after thermal cycle (P=0.171, 0.582) respectively. However, a significance difference after cementation (P=0.026). In regard to the difference between Zirconia Multilink and Gradia Variolink, the study results indicate a difference between before cementation (P=0.05). Though, no difference between after cementation and after thermal cycle (P=0.165, 0.371) respectively. Finally, in relation to the difference between E-max Variolink and Gradia Variolink the results show a significance difference between after cementation and after thermal cycle (P=0.008, 0.045) respectively. However, there is no difference between before cementation (P=0.395).

Table 13: The difference between cements before and after cementation and after thermal cycle

Material		T	P value	95% Confidence Interval	
				Lower	**Upper**
Zirconia Multilink vs Zirconia Nexus	BC	-1.233	0.584	-0.270	0.704
	AC	-4.638	0.666	-1.119	-0.421
	AT	-2.357	0.165	-1.589	-0.091
E-max Variolink vs E-max Nexus	BC	0.714	0.154	-0.291	0.591
	AC	-6.215	0.186	-3.011	-1.490
	AT	-2.244	0.334	-1.240	-0.408
Gradia Variolink vs Gradia Nexus	BC	-1.414	0.472	-0.372	0.729
	AC	1.965	0.040	0.339	1.013
	AT	-1.157	0.928	-1.070	0.310
Zirconia Multilink vs E-max Variolink	BC	-8.744	0.171	-1.166	-0.714
	AC	-0.734	0.026	-0.927	0.447
	AT	-6.884	0.582	-2.284	1.216
Zirconia Nexus vs E-max Nexus	BC	-3.487	0.050	-1.106	-0.274
	AC	-10.376	0.165	-3.740	-2.480
	AT	-4.089	0.371	-2.346	-0.7536
Zirconia Multilink vs Gradia Variolink	BC	-0.234	0.511	-0.120	0.160
	AC	-1.368	0.338	-0.481	0.102
	AT	-0.968	0.241	-0.920	0.340
Zirconia Nexus vs Gradia Nexus	BC	-0.683	0.351	-0.285	-0.145
	AC	4.031	0.089	-0.285	0.145
	AT	0.446	0.488	0.512	1.628
E-max Variolink vs Gradia Variolink	BC	8.008	0.395	0.679	1.161
	AC	0.159	0.008	-0.609	0.709
	AT	5.213	0.045	-0.872	2.048
E-max Nexus vs Gradia Nexus	BC	3.018	0.113	0.188	1.051
	AC	9.059	0.608	2.142	3.437
	AT	5.168	0.755	1.021	2.419

4.1.2. The difference between E-max, Gradia and Zirconia before and after thermal cycle (Group A)

One-way ANOVA (Tukey test) was used to determine the best material among E-max, Gradia and Zirconia before and after thermal cycle (group A). In regard to control group before thermal cycle the study results shown in Table 14 reveal a statistical significant difference between Zirconia and E-max (P=0.000) mean difference (-0.6000) and a difference between Zirconia and Gradia (P=0.000) mean difference (0.5900). However, no statistical significant difference between E-max and Gradia (P=0.996) mean difference (0.0100). Moreover, in regard to control after thermal cycle the study results revealed a statistical significant difference between Zirconia and E-max (P=0.000) mean difference (-2.1600) and a difference between E-max and Gradia (P=0.000) mean difference (2.2100). However, no statistical significant difference between Zirconia and Gradia (P=0.996) mean difference (0.5000). Paired sample T-test was also used to determine the difference between E-max, Gradia and Zirconia before and after thermal cycle (Group A). The study results shown in Table 15 reveal a statistical significance difference between all the materials (Zirconia, E-max and Gradia) before and after thermal cycle with (P values of 0.000, 0.003 and 0.000) respectively.

Table 14: The difference before and after the thermal cycle (Group A) for each material

Material	T	P value	95% Confidence Interval	
			Lower	**Upper**
Zirconia control before and after thermal cycle	6.343	0.000	0.5340	1.126
E-max control before and after thermal cycle	-4.138	0.003	-1.129	-0.331
Gradia control before and after thermal cycle	8.485	0.000	1.078	1.862

Table 15: Difference between materials of control and control after thermal cycle (Group A)

			Difference of mean	P value	95% Confidence Interval	
					Lower limit	**Upper limit**
Control	Zirconia	E-max	-0.6000	.000	-0.9069	-0.2931
		Gradia	-0.5900	.000	-0.8969	-0.2831
	E-max	Zirconia	0.6000	.000	0.2931	0.9069
		Gradia	0.0100	.996	-0.2969	0.3169
	Gradia	Zirconia	0.5900	.000	0.2831	0.8969
		E-max	-0.0100	.996	-0.3169	0.2969
Control after thermal cycle	Zirconia	E-max	-2.1600	.000	-2.6556	-1.6644
		Gradia	0.5000	.966	-0.4456	0.5456
	E-max	Zirconia	2.1600	.000	1.6644	2.6556
		Gradia	2.2100	.000	1.7144	2.7056
	Gradia	Zirconia	-0.5000	.966	-0.5456	0.4456
		E-max	-2.2100	.000	-0.7056	-1.7144

4.1.3. The changes that will occur to the colour of E-max, Gradia and Zirconia after coffee and tea

One-way ANOVA (post hoc test) was used to assess the difference between E-max, Gradia and Zirconia after staining for groups A and C. According to the study results presented in Table 16 there is a statistical significance difference between Zirconia and E-max (P=0.000), there is also a significance difference between Zirconia and Gradia (P=0.000), however, there was no significance difference between E-max and Gradia (P=0.936). After tea and coffee, the results show a statistical significance difference between Zirconia and E-max and a difference between E-max and Gradia (P=0.000; 0.000). However, there is no significance difference between Zirconia and Gradia (P=0.804).

Table 16: Difference between E-max, Gradia and Zirconia after staining

	Materials	**Difference of mean**	**P value**	**95% Confidence Interval**	
				Lowe limit	**Upper limit**
Group A	Zirconia vs E-max	-0.600	0.000	-0.854	-0.346
	Zirconia vs Gradia	-0.590	0.000	0.346	0.854
	E-max vs Gradia	0.010	0.936	-0.244	0.264
Group C	Zirconia vs E-max	-2.160	0.000	-2.570	-1.750
	Zirconia vs Gradia	0.050	0.804	-0.360	0.460
	E-max vs Gradia	2.210	0.000	1.800	2.620

One sample t-test was used to determine the difference between coffee and tea. According to the study results shown in Table 17 there is a statistical significant difference between coffee and tea (P=0.017).

Table 17: Mean difference between coffee and tea

Material	**Coffee Mean (Std)**	**Tea Mean (Std)**
Zirconia	2.0	1.6
E-max	1.7	2.0
Gradia	2.4	1.6
Total	2.0	1.8
	P=0.017	

In addition, the difference between materials after coffee and tea according to cements used was assessed by One-way ANOVA (Tukey test). According to the study results shown in Table 18 there is no significant difference among the majority of the variables. For instance, there was no significant difference between Variolink and Nexus in the Zirconia coffee group (P=0.935) and no difference between Variolink and Nexus in the Zirconia tea group (P=0.454). There was only a significant difference between Variolink and control (P=0.001) and Variolink as well as a difference between control and Nexus (0.000) in the Gradia coffee group.

Table 18: Difference between materials after coffee and tea according to cements used (Group A and C)

			Difference of mean	P value	95% Confidence Interval	
					Lower limit	**Upper limit**
Zirconia coffee	Variolink	Control	.02000	.935	-.5035	.5435
		Nexus	.38000	.140	-.1435	.9035
	Nexus	Control	-.36000	.160	-.8835	.1635
		Variolink	-.38000	.140	-.9035	.1435
Zirconia tea	Variolink	Control	.28000	.454	-.5088	1.0688
		Nexus	-.28000	.454	-1.0688	.5088
	Nexus	Control	.56000	.148	-.2288	1.3488
		Variolink	.28000	.454	-.5088	1.0688
E-max coffee	Variolink	Control	-.04000	.917	-.8610	.7810
		Nexus	-.32000	.412	-1.1410	.5010
	Nexus	Control	.28000	.472	-.5410	1.1010
		Variolink	.32000	.412	-.5010	1.1410
E-max tea	Variolink	Control	-.68000*	.042	-1.3312	-.0288
		Nexus	-.22000	.476	-.8712	.4312
	Nexus	Control	-.46000	.150	-1.1112	.1912
		Variolink	.22000	.476	-.4312	.8712
Gradia coffee	Variolink	Control	-1.90000*	.001	-2.9054	-.8946
		Nexus	.52000	.282	-.4854	1.5254
	Nexus	Control	-2.42000*	.000	-3.4254	-1.4146
		Variolink	-.52000	.282	-1.5254	.4854
Gradia tea	Variolink	Control	.06000	.863	-.6834	.8034
		Nexus	-.60000	.104	-1.3434	.1434
	Nexus	Control	.66000	.077	-.0834	1.4034
		Variolink	.60000	.104	-.1434	1.3434

4.2. Flexural strength

This section presents the descriptive statistics results for flexural strength among the materials. The results were converted from newton to megapascal using the equations mentioned in the methodology chapter (see page 48). Table 19 shows the results of flexural strength among the three materials E-max, Gradia and Zirconia. For E-max group A (control) and (control group after thermal cycle) the mean values are 168.4 and 158.2 respectively. Additionally, for E-max group B (Variolink) and (Nexus) the mean values are 480.2 and 302.3 respectively. Moreover, for E-max group C (Variolink) and (Nexus) the mean values are 268.8 and 239.8 respectively. In regard to Zirconia group A (control) and (control group after thermal cycle) the mean values are 700.0 and 606.2 respectively. Additionally, for Zirconia group B (Multilink) and (Nexus) the mean values are 936.6 and 975.9 respectively. Moreover, for Zirconia group C (Multilink) and (Nexus) the mean values are 861.7 and 865.9 respectively. Finally, in relation to Gradia group A (control) and (control group after thermal cycle) the mean values are 99.5 and 79.8 respectively. Additionally, for Gradia group B (Variolink) and (Nexus) the mean values are 247.6 and 314.9 respectively. Lastly, for Gradia group C (Variolink) and (Nexus) the mean values are 175.5 and 231.6 respectively.

Table 19: Flexural strength results of the three materials E-max, Zirconia and Gradia for all the groups (A, B and C)

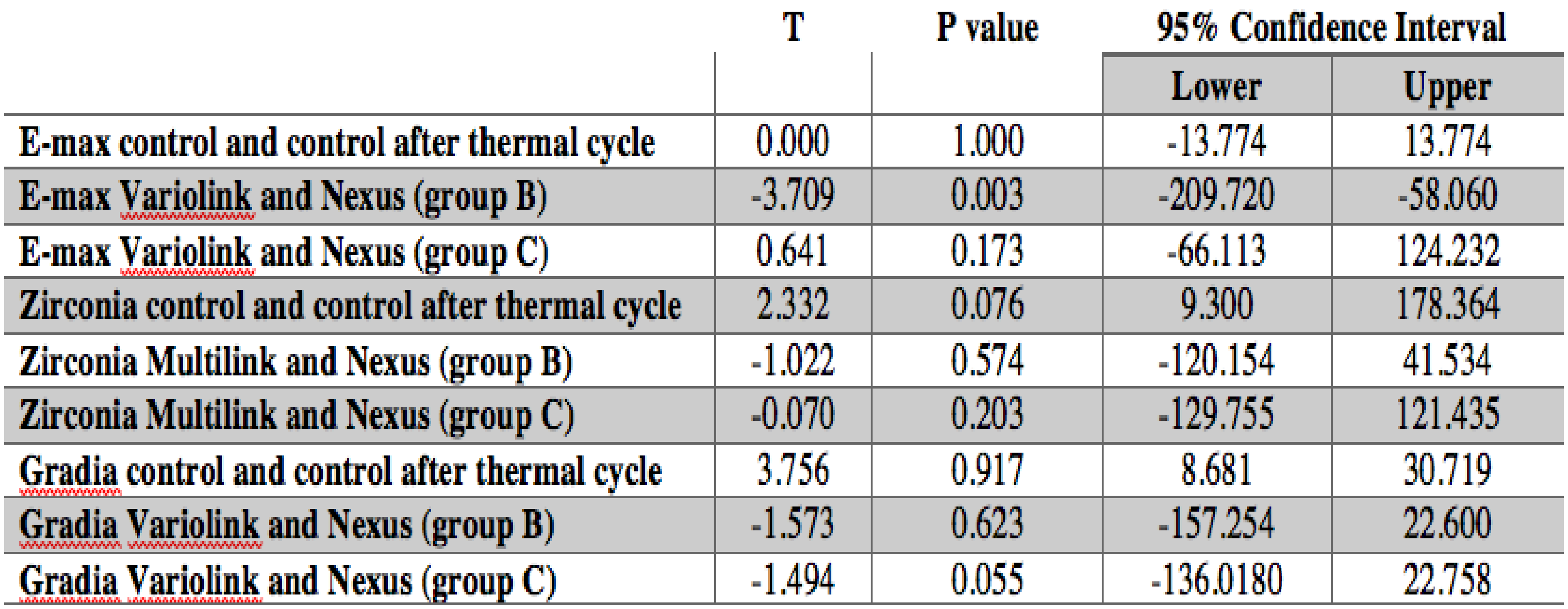
	E-max (n=60)						**Zirconia (n=60)**						**Gradia (n=60)**					
	A Group (n=20)		**B Group (n=20)**		**C Group (n=20)**		**A Group (n=20)**		**B Group (n=20)**		**C Group (n=20)**		**A Group (n=20)**		**B Group (n=20)**		**C Group (n=20)**	
S	**C**	**CT**	**V**	**N**	**V**	**N**	**C**	**CT**	**M**	**N**	**M**	**N**	**C**	**CT**	**V**	**N**	**V**	**N**
S1	163.8	163.5	513.5	212	197.2	284	582.5	607.3	864.4	1094.4	741.3	904.3	110	86.6	457.7	407.3	273	389
S2	172.9	155.9	642.9	185	448	240.8	659.5	753.4	1007.7	1007.6	753.9	958.8	95.9	81	261	435.3	143.6	367.8
S3	152.5	185.2	367.6	335.6	157.3	193.3	713.9	718.3	943.7	947.8	917.8	890.2	87	65.8	297.3	223.9	132.7	149
S4	169.4	204.4	446.5	348.4	232.7	183.8	703.9	667.2	896.2	935.4	879.2	600.2	117.4	72.4	297.6	296.2	154.8	172.1
S5	150.6	120.4	346.2	294.8	140.4	284.8	735.4	558.2	1014.8	1028.4	899.4	984.6	108.7	107.7	244.3	314.6	262.2	248.9
S6	200.0	134.6	457.6	209.7	216.2	141.5	816.9	614.3	1009.6	942.9	863.5	859	94.3	81.2	199.6	306.4	187.6	159.2
S7	155.4	140.6	582.6	222.3	366	141.9	660.3	715.3	854	855.5	745.5	910.3	105.3	63.7	161.6	159.8	98.7	138.2
S8	166.2	130.3	519.7	555.1	226.4	310.9	680.8	482.9	941.6	1050.5	996.3	1002.7	100.5	88.5	108.9	399	129.3	107.8
S9	179.7	168.9	358	399.5	226.9	221.8	708.9	407.4	1075.9	882.2	970.6	1013.1	87	74.4	244.1	407.3	132.7	319.1
S10	173.1	178.5	566.9	260.1	477.3	395	738.1	537.6	757.7	1014	849.5	535.4	88.6	76.4	203.9	199.5	240.8	264.7
Mean	168.4	158.2	480.2	302.3	268.8	239.8	700	606.2	936.6	975.9	861.7	865.9	99.5	79.8	247.6	314.9	175.5	231.6

S: Sample
C: Control group
CT: Control After thermal cycle
V: Variolink cement
N: Nexus cement

4.2.1. The effect of fracture resistance on the materials and resin cements

The independent sample t-test was used to determine the difference of flexural strength between groups of materials (A, B and C). According to the study results shown in Table 20 there is only a significance difference between E-max Variolink and Nexus in group B (P=0.003). For instance, there was no difference between E-max control and control after thermal cycle (P=1.000), Zirconia Multilink and Nexus in group C (P=0.203) and no difference between Gradia Variolink and Nexus in group C (P=0.055).

