T.C.
YEDITEPE UNIVERSITY
INSTITUTE OF HEALTH SCIENCES
DEPARTMENT OF PROSTHETIC DENTISTRY

COMPERISON OF
LIGHT TRANSMITTANCE
OF CAD/CAM CERAMIC BLOCKS
REINFORCED WITH DIFFERENT FILLERS

DOCTOR OF PHILOSOPHY THESIS

Mahmut ALOLO, DDS, PhD

İSTANBUL-2021

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DECLARATION

I hereby declare that this thesis is my own work and that to the best of my knowledge and belief it contains no material previously published or writtn by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

DATE
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LIST of SYMBOLS and ABBREVIATIONS

SiO_4 : Silisyum Tetraoxide

^0C : Celcius

MPa : Megapascal

CAD/CAM : Computer Aided Software / Computer Aided Manufacturing

HT : High Translucency

LT : Low Translucency

Ivoclar IPS Empress CAD : Empress CAD

Ivoclar IPS E.max CAD: E.max CAD

QTH : Kuartz-Tungsten Halogen

PAC : Plazma Arc

Nm : Nanometer

mW/cm^2 : Mili Watt / square centimeter

sn : Second

SEM : Scanning Electron Microscope

GC Initial LRF BLOCK : LRF Block

SiO_2 : Silisyum Dioxide

Li_2O : Lithium Oxide

K_2O : Potassium Oxide

P_2O_5 : Phosphorus Pentaoxide

ZrO_2 : Zirconium Dioxide

ZnO : Zinc Oxide

Al_2O_3 : Alumina

MgO : Magnesium Oxide

Na_2O : Sodium Oxide

CaO : Quicklime

BaO : Barium Oxide

CeO_2 : Cerium Oxide

CeF_3 : Cerium Fluoride

ABSTRACT

Alolo, M (2021) Comparison of Light Transmittance of CAD / CAM Ceramic Blocks Reinforced with Different Fillers. Yeditepe University, Institute of Health Sciences, Department of Prosthodontics, PhD Thesis, Istanbul.

In recent years, many new materials have been introduced to dentistry and new techniques have been developed. CAD / CAM technology is at the forefront of these innovations, and manufacturers are developing new ceramic materials with superior physical and aesthetic properties that can be used with CAD / CAM. The effects of light transmittance, which is one of the features that most affect the aesthetics of the materials, on the final restoration are frequently examined. In our study, We aimed to evaluate the light transmittance properties of samples of three different ceramic CAD / CAM materials with different translucency, thickness and color. For this reason, from E.max CAD (Ivoclar Vivadent, Schaan, Liechtenstein), Empress CAD (Ivoclar Vivadent, Schaan, Liechtenstein) and LRF Block (GC, Japan) materials, 1mm and 2mm from A1 and A3 blocks with high translucency and low translucency properties The samples in thicknesses were cut with a precision cutting device and polished with 600, 800 and 1200 grit sanders with a sanding machine. Following the sanding process, E.max CAD samples were sintered for crystallization according to the manufacturer's instructions. After all samples were subjected to glazing, one surface of the samples was treated with hydrofluoric acid in accordance with the manufacturer's instructions and made ready for the light transmission test.

In the study, the light transmittance measurements of the samples were made using the LED Radiometer device (SDI (Victoria, Australia), and the Bluephase N (Ivoclar Vivadent, Schaan, Liechtenstein) LED light device. SEM images were taken to examine the surface differences in the samples. In the evaluation of the data, one-way analysis of variance was used for the comparison of variables with normal distribution, the Tukey multiple comparison test was used for subgroup comparisons, and the independent t test was used for the comparison of paired groups. Results, significance $p < 0,05$. When the results of our study are evaluated, for all material groups, A1 color samples compared to A3 color samples, 1mm thick samples compared to 2mm thick samples and high translucency samples It has been shown to have higher light transmittance than translucent samples (p=0,0001). No difference was found between E.max CAD and LRF block materials in both 1mm and 2mm thick samples in high translucency block groups in A1 and A3 color (p=0,623) (p=0,160), but lower values were obtained than Empress CAD material (p=0,0001). No significant difference was found between Empress CAD and LRF block samples in 1mm and 2mm thick samples in low translucency block groups in A1 color (p=0,717) (p=0,962), and higher values were observed than E.max CAD samples (p=0,0001). No significant difference was observed between E.max CAD and Empress CAD samples in the low translucency block groups in A3 color and in samples with both 1mm and 2mm thickness (p=0,356) (p=0,695), but lower light transmittance values were measured than the LRF block samples (p=0,0001).

Keywords: CAD / CAM blocks, color, thickness, light transmittance, radiometer

ÖZET

Alolo, M (2021) Farklı Doldurucular İle Güçlendirilmiş CAD/CAM Seramik Bloklarının Işık Geçirgenliklerinin Karşılaştırılması. Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Protetik Diş Tedavisi Anabilim Dalı, Doktora Tezi, İstanbul.

Son yıllarda diş hekimliğine bir çok yeni materyal sunulmuş ve yeni teknikler geliştirilmiştir. CAD/CAM teknolojisi bu yeniliklerin başında gelmektedir ve üreticiler CAD/CAM ile kullanılabilen yeni ve üstün fiziksel ve estetik özelliklere sahip seramik materyaller geliştirmektedir. Materyallerin estetiği en çok etkileyen özelliklerinden biri olan ışık geçirgenliğinin final restorasyona olan etkileri sıklıkla incelenmektedir. Çalışmamızda amaç üç farklı seramik CAD/CAM materyalinin farklı yarı saydamlık ve kalınlık ve renkteki örneklerinin ışık geçirgenliği özelliğini değerlendirmektir. Bu sebeple E.max CAD (Ivoclar Vivadent, Schaan, Liechtenstein), Empress CAD (Ivoclar Vivadent, Schaan, Liechtenstein) ve LRF Blok (GC, Japan) materyallerinden yüksek yarı saydamlık ve düşük yarı saydamlık özelliklerine sahip A1 ve A3 bloklardan 1mm ve 2mm kalınlıklarda örnekler hassas kesme cihazı ile kesilmiş ve zımpara makinası ile 600, 800 ve 1200 gritlik zımparalar ile cilalandı. Zımpara işlemini takiben E.max CAD örnekler üretici firmaların talimatları doğrultusunda kristalizasyon için fırınlandı. Tüm örnekler glaze işlemine tabi tutulduktan sonra örneklerin bir yüzeyi hidroflorik asitle üretici talimatlarına uygun şekilde muamele edildi ve ışık geçirgenliği deneyine hazır hale getirildi.

Çalışmada örneklerin ışık geçirgenliği ölçümleri LED Radiometre cihazı (SDI (Victoria, Australia) ile, Bluephase N (Ivoclar Vivadent, Schaan, Liechtenstein) LED ışık cihazı kullanılarak yapıldı. Ölçüm esnasında koşulları standardize edebilmek için radyometre ölçüm yüzeyine silikon bir kalıp yerleştirildi ve ışık verilmesi bu silikon kalıp yardımıyla yapıldı. Örneklerdeki yüzey farklılıklarını incelenmesi için SEM görüntüleri alındı. Verilerin değerlendirilmesinde normal dağılım gösteren değişkenlerin gruplar arası karşılaştırmalarında tek yönlü varyans analizi, alt grup karşılaştırmalarında Tukey çoklu karşılaştırma testi, ikili grupların karşılaştırmasında bağımsız t testi kullanıldı. Sonuçlar, anlamlılık $p<0,05$ düzeyinde değerlendirildi. Çalışmamızın sonuçları değerlendirildiğinde tüm materyal grupları için A1 renkteki örneklerin A3 renkteki örneklere göre, 1mm kalınlıktaki örneklerin 2mm kalınlıktaki örneklere göre ve yüksek yarı saydamlıktaki örneklerin düşük yarı saydamlıktaki örneklere göre daha yüksek ışık geçirgenliğine sahip olduğu saptandı (p=0,0001). A1 ve A3 renkte yüksek yarı saydamlıktaki blok gruplarında hem 1mm hem 2mm kalınlıktaki örneklerde E.max CAD ve LRF blok materyalleri arasında istatistiksel olarak fark bulunamadı (p=0,623) (p=0,160) ancak Empress CAD materyalinden istatistiksel olarak daha düşük değerler elde edildi (p=0,0001). A1 renkte düşük yarı saydamlıktaki blok gruplarında hem 1mm hem de 2mm kalınlıktaki örneklerde ise Empress CAD ve LRF blok örnekler değerleri arasında istatistiksel olarak anlamlı fark bulunamadı (p=0,717) (p=0,962), ve E.max CAD örneklerinden istatistiksel olarak daha yüksek değerler gözlendi(p=0,0001). A3 renkte düşük yarı saydamlıktaki blok gruplarında hem 1mm hem de 2mm kalınlıktaki örneklerde ise E.max CAD ve Empress CAD örnekleri arasında anlamlı farklılık saptanmadı (p=0,356) (p=0,695), ancak LRF blok örneklerinden istatistiksel olarak daha düşük ışık geçirgenliği değerleri ölçüldü(p=0,0001).

Anahtar Kelimeler: CAD/CAM bloklar, renk, kalınlık, ışık geçirgenliği, radyometre

1. INTRODUCTION AND PURPOSE

The increasing use of social media applications and photo sharing sites in recent years has caused all people to evaluate the aesthetics of their smiles and to have higher aesthetic expectations (1). For this reason, metal ceramics, which have been used safely for years but are less aesthetically pleasing and cause gray reflections in the gingival area, have begun to leave their places to full-ceramic restorations (2). The fact that ceramic materials are frequently preferred has led researchers and material producers to work in this direction and has often led to the introduction of new materials.

Dental ceramics are materials that show the closest properties to the optical properties of dental tissue, thanks to their content (2,3). This allows restorations to be made very close to nature by imitating the appearance of the tooth. Ceramics are materials that have proven their success in the mouth for many years, not only with their optical properties but also with their physical and mechanical properties (3,4).

In the century we live in, technological developments are at a level that will affect daily life and lifestyle. Dentistry is also affected by this, and new techniques and methods are developed and put into use almost every day. The most important of these can be stated as CAD / CAM technology. The advantages of CAD / CAM systems are that traditional impression methods offer the opportunity to get away from human errors, eliminate the discomfort of traditional impressions in some patients, enable rapid digital production of models by skipping many laboratory stages, and enable the production of restorations within a few hours (5,6) .

Material manufacturers produce new materials that work in harmony with these new systems and meet the ever-increasing aesthetic expectation of both patients and dentists, at the same time with high clinical success, or try to develop materials that have been put on the market.

The light transmittance feature of dental ceramics is one of their optical properties and affects the aesthetic criteria and the polymerization amount of the cement between the tooth and the tooth. These effects significantly alter the clinical success of the ceramic restoration. The light transmittance of the dental ceramic material is affected by many factors. In our study, we aimed to evaluate the light transmittance properties of three different CAD / CAM materials, including the newly introduced material, of which there is not much work, in different translucency, thickness and color. Thus, we wanted to evaluate the factors that may affect the success of the material in clinical use.

Our null hypotheses that we have formed in our study are as follows.

H_0: There is no difference in light transmittance of CAD / CAM ceramic blocks reinforced with different fillers (leucite-lithium disilicate).

H_1CAD / CAM ceramic blocks reinforced with different fillers (leucite-lithium disilicate) differ in their light transmittance.

H_0: There is no difference in light transmittance between ceramic block groups with different thicknesses (1mm-2mm).

H_1: There is a difference in light transmittance between ceramic block groups with different thicknesses (1mm-2mm).

H_0: There is no difference in light transmittance between ceramic block groups with different translucency values (HT-LT).

H_1: There is a difference in light transmittance between ceramic block groups with different translucency values (HT-LT).

H_0: There is no difference in light transmittance between ceramic block groups of different colors (A1-A3).

H_1: There is a difference in light transmittance between ceramic block groups of different colors (A1-A3).

2. LITARETURE REVIEW

2.1 Dental Ceramics

2.1.1 History of Dental Ceramics

The word ceramic takes its origin from the Greek word "keramos - keramikos" and has a meaning made from soil. The discovery of ceramic objects made of clay, thought to date back to 2300 BC in the Czech Republic, shows that starting from that period, people processed and used materials such as sand and clay with the help of heat (7). The term ceramic is a very broad term and includes many subgroups. The word porcelain originates from the Italian word "porcelanne" and means sea shell. The term "dental porcelains" is used to mean ceramics with different crystal particles in the glass matrix (8,9).

Ionic and covalent bonds exist together in ceramics. While these strong bonds add properties such as hardness, resistance to factors and stability, they also cause fragility. Dental ceramics are formed by sintering, that is, by the melting of particles by heat, in other words, they are a glass matrix that contains many different crystals that have not completely passed into the glass phase (10,11).

The idea of using ceramics in the field of dentistry was first expressed by Pierre Fauchard in a book he wrote in 1728 (12). Fonzi, an Italian dentist, was the first to produce custom porcelain teeth in 1808. However, the porcelains it produces are porous and fragile. In 1838, Elias Wildman regulated the color and translucency of porcelain using a vacuum oven (10,13). With the realization that ceramic is a real alternative for dental restorations, studies in the field have gained momentum. In 1925, Dr. The book "Ceramics in Dentistry" has been published by Le Gro. In 1949, German Gatz succeeded in reducing the porous structure by firing the porcelain with vacuum. In the 1950s, the number of expansion was increased with the addition of leucite to the porcelain content, thereby reducing the fragility (8,9). The idea of supporting ceramic restorations with metals emerged after the 1950s and studies aimed at increasing the connection between alloys gained weight (8,9).

Despite all the advances, dental ceramics did not gain popularity until alumina was added to its content. The alumina crystals, which form the basis of all ceramics, which are one of the most frequently used porcelain systems today, were added to the content by McLean and Hughes in 1965, thus the mechanical properties of the ceramic were significantly increased and the first jacketed crowns were made in the same year (14-16). In the 1980s, with the introduction of ceramic crowns with low shrinkage rate and glass ceramic material containing tetracyclic flormica in the market, more aesthetic results were obtained and full ceramic restorations became the focus of attention (17,18). For example, laminated veneer in today's sense was first made by Hart in 1983 with platinum foil method, and in 1985 Grossman, Hobb and Iwata produced laminated veneers from pourable apatite (19). Research into the development of dental ceramics has focused on both the aesthetic and microstructural properties of the material. The increasing interest and desire for aesthetic restorations in today's society enables the studies on ceramics to continue (10,19,20).

2.1.2 Structure of Dental Ceramics

Dental ceramic is an organic compound made by one or more metal / semi-metals with a non-metal element such as oxygen (10,21-23).

The ceramic used in dentistry consists of silicon tetraoxide (SiO_4), which is formed by the chemical bond of the silicon atom in the center and the 4 oxygen atoms around it. Among its main binders, feldspar (75-85%), kaolin (3-5%), quartz (12-22%) can be counted (21-23).

Ceramics consist of crystalline and glassy phase, optical and mechanical properties depend on the structure and quantity of the crystalline phase. As a result of the more glass phase, a higher light transmission ceramic will be obtained, while the resistance will be less. Likewise, in the case of excessive crystallized phase, the aesthetic feature will be negatively affected (24).

2.1.2.1 Feldspar

It is the main material forming the glass phase and the component with the lowest melting temperature in the content. It is a natural mineral composed of two alkali aluminum silicates (potassium alumina silicate - sodium alumina silicate), but it is not found in pure form in nature. Melting temperature is between 1100-13000C. When heated, potassium causes the formation of a glassy phase with other components, which gives the material translucency. Sodium, on the other hand, reduces the melting temperature and allows to work at lower firing temperatures. There is feldspar between 75-85% in the structure of ceramics (11,20,22,23,25).

2.1.2.2 Quartz

It is in the form of quartz silica, which has a higher melting temperature (16850C) than other components, and acts as a filler in the ceramic. Thus, it contributes to the mechanical structure of the ceramic, reduces shrinkage and increases durability. However, as the ratio increases, it reduces the translucency and reduces the aesthetic properties. It is found in the structure of ceramics at a rate of 12-22% (25,26).

2.1.2.3 Kaolin

Kaolin, also known as china clay, is aluminum hydrosilicate and is a binder between components. It allows the ceramic to be shaped easily before it is baked. At the same time, it is added in limited amounts, between 1-5%, as it increases the opacity in the ceramic (25,26).

2.1.2.4 Pigments

Nickel, iron, chromium, cobalt, metallic gold, brass, titanium can be counted among the various pigments used to color the ceramic. The fluorescence feature in the material is also given by these pigments (27).

2.1.2.5 Thickeners and Glass Modification Agents

The thickeners and glass modification agents required for shaping dental ceramics are potassium, sodium and calcium. These function by disrupting the integrity of the SiO4 network and reducing the melting temperature. In this way, the fluidity of the ceramic increases (25,28).

It is possible to produce ceramics with different melting temperatures, aesthetic and mechanical properties by changing their contents. Today, the most frequently used ceramics in laboratories are low temperature (850-10500C) ceramics (23,24).

Ceramics are materials with low thermal and electrical conductivity, no voltage resistance (20-60 MPa), high compressive strength (350-550 MPa), and advanced optical properties. Thanks to the ionic and covalent bonds they contain, they are stable and insoluble (21,22)

2.2 General Classifications of Dental Ceramics

Classification of ceramics can be made according to many features (10,29).

According to their melting point (25):

- High temperature ceramics (1290-13700C)
- Medium temperature ceramics (1090-12600C)
- Low temperature ceramics (870-1070^{0}C)
- Ultra Low temperature ceramics (650-850^{0}C)

According to usage areas (24):

- Metal ceramics
- Full ceramics
- Ceramic teeth used in removable partial dentures

According to the construction techniques (23):

- Castable ceramics
- All-ceramic systems fired on refractory days
- Compressible all-ceramic systems
- Ceramics produced by computer aided design and manifacturing (CAD/CAM) technique

According to the contents (30):

- Glass ceramics
    1. Feldspathic ceramics
    2. Ceramics reinforced with leucite crystals

3. Ceramics reinforced with lithium disilicate crystals

- Alumina-based ceramics
- Zirconium-based ceramics

With a classification made by Gracis et al. (29) in 2015, ceramic and ceramic-like restorative materials are examined in 3 main groups according to their structures (29).