Table 20: The difference of flexural strength between groups of materials (A, B and C)



	T	P value	95% Confidence Interval	
			Lower	Upper
E-max control and control after thermal cycle	0.000	1.000	-13.774	13.774
E-max Variolink and Nexus (group B)	-3.709	0.003	-209.720	-58.060
E-max Variolink and Nexus (group C)	0.641	0.173	-66.113	124.232
Zirconia control and control after thermal cycle	2.332	0.076	9.300	178.364
Zirconia Multilink and Nexus (group B)	-1.022	0.574	-120.154	41.534
Zirconia Multilink and Nexus (group C)	-0.070	0.203	-129.755	121.435
Gradia control and control after thermal cycle	3.756	0.917	8.681	30.719
Gradia Variolink and Nexus (group B)	-1.573	0.623	-157.254	22.600
Gradia Variolink and Nexus (group C)	-1.494	0.055	-136.0180	22.758

One-way ANOVA (post hoc test) was used to examine the difference of flexural strength between materials according to the cements used and the difference between groups (A, B, and C). For instance, the difference between E-max Variolink control group A and E-max Variolink group B, and the difference between Variolink group B and Variolink group C etc (Table 21). The study results showed a statistical significance difference between the groups and material used in most of the variables. For instance, there was a significant difference between E-max control group (without cementation and thermal cycle) and Variolink Group B (cementation without thermal cycle) (P=0.000) and also a difference between control group and Variolink Group C (cementation with thermal cycle) (P=0.020). In addition, a difference between Groups B and C (P=0.000). However, in relation to E-max Nexus the results indicate no significance difference between Groups B and C (P=0.094) and no difference between control group and Group C (P=0.058). However, a significance difference between control group and group B (P=0.000). There was also a significant difference between E-max control group after thermal cycle (CAT) and Variolink Group B (0.000) and a difference between Variolink Groups B and C (P=0.001) as well as a difference between Variolink E-max (CAT) and group C (P=0.012). Additionally, there was also a significant difference between E-max (CAT) and Nexus Group B (P=0.000) and a difference between (CAT) group and Nexus Group C (P=0.034).

In regard to Zirconia the study results reported a significant difference between Zirconia control group and Multilink Group B (cementation without thermal cycle) (P=0.000) and also a difference between control group and Multilink Group C (cementation with thermal cycle) (P=0.000) but no difference between Groups B and C (P=0.056). Moreover, there was a significant difference between Zirconia control group and Nexus Group B (P=0.000) and also a difference between control group and Nexus Group C (P=0.002), as well as a difference between groups B and C (P=0.035). In addition, there was also a significant difference between Zirconia (CAT) and Multilink Group B (0.000) and a difference between CAT group and Multilink Group C (P=0.000). In relation to the Nexus groups, there was a significant difference between Zirconia (CAT) and Nexus Group B (P=0.000) and a difference between (CAT) group and Nexus Group C (P=0.000).

For Gradia, the results reported a significance difference between all the variables. In Table 21 it is shown that there was a significant difference between Gradia control group and Variolink Group B (P=0.000), a difference between control group and Variolink Group C (P=0.015) as well as a significant difference between Groups B and C (P=0.021). Moreover, there a difference between control group and Nexus Group B (P=0.000), a significant difference between control group and Nexus Group C (P=0.001) and a difference between Groups B and C (P=0.030). There was also a significant difference between Gradia (CAT) and Variolink Group B (0.000) and a significant difference between (CAT) group and Variolink Group C (0.000). Furthermore, there was a significant difference between Gradia (CAT) and Nexus Group B (0.000) and a difference between (CAT) group and Nexus Group C (P=0.000).

Table 21: The difference of flexural strength between materials according to the cements used and the difference between groups (A, B, and C)

Material			Difference of mean	P value	95% Confidence Interval	
					Lowe limit	**Upper limit**
E-max	Control	Variolink Group B	-311.79000*	.000	-395.1812	-228.3988
		Variolink Group C	-100.48000*	.020	-183.8712	-17.0888
	Variolink Group B	Control	311.79000*	.000	228.3988	395.1812
		Variolink Group C	211.31000*	.000	127.9188	294.7012
	Control group (A)	Nexus Group B	-133.89000*	.001	-207.8151	-59.9649
		Nexus Group C	-71.42000	.058	-145.3451	2.5051
	Nexus Group B	Control	133.89000*	.001	59.9649	207.8151
		Nexus Group C	62.47000	.094	-11.4551	136.3951
	Control after thermal cycle (CAT)	Variolink Group B	-321.92000*	.000	-406.1601	-237.6799
		Variolink Group C	-110.61000*	.012	-194.8501	-26.3699
	Control after thermal cycle (CAT) group (A)	Nexus Group B	-144.02000*	.001	-218.9014	-69.1386
		Nexus Group C	-81.55000*	.034	-156.4314	-6.6686
Zirconia	Control group (A)	Multilink Group B	-236.54000*	.000	-313.5809	-159.4991
		Multilink Group C	-161.68000*	.000	-238.7209	-84.6391
	Multilink Group B	Control	236.54000*	.000	159.4991	313.5809
		Multilink Group C	74.86000	.056	-2.1809	151.9009
	Control group (A)	Nexus Group B	-275.85000*	.000	-377.7059	-173.9941
		Nexus Group C	-165.84000*	.002	-267.6959	-63.9841
	Nexus Group B	Control	275.85000*	.000	173.9941	377.7059
		Nexus Group C	110.01000*	.035	8.1541	211.8659
	Control after thermal cycle (CAT) group (A)	Multilink Group B	-330.37000*	.000	-421.7789	-238.9611
		Multilink Group C	-255.51000*	.000	-346.9189	-164.1011
	Control after thermal cycle (CAT) group (A)	Nexus Group B	-369.68000*	.000	-482.7945	-256.5655
		Nexus Group C	-259.67000*	.000	-372.7845	-146.5555
Gradia	Control group (A)	Variolink Group B	-148.13000*	.000	-208.2132	-88.0468
		Variolink Group C	-76.07000*	.015	-136.1532	-15.9868
	Variolink Group B	Control	148.13000*	.000	88.0468	208.2132
		Variolink Group C	72.06000*	.021	11.9768	132.1432
	Control group (A)	Nexus Group B	-215.46000*	.000	-289.9173	-141.0027
		Nexus Group C	-132.11000*	.001	-206.5673	-57.6527
	Nexus Group B	Control	215.46000*	.000	141.0027	289.9173
		Nexus Group C	83.35000*	.030	8.8927	157.8073
	Control after thermal cycle (CAT) group (A)	Variolink Group B	-167.83000*	.000	-228.0255	-107.6345
		Variolink Group C	-95.77000*	.003	-155.9655	-35.5745
	Control after thermal cycle (CAT) group (A)	Nexus Group B	-235.16000*	.000	-309.7080	-160.6120
		Nexus Group C	-151.81000*	.000	-226.3580	-77.2620

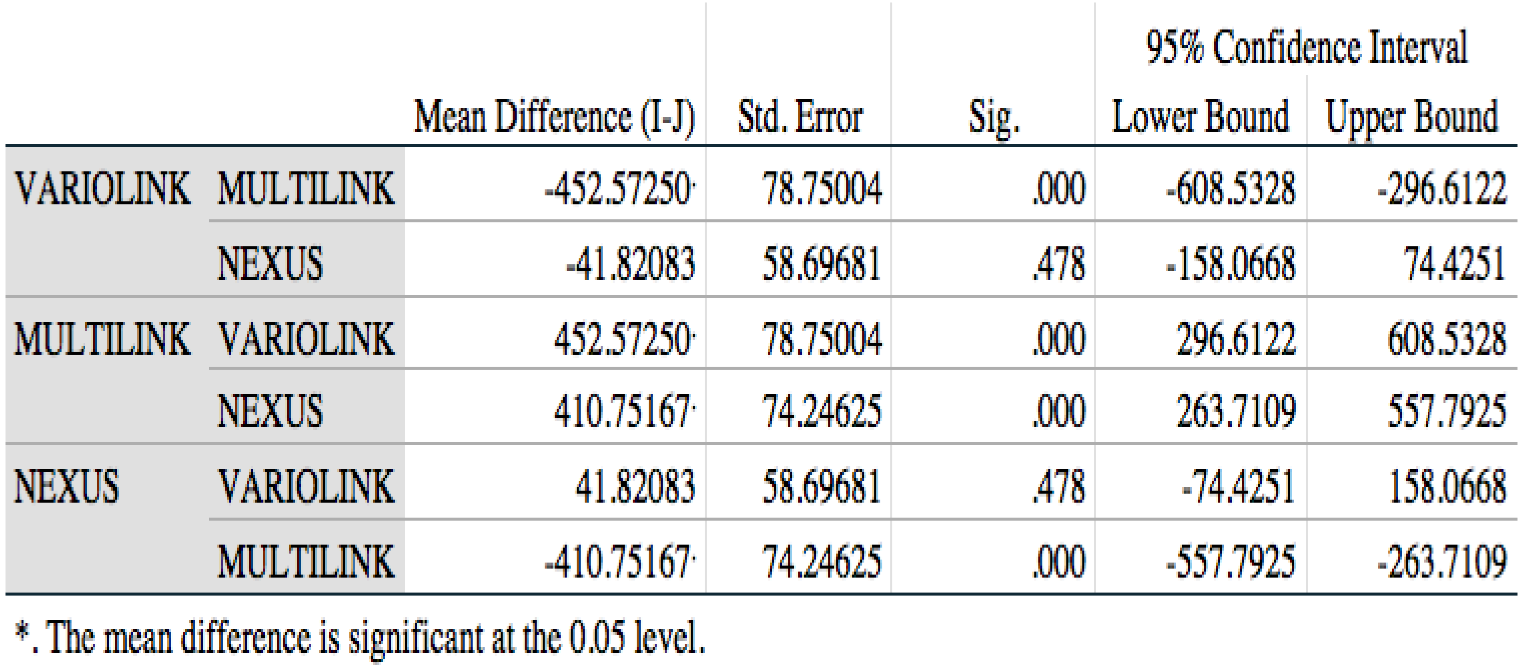
One-way ANOVA (post hoc test) was also used to examine the difference between flexural strength of the three materials among all the groups. According to the study results presented in Table 22 there is statistical significance difference between the majority of the variables. In regard to the control groups there was a statistical significance difference between E-max control group and Zirconia, a difference between E-max and Gradia and a difference between Zirconia and Gradia (P=0.000, 0.000, 0.000) respectively. Moreover, in relation to the control group after thermal cycle there was a statistical significance difference between E-max control group and Zirconia, a difference between E-max and Gradia and a difference between Zirconia and Gradia (P=0.000, 0.014, 0.00) respectively. Similarly, this was found among groups B and C in both Variolink/Multilink and Nexus. For example, in the Variolink/Multilink group B there was a statistical significance difference between E-max and Zirconia, a difference between E-max and Gradia and a difference between Zirconia and Gradia (P=0.000, 0.000, 0.000) respectively. The only insignificance difference was among E-max and Gradia (Variolink group C), E-max and Zirconia (Nexus group B) and E-max and Gradia (Nexus group C) with (P=0.084; 0.954; 0.987) respectively.

Table 22: The difference between flexural strength of the three materials among all groups

			Difference of mean	P value	95% Confidence Interval	
					Lowe limit	**Upper limit**
Control group Group A	E-max	Zirconia	-531.66000*	.000	-565.6306	-497.6894
		Gradia	68.89000*	.000	34.9194	102.8606
	Zirconia	E-max	531.66000*	.000	497.6894	565.6306
		Gradia	600.55000*	.000	566.5794	634.5206
Control group after thermal Group A	E-max	Zirconia	-447.96000*	.000	-509.0345	-386.8855
		Gradia	78.46000*	.014	17.3855	139.5345
	Zirconia	E-max	447.96000*	.000	386.8855	509.0345
		Gradia	526.42000*	.000	465.3455	587.4945
Variolink/ Multilink Group B	E-max	Zirconia	-456.4100	.000	-564.41610	-348.403898
		Gradia	232.55000	.000	124.543898	340.556102
	Zirconia	E-max	456.41000	.000	348.403898	564.416102
		Gradia	688.96000	.000	580.953898	796.966102
Variolink/ Multilink Group C	E-max	Zirconia	-592.8600	.000	-696.50465	-489.215343
		Gradia	93.30000	.084	-10.344657	196.944657
	Zirconia	E-max	592.860000	.000	489.215343	696.504657
		Gradia	686.160000	.000	582.515343	789.804657
Nexus Group B	E-max	Zirconia	-673.6200	.000	-780.66878	-566.571217
		Gradia	-12.68000	.954	-119.72878	94.368783
	Zirconia	E-max	673.62000	.000	566.571217	780.668783
		Gradia	660.94000	.000	553.891217	767.988783
Nexus Group C	E-max	Zirconia	-626.0800	.000	-760.54135	-491.618650
		Gradia	8.20000	.987	-126.26135	142.661350
	Zirconia	E-max	626.08000	.000	491.618650	760.541350
		Gradia	634.28000	.000	499.818650	768.741350

One-way ANOVA (post hoc test) was also used to assess the difference between flexural strength of cements for instance the difference between Variolink and Multilink (Table 23). According to study results there is a statistical significance difference between Variolink and Multilink (P=0.000) and a significance difference between Multilink and Nexus (P=0.000). However, there is no significance difference Variolink and Nexus (P=0.478).

Table 23: The difference between flexural strength of materials according to cement used



					95% Confidence Interval	
		Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
VARIOLINK	MULTILINK	-452.57250*	78.75004	.000	-608.5328	-296.6122
	NEXUS	-41.82083	58.69681	.478	-158.0668	74.4251
MULTILINK	VARIOLINK	452.57250*	78.75004	.000	296.6122	608.5328
	NEXUS	410.75167*	74.24625	.000	263.7109	557.7925
NEXUS	VARIOLINK	41.82083	58.69681	.478	-74.4251	158.0668
	MULTILINK	-410.75167*	74.24625	.000	-557.7925	-263.7109

*. The mean difference is significant at the 0.05 level.

5. Discussion and Results

This study involves an examination of three esthetic materials, which are considered the most popular esthetic materials used in the field of dentistry. The materials include Lithium disilicate, Indirect Resin Composite and Zirconia. These materials are considered to be strong, have high colour stability and good surface texture. These features result in good esthetic outcomes in all dental cases (de Oliveira and Botta, 2014; Topcu et al, 2009; Christensen, 2003). In the current study we used Dual cure resin cements NX3 Nexus Third Generation, Variolink N and Multilink N which has higher mean colour (ΔE) change compared to the light cure resin cements such as Rely X Veneer Cement (3M ESPE, St. Paul, Minn.), Variolink Veneer (Ivoclar, Vivadent, Amherst, N.Y.) and Choice 2 Light Cured Veneer Cement (Bisco, Schaumburg, Ill). This indicates that the dual cure resin cements have more ageing induced colour change than the light cure resin cements (Nathanson and Banasr, 2002). The Bluephase N light cured device was used as it has a high-quality medical device with (polywave) broadband spectrum and it is suitable for the polymerization of all light curing dental materials in the wavelength range of 385-515nm (Ivoclar Vivadent; 2013). Moreover, aging process has been used on the materials by using thermal cycle machine (10,000 cycles), which is equivalent to one year of clinical service of composite (Gale and Darvell, 1999). The sample discs were emerged in coffee and tea for 7 days as it has been reported that significant staining will take up in the first week of exposure (Arocha et al, 2014). According to McLaren and Chang (2006) vita easy shade V device is considered the simplest and more accurate in taking the colour shade with more advanced system compared to other devices such as Xrite Shade-X and the Crystaleye (Olympus America) to measure (ΔE) of materials.

The current study examined the colour stability and fracture resistance of E-max, Gradia and Zirconia by using dual cure resin cements. This section includes a discussion and conclusions of the main findings of the study and comparing the results with previous research results. The first objective of the study was to assess the difference between E-max, Gradia and Zirconia (groups A, B and C) before and after cementation and after thermal cycle. According to the study results shown in Table 11 E-max ceramic discs showed the highest mean value before and after cementation and after thermal cycle. In addition, there was no difference between Zirconia and Gradia. Acar et al (2016) found that lithium disilicate (E-max) had the most colour stable material compared to hybrid nano-ceramic and nano-composite. However, Lee and Choi (2018) found that resin cement systems influenced the colour change of laminate veneers. They also found the high translucency of lithium disilicate ceramics exhibited greater colour changes after aging. The current study also determined the best material among E-max, Gradia and Zirconia before and after thermal cycle (group A). According to the study results Zirconia was the least material at preserving its colour before thermal cycle. This may be due to the fact that Zirconia is less translucent when compared to E-max and thus more likely to stain (Kurtulmus-Yilma and Ulusoy, 2014). However, there was no significance difference between E-max and Gradia ($P<0.05$). On the other hand, the results discovered that E-max was the best material at preserving its colour after thermal cycle. However, there was no significance difference between Zirconia and Gradia ($P<0.05$). Hamza et al (2018) found that the colour stability of IPS E-max and IPS Empress were not affected by weathering process aging. Papadopoulos et al (2010) found that indirect resin composites (Adoro, HFO, Gradia) showed a yellow shift after accelerated aging. Additionally, Nakamura et al (2002) found that indirect resin composite Gradia and Solidex demonstrated a colour change after two weeks in water immersion. It is argued that the colour change may be caused by polymerization caused by water (Ferracane and Condon, 1992). The study results shown in Table 12 found that there a significant difference between nearly all variables ($P<0.05$). Thus, the tested null hypothesis was rejected. This clearly indicate that the colour stability of the three materials Zirconia, E-max and Gradia were affected by both cements and thermal cycle machine. However, the results indicate no difference between cements used before and after cementation and after thermal cycle (Table 13). It was also demonstrated in Table 18 that there is no statistical difference between materials after coffee and tea according to cements used ($P<0.05$). Which clearly means that the type of cement has no dramatic impact on the colour of the ceramic. Kilinc et al (2011) evaluated the amount of resin cement colour change and its effect on the final shade of all-ceramics. According to their study, all resin cements showed discolouration when exposed to dual cure resin cements. In addition, Chang et al (2014) assessed that impact of Variolink II, Esthetic, and Nexus II cements on the colour of IPS Empress (Ivoclar). According to their study results combining the cement colour with the ceramic has a significant influence on the final colour of the restoration. It has been argued that the colour of cement has an impact on the ceramic colour stability. For instance, Vafaee et al (2018) found that the cement colour had a significant effect on the final colour of ceramic. Thus, in the current study we chose a translucent shade for all the cements.

In relation to thermal cycle and colour changes, Goiato et al (2013) found that exposing the materials to thermal cycle significantly affected the colour stability of the samples. In addition, the current study results also indicate that the materials were less likely to be affected by the cement Nexus when compared to Multilink and Variolink (Table 12). On the other hand, (Smith, 2011) found that Nexus had the lowest colour change under curing conditions when compared with Variolink. Tabatabaian et al (2018) evaluated the effect of resin cement brand on the colour of zirconia-based restorations. Their study results detected a significant difference between resin cement brands on the colour stability of zirconia. Dede et al (2017) similarly examined the impact of several brands and shades of resin cements on the colour of a lithium disilicate (E-max) ceramic and also reported that resin cements from different brands had different impacts on the ceramic colour. Unlike the current study results, their study revealed that Variolink II translucent cement had the most unacceptable colour changes. Kilinc et al (2011) found that in all groups the ceramic materials actual colour was not affected by the resin cement and only Nexus 2 DC made a change to the ceramic. Moreover, the current study results (Table 13) show no significant difference between cements for each material before and after thermal cycle ($P>0.05$). This accepts the null hypothesis. However, a significant difference between Gradia Variolink and Gradia Nexus (after cementation), Zirconia Multilink and E-max Variolink (after cementation), E-max Variolink and Gradia Variolink (after cementation). Which clearly states that the type of cementation may impact the colour stability of the materials. According to Kilinc et al (2011) none of the resin cements caused a noticeable colour change to the ceramic materials. Another objective of the study was to determine the difference between E-max, Gradia and Zirconia before and after thermal cycle. According to the study results shown in Table 14 and 15 there is a statistical significance difference between before and after thermal cycle in all materials ($P<0.05$) which rejects the null hypothesis. These results clearly indicate that the thermal cycle machine has a great impact on the colour stability of the materials. According to Goiato et al (2013) thermocycling caused colour changes in the acrylic resin's samples. Moreover, other studies found that thermocycling is associated with volumetric contraction and expansion of materials which can causes degradation (Shimizu et al, 2008; Gurdal et al, 2002). However, it is argued that the colour changes may also be as a result of other factors such as water and changes in cast or material ageing (Wagner et al, 1995; Shimizu et al, 2008; Gurdal et al, 2002).

The study also assessed the impact of coffee and tea on the colour stability of the three materials. The results shown in Table 16 show that there is a statistical difference between Zirconia and E-max and E-max and Gradia (P<0.05). According to the study results there was less changes made to E-max after coffee and tea when compared with Zirconia (mean difference: -2.160). Additionally, when comparing E-max and Gradia, the results indicate that E-max was less affected by coffee and tea when compared with Gradia (mean difference: 2.210). However, there was no difference between Zirconia and Gradia in relation to colour change. These results indicate that E-max is best material at maintaining its colour when compared to Zirconia and Gradia. Sayed et al (2016) also found that IPS. E-max veneers exhibited the best colour stability when compared with Nano hybrid and Vita Enamic veneers. According to Kelly and Benetti (2016) E-max is considered more translucent than Zirconia, this means that E-max ceramics allow more light, thus less likely to stain. Moreover, they argue that E-max ceramics are preferred to other ceramic materials because they are long lasting, tough, durable, they match with natural teeth and have better aesthetics qualities.

Many studies found that different beverages have varying degrees of staining on different types of materials (Nikzad et al, 2012; Lamba et al, 2012; Reis et al, 2003). In the present study there was a statistical significant difference between coffee and tea (Table 17). Sayed et al (2016) similarly found that coffee had the highest impact on the materials. This may be due to the fact that coffee is much easily absorbed into the material (Malekipour et al, 2012; Al kheraif et al, 2013). On the other hand, it is argued that tea may only be absorbed on the surface of the teeth (Al kheraif et al, 2013). Similarly, Raeisosadat et al (2016) assessed the colour stability of three commonly used resin-based materials. Their study revealed that all the materials were more significantly affected by coffee when compared with tea. Bagheri et al (2005) argued that coffee includes a yellow colour which causes the materials with low polarity to easily stain.

The current study also determined the difference of flexural strength between the materials (Zirconia, E-max and Gradia). The null hypothesis has been accepted as the results revealed that there is only a significance difference between E-max Variolink and Nexus in group B (samples not placed in thermal cycle) (Table 20) This means that the type of cement did not affect the ceramic when tested within the same group. Moreover, the study also compared the difference of flexural strength between different groups. For instance, the difference between control groups (without cementation and thermal cycle) and group B (cementation without thermal cycle). This assists in examining the effect of the cementation and thermal cycling on the three ceramics. According to the results shown in Table 21 there is a statistical significance difference between nearly all the variables. However, there was no significant difference between E-max Nexus group B (cementation without thermal cycle) and E-max Nexus group C (cementation with thermal cycle) (P=0.094). The reason for this could be that the Nexus cement was better at maintaining the strength of the material even after thermal cycling. According to (Lambade et al, 2015) Nexus NX3 had the highest value of shear bond strength and Variolink II had the lowest. Moreover, the results showed a significant difference between E-max control group (without cementation and thermal cycle) and Variolink Group B (cementation without thermal cycle), a difference between control group and Variolink Group C (cementation with thermal cycle) and a difference between Groups B and C (P<0.050) mean difference (-311.79000; -100.48000; 211.31000*). Group B (cementation without thermal cycle) showed the highest mean values which indicates that is the best group when compared to group A and C. This was similarly found among the other materials, which clearly indicate that cementation with thermal cycling could have an impact on the aging of the ceramics. However, the study determined the effect of thermal cycle on the flexural strength of each material (Table 20). According to the study results there was no statistical significant difference between control group A before thermal cycle and control group A after thermal cycle in all materials (P<0.05). Porto et al (2018) evaluated the effect of thermal cycling process on four ceramic materials and found that thermal cycle had a significant impact on the toughness of all materials. In addition, according to Shafter et al (2017) also found that thermocycling has an impact on the flexural strength of different materials, however, their study found no significant difference between the impact of thermal cycle and water soaking. Moresi et al (2015) similarly found that flexural strength significantly decreased after thermal cycling protocols in all composite's materials tested. In the current study it was demonstrated that in most samples there is a difference between the material used, cement used and its exposure to thermal cycle. This indicates that factors such as the material, type of cement and heat exposure all have an impact on the aging and the flexural strength of teeth. In the current study it was also demonstrated that in most samples there was a difference between control and cemented discs (groups B and C) (Table 21). Li et al (2015) compared the differences in flexural strength and compressive strength between different resin-modified luting glass cements that are commonly used in clinics. According to their study, all cements had an impact on the flexural strength on the ceramic, chemical cure cements had a superior flexural strength. Moreover, Fracncescantonio et al (2012) evaluated the effects of curing mode and viscosity on the biaxial flexural strength (FS) and modulus (FM) of dual resin cements. Their study found that the use of different cements with different viscosities has an impact on the biomechanical behaviour of luting materials. Besides, insignificance difference between the groups that was revealed in the current study was more apparent in group B (cementation without thermal cycle). This again indicates that not exposing the teeth to heat will lengthen its age. Prakki et al (2007) found that the non-cemented groups had a lower fracture loads compared to the cemented groups. Moreover, Scherrer et al (1994) found that treating ceramics with resin cements smoothed its sharpness and roughness which makes it more prone to fracture. The current study results found a difference between cements used and their impact on the fracture resistance of the ceramics. Results in Table 23 revealed a statistical significance difference between Multilink and Variolink and a significance difference between Multilink and Nexus ($P<0.05$) mean difference (-452.57250; -410.75167). These results indicate the Multilink is a better cement at maintaining the strength of the material. However, we cannot rely on these results as the Multilink was only performed on the Zirconia ceramic.

In addition, the current study results also found a significant difference between flexural strength of the three materials (control groups) and (control group after thermal cycle). Moreover, the study also detected a significant difference between the materials in nearly all variable in group B and C (Table 22). Therefore, the null hypothesis has been rejected. It was clearly shown in the results presented in Table 22 that Zirconia has a better flexural strength in all the groups followed by E-max and then Gradia. Jihad et al (2018) similarly found that Zirconia materials showed superior biaxial flexural strength values than the lithium disilicate glass ceramics. According to Piconi and Maccauro (1999) Zirconia is strongly dependent on its grain size, thus, it cannot be easily transformed. Johansson et al (2014) also found higher strength for the zirconia crowns compared to lithium disilicate crowns when undergone the thermal cycle machine. In relation to Gradia, there is a lack of studies on the flexural strength difference between Gradia (indirect composite) and Zirconia. Most studies assessed the difference between indirect and direct composite. For instance, Borba et al (2007) evaluated the flexural strength and hardness of direct and indirect composites. According to their study results direct composite showed higher mean value than the indirect composites. Similarly, Cesar et al (2001) found that the flexural strength of direct composite (Z100) was much higher than indirect composite materials (Artglass, Belleglass, Sculpture and Targis). Nevertheless, the current study found insignificance difference was between E-max and Gradia (Variolink group C), E-max and Zirconia (Nexus group B) and E-max and Gradia (Nexus group C) with (P>0.05). This may be due that fact that Nexus NX3 has a higher value of shear bond strength than Variolink as mentioned earlier (Lambade et al, 2015). Thus, the Nexus balanced between E-max and Gradia, whilst Zirconia remained with the highest flexural strength.

5.1. Conclusion

The current study examined the colour stability and fracture resistance of E-max, Gradia and Zirconia by using dual cure resin cements. Within the limitations of this study the following conclusions may be drawn:

1- There is a difference in colour stability among the three materials E-max, Gradia and Zirconia before and after cementation and after thermal cycle. E-max has the best colour stability when compared to Gradia and Zirconia ($P<0.005$).

2- There is a difference in colour stability among the three materials E-max, Gradia and Zirconia when exposed to coffee and tea, E-max has the best colour stability when compared to Gradia and Zirconia ($P<0.005$).

3- There is no difference between the types of cements (Variolink, Multilink and Nexus 3rd generation) on the colour of the materials ($P>0.005$).

4- There is a difference between the flexural strength of the three materials, Zirconia has a better flexural strength when compared to E-max and Gradia ($P<0.005$).