1. Glass matrix ceramics

   a. Feldspathic ceramics

   b. Synthetic ceramics

      i. Ceramics reinforced with leucite

      ii. Ceramics reinforced with lithium disilicate

   c. Glass infiltrated ceramics

      i. Ceramics reinforced with alumina

2. Polycrystalline ceramics

   a. Alumina ceramics
   b. Stabilized zirconia ceramics
   c. Alumina ceramics reinforced with zirconia
   d. Zirconia ceramics reinforced with alumina

3. Resin-matrix ceramics

2.2.1 Classification of Dental Ceramics by Microstructure (31)

2.2.1.1 Feldspathic Ceramics

The structure of felspathic glass ceramics is obtained by homogeneously dispersing feldspar particles of 3-4 microns in the glass matrix. It contains 69% silica, 8% alumina, 8 to 10% potassium and 1% boric acid (31).

The small building blocks enable feldspathic ceramics to have high translucency and aesthetic properties. Thanks to the glass matrix, micromechanical roughnesses on the inner surface of the restoration can be obtained, which allows it to be cemented as an adhesive and affects the long-term success of the tooth-restoration connection (32). Feldspathic ceramics can also be well polished with mechanical polish, which brings the advantage that the restoration can be re-polished in the mouth after necessary adjustments after cementation.

Although the low particle size and high glass matrix ratio provide good esthetics, they reduce the compressive and tensile strength of the restoration. For this reason, while feldspathic ceramics can be used for inlay-onlay, lamina veneer and anterior crowns, their use is not indicated for restorations that require high compression resistance such as bridges and endocurons (32,33).

Vita Mark II bloklarda A1, A2, A3, A3,5, A4, B2, B3, C2, C3 ve D3 renkleri bulunmaktadır. The first feldspathic block that can be used with CAD/CAM systems was produced in 1985 (Vita Mark I, Vita Zahnfabrik, Bad Sackingen, Germany) (35). In 1991, Vita Mark II blocks specially produced for the CEREC CAD/CAM system were launched. CAD/CAM feldspathic blocks are produced by external molding, unlike traditional feldspathic ceramics (36). Vita Mark II blocks are available in A1, A2, A3, A3,5, A4, B2, B3, C2, C3 and D3 colors.

2.2.1.2 Glass Ceramics

2.2.1.2.A Castable Glass Ceramics

After the wax modeling prepared on the model is evaporated, the heated glass ceramic material is poured, then the restoration is subjected to a crystallization called “ceramming”. High durability and machinability are achieved with the mica crystals in the glass structure (36,37).

2.2.1.2.B Leucite Reinforced Ceramics

The IPS Empress system (Ivoclar-Vivadent, Schaan, Liechtenstein) was introduced to the market in 1983 as a ceramic system reinforced with leucite. Its main components are feldspathic ceramics and teragonal leucite crystals containing 63% silicon dioxide and 19% aluminum oxide. Crystallization is a heat treatment applied to the glass matrix, whereby leucite crystals grow from the surface to the center by nucleation in the glass matrix. Leucite crystals are 1-5 micrometers in size. The light refractive index of leucite crystals is very close to that of feldspathic ceramics, thus its translucency is preserved (16,18,38).

While the temperature decreases after the crystallization process, stress occurs within the material due to the expansion coefficient difference between the leucite crystals and the glass matrix, thus preventing the formation of cracks and increasing the mechanical properties (39). IPS Empress CAD (Ivoclar-Vivadent, Schaan, Liechtenstein) (Empress CAD) is a leucite-reinforced glass-ceramic system that can be produced with CAD/CAM. Single crowns, inlay-onlays and laminated veneers can be made with leucite-reinforced ceramic systems. The inner surface of the restoration must be etched with acid before cementation. Since leucite crystals take the acid effect earlier than the glass matrix, micro-indents are formed that facilitate the flow of cement. With this feature, it contributes to attachment (40). There are high translucency (HT), low translucency (LT) and polychromatic blocks (Multi), blocks in A-D color groups and Bleach scale (Bl1-Bl4) in the Empress CAD system.

2.2.1.2.C Lithium Disilicate Reinforced Ceramics

The microstructure of lithium disilicate consists of small crystals dispersed in a glass matrix. These acicular crystals prevent the propagation or branching of cracks that may occur due to stress in the material, increasing the bending resistance.

Figure 1 : Microscopic image of lithium disilicate crystals (41)

The type and distribution of crystals in ceramics reinforced with lithium disilicate crystals are different from other ceramics. Thin and durable laminated veneers can be prepared because they are both highly translucent and have advanced mechanical properties (42).

An example of lithium disilicate reinforced ceramics is the IPS E.max (Ivoclar-Vivadent, Schaan, Liechtenstein) system. The bending strength is approximately twice that of the IPS Empress (440 MPa). The reason for this difference is due to firing differences and minor changes in its structure. It can be produced with heat, pressure and CAD/CAM techniques.

IPS E.max CAD (E.max CAD) blocks produced with the CAD / CAM technique are crystallized in 2 stages after scraping on the machine during the production of the restoration. In the pre-crystallization stage, the blocks show a bending strength of approximately 130-150 MPa. After half an hour of firing, the crystallization is completed and the purple block becomes the final color of the restoration (43,44).

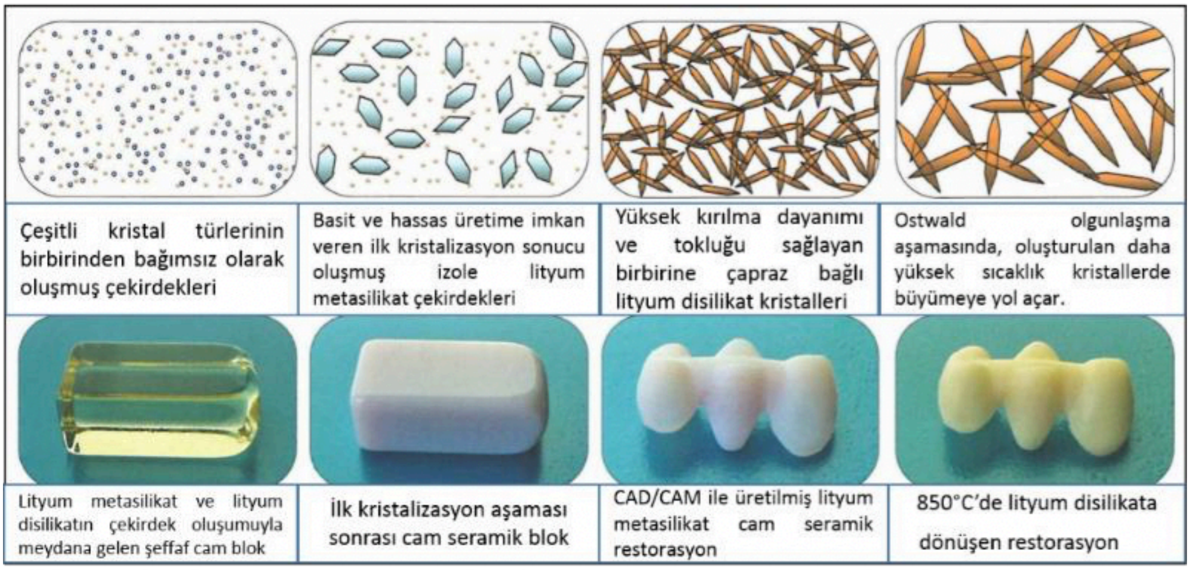


Figure 2: Crystallization stages of E.max CAD (45) (Vivadent Scientific Documents)

Figure 3: E.max CAD blocks (45)

In precrystalline blocks, scraping can be done much faster and easier. In the E.max CAD system, there are blocks in high translucency (HT), medium translucency (MT) and medium opaque (MO) and A-D color groups and Bleach scale (Bl1-Bl4).

2.2.1.3 Glass Infiltrated Ceramics

In this system, ceramic restoration production is made by infiltrating molten glass particles into the oxide structure (46,47).

2.2.1.4 Polycrystalline Ceramics

Polycrystalline ceramics are materials that do not have glassy contents and contain atoms that are densely and tightly packed, so that cracks in the internal structure are more difficult to propagate. Compared to glass ceramics, they are observed to be more durable but more opaque, so they are considered as infrastructure material (48,49).

2.3 Production Forms of Ceramics

2.3.1 Ceramics Produced by Condensing Porcelain Powders

It is based on the principle of applying and shaping the paste-like mixture, which is obtained by mixing porcelain powders with liquid, on the model with a damp brush. In this method, the moisture that keeps the powders together is evaporated with the help of heat and pressure in the oven. The glass phase in the trapped content becomes more viscous due to the heat and allows the porcelain to come together. In this method, internal and external porosities may occur (37).

2.3.2 Ceramics Produced by Slip-Cast Technique

In the slip-cast technique, an investment resistant to high temperatures is poured into the measurement taken on the main model, and thus a refractory model is obtained. Liquefied ceramic is poured on this refractory mold. The mold is formulated to shrink at high temperatures so that it can be easily separated from the cooled clay. Following the firing of the first structure containing alumina particles, the glassy structure is infiltrated and fired again. Ceramics produced with this technique have higher fracture resistance than traditionally produced ceramics due to the fact that their contents are reinforced with alumina (46,50).

2.3.3 Ceramics Produced by Heat Pressing Technique

In the heat pressing technique, the wax modeling prepared on the model is heated and blown away, and the resulting mold is sent to the mold with a hydrostatic pressure by using a ceramic vacuum unit that has liquefied at high temperature. Ceramics produced with this system are also called hot pressed ceramics (37,51).

2.3.4 Ceramics produced with CAD-CAM systems

The tooth and surrounding tissues prepared in the CAD/CAM system or the measurement obtained from the taken model are transferred to the digital environment by means of the scanner, the restoration is designed here (CAD-Computer Aided Design) and produced by scraping from the blocks in special devices (CAM-Computer Aided Manufacturing/ Computer Aided Manufacturing) (35).

2.4 CAD/CAM Systems

CAD/CAM (computer aided design/computer aided manufacturing) technology is the design and production of a three-dimensional product using computer software. It was in the 1980s that CAD/CAM technology, which has been used in the machinery industry since the 1960s, began to be used in dentistry to obtain restoration (52,53).

Obtaining the data of the tooth to be restored in the CAD / CAM system can be performed with a scanner directly from the mouth or by scanning on the model. By transferring the data to the computer, the designs become digitally doable.

The first time to scan and transfer the oral tissues to the computer by means of optical readers was carried out by Bruce Altschuster in 1977 (54). In 1984, a French researcher named François Duret developed a system that could design a restoration suitable for intraoral impression taking and chewing functions and produced a restoration (52).

In 1988, Wörmann and Brandestini took the measurement of the tooth to be restored at the bedside with the Cerec system with a scanner and produced the restoration in the same session. The ability to prepare and cement the restoration in one session has been considered a revolution for dentistry (55).

Today, it is possible to prepare inlay-onlay, laminates, bridges and crowns with CAD/CAM systems. With this wide indication area, CAD/CAM systems are increasingly finding their place in clinics and practices (42,56-58).

Below are the advantages and disadvantages of CAD / CAM systems (53,59-61):

2.4.1 Advantages of CAD/CAM Systems

- Taking measurements by means of optical readers and camera is both easier and more comfortable for the patient than traditional methods. It is reported that the technical precision of the measurement stage in CAD / CAM systems is comparable to traditional methods.
- Restoration can be achieved in a shorter time as the waiting times in model casting and preparation processes are eliminated.
- Thanks to this technology, information exchange between dentist and dental laboratory is facilitated.
- More compatible restorations can be prepared thanks to the improved precision of readers and scrapers.
- In general, the potential for error has decreased as the physical difficulties in the stages have been eliminated.
- The risk of cross-contamination is reduced, as the need for traditional disinfection is eliminated.
- Since the applications can be done in a single session on the same day, the need for temporary work is reduced and time losses are prevented. (53, 59-61)

2.4.2 Disadvantages of CAD/CAM Systems

- The high cost of installation of CAD/CAM systems is one of its disadvantages. Since intraoral scanners and scrapers are very costly equipment, their use is restricted.
- Monochromatic blocks do not always show sufficient success in anterior region restorations where aesthetic expectations are very high.
- In cases where the preparation limits are below the gingiva, it is very difficult for the scanner to read and transfer these areas properly. However, traditional measurement methods may not always provide accurate information transmission in these regions. (53, 59-61)

Restoration can be produced in three ways with CAD/CAM systems (62,64)

1. Production of the restoration in the system center: the measurement taken with a scanner from the mouth is digitally directed to the system center. The center produces the restoration and sends it to the physician. An example is the Procera (Nobel, Sweden) system.
2. Production of the restoration in the dental laboratory: the impression taken with a scanner from the mouth is sent to the laboratory digitally or the traditional impression is scanned with an impression scanner in the laboratory and the model is obtained. The restoration is either completely scraped off or the technician finishes the scraped infrastructure by layering. Examples are the Cerec Inlab (Sirona, Germany) and Everest (Kavo, Germany) systems.
3. Making the production of the restoration in the clinic: The restoration is designed on the computer based on the impression taken with a scanner inside the mouth, and the restoration is produced from the CAD / CAM blocks in the scraper in the clinic. In terms of time planning, these systems are practical systems, but the need for personnel to complete the design and restoration should be considered. An example is Cerec (Sirona, Germany).

2.4.3 Impression, Design and Production Stages in CAD/CAM Systems

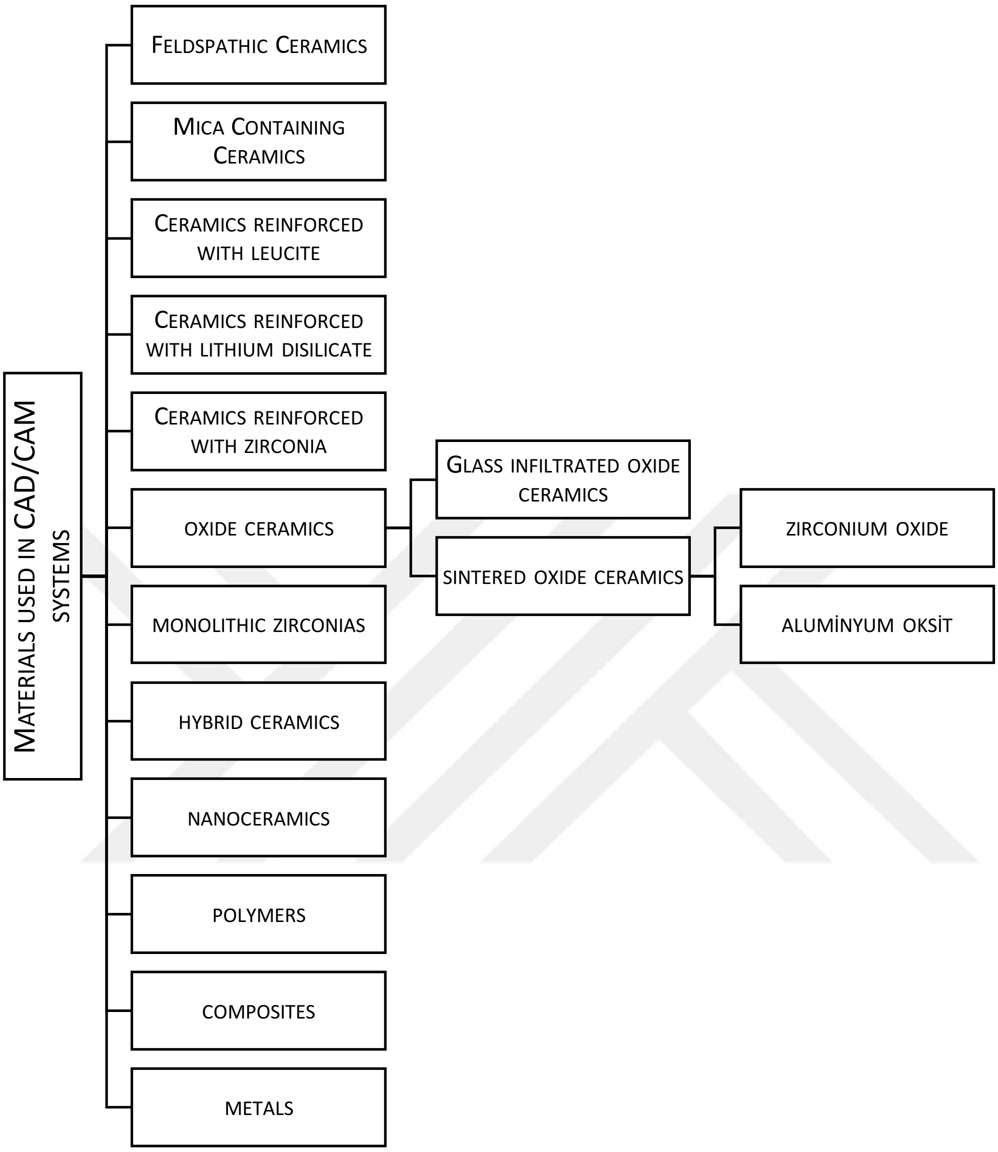
Intraoral scanning devices contain a camera with a light source. For example, Cerec Omnicam (Sirona, Germany) actively triangulates the image and calculates the light values during scanning, the light of different wavelengths reflected from the tooth and surrounding tissues is transferred to the device and processed. Thus, a three-dimensional image is formed. After the digital measurement is taken and the image is processed on the computer, the model is obtained. Restoration borders are drawn, the access route is arranged, the approximal contact areas and the occlusal surface are prepared according to the opposing teeth. All arrangements and changes can be made on the digital model. When all the desired changes are made and the design is completed, it is decided to place the restoration on the block to be scraped and all this information is sent to the scraper (57,65).

The selected block is placed in the scraping machine in proportion to the type, color and size of the restoration. The cutting process is carried out under water cooling by means of burs. The restoration, which is completed when the scraping phase with the bur is completed, is ready for polishing and glazing processes after the intraoral adjustments are made (57,66).

2.4.4 Materials Used in CAD/CAM Systems

Today, with the development of CAD / CAM production stages, many materials have been introduced to the market. Examples of these are ceramics, glass ceramics reinforced with lithium disilicate, glass ceramics reinforced with leucite, and hybrid ceramic materials (32,33,36,61,62). Polymers, metals and composites are also used for many purposes. Table 1 shows all current materials used in CAD / CAM systems.

Table 1: Materials used in CAD/CAM systems (67)



2.5 Optical Properties of Dental Ceramics

Especially the restoration of teeth in the anterior region can be challenging for clinicians as the optical properties of the materials must be compatible with the optical properties of enamel and dentin. Light passing through amorphous crystals in the ceramic structure is reflected and absorbed differently than it is reflected when passing through the dentin and enamel complex (24).