5- There is a difference between the types of cements (Variolink, Multilink and Nexus 3rd generation) on the flexural strength of the materials. Multilink is a better cement at maintaining the strength of the material when compared to Variolink and Nexus ($P<0.005$).

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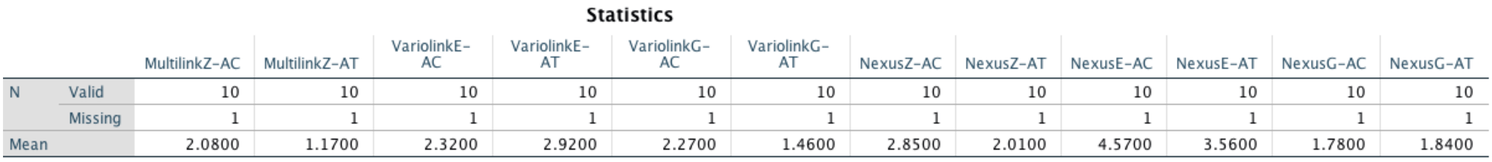
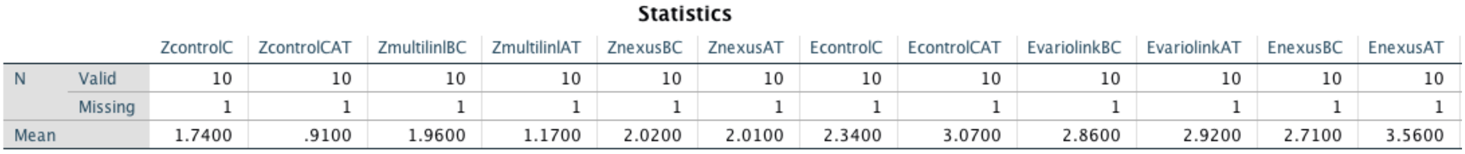
Enclosure



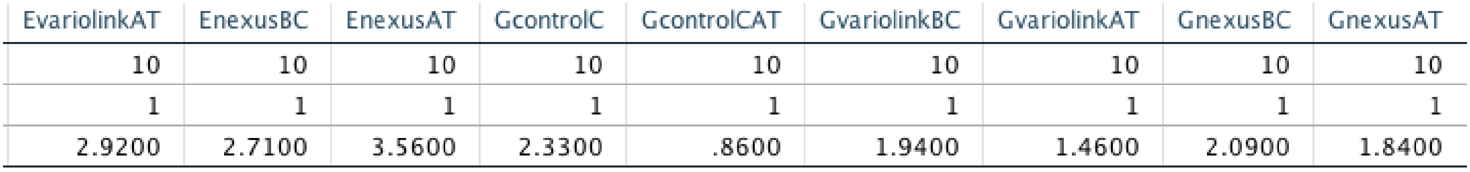
Statistics

		MultilinkZ-AC	MultilinkZ-AT	VariolinkE-AC	VariolinkE-AT	VariolinkG-AC	VariolinkG-AT	NexusZ-AC	NexusZ-AT	NexusE-AC	NexusE-AT	NexusG-AC	NexusG-AT
N	Valid	10	10	10	10	10	10	10	10	10	10	10	10
	Missing	1	1	1	1	1	1	1	1	1	1	1	1
Mean		2.0800	1.1700	2.3200	2.9200	2.2700	1.4600	2.8500	2.0100	4.5700	3.5600	1.7800	1.8400



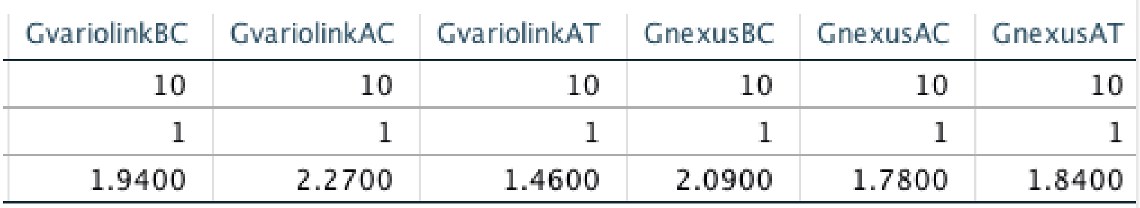
Statistics

		ZcontrolC	ZcontrolCAT	ZmultilinlBC	ZmultilinlAT	ZnexusBC	ZnexusAT	EcontrolC	EcontrolCAT	EvariolinkBC	EvariolinkAT	EnexusBC	EnexusAT
N	Valid	10	10	10	10	10	10	10	10	10	10	10	10
	Missing	1	1	1	1	1	1	1	1	1	1	1	1
Mean		1.7400	.9100	1.9600	1.1700	2.0200	2.0100	2.3400	3.0700	2.8600	2.9200	2.7100	3.5600

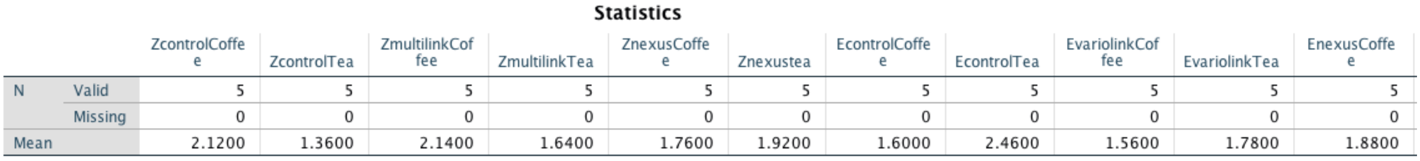


EvariolinkAT	EnexusBC	EnexusAT	GcontrolC	GcontrolCAT	GvariolinkBC	GvariolinkAT	GnexusBC	GnexusAT
10	10	10	10	10	10	10	10	10
1	1	1	1	1	1	1	1	1
2.9200	2.7100	3.5600	2.3300	.8600	1.9400	1.4600	2.0900	1.8400

SPSS sheets

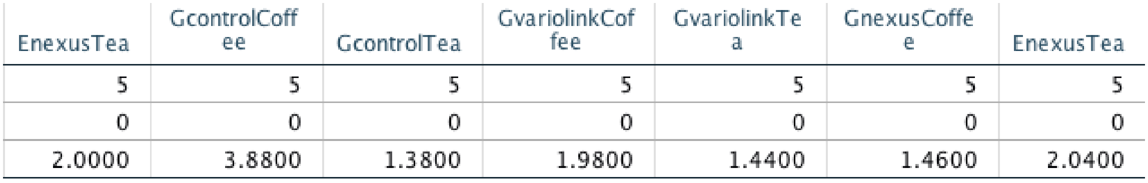


GvariolinkBC	GvariolinkAC	GvariolinkAT	GnexusBC	GnexusAC	GnexusAT
10	10	10	10	10	10
1	1	1	1	1	1
1.9400	2.2700	1.4600	2.0900	1.7800	1.8400

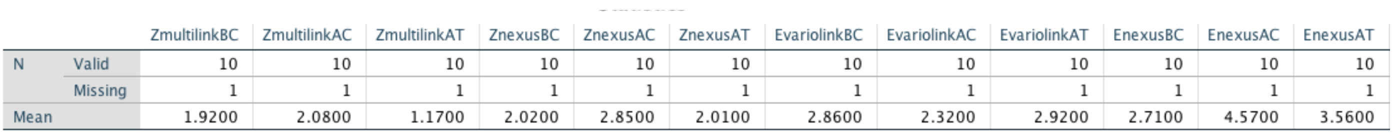


Statistics

		ZcontrolCoffee	ZcontrolTea	ZmultilinkCoffee	ZmultilinkTea	ZnexusCoffee	Znexustea	EcontrolCoffee	EcontrolTea	EvariolinkCoffee	EvariolinkTea	EnexusCoffee
N	Valid	5	5	5	5	5	5	5	5	5	5	5
	Missing	0	0	0	0	0	0	0	0	0	0	0
Mean		2.1200	1.3600	2.1400	1.6400	1.7600	1.9200	1.6000	2.4600	1.5600	1.7800	1.8800

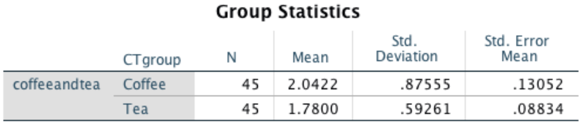


EnexusTea	GcontrolCoffee	GcontrolTea	GvariolinkCoffee	GvariolinkTea	GnexusCoffee	EnexusTea
5	5	5	5	5	5	5
0	0	0	0	0	0	0
2.0000	3.8800	1.3800	1.9800	1.4400	1.4600	2.0400



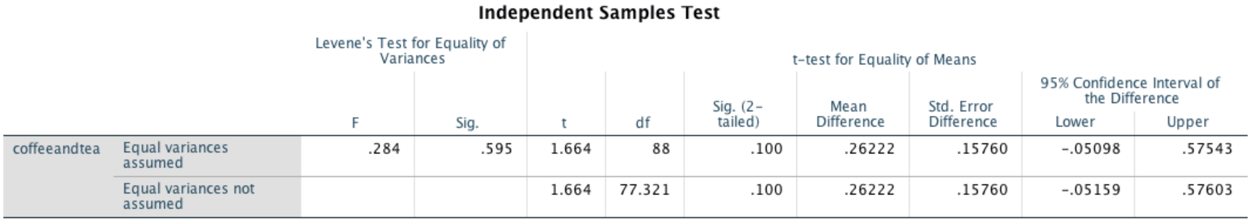
		ZmultilinkBC	ZmultilinkAC	ZmultilinkAT	ZnexusBC	ZnexusAC	ZnexusAT	EvariolinkBC	EvariolinkAC	EvariolinkAT	EnexusBC	EnexusAC	EnexusAT
N	Valid	10	10	10	10	10	10	10	10	10	10	10	10
	Missing	1	1	1	1	1	1	1	1	1	1	1	1
Mean		1.9200	2.0800	1.1700	2.0200	2.8500	2.0100	2.8600	2.3200	2.9200	2.7100	4.5700	3.5600

T-Test



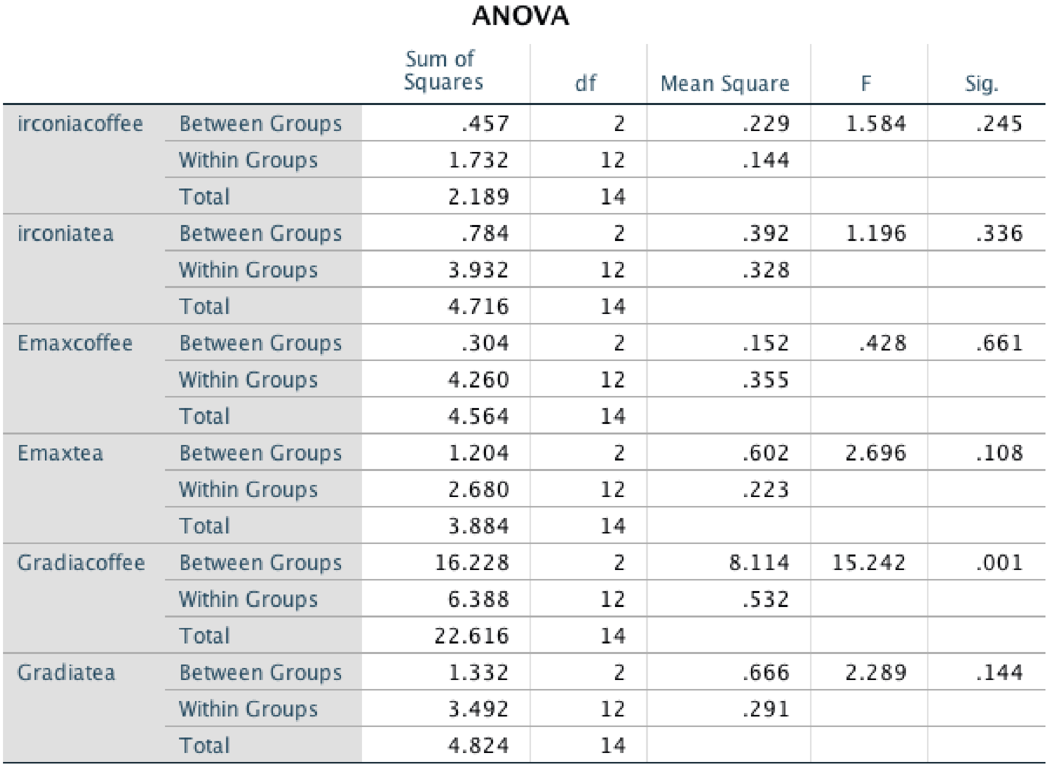
Group Statistics

	CTgroup	N	Mean	Std. Deviation	Std. Error Mean
coffeeandtea	Coffee	45	2.0422	.87555	.13052
	Tea	45	1.7800	.59261	.08834



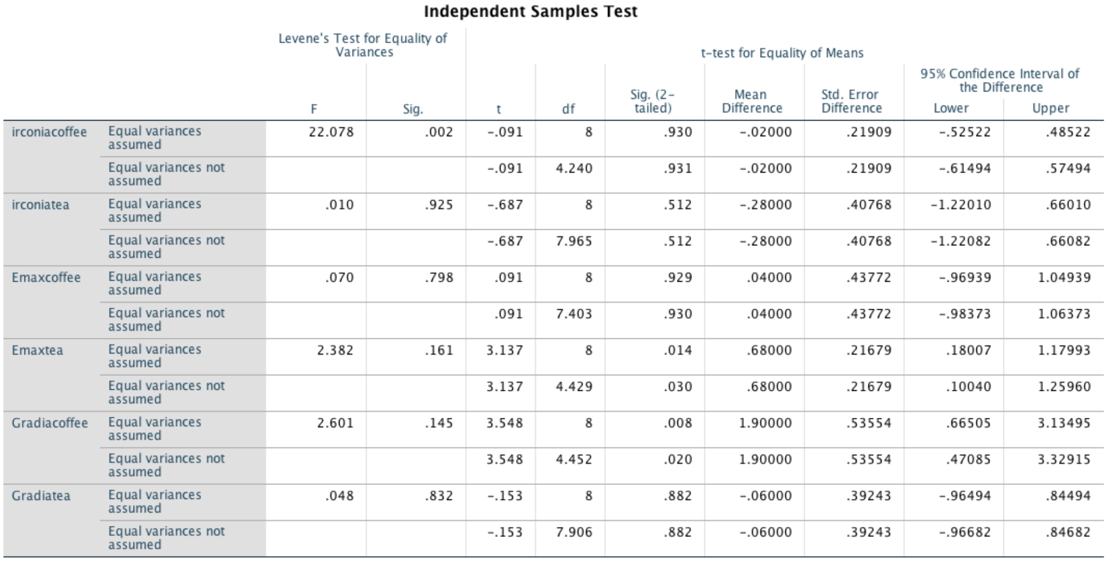
Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
coffeeandtea	Equal variances assumed	.284	.595	1.664	88	.100	.26222	.15760	-.05098	.57543
	Equal variances not assumed			1.664	77.321	.100	.26222	.15760	-.05159	.57603



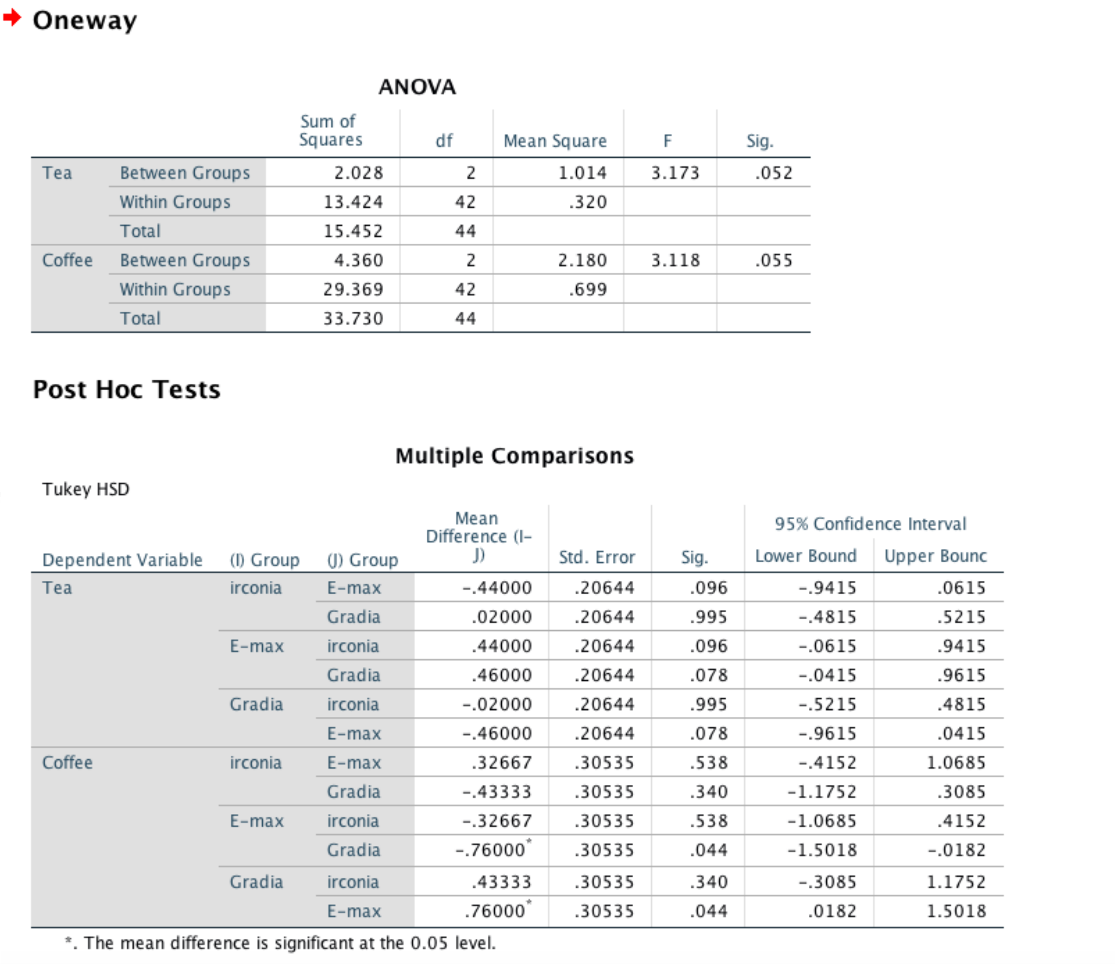
ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
irconiacoffee	Between Groups	.457	2	.229	1.584	.245
	Within Groups	1.732	12	.144		
	Total	2.189	14			
irconiatea	Between Groups	.784	2	.392	1.196	.336
	Within Groups	3.932	12	.328		
	Total	4.716	14			
Emaxcoffee	Between Groups	.304	2	.152	.428	.661
	Within Groups	4.260	12	.355		
	Total	4.564	14			
Emaxtea	Between Groups	1.204	2	.602	2.696	.108
	Within Groups	2.680	12	.223		
	Total	3.884	14			
Gradiacoffee	Between Groups	16.228	2	8.114	15.242	.001
	Within Groups	6.388	12	.532		
	Total	22.616	14			
Gradiatea	Between Groups	1.332	2	.666	2.289	.144
	Within Groups	3.492	12	.291		
	Total	4.824	14			



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
irconiacoffee	Equal variances assumed	22.078	.002	-.091	8	.930	-.02000	.21909	-.52522	.48522
	Equal variances not assumed			-.091	4.240	.931	-.02000	.21909	-.61494	.57494
irconiatea	Equal variances assumed	.010	.925	-.687	8	.512	-.28000	.40768	-1.22010	.66010
	Equal variances not assumed			-.687	7.965	.512	-.28000	.40768	-1.22082	.66082
Emaxcoffee	Equal variances assumed	.070	.798	.091	8	.929	.04000	.43772	-.96939	1.04939
	Equal variances not assumed			.091	7.403	.930	.04000	.43772	-.98373	1.06373
Emaxtea	Equal variances assumed	2.382	.161	3.137	8	.014	.68000	.21679	.18007	1.17993
	Equal variances not assumed			3.137	4.429	.030	.68000	.21679	.10040	1.25960
Gradiacoffee	Equal variances assumed	2.601	.145	3.548	8	.008	1.90000	.53554	.66505	3.13495
	Equal variances not assumed			3.548	4.452	.020	1.90000	.53554	.47085	3.32915
Gradiatea	Equal variances assumed	.048	.832	-.153	8	.882	-.06000	.39243	-.96494	.84494
	Equal variances not assumed			-.153	7.906	.882	-.06000	.39243	-.96682	.84682



Oneway

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Tea	Between Groups	2.028	2	1.014	3.173	.052
	Within Groups	13.424	42	.320		
	Total	15.452	44			
Coffee	Between Groups	4.360	2	2.180	3.118	.055
	Within Groups	29.369	42	.699		
	Total	33.730	44			

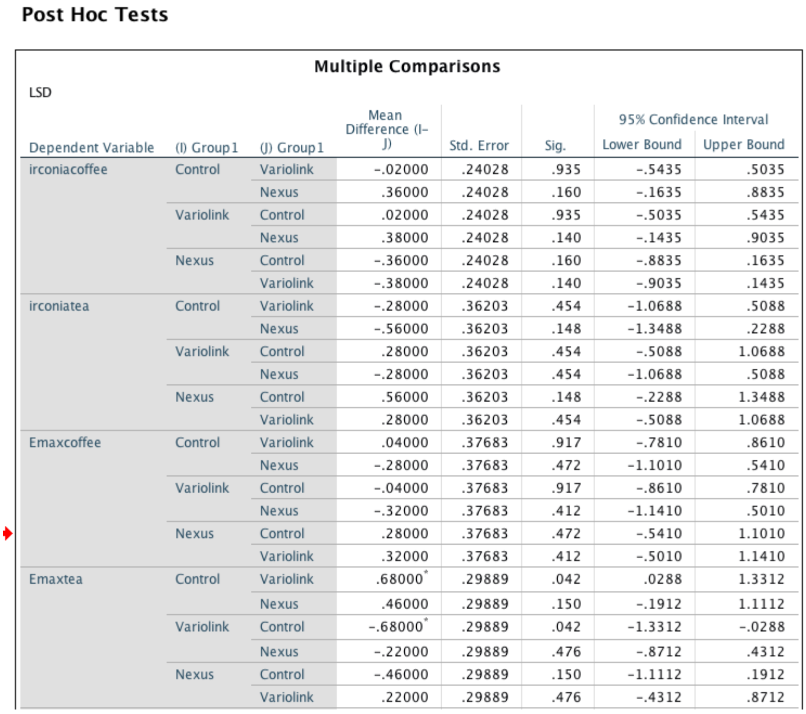
Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bounc
Tea	irconia	E-max	-.44000	.20644	.096	-.9415	.0615
		Gradia	.02000	.20644	.995	-.4815	.5215
	E-max	irconia	.44000	.20644	.096	-.0615	.9415
		Gradia	.46000	.20644	.078	-.0415	.9615
	Gradia	irconia	-.02000	.20644	.995	-.5215	.4815
		E-max	-.46000	.20644	.078	-.9615	.0415
Coffee	irconia	E-max	.32667	.30535	.538	-.4152	1.0685
		Gradia	-.43333	.30535	.340	-1.1752	.3085
	E-max	irconia	-.32667	.30535	.538	-1.0685	.4152
		Gradia	-.76000*	.30535	.044	-1.5018	-.0182
	Gradia	irconia	.43333	.30535	.340	-.3085	1.1752
		E-max	.76000*	.30535	.044	.0182	1.5018

*. The mean difference is significant at the 0.05 level.



Post Hoc Tests

Multiple Comparisons

LSD

Dependent Variable	(I) Group1	(J) Group1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
irconiacoffee	Control	Variolink	-.02000	.24028	.935	-.5435	.5035
		Nexus	.36000	.24028	.160	-.1635	.8835
	Variolink	Control	.02000	.24028	.935	-.5035	.5435
		Nexus	.38000	.24028	.140	-.1435	.9035
	Nexus	Control	-.36000	.24028	.160	-.8835	.1635
		Variolink	-.38000	.24028	.140	-.9035	.1435
irconiatea	Control	Variolink	-.28000	.36203	.454	-1.0688	.5088
		Nexus	-.56000	.36203	.148	-1.3488	.2288
	Variolink	Control	.28000	.36203	.454	-.5088	1.0688
		Nexus	-.28000	.36203	.454	-1.0688	.5088
	Nexus	Control	.56000	.36203	.148	-.2288	1.3488
		Variolink	.28000	.36203	.454	-.5088	1.0688
Emaxcoffee	Control	Variolink	.04000	.37683	.917	-.7810	.8610
		Nexus	-.28000	.37683	.472	-1.1010	.5410
	Variolink	Control	-.04000	.37683	.917	-.8610	.7810
		Nexus	-.32000	.37683	.412	-1.1410	.5010
	Nexus	Control	.28000	.37683	.472	-.5410	1.1010
		Variolink	.32000	.37683	.412	-.5010	1.1410
Emaxtea	Control	Variolink	.68000*	.29889	.042	.0288	1.3312
		Nexus	.46000	.29889	.150	-.1912	1.1112
	Variolink	Control	-.68000*	.29889	.042	-1.3312	-.0288
		Nexus	-.22000	.29889	.476	-.8712	.4312
	Nexus	Control	-.46000	.29889	.150	-1.1112	.1912
		Variolink	.22000	.29889	.476	-.4312	.8712

Gradiacoffee	Control	Variolink	1.90000*	.46145	.001	.8946	2.9054
		Nexus	2.42000*	.46145	.000	1.4146	3.4254
	Variolink	Control	-1.90000*	.46145	.001	-2.9054	-.8946
		Nexus	.52000	.46145	.282	-.4854	1.5254
	Nexus	Control	-2.42000*	.46145	.000	-3.4254	-1.4146
		Variolink	-.52000	.46145	.282	-1.5254	.4854
Gradiatea	Control	Variolink	-.06000	.34117	.863	-.8034	.6834
		Nexus	-.66000	.34117	.077	-1.4034	.0834
	Variolink	Control	.06000	.34117	.863	-.6834	.8034
		Nexus	-.60000	.34117	.104	-1.3434	.1434
	Nexus	Control	.66000	.34117	.077	-.0834	1.4034
		Variolink	.60000	.34117	.104	-.1434	1.3434

*. The mean difference is significant at the 0.05 level.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Control	Between Groups	2.361	2	1.180	15.403	.000
	Within Groups	2.069	27	.077		
	Total	4.430	29			
CAT	Between Groups	31.841	2	15.920	79.690	.000
	Within Groups	5.394	27	.200		
	Total	37.235	29			

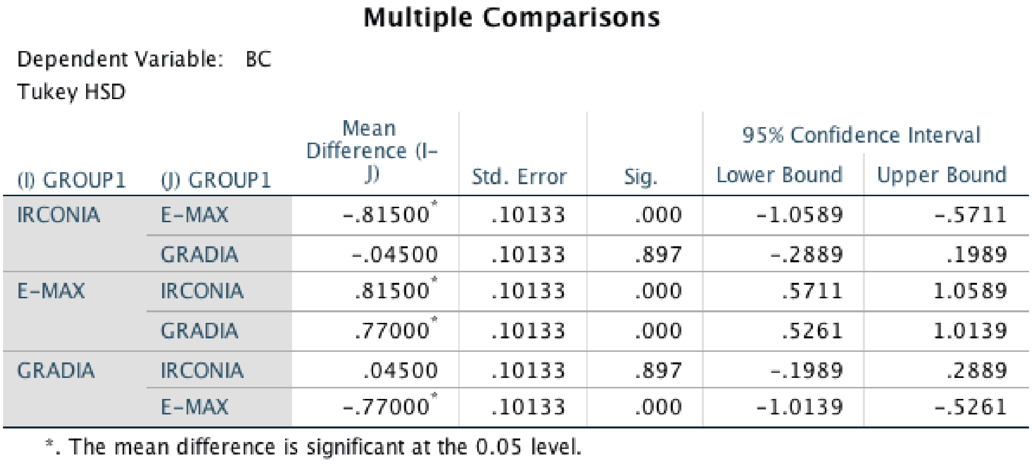
Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Control	irconia	E-max	-.60000*	.12380	.000	-.9069	-.2931
		Gradia	-.59000*	.12380	.000	-.8969	-.2831
	E-max	irconia	.60000*	.12380	.000	.2931	.9069
		Gradia	.01000	.12380	.996	-.2969	.3169
	Gradia	irconia	.59000*	.12380	.000	.2831	.8969
		E-max	-.01000	.12380	.996	-.3169	.2969
CAT	irconia	E-max	-2.16000*	.19989	.000	-2.6556	-1.6644
		Gradia	.05000	.19989	.966	-.4456	.5456
	E-max	irconia	2.16000*	.19989	.000	1.6644	2.6556
		Gradia	2.21000*	.19989	.000	1.7144	2.7056
	Gradia	irconia	-.05000	.19989	.966	-.5456	.4456
		E-max	-2.21000*	.19989	.000	-2.7056	-1.7144

*. The mean difference is significant at the 0.05 level.



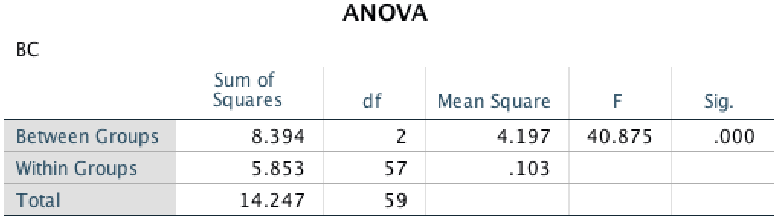
Multiple Comparisons

Dependent Variable: BC
Tukey HSD

(I) GROUP1	(J) GROUP1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
IRCONIA	E-MAX	-.81500*	.10133	.000	-1.0589	-.5711
	GRADIA	-.04500	.10133	.897	-.2889	.1989
E-MAX	IRCONIA	.81500*	.10133	.000	.5711	1.0589
	GRADIA	.77000*	.10133	.000	.5261	1.0139
GRADIA	IRCONIA	.04500	.10133	.897	-.1989	.2889
	E-MAX	-.77000*	.10133	.000	-1.0139	-.5261

*. The mean difference is significant at the 0.05 level.