Today, the ceramic powders on the market are in the range of yellow - red tones, but it is not possible to talk about such a range for teeth. For this reason, companies produce color changers containing pigments in pink, orange, blue, red and gray colors, which enable the color of the ceramic to be changed. Another way to change the color of the restoration is to paint the surface, but it should be kept in mind that this process can reduce translucency (24).

Opalescence also plays an important role in the optical properties of enamel. Opalescence is the mode of propagation of light and occurs when the wavelength of light is equal to or greater than the crystal size (68).

The fluorescence property of enamel is obtained by soil-derived oxides such as cerium oxide added to ceramics (24).

Translucency is another very critical feature for the success of restorations. There are ceramics with different translucency properties such as opaque, dentin, enamel etc. Ceramics with low translucency are used in metal porcelain restorations where masking is required. The materials added to the content to increase the opacity are tin oxide and titanium oxide. In all-ceramic restorations, on the other hand, translucency and opacity vary according to the crystal phase in the material. The size, type and variety of the crystals it contains are decisive in both aesthetic and mechanical properties of ceramics. For example, ceramics containing alumina are more opaque, while ceramics reinforced with leucite are more translucent (23,24).

Due to the translucency of ceramic restorations, the final color is affected by the inner areas, the underlying ceramic and the natural tooth color. However, the color and translucency of the resin cement, which is a part of the restoration complex, is also important. While the resin cements used in the cementation of more opaque ceramic restorations containing alumina can be selected from a wider range, the translucency of the resin cement is also decisive in the final color of the restoration in the cementation of restorations with more translucent properties such as laminated veneers, inlays and onlays. It requires making a choice taking into account this information.

These properties provided by the content in dental ceramics offer a great potential for reflecting the optical properties of natural teeth (22).

2.6 Light-Curing Units Used in Dentistry

Light-curing units are one of the main factors that allow the polymerization of composite resins, in other words, adhesive cementation of restorations. Light curing units used in dentistry; quartz-tungsten halogen (QTH), LED, plasma arc (PAC) and laser light curing units (69). These light sources must produce light at the right wavelength and with sufficient energy for adequate and correct conversion rate polymerization70. Light-cured resin systems often contain camphoroquinone, which is activated at a wavelength of 470 nm as a photoactivator (71).

Ultraviolet light sources, which were used for the polymerization of the first composite materials produced in the 1970s, are now used only with filters (1014mW/cm2) or without a filter (574mW/cm2) in the polymerization of indirect composite restorations in dental laboratories (72). Light sources are used in the polymerization of many materials such as composites, resin modified glass ionomers, fissure sealants, bondings, adhesive resin cements, temporary restorative materials in dentistry (73).

2.6.1 Quartz-Tungsten Halogen Light Curing Units

It was developed after ultraviolet systems and is still used today. These systems, which are also known as traditional light sources, have tungsten filament halogen bulbs (74,75). These devices, which emit visible light with a wavelength of 380-520nm with an intensity of 300-850 mW / cm2, have systems that produce blue light by absorbing white light and filter light of other wavelengths (75). Failure to filter the light correctly due to defects in the filters inside the device may cause an increase in temperature and this may cause damage to the pulpal tissues (76).

For this reason, halogen light devices should be checked at regular intervals. In addition, heat dissipation than normal causes shortening of lamp life. In order to prevent this, a cooling fan is mounted inside the device (74,76).

Halogen light devices have a wide wavelength range and are relatively inexpensive devices, but they have disadvantages such as limited lamp life of 100 hours, reduced filter effectiveness with use, and reduced light power (74,76).

Following their introduction, halogen devices have been continuously improved and updated with additions such as high light intensity, standard/soft and gradual light exposure (78).

2.6..2 LED Light-curing Units

LED light curing units have been developed in order to eliminate the problems seen in halogen light sources (79).

The production of light in LED devices occurs during the passage of electrons from the semiconductor materials called gallium-nitride in the device and no heat is released. Since light is released only at the wavelength to be used, there is no need for light filtration (80).

Since there is no cooling fan in the system, they are quieter, smaller and low-powered light-producing devices compared to halogen light units (81-82).

Despite these advantages, since the wavelength is narrower than halogen lamps, it may not be fully absorbed by some reaction initiators in composites. In order to eliminate the narrow wavelength and insufficient polymerization problems of the first LED devices on the market, 2nd generation devices were introduced to the market. These are systems with a density of 1000-1200 mW/cm2 or more, with a wide wavelength range in the range of 390-490 nm (69.83). Due to the increase in light power density, the time required for polymerization has decreased, and the manufacturers have stated that 10-20 seconds are sufficient.

2.6.3 Plasma Arc Light-Curing Units

Plasma arc light units introduced in the 1990s generally have a xenon gas cathode and a tungsten anode filled in a quartz tube. As the current passes through the gas, xenon is ionized and a plasma is formed (85).

They produce light at a more intense light power level (900 mW/cm2) and narrower wavelength (430-490nm) than halogen light sources. Less time required for polymerization also prevents temperature increase in teeth and surrounding tissues85. In the renewed versions of plasma arc devices, the luminous power was increased to 2000 mW/cm2, and it was thought that improved mechanical properties would be achieved in the resins (86).

With the short irradiation time, the temperature rise is kept under control, but high polymerization shrinkage, which is a result of rapid polymerization, is one of the disadvantages of these systems. The light produced in plasma arc systems also creates different light waves than the resins using camforoquinone as a photoactivator, and these light waves have no function other than the increase in temperature, which can be quite harmful for teeth and surrounding tissues (87).

2.6.4 Argon Laser Light-Curing Units

They are lasers that emit continuous light at a wavelength of 457-502nm. Since there is no infrared rays in argon lasers, the temperature increase in the teeth and surrounding tissues occurs at a negligible level. Visible light is transmitted by a fiberoptic system. Composite resin polymerization is used in bleaching and soft tissue surgeries (76).

In the study published by Hicks et al. (88) in 2000, it was shown that the time and residual monomer amount decreased in polymerization with argon laser, and the physical properties of composite resins were better in the study of Blankenau et al. Despite these studies, there are also studies showing that argon lasers may not be suitable for some photoactivators due to their narrow wavelength (89-90).

Compared to other light sources, laser systems are expensive and require high technical knowledge and equipment (89-91).

2.7 Measurement Methods of Light Power in Dentistry

When using a light device, the intensity of the emitted blue light and the hardness of the resin in the top layer cannot provide the dentist with accurate and sufficient information about the depth of curing to evaluate the curing power of the light. Units within the light source may deteriorate over time and power drops. In addition, some deposits or fractures on the light tip may cause the transmitted light to be weaker than the produced light and to progress by reflecting. These reasons reduce the success of the adhesive process by reducing the polymerization efficiency by not performing at full capacity of the light device (78,92,93). For this reason, it is necessary to regularly measure the power of the light device and to record the current state of the device with these measurements in order to evaluate its performance in the future (94,95).

Many studies show that the radiation produced by dental light sources cannot be evenly distributed from all areas of the conduction tip (66,96-99).

In addition, due to the way light is produced, the spread spectrum is not evenly distributed in some broad-spectrum LED devices. This heterogeneous distribution causes the light to fall intensely in some areas, less strongly in some areas, and light in different wavelengths in some areas. This shows that the dentist directing the light device should pay close attention to the beam direction and the right angle of the light to ensure adequate polymerization, especially in hard-to-reach areas of the restoration, such as the gingival margins and approximal areas (96,97,100).

2.7.1 Dental radiometers

This type of radiometer usually converts light into electrical units and displays the result on an analog or digital display. Radiometers consist of an input port, diffusers, various filters, a detector and a display that allows us to read the output value. On the front of the silicon photodiode detector is a band-shaped filter that converts photons from the light device into electric current and, if calibrated, into radiating units. In order for the results to be accurate, the light tip of the device must be compatible with the light entry points of the radiometer. In addition, the way the tip is placed in the detector area and its angle are important for the accuracy of the measurement results (101-103). Since the spectrum and type of light transmitted by the light device may be different, it is recommended to choose a radiometer suitable for the light device used, since the filter inside the radiometer is also different (103,104).Dental radyometrelerin en önemli avantajlarından biri, diğer ölçüm cihazlarının aksine hekimler tarafından kolay ulaşılabilir olması ve laboratuvar ortamına ihtiyaç duyulmadan klinik ortamda rahatça kullanılabilir olmasıdır (101-104, 146)

Figure 4: Examples of commercially available dental radiometer devices (105)

2.7.2 Spectral radiant power measurement

An optical spectrometer, or more accurately a spectrophotometer, measures the properties of a specific part of the electromagnetic spectrum of a light source. In the spectrophotometer, light is separated into its components of different wavelengths and the wavelength and power function are digitized into signals. The first step of this process is the entry of light from the source under examination through the narrow gap, also known as the entrance opening. This gap scatters the light and makes it fall onto a grid. With the help of the grating, the light is separated into its various spectral components, just like a prism does, and falls on the detector at a slight angle. The grid can be striped or holographic. Holographic grids have less stray light. The depth and intensity of the recesses on the grating are important as they affect the way the light is dispersed and its distribution in the optimum spectral bandwidth. As the indentation depth increases, more successful optical results can be obtained. For this reason, aperture size, grating indentation depth and intensity must be carefully selected to obtain the most accurate data from a spectrophotometer and measure the radiant power and wavelength of the light source.

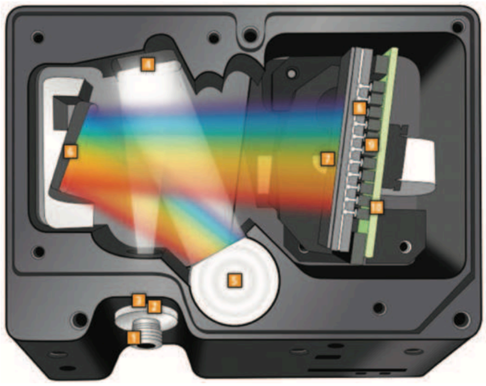


Figure 5: Schematic diagram of the spectrophotometer (105)

3. MATERIALS AND METHODS

Our research was planned to evaluate the light transmittance of CAD/CAM ceramic blocks reinforced with different fillers. The preparation of samples from ceramic blocks whose light transmittance will be evaluated in the study was carried out in the hard tissue laboratories of Yeditepe University Faculty of Dentistry. The images of the selected sample blocks under scanning electron microscopy (SEM) were made at Tübitak Marmara Research Center.

3.1 Formation of Experimental Groups

Three different CAD/CAM ceramic materials were used in the study. These are leucite reinforced glass ceramic (Initial LRF BLOCK (GC, Japan)), lithium disilicate reinforced glass ceramic (IPS E.Max CAD (Ivoclar Vivadent, Schaan, Liechtenstein)), leucite reinforced glass ceramic (IPS Empress CAD (Ivoclar) Vivadent, Schaan, Liechtenstein)) systems (Table 2).

Leucite reinforced glass ceramic (IPS Empress CAD (Ivoclar Vivadent, Schaan, Liechtenstein)) was used as the control group in the study.

Table 2: CAD/CAM ceramic blocks used in the study and their properties

Material	Manufacturer	Content	Lot Number
LRF BLOK	GC, Schaan, Japan	SiO_2, Al_2O_3, K_2O, Na_2O, Li_2O, CaO, BaO, CeO_2 , CeF_3 , other oxides and pigments	1802191
Empress CAD	Ivoclar Vivadent, Schaan, Liechtenstein	SiO_2, Al_2O_3, K_2O, Na_2O, other oxides and pigments	V11522
E.max CAD	Ivoclar Vivadent, Schaan, Liechtenstein	SiO_2, Li_2O, K_2O, P_2O_5, ZrO_2, ZnO, Al_2O_3, MgO	W10813

Samples prepared from the materials of the test and control groups included in our study, blocks with HT and LT values in A1 and A3 colors in the Vitapan Classical (VITA Zahnfabrik, Bad Säckingen, Germany) color scale were preferred. Samples of 1mm and 2mm thick were prepared from these blocks. (Table 3)

Table 3: Ceramic blocks used in the study and their color, translucency and thickness

Material	Color	Translucency		Thickness	
LRF Blok	A1	HT	LT	1mm	2mm
	A3	HT	LT	1mm	2mm
E.max CAD	A1	HT	LT	1mm	2mm
	A3	HT	LT	1mm	2mm
Empress CAD	A1	HT	LT	1mm	2mm
	A3	HT	LT	1mm	2mm

Glazing was applied to one surface of the CAD/CAM ceramic samples, while hydrofluoric acid was applied to the other surface in order to imitate the restorations ready to be cemented. The light transmittance measurements of the samples were made with the LED Radiometer device (SDI (Victoria, Australia).Each system was divided into subgroups with different colors, different thicknesses and different translucency values, and the light transmittance within and between groups was evaluated.

3.2 Preparation of Samples

3.2.1. Creating samples by cutting porcelain blocks

In our study, porcelain CAD/CAM blocks belonging to the GC Initial LRF Block A1 LT, A1 HT, A3 LT, A3 HT subgroups were in each group with Isomet 1000 (Buehler USA) cutting device (Yeditepe University Dental Faculty Hard tissue laboratory) (Figure 6). It was cut to be 1mm (n=15) and 2mm (n=15) thick (Picture 7- Picture 8). The same procedures were applied to the other test group IPS Empress CAD A1 LT, A1 HT, A3 LT, A3 HT and the control group IPS E.max CAD A1 LT, A1 HT, A3 LT, A3 HT. The porcelain discs obtained were polished with 600, 800 and 1200 grit abrasives, respectively, in Phoenix Beta (Buehler USA) polishing and sanding equipment in

Yeditepe University Faculty of Dentistry Hard tissue laboratory in order to avoid any roughness on the cutting process. (Picture 9)

Figure 6: Precision cutting device used in the preparation of samples (Isomet 1000 (Buehler USA))

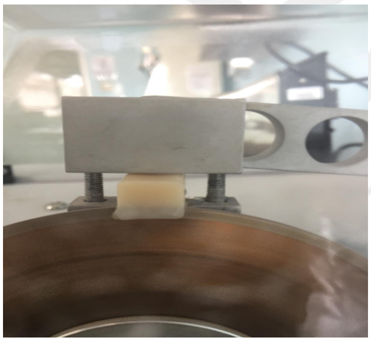


Figure 7: Cutting the samples on the precision cutting device (side view)

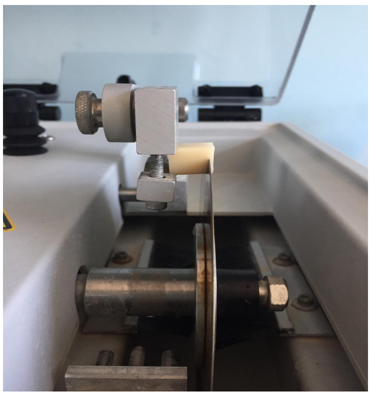


Figure 8: Cutting the samples on the precision cutting device (front view)

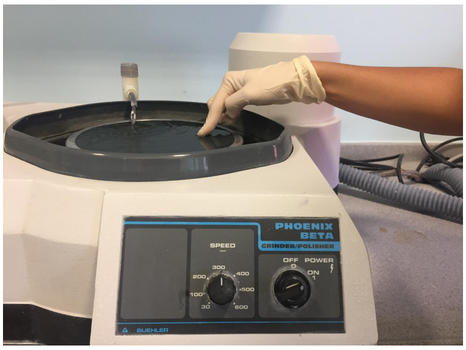


Figure 9: Smoothing the samples on the sander

Porcelain discs belonging to the E.max CAD group were fired in a vacuum porcelain furnace (Programat P300, Ivoclar Vivadent, Schaan, Liechtenstein) in line with the manufacturer's recommendations for crystallization.

3.2.2. Glazing the samples

Glazing was applied as recommended by the manufacturer of each brand to create the polished surfaces of all samples included in the study. The glaze materials applied to the samples in the study and their manufacturers are shown in Table 4. The final thickness of the polished and glazed samples (Picture 10) was checked with a digital caliper (Picture 11) (Alpha-tools, Mannheim, Germany).

Table 4: Applied glazing materials and manufacturers

CAD/CAM Block Material	**Glaze**	**Manufacturer**
LRF Blok	Initial LRF Glaze Paste	GC (Japan)
Empress CAD	IPS Empress Universal Glaze Paste	Ivoclar Vivadent, Schaan, Liechtenstein
E.max CAD	IPS E.max CAD Crystall	Ivoclar Vivadent, Schaan, Liechtenstein

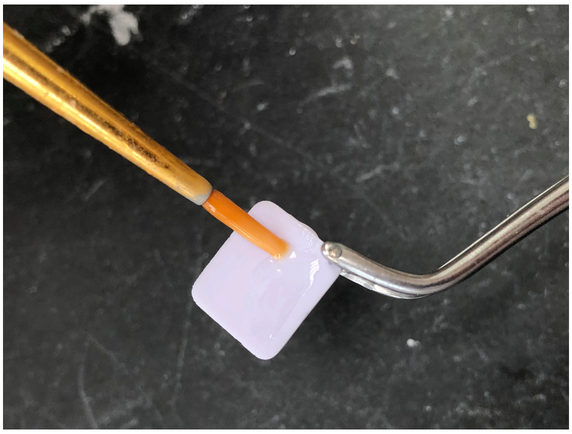


Figure 10: Preparation of the sample for glazing

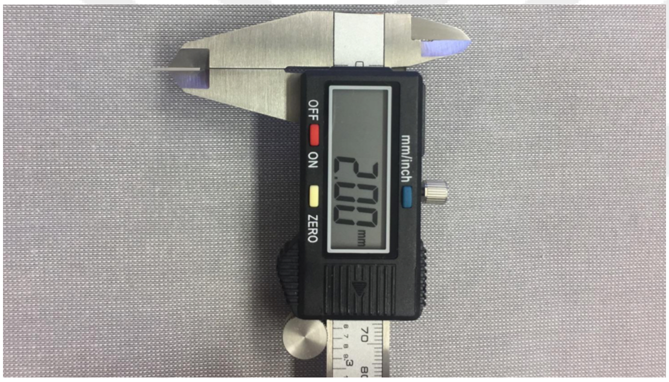


Figure 11: Measurement of sample thickness after glazing with digital caliper

3.2.3. Etching of Samples

Hydrofluoric acid was applied to the unglazed surfaces of each porcelain disc belonging to all groups included in the study, as recommended by the manufacturer for each brand, in order to imitate the cementation process. Accordingly, hydrofluoric acid (5%) was applied to the samples of the Empress CAD and LRF Block groups for 60 seconds, while hydrofluoric acid (5%) was applied to the samples in the E.max CAD group for 20 seconds (Table 5). After the application, the surfaces were rinsed with pressurized water for 30 seconds and then dried.