Oneway

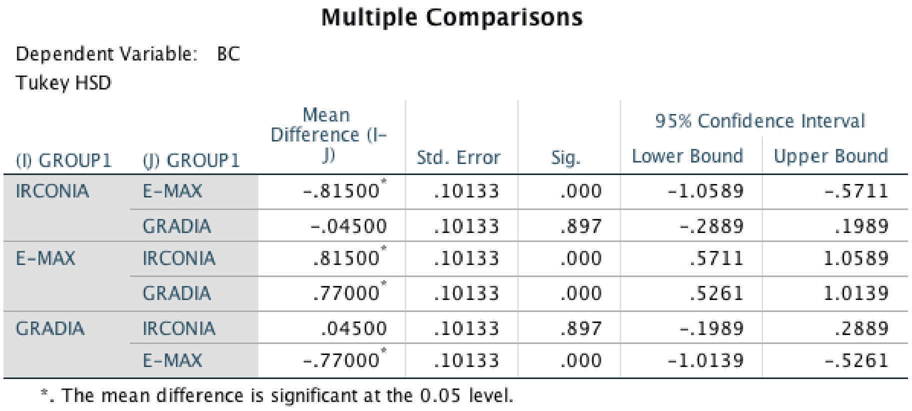


ANOVA

BC

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.394	2	4.197	40.875	.000
Within Groups	5.853	57	.103		
Total	14.247	59			

Post Hoc Tests

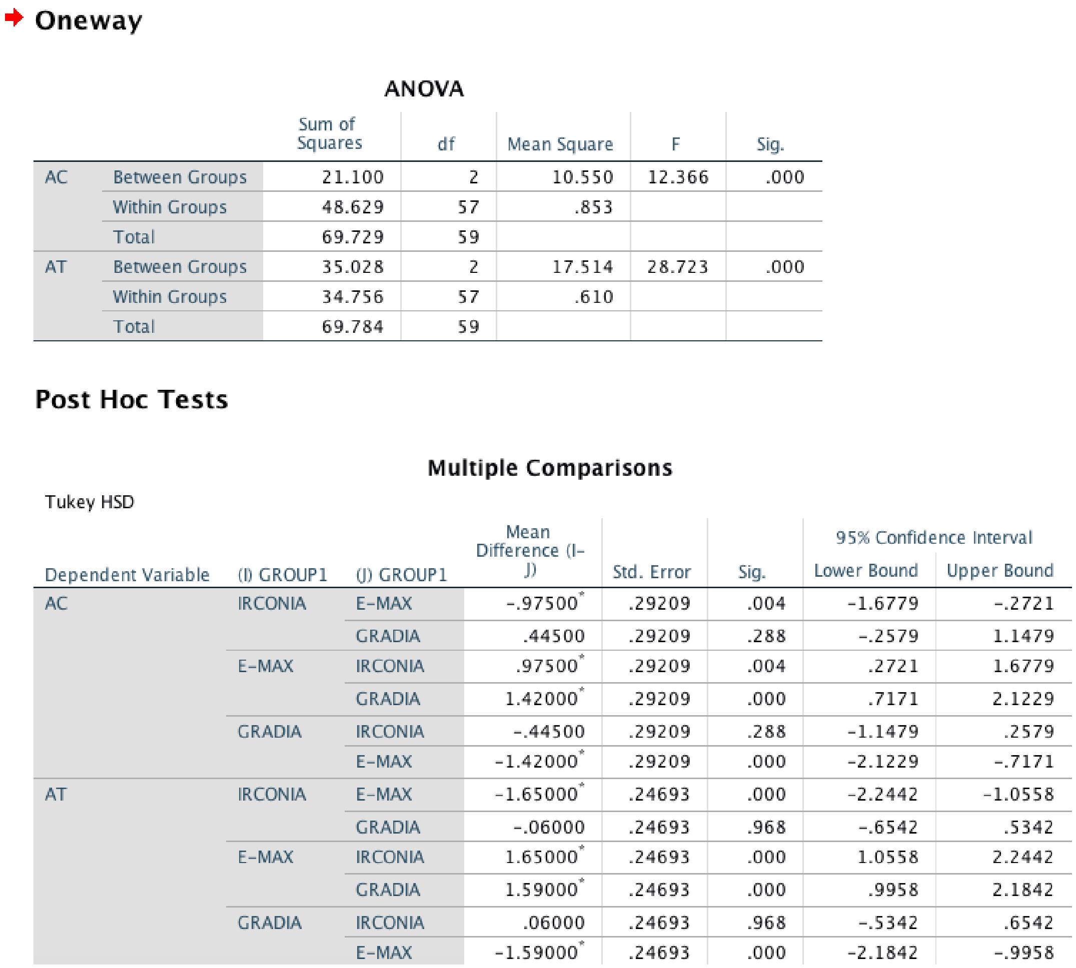


Multiple Comparisons

Dependent Variable: BC
Tukey HSD

(I) GROUP1	(J) GROUP1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
IRCONIA	E-MAX	-.81500*	.10133	.000	-1.0589	-.5711
	GRADIA	-.04500	.10133	.897	-.2889	.1989
E-MAX	IRCONIA	.81500*	.10133	.000	.5711	1.0589
	GRADIA	.77000*	.10133	.000	.5261	1.0139
GRADIA	IRCONIA	.04500	.10133	.897	-.1989	.2889
	E-MAX	-.77000*	.10133	.000	-1.0139	-.5261

*. The mean difference is significant at the 0.05 level.



Oneway

ANOVA

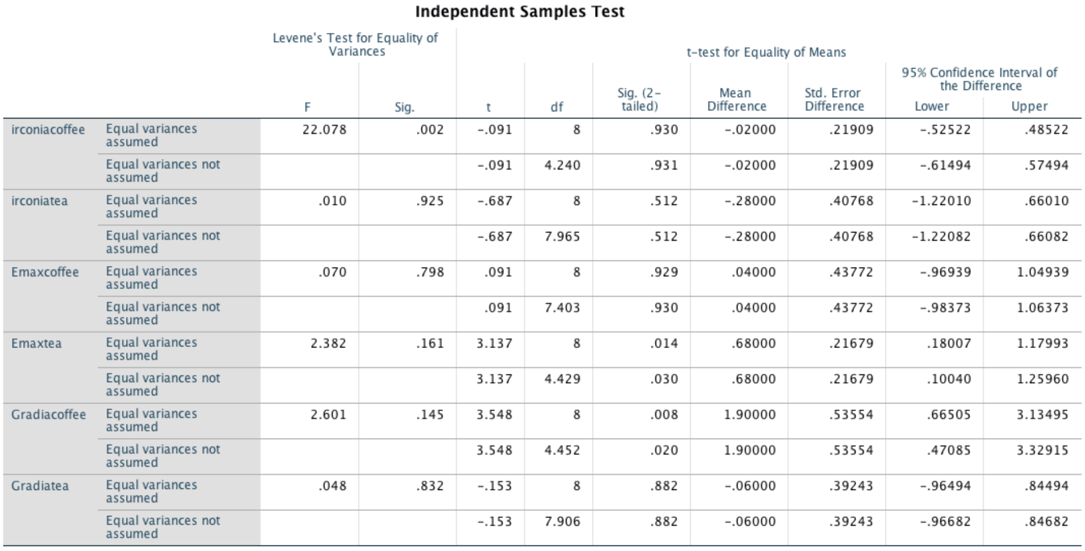
		Sum of Squares	df	Mean Square	F	Sig.
AC	Between Groups	21.100	2	10.550	12.366	.000
	Within Groups	48.629	57	.853		
	Total	69.729	59			
AT	Between Groups	35.028	2	17.514	28.723	.000
	Within Groups	34.756	57	.610		
	Total	69.784	59			

Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) GROUP1	(J) GROUP1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
AC	IRCONIA	E-MAX	-.97500*	.29209	.004	-1.6779	-.2721
		GRADIA	.44500	.29209	.288	-.2579	1.1479
	E-MAX	IRCONIA	.97500*	.29209	.004	.2721	1.6779
		GRADIA	1.42000*	.29209	.000	.7171	2.1229
	GRADIA	IRCONIA	-.44500	.29209	.288	-1.1479	.2579
		E-MAX	-1.42000*	.29209	.000	-2.1229	-.7171
AT	IRCONIA	E-MAX	-1.65000*	.24693	.000	-2.2442	-1.0558
		GRADIA	-.06000	.24693	.968	-.6542	.5342
	E-MAX	IRCONIA	1.65000*	.24693	.000	1.0558	2.2442
		GRADIA	1.59000*	.24693	.000	.9958	2.1842
	GRADIA	IRCONIA	.06000	.24693	.968	-.5342	.6542
		E-MAX	-1.59000*	.24693	.000	-2.1842	-.9958

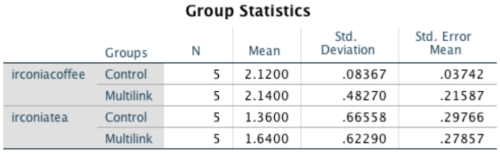


Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
irconiacoffee	Equal variances assumed	22.078	.002	-.091	8	.930	-.02000	.21909	-.52522	.48522
	Equal variances not assumed			-.091	4.240	.931	-.02000	.21909	-.61494	.57494
irconiatea	Equal variances assumed	.010	.925	-.687	8	.512	-.28000	.40768	-1.22010	.66010
	Equal variances not assumed			-.687	7.965	.512	-.28000	.40768	-1.22082	.66082
Emaxcoffee	Equal variances assumed	.070	.798	.091	8	.929	.04000	.43772	-.96939	1.04939
	Equal variances not assumed			.091	7.403	.930	.04000	.43772	-.98373	1.06373
Emaxtea	Equal variances assumed	2.382	.161	3.137	8	.014	.68000	.21679	.18007	1.17993
	Equal variances not assumed			3.137	4.429	.030	.68000	.21679	.10040	1.25960
Gradiacoffee	Equal variances assumed	2.601	.145	3.548	8	.008	1.90000	.53554	.66505	3.13495
	Equal variances not assumed			3.548	4.452	.020	1.90000	.53554	.47085	3.32915
Gradiatea	Equal variances assumed	.048	.832	-.153	8	.882	-.06000	.39243	-.96494	.84494
	Equal variances not assumed			-.153	7.906	.882	-.06000	.39243	-.96682	.84682

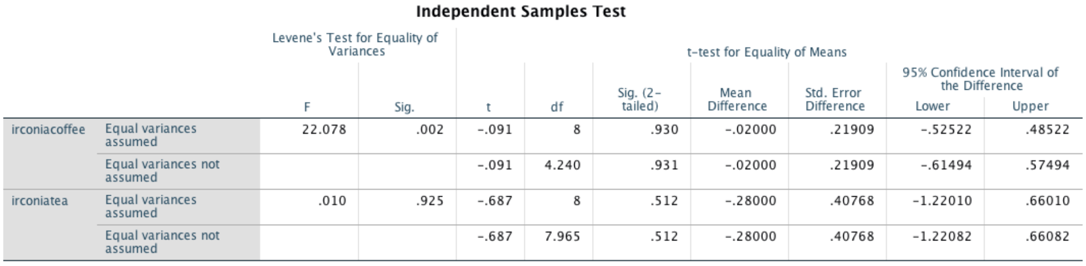
T-Test

`[DataSet0]`



Group Statistics

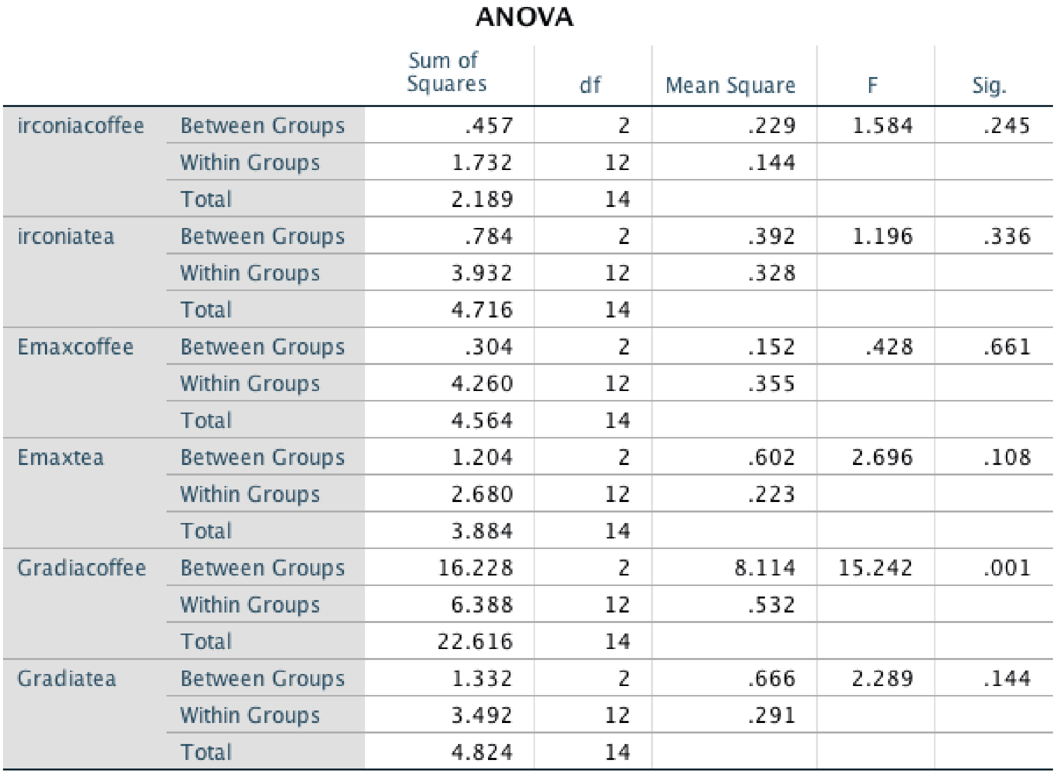
	Groups	N	Mean	Std. Deviation	Std. Error Mean
irconiacoffee	Control	5	2.1200	.08367	.03742
	Multilink	5	2.1400	.48270	.21587
irconiatea	Control	5	1.3600	.66558	.29766
	Multilink	5	1.6400	.62290	.27857



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
irconiacoffee	Equal variances assumed	22.078	.002	-.091	8	.930	-.02000	.21909	-.52522	.48522
	Equal variances not assumed			-.091	4.240	.931	-.02000	.21909	-.61494	.57494
irconiatea	Equal variances assumed	.010	.925	-.687	8	.512	-.28000	.40768	-1.22010	.66010
	Equal variances not assumed			-.687	7.965	.512	-.28000	.40768	-1.22082	.66082

Oneway



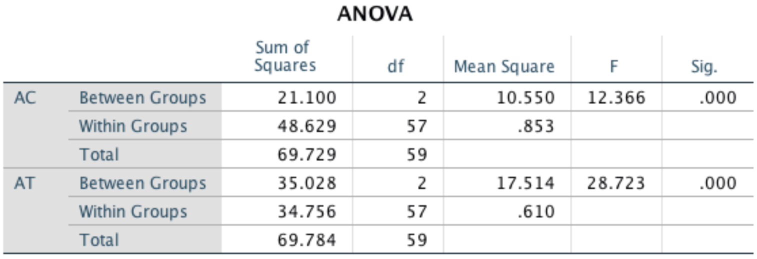
ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
irconiacoffee	Between Groups	.457	2	.229	1.584	.245
	Within Groups	1.732	12	.144		
	Total	2.189	14			
irconiatea	Between Groups	.784	2	.392	1.196	.336
	Within Groups	3.932	12	.328		
	Total	4.716	14			
Emaxcoffee	Between Groups	.304	2	.152	.428	.661
	Within Groups	4.260	12	.355		
	Total	4.564	14			
Emaxtea	Between Groups	1.204	2	.602	2.696	.108
	Within Groups	2.680	12	.223		
	Total	3.884	14			
Gradiacoffee	Between Groups	16.228	2	8.114	15.242	.001
	Within Groups	6.388	12	.532		
	Total	22.616	14			
Gradiatea	Between Groups	1.332	2	.666	2.289	.144
	Within Groups	3.492	12	.291		
	Total	4.824	14			

Multiple Comparisons

LSD

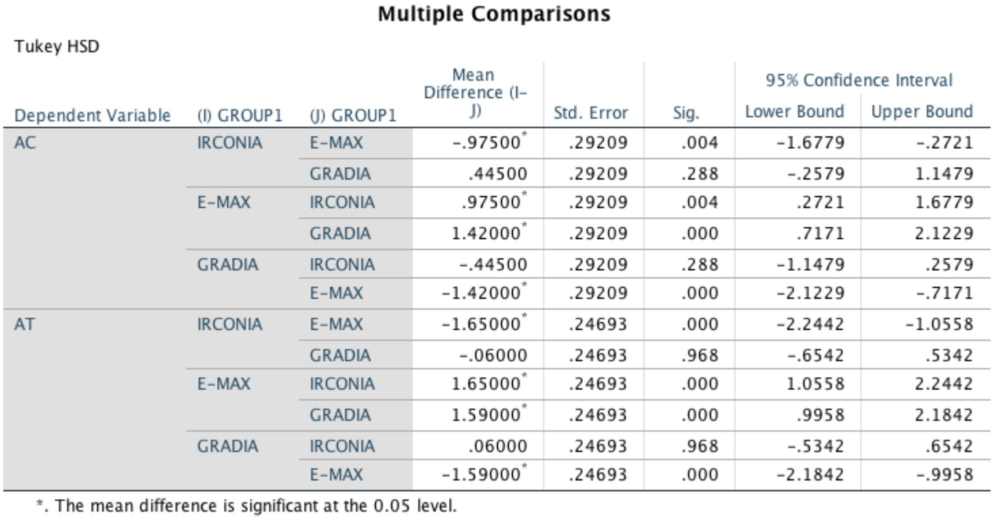
Dependent Variable	(I) Group1	(J) Group1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
irconiacoffee	Control	Variolink	-.02000	.24028	.935	-.5435	.5035
		Nexus	.36000	.24028	.160	-.1635	.8835
	Variolink	Control	.02000	.24028	.935	-.5035	.5435
		Nexus	.38000	.24028	.140	-.1435	.9035
	Nexus	Control	-.36000	.24028	.160	-.8835	.1635
		Variolink	-.38000	.24028	.140	-.9035	.1435
irconiatea	Control	Variolink	-.28000	.36203	.454	-1.0688	.5088
		Nexus	-.56000	.36203	.148	-1.3488	.2288
	Variolink	Control	.28000	.36203	.454	-.5088	1.0688
		Nexus	-.28000	.36203	.454	-1.0688	.5088
	Nexus	Control	.56000	.36203	.148	-.2288	1.3488
		Variolink	.28000	.36203	.454	-.5088	1.0688
Emaxcoffee	Control	Variolink	.04000	.37683	.917	-.7810	.8610
		Nexus	-.28000	.37683	.472	-1.1010	.5410
	Variolink	Control	-.04000	.37683	.917	-.8610	.7810
		Nexus	-.32000	.37683	.412	-1.1410	.5010
	Nexus	Control	.28000	.37683	.472	-.5410	1.1010
		Variolink	.32000	.37683	.412	-.5010	1.1410
Emaxtea	Control	Variolink	.68000*	.29889	.042	.0288	1.3312
		Nexus	.46000	.29889	.150	-.1912	1.1112
	Variolink	Control	-.68000*	.29889	.042	-1.3312	-.0288
		Nexus	-.22000	.29889	.476	-.8712	.4312
	Nexus	Control	-.46000	.29889	.150	-1.1112	.1912
		Variolink	.22000	.29889	.476	-.4312	.8712



ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
AC	Between Groups	21.100	2	10.550	12.366	.000
	Within Groups	48.629	57	.853		
	Total	69.729	59			
AT	Between Groups	35.028	2	17.514	28.723	.000
	Within Groups	34.756	57	.610		
	Total	69.784	59			

Post Hoc Tests

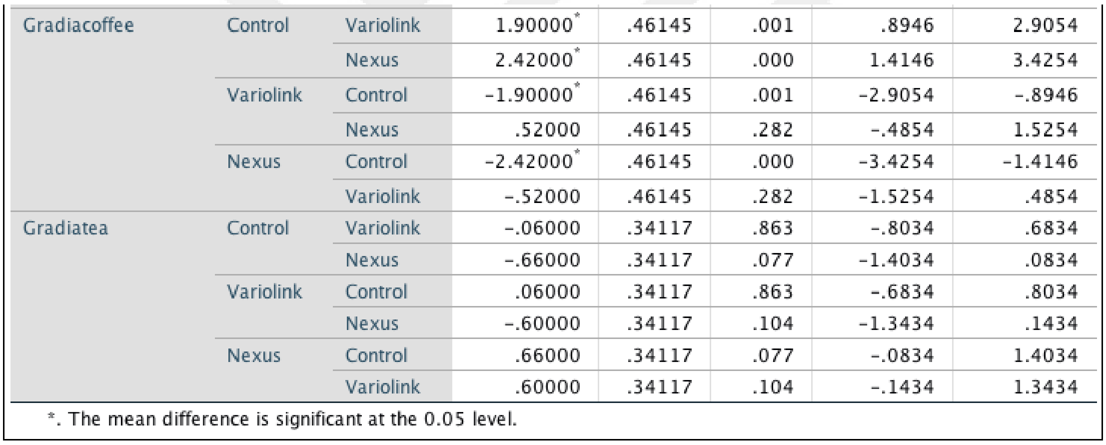


Multiple Comparisons

Tukey HSD

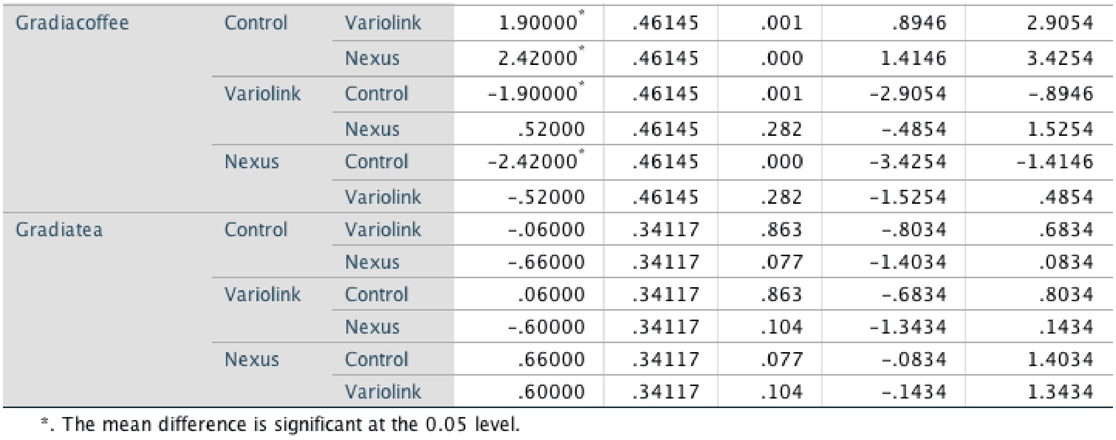
Dependent Variable	(I) GROUP1	(J) GROUP1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
AC	IRCONIA	E-MAX	-.97500*	.29209	.004	-1.6779	-.2721
		GRADIA	.44500	.29209	.288	-.2579	1.1479
	E-MAX	IRCONIA	.97500*	.29209	.004	.2721	1.6779
		GRADIA	1.42000*	.29209	.000	.7171	2.1229
	GRADIA	IRCONIA	-.44500	.29209	.288	-1.1479	.2579
		E-MAX	-1.42000*	.29209	.000	-2.1229	-.7171
AT	IRCONIA	E-MAX	-1.65000*	.24693	.000	-2.2442	-1.0558
		GRADIA	-.06000	.24693	.968	-.6542	.5342
	E-MAX	IRCONIA	1.65000*	.24693	.000	1.0558	2.2442
		GRADIA	1.59000*	.24693	.000	.9958	2.1842
	GRADIA	IRCONIA	.06000	.24693	.968	-.5342	.6542
		E-MAX	-1.59000*	.24693	.000	-2.1842	-.9958

*. The mean difference is significant at the 0.05 level.



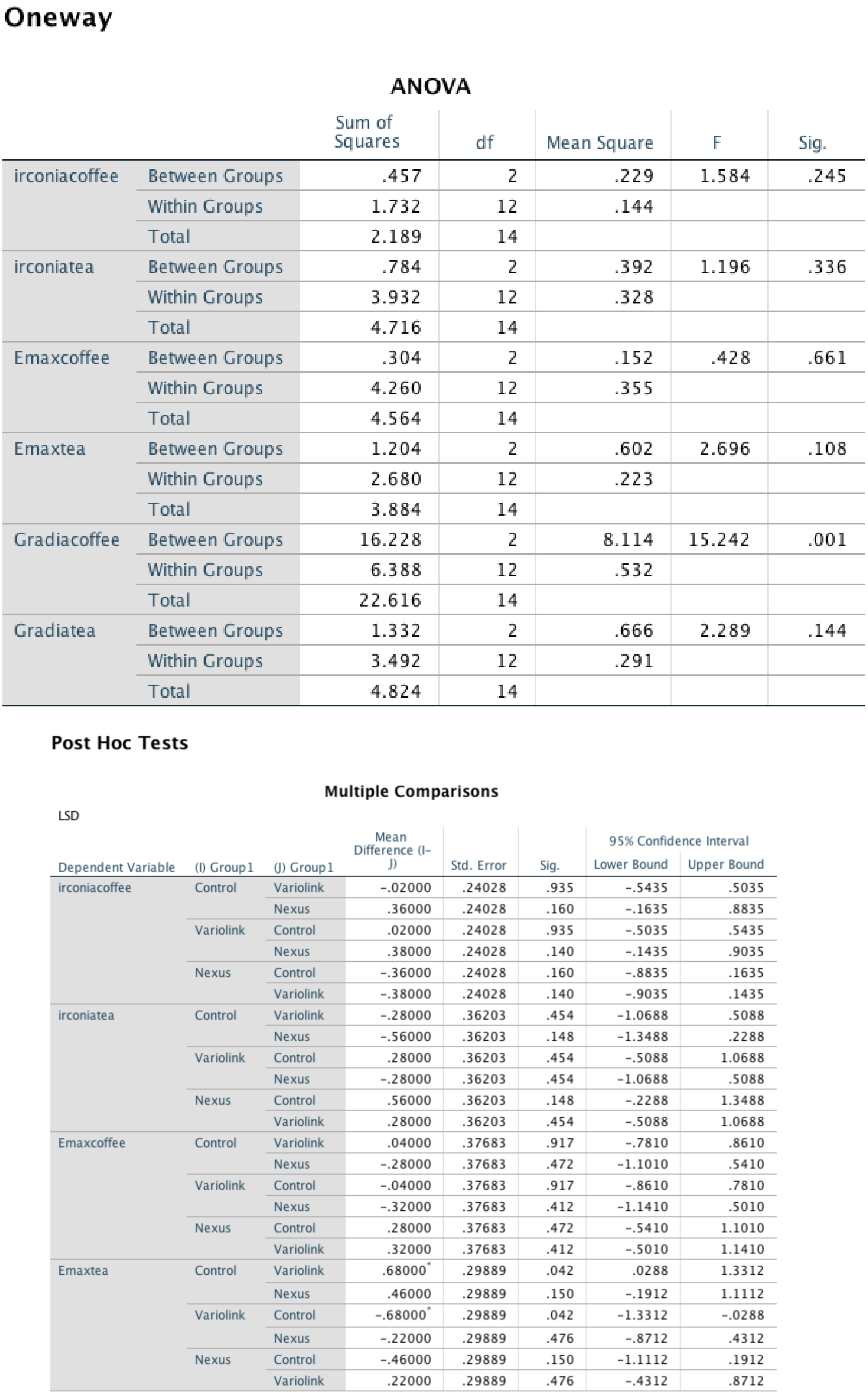
Gradiacoffee	Control	Variolink	1.90000*	.46145	.001	.8946	2.9054
		Nexus	2.42000*	.46145	.000	1.4146	3.4254
	Variolink	Control	-1.90000*	.46145	.001	-2.9054	-.8946
		Nexus	.52000	.46145	.282	-.4854	1.5254
	Nexus	Control	-2.42000*	.46145	.000	-3.4254	-1.4146
		Variolink	-.52000	.46145	.282	-1.5254	.4854
Gradiatea	Control	Variolink	-.06000	.34117	.863	-.8034	.6834
		Nexus	-.66000	.34117	.077	-1.4034	.0834
	Variolink	Control	.06000	.34117	.863	-.6834	.8034
		Nexus	-.60000	.34117	.104	-1.3434	.1434
	Nexus	Control	.66000	.34117	.077	-.0834	1.4034
		Variolink	.60000	.34117	.104	-.1434	1.3434

*. The mean difference is significant at the 0.05 level.



Gradiacoffee	Control	Variolink	1.90000*	.46145	.001	.8946	2.9054
		Nexus	2.42000*	.46145	.000	1.4146	3.4254
	Variolink	Control	-1.90000*	.46145	.001	-2.9054	-.8946
		Nexus	.52000	.46145	.282	-.4854	1.5254
	Nexus	Control	-2.42000*	.46145	.000	-3.4254	-1.4146
		Variolink	-.52000	.46145	.282	-1.5254	.4854
Gradiatea	Control	Variolink	-.06000	.34117	.863	-.8034	.6834
		Nexus	-.66000	.34117	.077	-1.4034	.0834
	Variolink	Control	.06000	.34117	.863	-.6834	.8034
		Nexus	-.60000	.34117	.104	-1.3434	.1434
	Nexus	Control	.66000	.34117	.077	-.0834	1.4034
		Variolink	.60000	.34117	.104	-.1434	1.3434

*. The mean difference is significant at the 0.05 level.