Table 5: Hydrofluoric acid applied and the manufacturer

CAD/CAM Block Material	Hydrofluoric acid	Manufacturer	Time
LRF Blok	IPS Ceramic Etching Gel (%5)	Ivoclar Vivadent, Schaan, Liechtenstein	60 sec.
Empress CAD	IPS Ceramic Etching Gel (%5)	Ivoclar Vivadent, Schaan, Liechtenstein	60 sec.
E.max CAD	IPS Ceramic Etching Gel (%5)	Ivoclar Vivadent, Schaan, Liechtenstein	20 sec.

3.3 Making Light Transmittance Measurements

In the study, the light transmittance measurements of the samples were made with an LED Radiometer (SDI (Victoria, Australia) (Figure 12). During the light transmittance measurements, a silicone mold was made on the measurement surface of the device in order to standardize the environmental conditions and to prevent the ambient light from causing errors in the measurements. Measurements were made by placing it inside the mold.

During the measurements, the Bluephase N (Ivoclar Vivadent, Schaan, Liechtenstein) LED light device and the recommended high power mode for the cementation of the device were used (Picture 13). Calibration of the light device was made before the measurement of each sample, leaving the measurement surface empty without placing a disc on it. During the calibration, it was checked that the light device gave light at the power value recommended by the company. Accordingly, the company states that the device operates at 1200 mW/cm2 in high power mode. During the calibration, it was checked that this power device works at a power value of 1200 mW/cm2. All light transmission measurements were performed by the same investigator.

Figure 12: LED radiometer (SDI (Victoria, Australia))

Figure 13: Bluepahse N Light Device (Ivoclar Vivadent, Schaan, Liechtenstein)

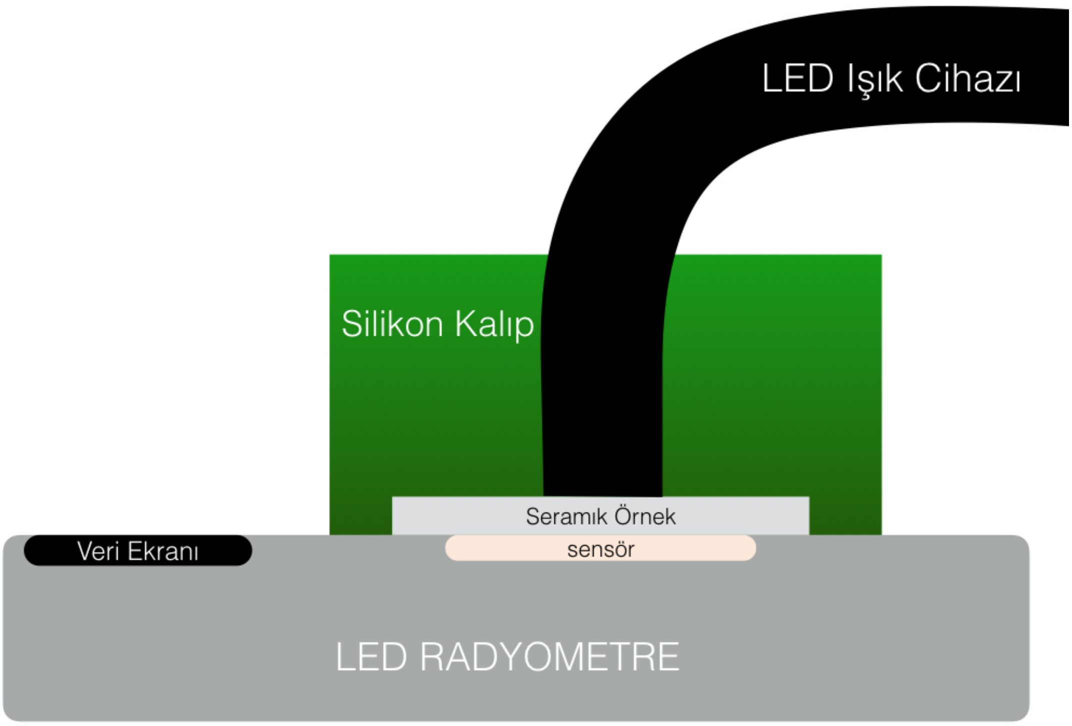


Figure 14: Measuring setup (Representation)

All devices used in the study, their areas of use and manufacturers are shown in Table 6.

Table 6: Devices used in the study, areas of use, manufacturers

Device Name	**Usage Area**	**Manufacturer**
Isomet 1000	Cutting samples from blocks	Buehler USA
Phoenix Beta	Smoothing of sample surfaces	Buehler USA
Programat P300	Crystallization and glazing of samples	Ivoclar Vivadent, Schaan, Liechtenstein
Digital caliper	Measuring sample thicknesses	Alpha-tools, Mannheim, Almanya
Bluephase N	Light curing unit for light transmittance testing	Ivoclar Vivadent, Schaan, Liechtenstein
LED Radiometer	Light transmittance test meter	SDI, Victoria, Australia

3.4 Measurements with Scanning Electron Microscope (SEM)

In the study, one side of the samples was polished while the other side was acidified. SEM images were taken to detect surface differences on the acidified side. One sample was randomly selected from each subgroup in the study. Images were taken from these samples under a scanning electron microscope with a magnification of 5000. All SEM images were taken in the SEM laboratory at TUBITAK Marmara Research Center.

3.5 Statistical Analysis

In this study, statistical analyzes were performed with NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) package program. In the evaluation of the data, besides descriptive statistical methods (mean, standard deviation), one-way analysis of variance was used for comparisons of variables showing normal distribution between groups, Tukey multiple comparison test for subgroup comparisons, and independent t test for comparison of paired groups. The results were evaluated at the significance level of $p<0.05$.

4. RESULTS

4.1 Evaluation of Light Transmittance Values of Material Variety

A statistically significant difference was observed between the average of high translucency 1 mm thickness A1 color light transmittance of E.max CAD, LRF Block and Empress CAD Groups (p = 0.0001). (Table 7). The A1 color light transmittance averages of the Empress CAD group were found to be statistically significantly higher than the A1 color light transmittance averages of the E.max CAD and LRF Block groups (p=0.0001). no significant difference was observed (p=0.623), (Table 8).

A statistically significant difference was observed between the high translucency 2 mm thickness A1 color light transmittance averages of the E.max CAD, LRF Block and Empress CAD groups (p=0.0001), (Table 7). The A1 color light transmittance averages of the Empress CAD group were found to be statistically significantly higher than the A1 color averages of the E.max CAD and LRF Block groups (p=0.0001). There was a statistically significant difference between the A1 light transmittance averages of the E.max CAD and LRF Block groups. not observed (p=0.160), (Table 8).

A statistically significant difference was observed between the low translucency 1 mm thickness A1 color light transmittance averages of the E.max CAD, LRF Block and Empress CAD groups (p=0.0001), (Table 7). The A1 color light transmittance averages of the E.max CAD group were found to be statistically significantly lower than the A1 color light transmittance averages of the LRF Block and Empress CAD groups (p=0.0001), there was no statistically significant difference between the A1 light transmittance averages of the LRF Block and Empress CAD groups (p=0.717), (Table 8).

A statistically significant difference was observed between the low translucency 2 mm thickness A1 color light transmittance averages of the E.max CAD, LRF Block and Empress CAD groups (p=0.0001), (Table 7). The A1 color light transmittance averages of the E.max group were found to be statistically significantly lower than the A1 color light transmittance averages of the LRF Block and Empress CAD groups (p=0.0001). (p=0.962), (Table 8).

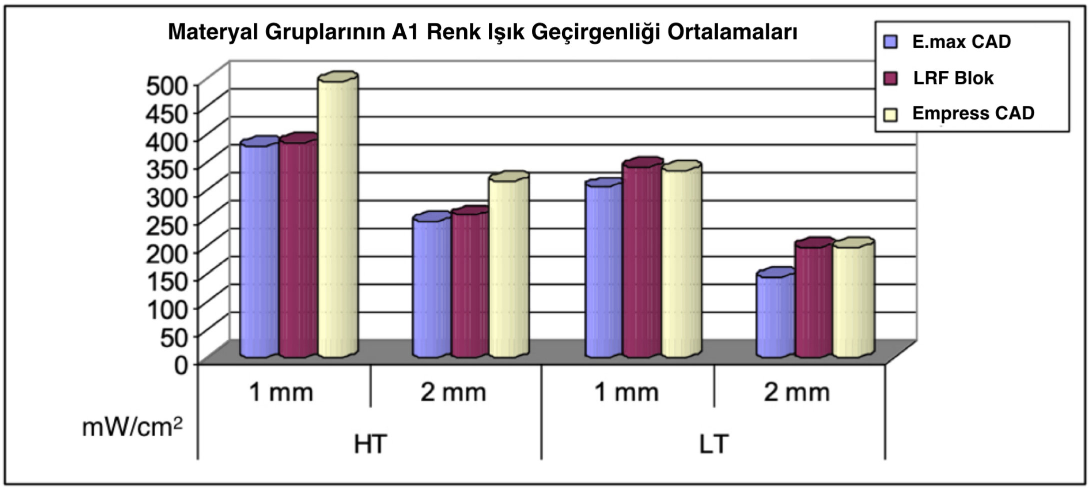
Table 7: Statistical evaluation of material types by means of light transmittance of different translucency and thickness groups in A1 color and one-way analysis of variance

Translucency	**Thickness**	**E.max CAD Group**	**LRF Block Group**	**Empress CAD Group**	**p**
HT	**1 mm**	379,00±10,56	384,67±15,17	494,00±22,14	**0,0001**
	2 mm	243,33±23,43	254,67±10,26	316,33±13,16	**0,0001**
LT	**1 mm**	305,00±24,13	341,33±19,32	335,33±19,41	**0,0001**
	2 mm	144,67±17,16	197,67±17,1	196,00±17,13	**0,0001**

One-Way Analysis of Variance

Table 8: Statistical evaluation of light transmittance averages of different translucency and thickness groups in A1 color of material types

Tukey Multiple Comparison Test	**HT**		**LT**	
	1 mm	**2 mm**	**1 mm**	**2 mm**
E.max CAD Group / LRF Block Group	0,623	0,160	**0,0001**	**0,0001**
E.max CAD Group / Empress CAD Group	**0,0001**	**0,0001**	**0,001**	**0,0001**
LRF Block Group / Empress CAD Group	**0,0001**	**0,0001**	0,717	0,962



Graphic 1 : Average values of different translucency and thickness light transmittance of A1 color groups of material types

A statistically significant difference was observed between the high translucency 1 mm thickness A3 color light transmittance averages of the E.max CAD, LRF Block and Empress CAD groups (p=0.0001), (Table 9). The A3 color light transmittance averages of the Empress group were found to be statistically significantly higher than the A3 color averages of the E.max and LRF Block groups (p=0.0001), no statistically significant difference was observed between the A3 light transmittance averages of the E max and LRF Block groups (p= 0.446), (Table 10).

A statistically significant difference was observed between the high translucency 2 mm thickness A3 color light transmittance averages of the E.max CAD, LRF Block and Empress CAD groups (p=0.0001), (Table 9). The A3 color light transmittance averages of the Empress group were found to be statistically significantly higher than the A3 color light transmittance averages of the E.max and LRF Block groups (p=0.0001), no statistically significant difference was observed between the A3 light transmittance averages of the E.max and LRF Block groups. (p=0.512), (Table 10).

A statistically significant difference was observed between the low translucency 1 mm thickness A3 color light transmittance averages of the E.max CAD, LRF Block and Empress CAD groups (p=0.0001), (Table 9). The A3 color light transmittance averages of the LRF Block group were found to be statistically significantly higher than the A3 color light transmittance averages of the E.max CAD and Empress CAD groups (p=0.0001). no significant difference was observed (p=0.356), (Table10).

A statistically significant difference was observed between the low translucency 2 mm thickness A3 color light transmittance averages of the E max CAD, LRF Block and Empress CAD groups (p=0.0001), (Table 9). The A3 color light transmittance averages of the LRF Block group were found to be statistically significantly higher than the A3 color light transmittance averages of the E.max CAD and Empress CAD groups (p=0.0001). no significant difference was observed (p=0.695), (Table 10).

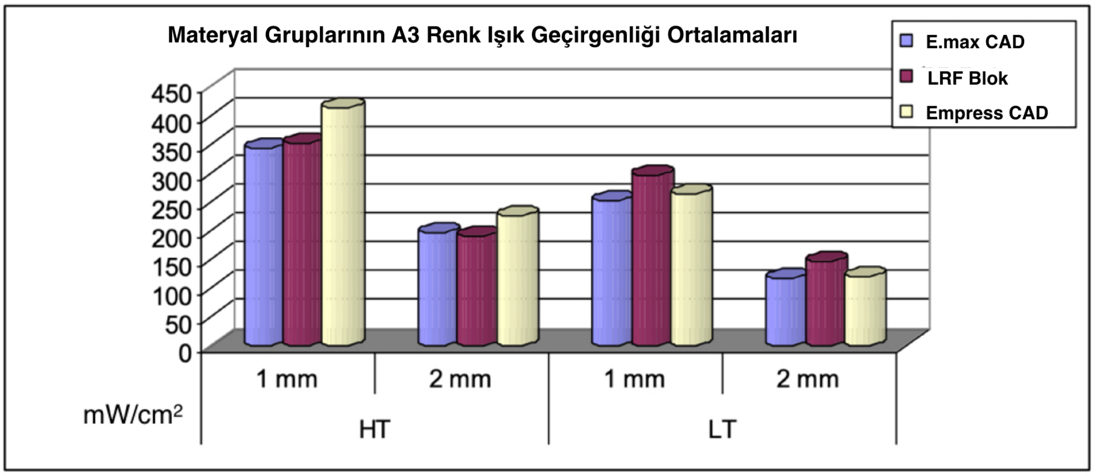
Table 9: Statistical evaluation of material types by means of light transmittance values of different translucency and thickness groups in A3 color and one-way analysis of variance

Translucency	**Thickness**	**E.max CAD Group**	**LRF Block Group**	**Empress CAD Group**	**p**
HT	**1 mm**	341,33±20,04	349,33±17,1	411,00±16,39	**0,0001**
	2 mm	196,33±11,87	190,33±11,57	223,67±19,5	**0,0001**
LT	**1 mm**	252,67±18,21	295,67±16,57	261,67±18,39	**0,0001**
	2 mm	116,00±14,29	145,00±9,45	119,33±9,04	**0,0001**

One-Way Variance Analysis Variance

Table 10: Statistical evaluation of different translucency and thickness group light transmittance averages in A3 color of material types

Tukey Multiple Comparison Test	HT		LT	
	1 mm	2 mm	1 mm	2 mm
E.max CAD Group / LRF Block Group	0,446	0,512	**0,0001**	**0,0001**
E.max CAD Group / Empress CAD Group	**0,0001**	**0,0001**	0,356	0,695
LRF Block Group / Empress CAD Group	**0,0001**	**0,0001**	**0,0001**	**0,0001**



Graphic 2: Different translucency and thickness average light transmittance values of A3 color groups of material types

A1 color light transmittance average of E.max CAD material HT 1 mm thickness group was found to be statistically significantly higher than 2 mm thickness group (p = 0.0001), (Table 11).

E.max CAD material A1 color light transmittance averages of the LT1 mm thickness group were found to be statistically significantly higher than the 2 mm thickness group (p=0.0001), (Table 11).

The mean A1 color light transmittance of LRF Block material HT 1 mm thickness group was statistically significantly higher than the 2 mm thickness group (p=0.0001), (Table 11).

LRF Block material A1 color light transmittance averages of the LT1 mm thickness group were found to be statistically significantly higher than the 2 mm thickness group (p=0.0001), (Table 11).

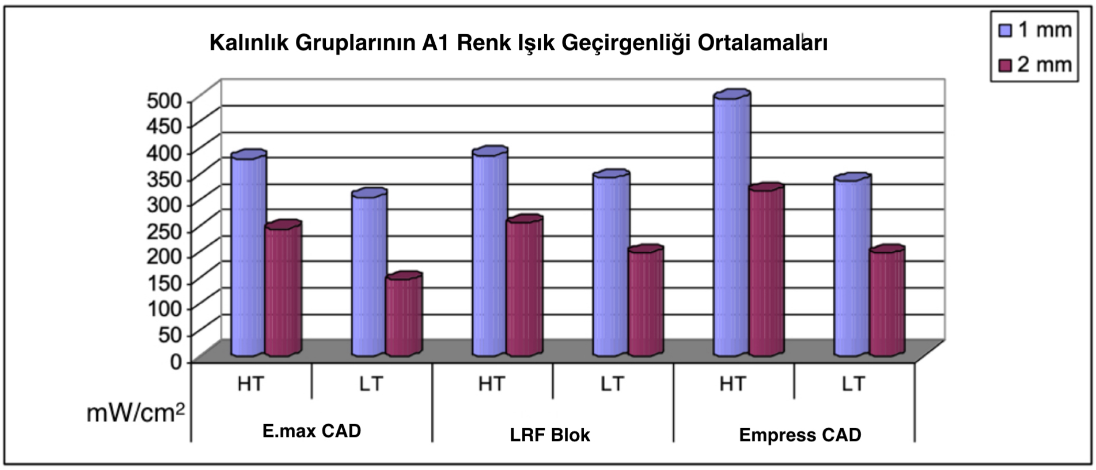
The mean A1 color light transmittance of the Empress CAD material HT 1 mm thickness group was found to be statistically significantly higher than the 2 mm thickness group (p=0.0001), (Table 11).

The A1 color light transmittance average of the Empress CAD material LT 1 mm thickness group was found to be statistically significantly higher than the 2 mm thickness group (p = 0.0001), (Table 11).