Oneway

ANOVA

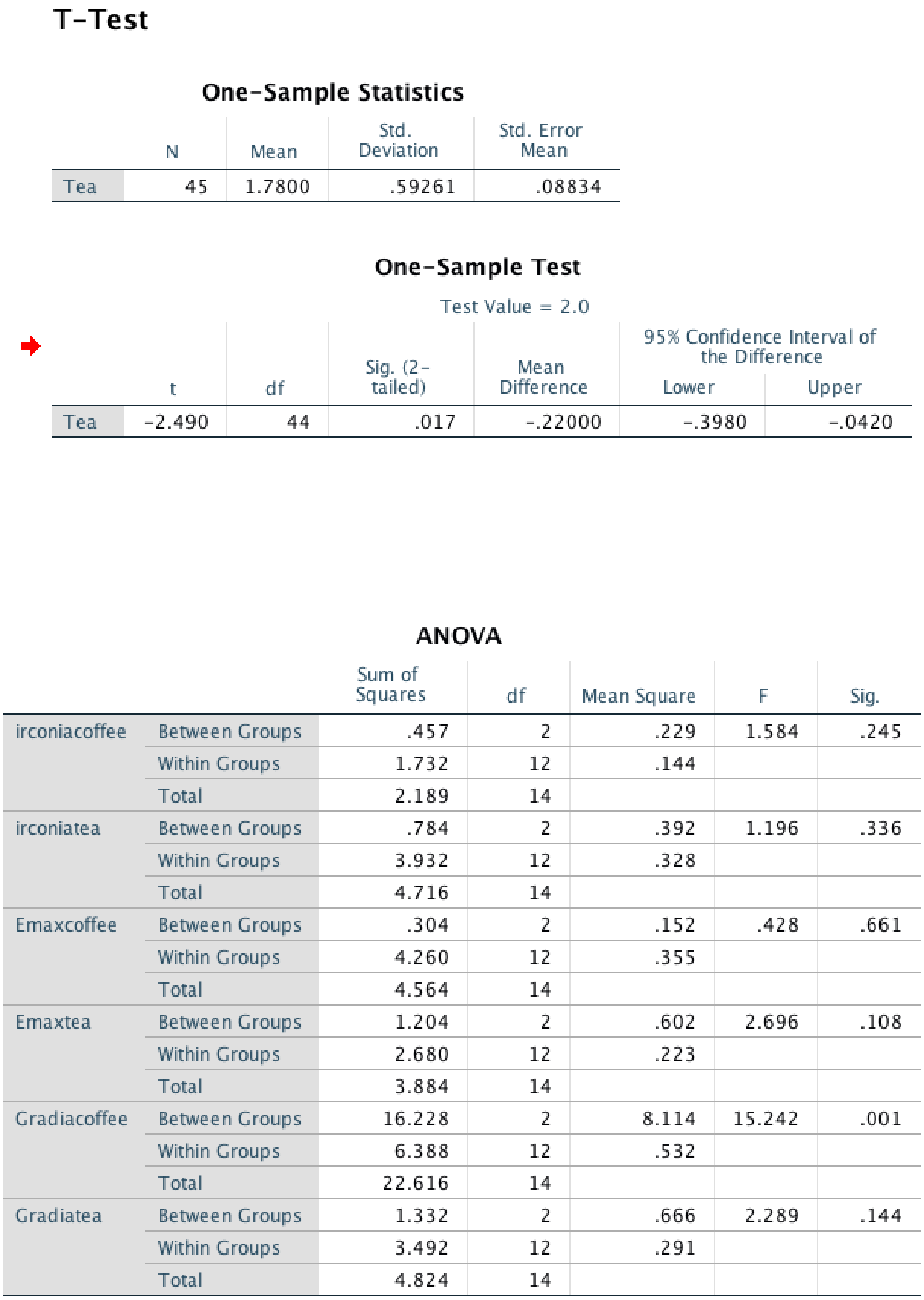
		Sum of Squares	df	Mean Square	F	Sig.
irconiacoffee	Between Groups	.457	2	.229	1.584	.245
	Within Groups	1.732	12	.144		
	Total	2.189	14			
irconiatea	Between Groups	.784	2	.392	1.196	.336
	Within Groups	3.932	12	.328		
	Total	4.716	14			
Emaxcoffee	Between Groups	.304	2	.152	.428	.661
	Within Groups	4.260	12	.355		
	Total	4.564	14			
Emaxtea	Between Groups	1.204	2	.602	2.696	.108
	Within Groups	2.680	12	.223		
	Total	3.884	14			
Gradiacoffee	Between Groups	16.228	2	8.114	15.242	.001
	Within Groups	6.388	12	.532		
	Total	22.616	14			
Gradiatea	Between Groups	1.332	2	.666	2.289	.144
	Within Groups	3.492	12	.291		
	Total	4.824	14			

Post Hoc Tests

Multiple Comparisons

LSD

Dependent Variable	(I) Group1	(J) Group1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
irconiacoffee	Control	Variolink	-.02000	.24028	.935	-.5435	.5035
		Nexus	.36000	.24028	.160	-.1635	.8835
	Variolink	Control	.02000	.24028	.935	-.5035	.5435
		Nexus	.38000	.24028	.140	-.1435	.9035
	Nexus	Control	-.36000	.24028	.160	-.8835	.1635
		Variolink	-.38000	.24028	.140	-.9035	.1435
irconiatea	Control	Variolink	-.28000	.36203	.454	-1.0688	.5088
		Nexus	-.56000	.36203	.148	-1.3488	.2288
	Variolink	Control	.28000	.36203	.454	-.5088	1.0688
		Nexus	-.28000	.36203	.454	-1.0688	.5088
	Nexus	Control	.56000	.36203	.148	-.2288	1.3488
		Variolink	.28000	.36203	.454	-.5088	1.0688
Emaxcoffee	Control	Variolink	.04000	.37683	.917	-.7810	.8610
		Nexus	-.28000	.37683	.472	-1.1010	.5410
	Variolink	Control	-.04000	.37683	.917	-.8610	.7810
		Nexus	-.32000	.37683	.412	-1.1410	.5010
	Nexus	Control	.28000	.37683	.472	-.5410	1.1010
		Variolink	.32000	.37683	.412	-.5010	1.1410
Emaxtea	Control	Variolink	.68000*	.29889	.042	.0288	1.3312
		Nexus	.46000	.29889	.150	-.1912	1.1112
	Variolink	Control	-.68000*	.29889	.042	-1.3312	-.0288
		Nexus	-.22000	.29889	.476	-.8712	.4312
	Nexus	Control	-.46000	.29889	.150	-1.1112	.1912
		Variolink	.22000	.29889	.476	-.4312	.8712



T-Test

One-Sample Statistics

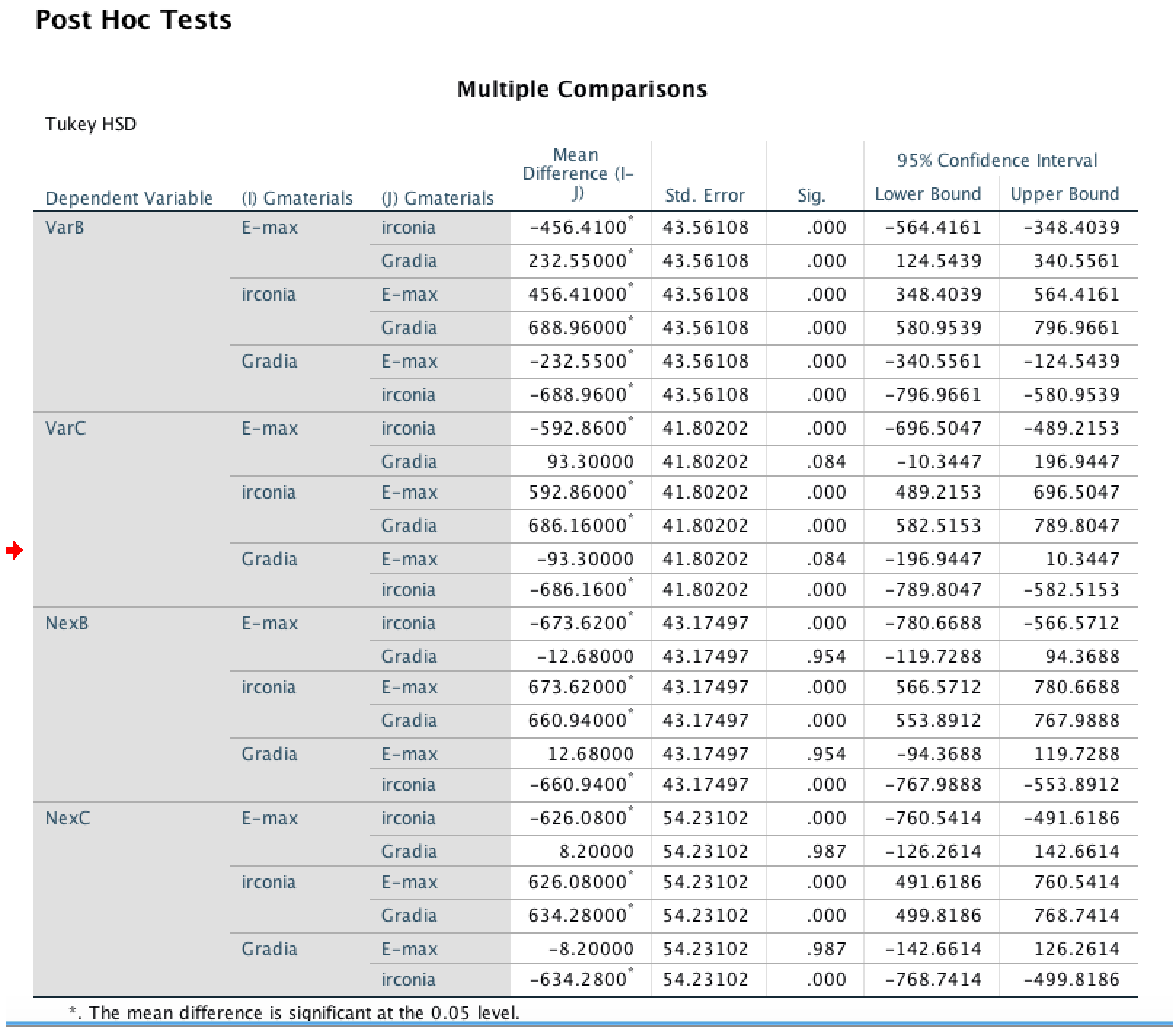
	N	Mean	Std. Deviation	Std. Error Mean
Tea	45	1.7800	.59261	.08834

One-Sample Test

	Test Value = 2.0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Tea	-2.490	44	.017	-.22000	-.3980	-.0420

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
irconiacoffee	Between Groups	.457	2	.229	1.584	.245
	Within Groups	1.732	12	.144		
	Total	2.189	14			
irconiatea	Between Groups	.784	2	.392	1.196	.336
	Within Groups	3.932	12	.328		
	Total	4.716	14			
Emaxcoffee	Between Groups	.304	2	.152	.428	.661
	Within Groups	4.260	12	.355		
	Total	4.564	14			
Emaxtea	Between Groups	1.204	2	.602	2.696	.108
	Within Groups	2.680	12	.223		
	Total	3.884	14			
Gradiacoffee	Between Groups	16.228	2	8.114	15.242	.001
	Within Groups	6.388	12	.532		
	Total	22.616	14			
Gradiatea	Between Groups	1.332	2	.666	2.289	.144
	Within Groups	3.492	12	.291		
	Total	4.824	14			



Post Hoc Tests

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Gmaterials	(J) Gmaterials	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
VarB	E-max	irconia	-456.4100*	43.56108	.000	-564.4161	-348.4039
		Gradia	232.55000*	43.56108	.000	124.5439	340.5561
	irconia	E-max	456.41000*	43.56108	.000	348.4039	564.4161
		Gradia	688.96000*	43.56108	.000	580.9539	796.9661
	Gradia	E-max	-232.5500*	43.56108	.000	-340.5561	-124.5439
		irconia	-688.9600*	43.56108	.000	-796.9661	-580.9539
VarC	E-max	irconia	-592.8600*	41.80202	.000	-696.5047	-489.2153
		Gradia	93.30000	41.80202	.084	-10.3447	196.9447
	irconia	E-max	592.86000*	41.80202	.000	489.2153	696.5047
		Gradia	686.16000*	41.80202	.000	582.5153	789.8047
	Gradia	E-max	-93.30000	41.80202	.084	-196.9447	10.3447
		irconia	-686.1600*	41.80202	.000	-789.8047	-582.5153
NexB	E-max	irconia	-673.6200*	43.17497	.000	-780.6688	-566.5712
		Gradia	-12.68000	43.17497	.954	-119.7288	94.3688
	irconia	E-max	673.62000*	43.17497	.000	566.5712	780.6688
		Gradia	660.94000*	43.17497	.000	553.8912	767.9888
	Gradia	E-max	12.68000	43.17497	.954	-94.3688	119.7288
		irconia	-660.9400*	43.17497	.000	-767.9888	-553.8912
NexC	E-max	irconia	-626.0800*	54.23102	.000	-760.5414	-491.6186
		Gradia	8.20000	54.23102	.987	-126.2614	142.6614
	irconia	E-max	626.08000*	54.23102	.000	491.6186	760.5414
		Gradia	634.28000*	54.23102	.000	499.8186	768.7414
	Gradia	E-max	-8.20000	54.23102	.987	-142.6614	126.2614
		irconia	-634.2800*	54.23102	.000	-768.7414	-499.8186

*. The mean difference is significant at the 0.05 level.

CURRICULUM VITAE

Name	Mohammed	**Surname**	Badwan
Place of Birth	Makkah	**Date of Birth**	26/12/1986
Nationality	Palestinian	**Tel**	05319291295
E-mail	dr.m.badwan@gmail.com		

Educational Level

	Name of the Institution where he/she was graduated	**Graduation year**
Postgraduate/Specialization		
Masters		
Undergraduate	PHAROS University	2012
High school	Hussain Bin Ali	2003

Job Experience

	Duty	**Institution**	**Duration (Year - Year)**
	Dentist	Raas Alteen General Hospital	January 2014- August 2014
	Dentist	Medical Research Institute (MRI), Alexandria	July 2013- January2014
	Dentist	El Raml Children Hospital	February 2013- July2013

Foreign Languages	**Reading comprehension**	**Speaking***	**Writing***
Arabic	Good	Fluent	Good
Turkish	Good	Good	Good
English	Good	Fluent	Good

Foreign Language Examination Grade#								
YDS	ÜDS	IELTS	TOEFL IBT	TOEFL PBT	TOEFL CBT	FCE	CAE	CPE

	Math	**Equally weighted**	**Non-math**
ALES Grade			
(Other) Grade			

Computer Knowledge

Program	**Use proficiency**
Excel, Word, power Point, SPSS	Very good

*Evaluate as very good, good, moderate, poor.