Table 11: Light transmittance averages and statistical evaluation of material types in A1 color of HT and LT groups according to material thickness

Material	**Translucency**	**1 mm**	**2 mm**	**P**
E.Max CAD Group	**HT**	379,00±10,56	243,33±23,43	**0,0001**
	LT	305,00±24,13	144,67±17,16	**0,0001**
LRF Block Group	**HT**	384,67±15,17	254,67±10,26	**0,0001**
	LT	341,33±19,32	197,67±17,10	**0,0001**
Empress CAD Group	**HT**	494,00±22,14	316,33±13,16	**0,0001**
	LT	335,33±19,41	196,00±17,13	**0,0001**

Independent t test



Graphic 3: Group averages of light transmittance according to material thickness of HT and LT groups in A1 color of material types

The mean A3 color light transmittance of the E.max CAD material HT 1 mm thickness group was found to be statistically significantly higher than the 2 mm thickness group (p=0.0001), (Table 12).

A1 color light transmittance averages of E.max CAD material LT 1 mm thickness group were found to be statistically significantly higher than the 2 mm thickness group (p=0.0001), (Table 12).

A3 color light transmittance averages of LRF Block material HT 1 mm thickness group were found to be statistically significantly higher than the 2 mm thickness group (p=0.0001).

LRF Block material A3 color light transmittance averages of the LT 1 mm thickness group were found to be statistically significantly higher than the 2 mm thickness group (p=0.0001), (Table 12).

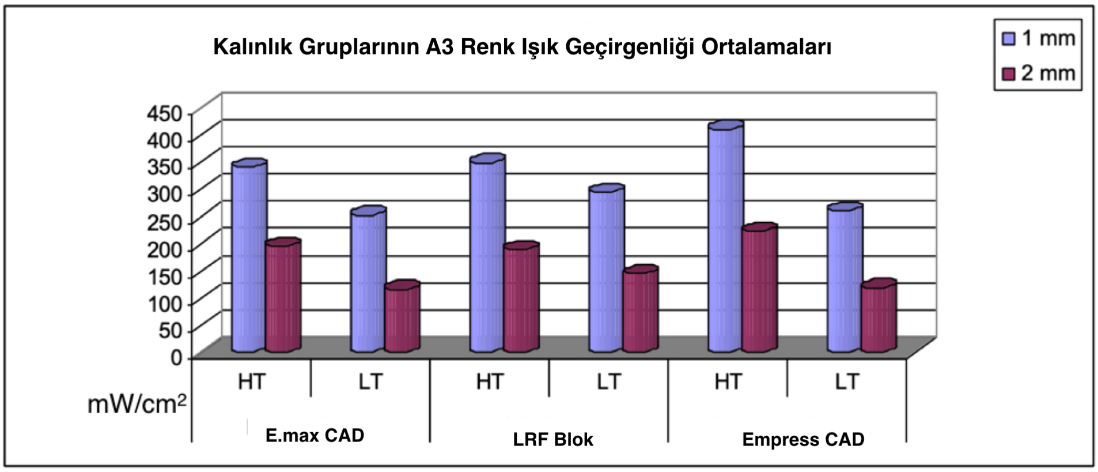
The A3 color light transmittance average of the Empress CAD material HT 1 mm thickness group was found to be statistically significantly higher than the 2 mm thickness group (p = 0.0001), (Table 12).

The mean A3 color light transmittance of the Empress CAD material LT 1 mm thickness group was statistically significantly higher than the 2 mm thickness group (p=0.0001), (Table 12).

Table 12: Group averages and statistical evaluation of light transmittance according to material thickness of high translucency and low translucency groups in A3 color of material types

Material	**Translucency**	**1 mm**	**2 mm**	**p**
E.max CAD Group	**HT**	341,33±20,04	196,33±11,87	**0,0001**
	LT	252,67±18,21	116,00±14,29	**0,0001**
LRF Blok Group	**HT**	349,33±17,1	190,33±11,57	**0,0001**
	LT	295,67±16,57	145,00±9,45	**0,0001**
Empress CAD Group	**HT**	411,00±16,39	223,67±19,5	**0,0001**
	LT	261,67±18,39	119,33±9,04	**0,0001**

Independent t test



Graphic 4: Group averages of light transmittance according to material thickness of HT and LT groups in A3 color of material types

E.max CAD material 1 mm thickness A1 color light transmittance averages of the HT group were found to be statistically significantly higher than the A1 color light transmittance averages of the LT group (p=0.0001), (Table 13).

E.max CAD material 2 mm thickness A1 color light transmittance averages of the HT group were found to be statistically significantly higher than the A1 color averages of the LT group (p=0.0001), (Table 13).

A1 color light transmittance averages of LRF Block material 1 mm thickness HT group were found to be statistically significantly higher than A1 color light transmittance averages of LT group (p = 0.0001), (Table 13).

LRF Block material 2 mm thickness A1 color light transmittance averages of the HT group were found to be statistically significantly higher than the A1 color light transmittance averages of the LT group (p=0.0001), (Table 13).

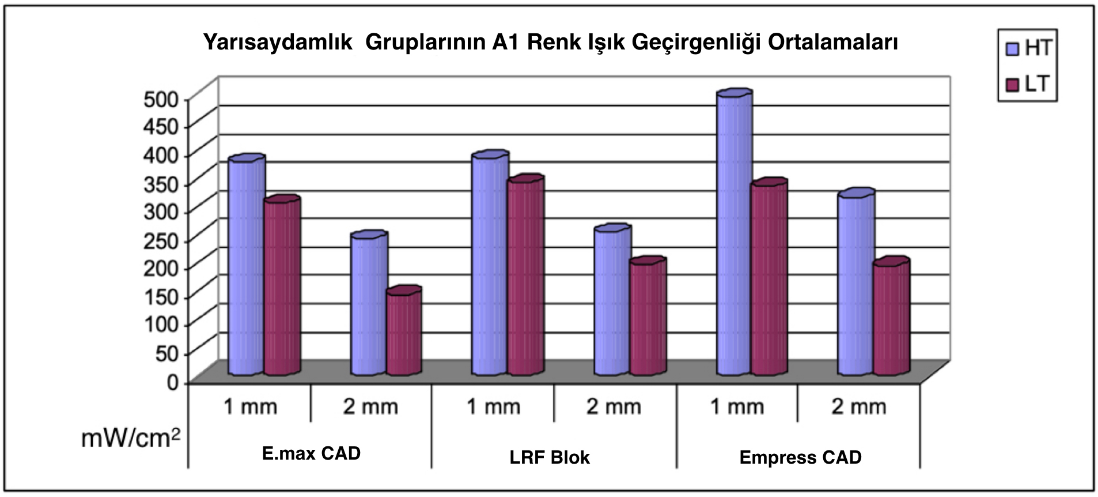
Empress CAD material 1 mm thickness A1 color light transmittance averages of the HT group were found to be statistically significantly higher than the A1 color light transmittance averages of the LT group (p=0.0001), (Table 13).

Empress CAD material was 2 mm thick. A1 color light transmittance averages of the HT group were found to be statistically significantly higher than the A1 color light transmittance averages of the LT group (p=0.0001), (Table 13).

Table 13: Mean and statistical evaluation of light transmittance according to translucency of 1mm and 2mm groups in A1 color of material types

Material	**Thickness**	**HT**	**LT**	**P**
E.max CAD Group	**1 mm**	379,00±10,56	305,00±24,13	**0,0001**
	2 mm	243,33±23,43	144,67±17,16	**0,0001**
LRF Block Group	**1 mm**	384,67±15,17	341,33±19,32	**0,0001**
	2 mm	254,67±10,26	197,67±17,1	**0,0001**
Empress CAD Group	**1 mm**	494,00±22,14	335,33±19,41	**0,0001**
	2 mm	316,33±13,16	196,00±17,13	**0,0001**

Independent t test



Graphic 5: Average values of light transmittance in different translucency of 1mm and 2mm groups in A1 color of material types

E.max CAD material 1 mm thickness A3 color light transmittance averages of the HT group were statistically significantly higher than the A1 color light transmittance averages of the LT group (p=0.0001), (Table 14).

E.max CAD material 2 mm thickness A3 color light transmittance averages of the HT group were found to be statistically significantly higher than the A1 color light transmittance averages of the LT group (p=0.0001), (Table 14).

LRF Block material 1 mm thickness A3 color light transmittance averages of the HT group were found to be statistically significantly higher than the A1 color light transmittance averages of the LT group (p=0.0001), (Table 14).

LRF Block material 2 mm thickness HT A3 color light transmittance averages were statistically significantly higher than the A1 color light transmittance average of LT group (p = 0.0001), (Table 14).

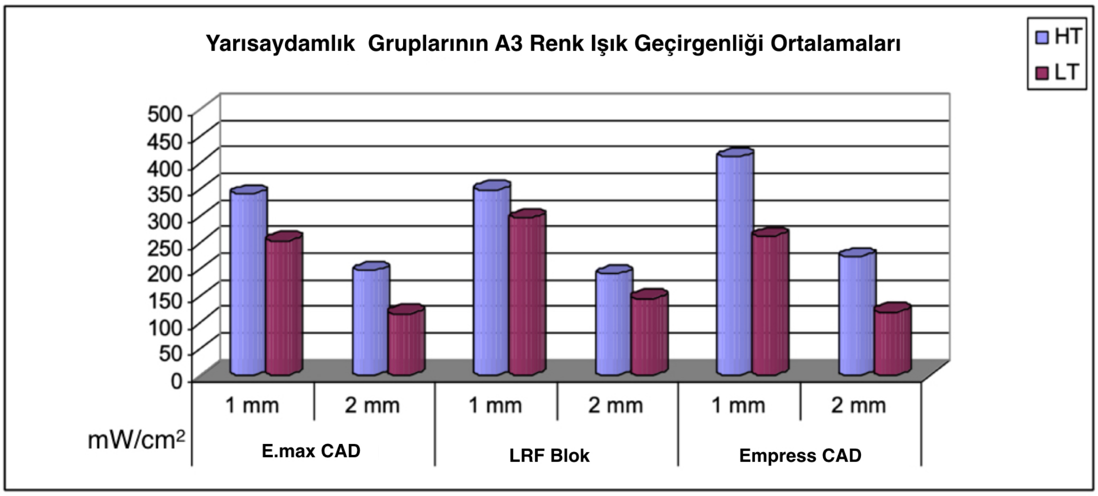
Empress CAD material 1 mm thickness A3 color light transmittance averages of the HT group were found to be statistically significantly higher than the A1 color light transmittance averages of the LT group (p=0.0001), (Table 14).

Empress CAD material was 2 mm thick. A3 color light transmittance averages of the HT group were found to be statistically significantly higher than the A1 color light transmittance averages of the LT group (p=0.0001), (Table 14).

Table 14: Mean and statistical evaluation of light transmittance according to translucency of 1mm and 2mm groups in A3 color of material types

Material	Thickness	HT	LT	p
E.max CAD Group	**1 mm**	341,33±20,04	252,67±18,21	**0,0001**
	2 mm	196,33±11,87	116,00±14,29	**0,0001**
LRF Block Group	**1 mm**	349,33±17,1	295,67±16,57	**0,0001**
	2 mm	190,33±11,57	145,00±9,45	**0,0001**
Empress CAD Group	**1 mm**	411,00±16,39	261,67±18,39	**0,0001**
	2 mm	223,67±19,5	119,33±9,04	**0,0001**

Independent t test



Graphic 6: Average light transmittance values in different translucency of 1mm and 2mm groups in A3 color of material types

E.max CAD material high translucency 1 mm thickness A1 color light transmittance averages were statistically significantly higher than A3 color light transmittance averages ($p = 0.0001$), (Table 15).

E.max CAD material high translucency 2 mm thickness A1 color light transmittance averages were found to be statistically significantly higher than A3 color light transmittance averages ($p=0.0001$), (Table 15).

E.max CAD material low translucency 1 mm thickness A1 color light transmittance averages were found to be statistically significantly higher than A3 color light transmittance averages ($p=0.0001$), (Table 15).

E.max CAD material low translucency 2 mm thickness A1 color light transmittance averages were found to be statistically significantly higher than A3 color light transmittance averages ($p=0.0001$), (Table 15).

LRF Block material high translucency 1 mm thickness A1 color light transmittance averages were found to be statistically significantly higher than A3 color light transmittance averages ($p=0.0001$), (Table 15).

LRF Block material high translucency 2 mm thickness A1 color light transmittance averages were found to be statistically significantly higher than A3 color light transmittance averages ($p=0.0001$), (Table 15).

LRF Block material low translucency 1 mm thickness A1 color light transmittance averages were found to be statistically significantly higher than A3 color light transmittance averages ($p=0.0001$), (Table 15).

LRF Block material low translucency 2 mm thickness A1 color light transmittance averages were found to be statistically significantly higher than A3 color light transmittance averages ($p=0.0001$), (Table 15).

Empress CAD material high translucency 1 mm thickness A1 color light transmittance averages were statistically significantly higher than A3 color light transmittance averages ($p = 0.0001$), (Table 15).

High translucency of Empress CAD Material, 2 mm thickness, A1 color light transmittance averages were found to be statistically significantly higher than A3 color light transmittance averages (p=0.0001), (Table 15).

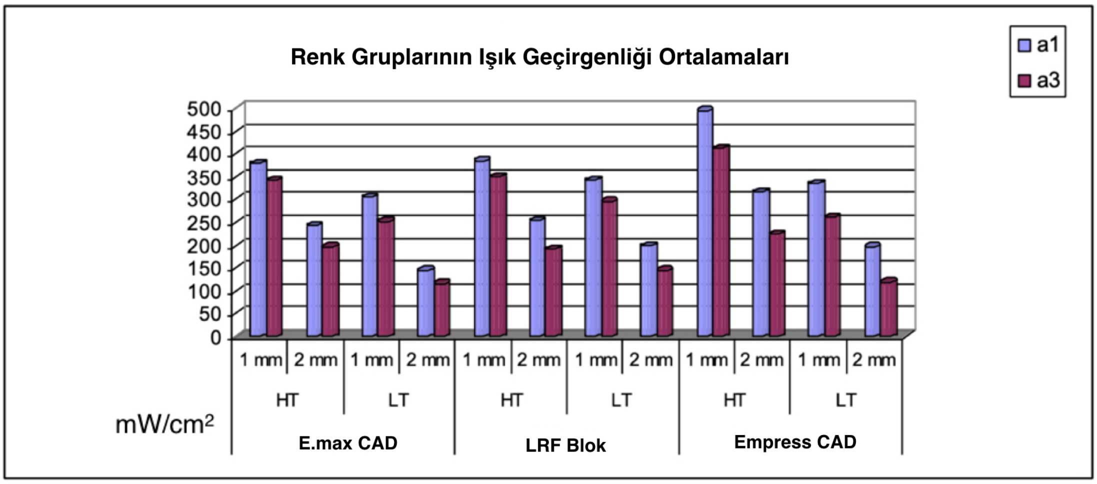
Empress CAD material low translucency 1 mm thickness A1 color light transmittance averages were found to be statistically significantly higher than A3 color light transmittance averages (p=0.0001), (Table 15).

Empress CAD material LT 2 mm thickness A1 color light transmittance averages were found to be statistically significantly higher than A3 color light transmittance averages (p=0.0001), (Table 15).

Table 15: Mean and statistical evaluation of light transmittance of A1 and A3 groups with different translucency and thickness of material types

Material	**Translucency**	**Thickness**	**A1**	**A3**	**p**
E.max CAD Group	**HT**	**1 mm**	379,00±10,56	341,33±20,04	**0,0001**
		2 mm	243,33±23,43	196,33±11,87	**0,0001**
	LT	**1 mm**	305,00±24,13	252,67±18,21	**0,0001**
		2 mm	144,67±17,16	116,00±14,29	**0,0001**
LRF Block Group	**HT**	**1 mm**	384,67±15,17	349,33±17,10	**0,0001**
		2 mm	254,67±10,26	190,33±11,57	**0,0001**
	LT	**1 mm**	341,33±19,32	295,67±16,57	**0,0001**
		2 mm	197,67±17,10	145,00±9,45	**0,0001**
Empress CAD Group	**HT**	**1 mm**	494,00±22,14	411,00±16,39	**0,0001**
		2 mm	316,33±13,16	223,67±19,50	**0,0001**
	LT	**1 mm**	335,33±19,41	261,67±18,39	**0,0001**
		2 mm	196,00±17,13	119,33±9,04	**0,0001**

Independent t test



Graphic 7: Average of light transmittance of A1 and A3 groups of material types with different translucency and thickness

Table 16: Light transmittance values of the experimental groups

				A1	A3
E.max CAD Group	HT	1 mm	N	15	15
			Mean	379,00	341,33
			SD	10,56	20,04
			Minimum	365,00	300,00
			Maximum	395,00	370,00
			Std. Error	2,73	5,18
			Skewness	0,36	-0,59
		2 mm	N	15,00	15,00
			Mean	243,33	196,33

			SD	23,43	11,87
			Minimum	220,00	170,00
			Maximum	300,00	215,00
			Std. Error	6,05	3,07
			Skewness	1,70	-0,40
			N	15,00	15,00
			Mean	305,00	252,67
			SD	24,13	18,21
			Minimum	255,00	230,00
			Maximum	350,00	295,00
			Std. Error	6,23	4,70
		1 mm	**Skewness**	0,21	1,50
			N	15,00	15,00
			Mean	144,67	116,00
			SD	17,16	14,29
			Minimum	120,00	95,00
			Maximum	190,00	155,00
			Std. Error	4,43	3,69
	LT	**2 mm**	**Skewness**	1,40	1,42
			N	15	15
			Mean	384,67	349,33
			SD	15,174	17,099
			Minimum	355	320
LRF Block Group	**HT**	**1 mm**	**Maximum**	410	380

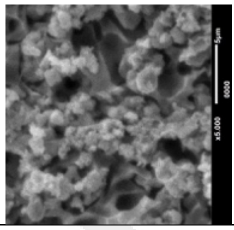
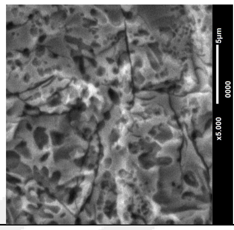
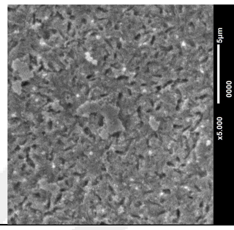
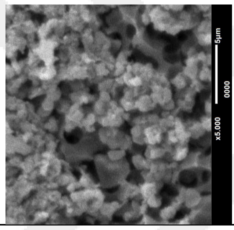
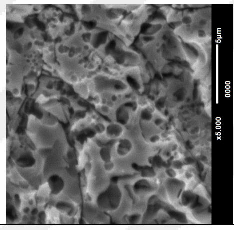
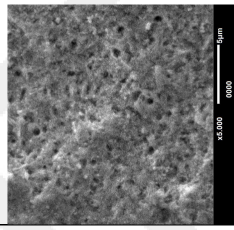
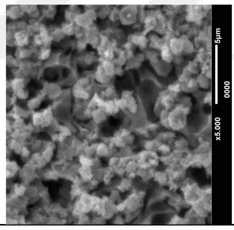
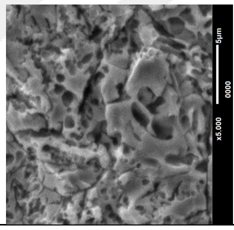
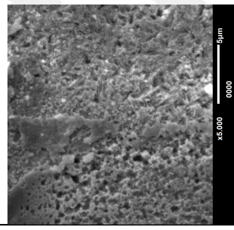
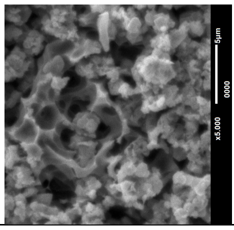
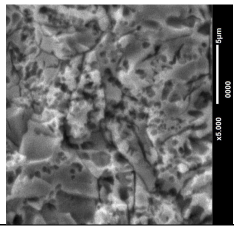
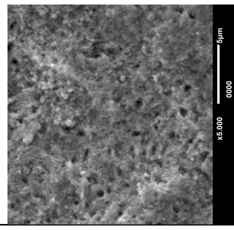
			Std. Error	3,918	4,415
			Skewness	-0,281	-0,03
			N	15	15
			Mean	254,67	190,33
			SD	10,259	11,568
			Minimum	230	165
			Maximum	270	215
			Std. Error	2,649	2,987
		2 mm	**Skewness**	-0,928	-0,053
			N	15	15
			Mean	341,33	295,67
			SD	19,316	16,569
			Minimum	315	280
			Maximum	390	320
			Std. Error	4,987	4,278
		1 mm	**Skewness**	1,062	0,49
			N	15	15
			Mean	197,67	145
			SD	17,099	9,449
			Minimum	170	130
			Maximum	230	165
			Std. Error	4,415	2,44
	LT	**2 mm**	**Skewness**	0,288	0,366
	HT	**1 mm**	**N**	15	15

Empress CAD Group			**Mean**	494	411
			SD	22,136	16,388
			Minimum	470	390
			Maximum	540	440
			Std. Error	5,715	4,231
			Skewness	0,621	0,357
		2 mm	**N**	15	15
			Mean	316,33	223,67
			SD	13,157	19,5
			Minimum	295	195
			Maximum	345	265
			Std. Error	3,397	5,035
			Skewness	0,236	0,765
	LT	**1 mm**	**N**	15	15
			Mean	335,33	261,67
			SD	19,408	18,387
			Minimum	305	230
			Maximum	370	295
			Std. Error	5,011	4,748
			Skewness	0,314	0,211
		2 mm	**N**	15	15
			Mean	196	119,33
			SD	17,134	9,037
			Minimum	165	105

			Maximum	220	140
			Std. Error	4,424	2,333
			Skewness	-0,061	0,563

4.2 Scanning Electron Microscopy (SEM) Results

Table 17: 5000 magnification SEM images of etched surfaces of all selected samples

A3 LT			
A3 HT			
A1 LT			
A1HT			
Material	**LRF Block**	**Empress CAD**	**E.max CAD**

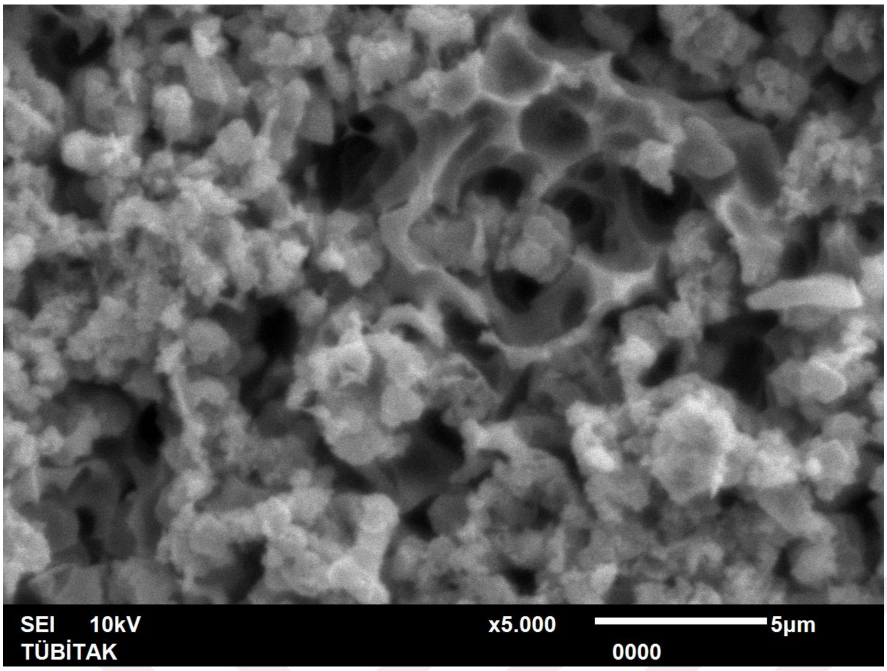


Figure 15: 5000 magnification SEM image of the etched surface of the LRF Block A1 HT sample

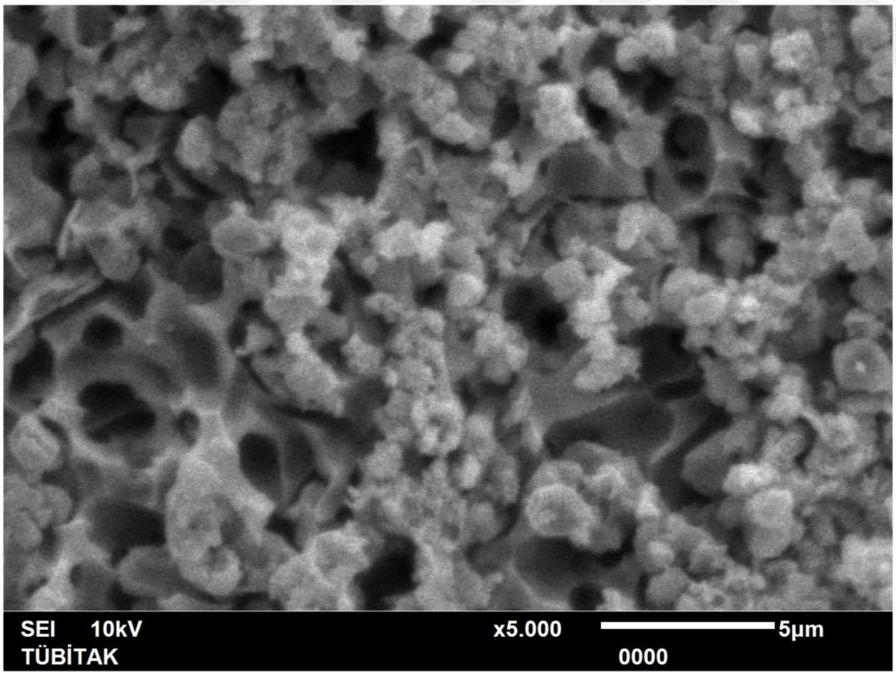


Figure 16: 5000 magnification SEM image of the etched surface of the LRF Block A1 LT sample

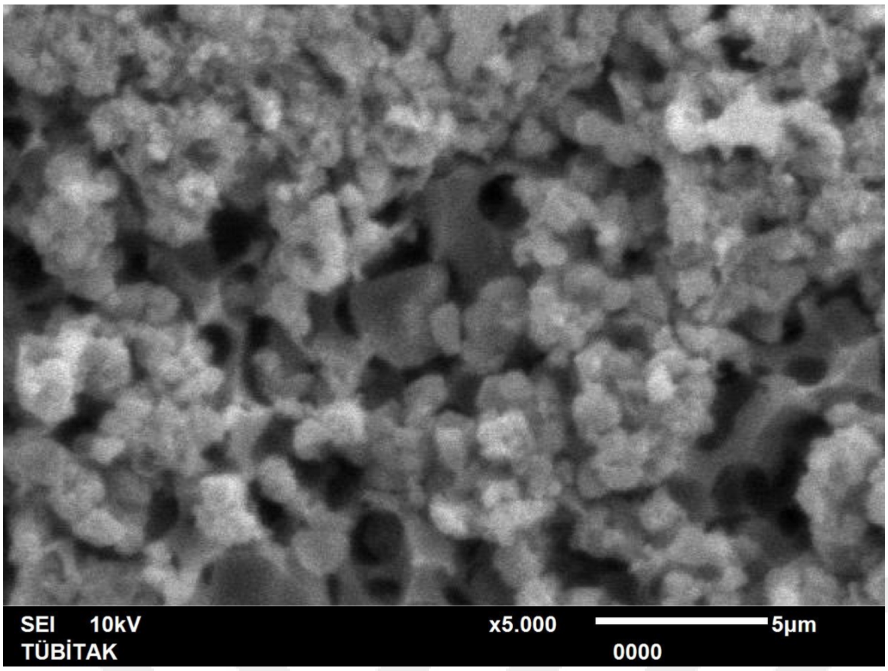


Figure 17: SEM image of the etched surface of the LRF Block A3 HT sample at 5000 magnification

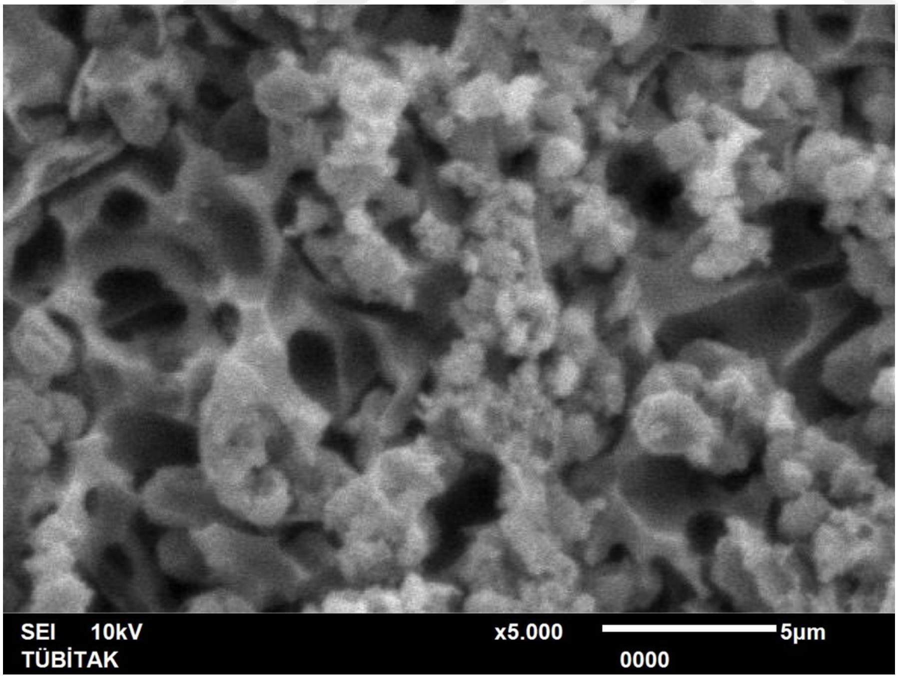


Figure 18: 5000 magnification SEM image of the etched surface of the LRF Block A3 LT sample

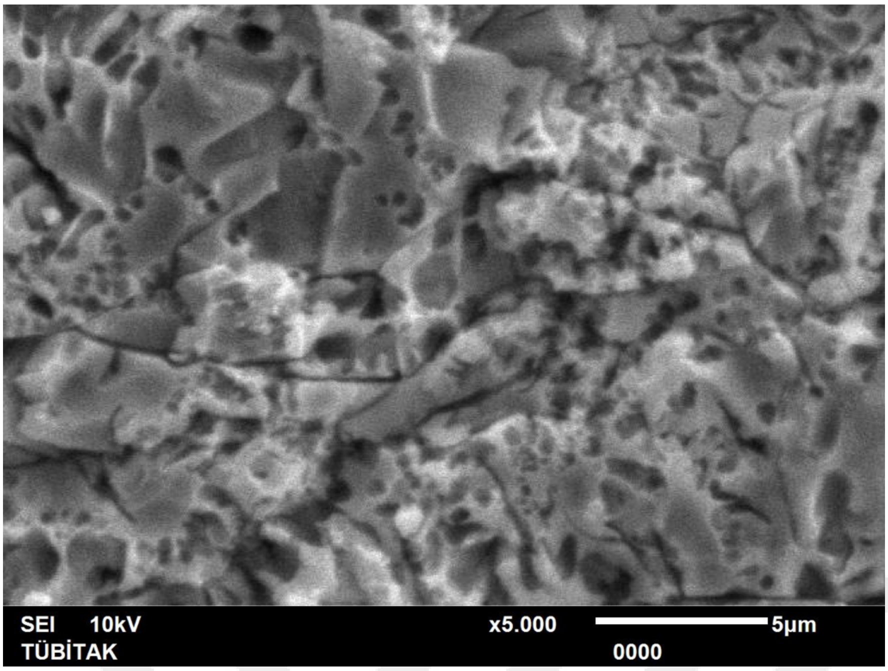


Figure 19: 5000 magnification SEM image of the etched surface of the Empress CAD A1 HT sample

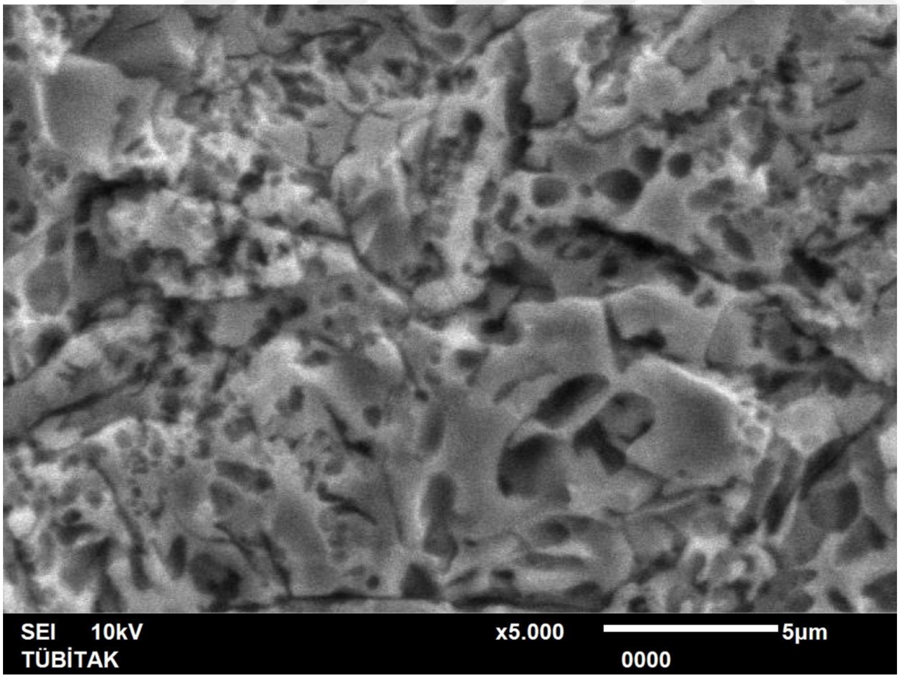


Figure 20: 5000 magnification SEM image of the etched surface of the Empress CAD A1 LT sample

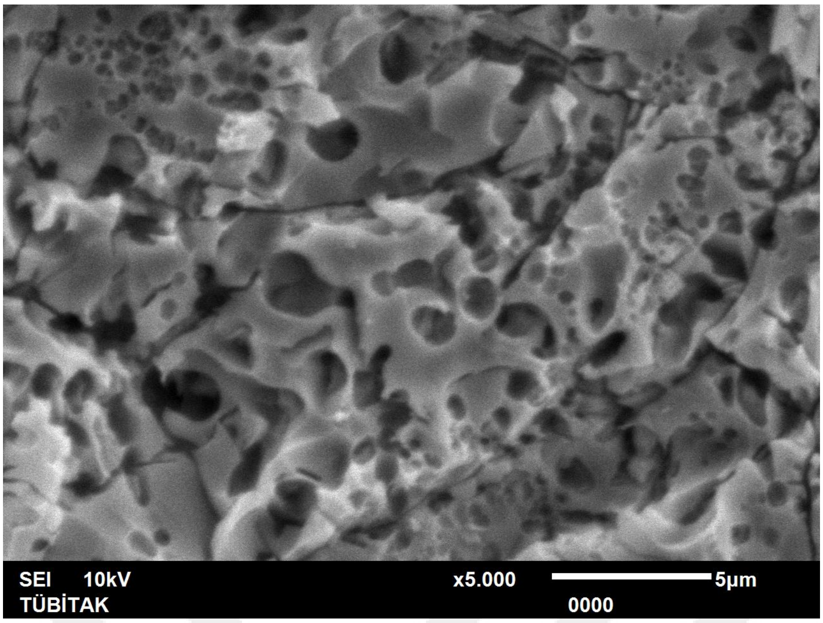


Figure 21: 5000 magnification SEM image of the etched surface of the Empress CAD A3 HT sample

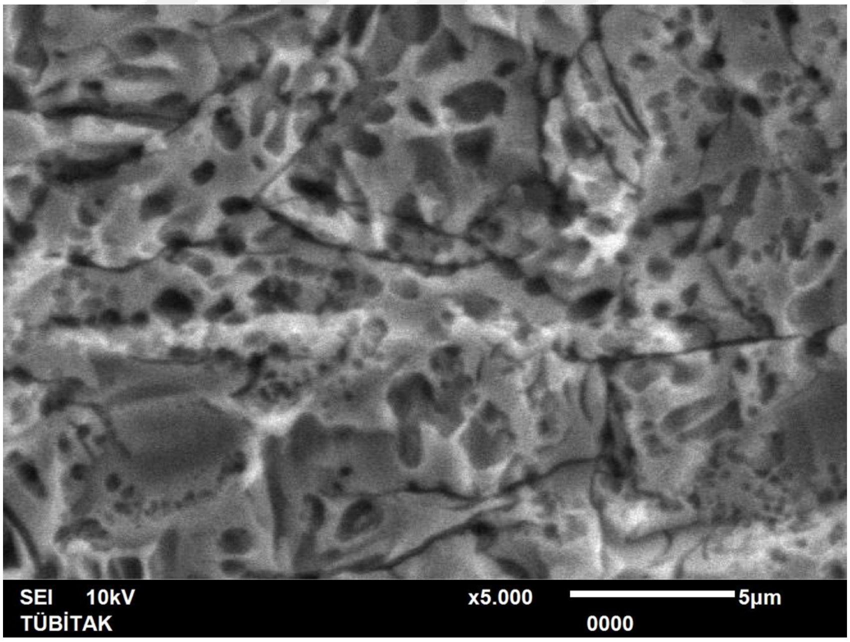


Figure 22: 5000 magnification SEM image of the etched surface of the Empress CAD A3 LT sample

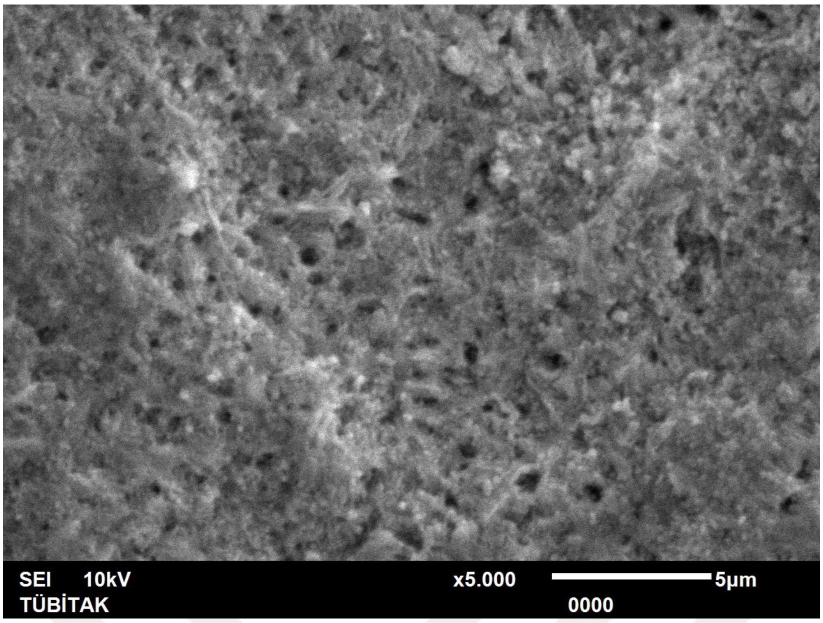


Figure 23: 5000 magnification SEM image of the etched surface of the E.max CAD A1 HT sample

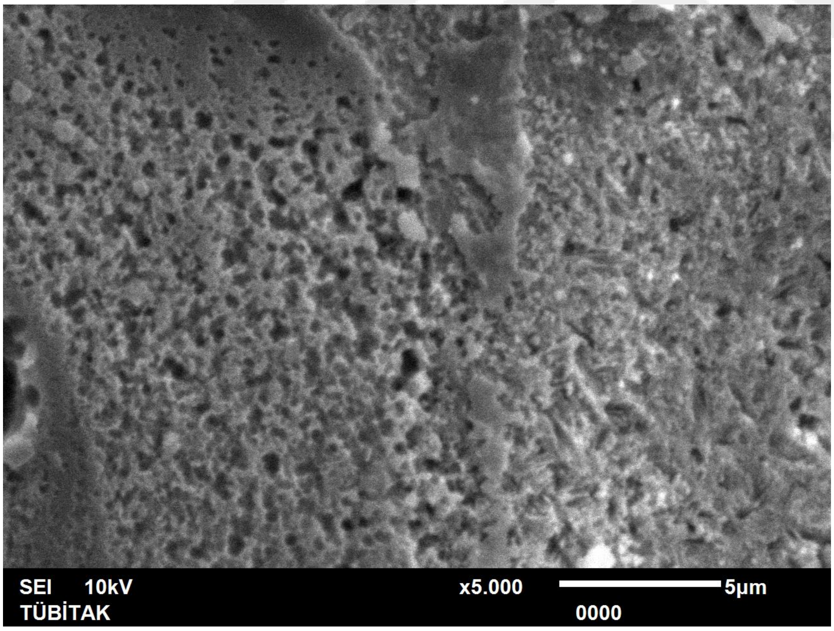


Figure 24: 5000 magnification SEM image of the etched surface of the E.max CAD A1 LT sample

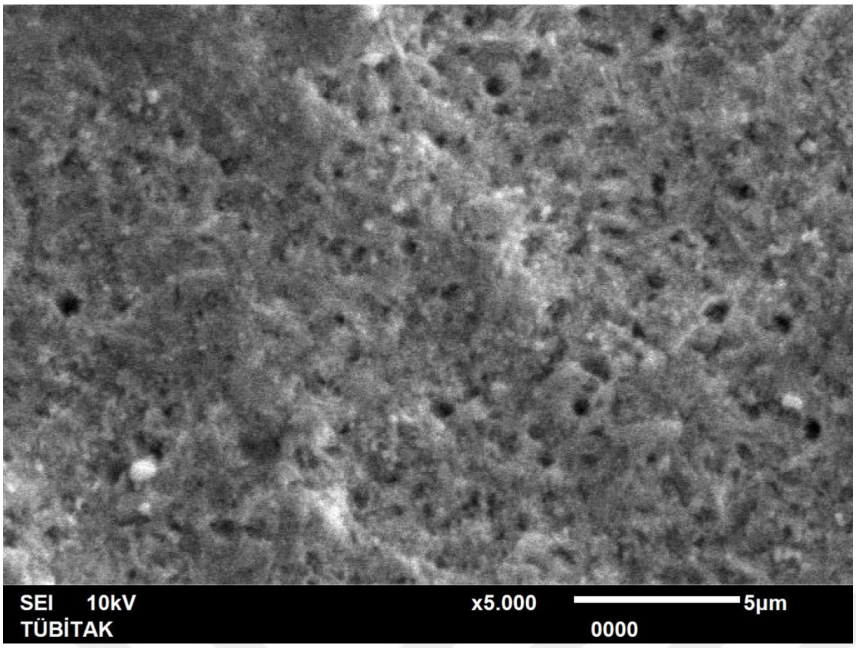


Figure 25: SEM image of the etched surface of the E.max CAD A3 HT sample at 5000 magnification

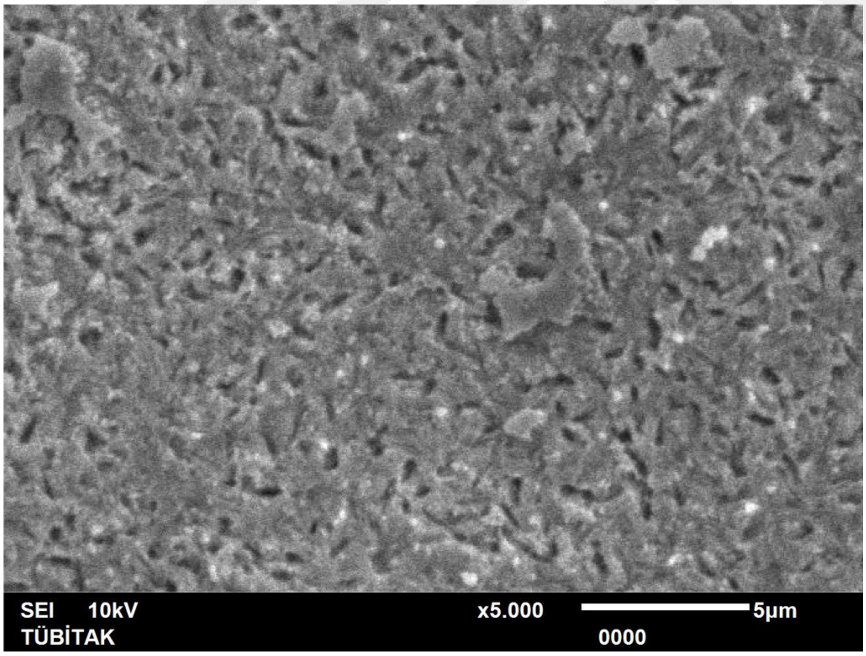


Figure 26: SEM image of the etched surface of the E.max CAD A3 LT sample at 5000 magnification

5. DISCUSSION

Aesthetic image has always been a feature sought by patients, but with the use of social media and the increase in snapshots, an aesthetic smile has become much more important in the daily life of all people (1). This has caused the aesthetic aspect of materials and restoration solutions to become the priority of dentists all over the world (106). For a restoration to look natural, it must be close to the optical properties of the tooth (2). Metal ceramics can meet the aesthetic expectations in today's world in a limited way. With the demand for superior aesthetic properties in materials used for prosthetic restorations, metal-based ceramic materials have begun to leave their place to full ceramics (1,107,108). All-ceramic restorations are translucent ceramic, transmitting and refracting light, a relationship similar to that of the tooth with light (2). In addition, they are materials with high compression resistance, high hardness and wear resistance, which closely approximate the natural aesthetic appearance of teeth (3,4).

As a reflection of the developments in technology to dentistry, new materials are constantly being introduced to the market and new techniques are being used. CAD/CAM technology is also gaining popularity thanks to the advantages it provides to the dentist, such as obtaining restorations in a short time, reducing errors as a result of the elimination of technical sensitivity in traditional impression methods, and increasing patient comfort (5,6,59). Along with these new popular systems, new materials and techniques to be used with them are being developed (5). Ceramic materials that are highly durable, enter the milling process, have superior aesthetic properties and can be used in various indications such as inlay, onlay, endocuron, crown, lamina veneer are being marketed (5,36).

In our study, in addition to materials such as leucite-enhanced ceramic IPS Empress CAD and lithium disilicate ceramic E.max CAD, which have been used for many years, the newly released leucite-enhanced GC Initial LRF Block was used. The effects of different thicknesses (1mm and 2mm), different translucency (HT and LT) and different colors (A1 and A3) of the materials on light transmission were evaluated.

One of the most important steps affecting the success of ceramic restorations with a long clinical life is adhesive cementing. In order to obtain high adhesion strength between the ceramic material and the resin cement, two mechanisms are mentioned; micromechanical bonding and chemical bonding (109,110). While micromechanical bonding is achieved by etching and / or sandblasting the material, it is necessary to use a silane agent for chemical bonding (109,111-113). Due to the different chemical composition and microstructure of various glass ceramic materials, it has been stated that the surface preparations and application process should be selected according to the content of the material to be used (109,110). In our study, leucite-reinforced ceramics Empress CAD and LRF Block were etched for 60 seconds, while lithium disilicate E.max CAD was etched with 5% hydrofluoric acid for 20 seconds. We tried to imitate the clinical work environment by etching one surface of the blocks used in our study and polishing the other surface. Acid etched surfaces are made to standardize all three groups in line with the recommendations of the manufacturers.

Awad et al. investigated the effect of thickness and surface roughness of CAD/CAM materials on translucency in their study in 2015 (107). IPS Empress CAD and E.max CAD blocks were selected in A2 color and low translucency, 1 and 2 mm thick samples were created, half of the samples were polished on both sides and the other half was roughened. The translucency of the samples was evaluated with the help of spectrophotometer. E.Max CAD samples were found to have significantly lower translucency values in polished and roughened groups than IPS Empress CAD samples. While there was no statistically significant difference in thickness translucency between E.max CAD polished and surface roughened samples, a numerical decrease was observed in all measurement results. The same results were seen in the IPS Empress CAD surface roughness groups, but the 2mm samples obtained statistically significantly lower translucency values in the polished samples. As the authors stated in the article, translucency is the refraction or absorption of light as it passes through the material (107,114). Since the surface roughness changes the refractive index of the light, it also affects the translucency. In our study, one side of the samples was roughened while the other side was polished in order to imitate clinical applications. However, the effect of this change in the samples on the light transmittance was not evaluated.

Nogueira and Della Bona evaluated the translucency of ceramics in their 2013 study. Experimental samples with 1mm thickness obtained from IPS Empress CAD and E.Max CAD low (LT) and high (HT) translucency A2 blocks were examined with a spectrophotometer and the amount of light transmission was recorded (115). In the results, E.Max CAD HT and IPS Empress CAD LT gave the same light transmittance values, while IPS Empress CAD HT gave the highest values and E.max CAD LT the lowest. While evaluating the study, the researchers drew attention to the difference between the ceramic shape in the experimental design and the restoration shape. They wanted to underline that light transmittance and refraction may differ due to shape in veneer restorations, where the color harmony and color in the anterior region are very important in terms of aesthetics. In our study, as in many studies (127-132-134-139-140-144), we used flat ceramic samples. However, we think that the design of ceramic samples should be taken into account in studies where optical properties are evaluated.

In the studies, visual or digital evaluation instruments such as radiometer (6,122,124) or spectrophotometer (106,114,131,132) were used to measure the light transmittance of the materials. In radiometers, which is one of them, usually the silicon photodiode converts the photons coming from the light device into electric current at the front of the detector. The light entry points of some dental radiometers are narrower than the light end of the device. For these reasons, dental radiometers may not be able to measure all the light coming from the light device. In addition, the way the tip is placed in the detector field and its angle also affect the measurement results. These limitations cause discussion of the results obtained with dental radiometer (101-103). In our study, as in many other studies (6,122,124), it was preferred because it can be easily obtained and used in clinical applications. At the same time, in our study, a silicon mold was prepared in order to prevent the possible problems that bring into question the reliability of the above mentioned radiometers and to standardize the light placement angle.

In the study of Pereira et al. (114), it was investigated that different thickness, color and translucency of E.Max CAD transmit the light of LED and halogen light sources (116). The light transmission of LED (Bluephase) and halogen (Demetron) light sources applied to the samples obtained from the colors A1, A2, A3 and A3,5 of the low and high translucency blocks with a thickness of 1, 2, 3, 4, 5 mm was investigated by spectrophotometer. It has been shown in the findings that both the increase in sample thickness and the darkening of the color decrease the light transmission of the ceramic. Light transmission of high translucency blocks was found to be higher than low translucency blocks. In addition, measurements and evaluations have shown that samples obtained from high translucency blocks have higher light transmittance than samples obtained from low translucency blocks. Especially in the samples of 3mm and above and

A3- A3.5 colors, the light transmittance decreased more. The authors drew attention to the importance of material choice in the polymerization of the resin cement used, since light transmission will decrease with increasing restoration thickness and dark color. Light transmittance decreased at similar rates in LED and halogen light devices. As the color and thickness findings of this study were similar to our study, LED light device was used in our study. (145-146)

At the same time, in the study of Pirmoradian et al. (146) LED and halogen light devices were compared and it was stated that LED light devices were better. According to these results, an LED light device was used in our study.

In the study published by Lee et al. in 2011, they measured the polymerization amount of resin cement and direct composite polymerized under three different thicknesses of ceramic materials (117). 0.5mm, 1mm and 2mm ceramic discs were prepared from E.max medium opacity (MO) ingot and placed on the dual cure resin cement and direct composite groups, half of the samples were polymerized with an LED light source for 20 seconds and the other half for 40 seconds. Resin cement and direct composite samples, which were kept in a container without light for 24 hours, were evaluated in terms of microhardness. In all cement and composite groups and ceramic thicknesses, higher microhardness values were measured in samples illuminated for 40 seconds. Again, the increase in ceramic thickness in all groups caused a decrease in microhardness values. LED light source and LED radiometer device were used in our study. The effect of the exposure times on the light transmittance was not evaluated while the measurements were made.

In the study of Vichi et al. published in 2014 (118), the aim is to measure the translucency of ceramic materials used with CAD/CAM. For this purpose, samples of 0.5 and 1 mm were prepared from blocks in zirconia-based materials, and translucency values were measured with the help of a spectrophotometer on black and white grounds (118). Empress CAD and E.max CAD concluded that the effect of thinness on translucency was statistically significant in 0.5mm and 1mm comparisons in high and low translucency groups. Empress CAD and E.max CAD 0.5mm thick high and low translucency groups and 1mm thick samples in the low translucency groups as a result of comparing the two materials with each other, there was no significant result between the values, while there was no statistically significant difference in the evaluation between the 1mm thick high translucency groups in the Empress CAD group. the translucency value was found to be higher (118). Many similarities were observed between the values obtained in this study and the values of our study.

However, in the publication of Willard et al. in 2018 (148), they stated that the manufacturer did not make any difference in the material used to create the low translucency and high translucency values, and their microstructures were changed. Accordingly, a less dense structure was created by using larger particles (1.5 x 0.8 mm) in high translucent materials. Likewise, in materials with low translucency, smaller particles (1.5 x 0.2 mm) are used to create a denser structure. In our study, the Empress CAD group obtained higher results than the E.max CAD group and similar results with the LRF Block group among the groups with different thicknesses in high translucency, while the materials with low translucency values gave higher results than lithium disilicate materials in the A1 groups. Rosenblum et al. (23) reported that some of the materials used in our study affect the translucency, crystal density and size of the ceramics. This explains the differences in results between materials and different translucency samples of the same material.

The materials can be defined as translucent and transparent according to their light transmittance. Translucency can be described as between transparent and opaque (119). Transparent materials do not reflect light but pass through, while translucent materials pass only a part of the light and reflect some of it. Translucency and light transmittance values of materials are two different definitions. Accordingly, as the translucency increases, the light transmittance also increases. For a material to transmit light, there must be no porosity, surface roughness, or reflective differences between phases (120). We think that the differences in the findings of different translucency groups of our study may also be influenced by porosity, surface roughness or reflective differences between phases.

De Jesus et al., In their study published in 2020, aimed to examine the transformation rate of light-cured cements under different translucent lithium disilicate ceramics, the translucency of the ceramic and the amount of light transmission (121). For this reason, 1.5 mm thick discs were obtained from E.max Press high translucency (HT), low translucency (LT) and medium opacity (MO) blocks in the A2 color chosen for the experiment. The cements were polymerized over the placed discs with a Bluephase LED light device, and the conversion rate of the samples was measured. In the results, it was seen that the translucency of the material was listed as HT> LT> MO. Very similar to this finding, HT (810 mW/cm2) > LT (692 mW/cm2) > MO (566 mW/cm2) results were obtained in light transmission results. In the resin cement conversion rate measurements, it was reported that the selected ceramic thickness did not affect the conversion rate. Clinical success in all-ceramic restorations depends on the physical properties of the resin-based adhesive material obtained at the end of polymerization (122,123). Although it has been shown in the literature that the amount of ceramic light transmission is also effective in the conversion rate (124), the authors reported that different results were obtained in this article, and the sample thicknesses were selected at a level that does not affect the block translucency. In our study, it was observed that HT groups had more light transmittance than LT groups, in parallel with the study of De Jesus et al.

In the study conducted by Flury et al. (6), the results of ceramic groups of different thicknesses in the part where the resin cement conversion rates were measured were evaluated statistically. Different results were obtained in different ceramic thicknesses according to the light device used in the conversion rates of resin cements, all of which were selected as dual-cure. It was observed that, in all light source samples of all five resin cements, 1.5mm samples reached a statistically significantly higher conversion rate than 3mm samples in IPS Empress CAD and E.max CAD groups. Similar to the findings of Flury et al. (6), in our study, it was found that the results of the groups with thinner samples were statistically significantly higher than the results of the groups with increased thickness, regardless of translucency, color and ceramic type of all ceramic groups. As the thickness of the material increases, the light transmittance property decreases. This finding supports the knowledge that dual cure cements should be used instead of light-cured cements as the thickness of the restoration increases (6).

The aim of Zhang and Fu's study in 2011 was to measure the effect of ceramic thickness and light exposure time on the polymerization of dual cure resin cements (125). The ceramic E.max Press material to be used in the study was chosen as medium opacity. The power from the light device was measured by placing 1mm, 2mm, 3mm discs obtained from ceramics on the radiometer. When the light device used was measured without the ceramic disc in between, the result was found to be 584mW/cm2, while this measurement was found to be 216mW/cm2 for the 1mm-thick disc, 85mW/cm2 for the 2mm-thick disc, and 52mW/cm2 for the 3mm-thick disc. Although the construction technique and translucency values of the materials used are not the same, in our study, in parallel with the work of Zhang and Wu, in the A1 and A3 experimental groups of E.max CAD ceramic samples, in the sample findings with high and low translucency, 1mm thick ceramic samples were found to be 2mm thick. It has been shown to have statistically significantly higher light transmittance than samples with a thickness. This finding shows the effect of increasing the ceramic thickness on the light transmittance (125).

Öztürk et al. in 2015, they investigated the micromechanical properties of light-cured resin cement when polymerized under samples prepared using different colors and thicknesses of a leucite-reinforced ceramic (126). In the study, the IPS Empress CAD block was selected in low translucency and in two colors, A1 and A3. Samples prepared in 1mm and 2mm thicknesses were placed on 4 different colors of light-cured resin cement and polymerized with the LED light device Bluephase (Ivoclar). When the resin cement samples were evaluated in terms of Vickers hardness, it was found that increasing the ceramic thickness in both colors negatively affected the hardness. The values of the A1 color 1mm group were found to be higher than the values of the A3 color 1mm group, and the values of the A1 color 2mm group were statistically significantly higher than the values of the A3 color 2mm group. In parallel with the study, in our study, it was found that 1mm thick samples had more light transmittance than 2mm thick samples and also A1 color groups had more light transmittance than A3 color groups, regardless of translucency in all experimental materials.

In a study by Runnacle et al. In 2014, the effect of different types and thicknesses of ceramic veneers on the conversion rate of light-cured resin cement was investigated (127). IPS Empress Esthetic and E.max (high (HT) and low (LT) translucency) A1 colored blocks prepared with CAD/CAM, 0.5, 1 and 2mm thick, light-cured resin cement was polymerized under the samples. . Then, the conversion rate of the resin cement was measured. The control group was illuminated only under the transparent tape. In the results of the study, the highest conversion rate was achieved in the E.max high translucency and 0.5mm thickness group. There was no difference between the findings in IPS Empress Esthetic 0.5 and 1mm, E.max HT 0.5 and 1mm, E.max LT 0.5 and 1mm groups. However, it was reported that the conversion rate of resin cement decreased statistically significantly when it was polymerized under 1.5 and 2 mm thick ceramic samples. The researchers underlined that the clinician should not forget that the success of the restoration may be at risk, resulting in different results than expected in the polymerization of the resin cement due to the decrease in light transmission in restorations with a thickness exceeding 1 mm.

The study published by Al-Juaila et al. in 2018 measured the translucency values of different ceramic materials at three different thicknesses (128). In the study, in which E.max CAD low (LT) and high (HT) translucent blocks were used, ceramic samples were prepared in 0.4mm, 0.6mm and 1mm thicknesses. Translucency values of the material were measured with a spectrophotometer on black and white backgrounds. While there was a statistically significant difference between the findings of LT and HT samples in the 0.4mm and 1mm groups, no difference was found in the 0.6mm groups. In the comparison of the HT and LT groups according to thickness, there was no statistically significant difference between the LT groups, while the highest translucency value in the HT groups was 0.6mm. The researchers explained this result with the possibility that the standard E.max CAD restoration should start from the 0.6-1mm range and that the thinner-than-normal structure of the 0.4mm may be damaged during firing. Parallel to the studies of Al-Juaila et al., in our study, light transmittance decreased statistically significantly with the increase of ceramic thickness in both E.max CAD groups and leucite-enhanced ceramics (IPS Empress CAD and GC Initial LRF) groups.

One of the factors affecting the color of the final restoration is the thickness of the restoration. It is often desirable for a porcelain restoration to mask the color of the underlying tooth. In this case, it should be kept in mind that the light transmittance of the material changes with its thickness (129,130). Studies have shown that the masking property of the ceramic material increases with the increase in the thickness of the restoration, which again shows that thinner restorations transmit more light (129-132). Researchers attribute this to the fact that thinner restorations allow more light to penetrate and scatter into the material (129,132). In other words, as the material gets thicker, the amount of light it will reflect from the substrate will decrease and its light transmission will decrease. Therefore, in restorations made on discolored teeth, the thickness of the selected ceramic material should be able to mask the underlying color (147).

Kilinc et al., in their study published in 2011, investigated the effect of ceramic thickness and color on the microhardness of resin cements at the end of polymerization (133). The IPS Empress Esthetic (Ivoclar) system used includes both pressable ingots and CAD blocks. Ceramic test samples prepared in ETC1 (A1, B1, C1), ETC2 (A3, A3,5, A4), ETC3 (B3, B4), ETC4 (C2, C3, C4) colors and 1mm, 2mm, 3mm, 4mm thickness The value in the radiometer was recorded by placing light on it with a light device. It was observed that the radiometer measurement decreased both with increasing ceramic thickness and with darker color. The value that was 800mW/cm2 in the measurement of the control group, 400, 250, 175, 100 800mW/cm2 in the ETC1 group, 375, 200, 125, 80 800mW/cm2 in the ETC2 group, 350, 180, 100, 60, 800mW in the ETC3 group, respectively. It was reported that 325, 190, 100, 60, 800mW / cm2 values were measured in / cm2 and ETC4 groups. Researchers have shown that the darkening of the color causes a decrease in the light transmittance of the ceramic.

Mendonça et al. Aimed to examine the effect of ceramics of different composition, opacity and color on the conversion rate of resin cements in their study in 2018 (134). Samples produced from lithium disilicate pressed ceramic E.max Press with 2mm thickness and low translucency ingots in A2, A3,5, B2, C2, D3 colors were measured by spectrophotometer. It has been reported that the A2 and B2 colored samples show more light transmittance than the A3,5, C2 and D3 samples, which are not statistically significantly different from each other.

Similar to the studies of Kılınç et al. and Mendonça et al., it was found that the darkening of the colors of all materials caused a statistically significant decrease in the measurement values (133,134). The light transmittance of ceramic materials is completely affected by the internal properties of the material. All crystals, fillers, thickeners and pigments that make up the material affect optical properties such as light transmittance and fluorescence. As the color of the ceramic restoration darkens, its light transmittance decreases due to the change in the pigment structure inside (133-135).

One of the studies evaluating ceramics reinforced with different fillers, Oh et al investigated the light transmittance of CAD / CAM ceramic blocks in their study published in 2018 (136). 0.5, 1, 2 and 4 mm samples were taken from low (LT) and high (HT) translucent blocks of IPS Empress CAD and E.max CAD ceramics. Light transmittance measurements were made with a photodetector. Light transmittance decreased statistically with thickness in all groups. In the examination between the ceramic groups, the difference was statistically significant, and the order was reported as IPS Empress CAD (HT), E.max CAD (HT), IPS Empress CAD (LT), E.max CAD (LT). The result of the study supports the findings of our study that the light transmittance decreases with thickness and that leucite-reinforced ceramics are more than lithium disilicate ceramics. High translucency has an important role in light transmittance. In addition, researchers such as Illie and El-Meliegy reported that the light transmittance of ceramic materials depends on the crystalline structure, crystalline size, pigments, porosity, number of firing and material thickness (139-142).

Stawarczyk et al., in their study published in 2016, used three different composites (LAVA Ultimate, Cerasmart, Shofu Block and two experimental CAD/CAM composites), hybrid (Vita Enamic), leucite-enhanced (IPS Empress CAD) to examine the mechanical and optical properties of CAD/CAM materials. and lithium disilicate (E.max CAD) prepared samples in the block (137). Translucency measurements of the test samples were made with spectrophotometer. As a result of the measurements, IPS Empress CAD and E.Max CAD achieved higher translucency values than VITA Enamic samples alone. It has been emphasized that the ratios of organic – inorganic substances affect not only the physical properties of the material, but also the optical properties, and that they must be taken into account when choosing materials for restoration.

Flury et al. In their study conducted in 2013, the differences in the conversion rate of 5 different resin cements when polymerized under Empress CAD and E.max CAD samples were investigated (6). In the study, 3 different light sources were used by operating at different times. Elipar Freelight 2 (3M Espe) is planned to be operated for 40 seconds (2 x20) in standard mode, 32 seconds (8 x4) in VALO (Ultradent) high power mode, and 18 seconds (6x3) in VALO (Ultradent) extra power mode. Ceramic samples obtained from blocks in A3 color and low translucency were prepared as 1.5 mm, 3 mm, 4.5 mm and 6 mm. Before the resin cements were polymerized under ceramic samples, the power of the light sources was measured with a radiometer. As a control group, resin cements were polymerized under clear tape. In addition, the output power of the light sources was controlled by measuring the amount of light passing through the ceramic samples with a radiometer. In the results, IPS Empress CAD achieved statistically higher results than E.max CAD in all ceramic thickness groups in both modes of Elipar Freelight 2 (3M Espe) and VALO (Ultradent). In other words, the light transmittance of IPS Empress CAD was found to be higher than that of E.Max CAD at all ceramic thicknesses. A result supporting these findings was also observed in the experimental group in which the conversion rates of resin cements were measured.

The researchers stated that the better results obtained with the leucite-reinforced ceramic Empress CAD compared to the lithium disilicate ceramic E.max CAD may be due to the lower density of crystals. In our study, Empress CAD showed statistically significantly higher light transmittance than E.max CAD in A1 and A3 color samples with high translucency (HT) and in both 1mm and 2mm sample groups. With LRF Block samples, similar findings were obtained with E.max CAD. In the low translucency evaluation, LRF Block findings in A1 color samples showed statistically insignificant differences from Empress CAD sample values, while statistically significantly higher values were found in E.max CAD samples. In low transparency and A3 color samples, LRF Block obtained statistically significantly higher values from both Empress CAD and E.max CAD samples. We think that Empress CAD and LRF Block, both of which are ceramic systems reinforced with leucite, give different findings in translucency, thickness and color changes due to the different brand contents and crystal densities. For LRF Block, which has just been released and there are not enough articles about it, the light transmittance of a lithium disilicate ceramic in the color A1 and A3 of the blocks with high translucency (HT) is more advanced than that of the other leucite reinforced ceramic in the color of A1 and A3 of the low translucency (LT) blocks. permeability was found in our study.

In study published in 2016, Ilie investigated the polymerization mechanism of a light-cured cement at different exposure times under different ceramic samples (138). 0.5mm, 1mm, 1.5mm and 2mm thick samples were prepared from IPS Empress CAD and E.max CAD blocks, both of which were selected in high translucency (HT) and A2 color. The light-cured resin cement, Variolink Aesthetic, was polymerized under the ceramic samples placed on it, with the Bluphase LED light device, half of the samples for 10 seconds and the other half for 20 seconds. Microhardness measurements of resin cement samples were made. In addition, the irradiance of the light unit was measured with a spectrophotometer by giving light on the ceramic samples. In the light transmittance measurement, the transmittance decreased with increasing thickness in both E.max CAD groups and IPS Empress CAD groups. The percentage of light passing through the ceramic in 2mm groups was measured as 20.7 and 22.8 for E.max CAD and IPS Empress CAD, respectively. As the radiation ceramic thickness increased, which was 1200 mW/cm2 in the control group at 360-430 nm wavelength, for IPS Empress CAD and E.max CAD, respectively; It has decreased to 720-680 mW / cm2, 500-480 mW / cm2, 380-360 mW / cm2 and 240-230 mW / cm2. Similar light power measurements were obtained in our study. In the microhardness part of the study, the researchers reported that the resin cement hardnesses polymerized under IPS Empress CAD were higher than the samples polymerized under E.max CAD. These results also support the light power measurement results of the study (138). The microhardness of the samples illuminated for 20 seconds was found to be statistically significantly higher than the microhardness of the samples irradiated for ten seconds. In our study, while the increase in thickness and the decrease in light transmittance were similar, the exposure time affecting the microhardness of the resin cement was not evaluated.

The most commonly used etching method in glass ceramic restorations is etching (143). In our study, all ceramic groups were etched with HF acid before the light transmittance evaluation. After this process, the surface image was examined with a scanning electron microscope and the surface topography was evaluated. Hou et al., in their study published in 2018, investigated the effect of different surface preparation methods on the bonding of glass-ceramic restorations (143). E.max CAD was etched with HF acid for 20 seconds and Empress CAD for 60 seconds. In the SEM examination, it was observed that the crystal surfaces that would provide micromechanical bonding were exposed in the E.max CAD material. They reported that uniform microporosities were observed in the Empress CAD material. Murillo-Gomez et al. Published their study evaluating the effect of surface roughening processes in 2018 (144). After HF acid applied to the evaluated E.max CAD and Empress CAD materials, in SEM imaging, micro-indentations of approximately the same dimensions were observed homogeneously in Empress CAD, while a more aggressive heterogeneous structure was observed in the E.max CAD material. In our study, parallel SEM images were obtained with these studies. While similar homogeneity and same size micro indentations were observed in the LRF

Block group in the Empress CAD group (Figure 19-22), no needle-like crystals were observed in the SEM images of the E.max CAD group (Figure 23-26).

According to the results of our study, it is observed that the light transmittance of CAD/CAM restorations applied in the clinic changes significantly with variables such as the selected block type, the translucency value of this block, and the restoration thickness. It is known that the polymerization type of the resin cement chosen for the cementation process in the clinic should be chosen depending on the light transmittance of the restorations. If the polymerization type of the resin cement is not chosen correctly, it will not be able to polymerize and this may cause problems such as microleakage, discoloration, retention that will directly affect the success of the treatment. Therefore, according to the results of our study, we recommend the use of dual cure resin cement due to the reduction in light transmission, especially in CAD/CAM restorations with a thickness of 2 mm and above, when choosing the resin cement to be used for the cementation process in the clinic. Again, based on the same results, we recommend choosing the polymerization type of the resin cement by evaluating in detail not only the thickness of the restoration, but also the color and translucency values. However, it should be taken into account that the light transmittance of CAD/CAM materials reinforced with leucite and lithium disilicate may differ, and the light transmittance of CAD/CAM materials of 2 different companies reinforced with leucite may vary.

The limitations of our study are that more sophisticated light measurement devices were not used and the transformation hardness of resin cement could not be examined. In new studies, studies can be carried out on samples imitating inlay-onlay and crown shape instead of flat ceramic samples.

Following are the null hypotheses we created in our study:

H1: There is a difference in light transmittance of CAD/CAM ceramic blocks reinforced with different fillers (leucite-lithium disilicate).

H1: There is a difference in light transmittance between ceramic block groups with different thicknesses (1mm-2mm).

H1: There is a difference in light transmittance between ceramic block groups with different translucency values (HT-LT).

H1: There is a difference in light transmittance between ceramic block groups of different colors (A1-A3).

This hypotheses were found to be significant.

6. CONCLUSION

1. In A1 color groups, all materials used in high translucency and low translucency samples showed higher light transmittance values than samples with 1mm thickness than samples with 2mm thickness.

2. In A3 color groups, all materials used in high translucency and low translucency samples showed higher light transmittance results than 1mm thick samples than 2mm thick samples.

3. In the A1 color groups, all materials used showed higher light transmission values in the 1mm and 2mm thick samples, with high translucency samples showing higher translucency than low translucency samples.

4. In the A3 color groups, all materials used showed higher light transmittance results in the 1mm and 2mm thick samples, with high translucency samples showing higher translucency than low translucency samples.

5. In the high translucency groups, all materials used in the 1mm and 2mm thick samples obtained higher light transmittance values in the A1 color samples than the A3 color samples.

6. In the low translucency groups, all materials used in the 1mm and 2mm thick samples obtained higher light transmission values in the A1 color samples than the A3 color samples.

7. When the A1 color and high translucency 1mm thick material samples were investigated, Empress CAD samples show Emax. It showed higher light transmittance values than CAD and LRF Block material samples.

8. When the material samples in A1 color and high translucency with 2mm thickness were investigated, Empress CAD samples reached higher light transmittance values than E.max CAD and LRF Block material samples, which gave similar values.

9. When the 1mm thick material samples in A1 color and low translucency were investigated, the Emax CAD samples showed lower light transmission values than the Empress CAD and LRF Block material samples, which gave similar values.

10. When the 2mm thick material samples in A1 color and low translucency were investigated, the Emax CAD samples showed lower light transmission values than the Empress CAD and LRF Block material samples, which gave similar values.

11. When the samples of 1mm thick material in A3 color and high translucency were investigated, Empress CAD samples show Emax. It showed higher light transmittance values than CAD and LRF Block material samples.

12. When examining the material samples in A3 color and high translucency 2mm thickness, Empress CAD samples give similar values with each other, Emax. It showed higher light transmittance values than CAD and LRF Block material samples.

13. When the material samples in A3 color and low translucency 1mm were investigated, the LRF Block samples are Emax. CAD and Empress showed higher light transmittance values than CAD material samples.

14. When the 2mm thick material samples in A3 color and low translucency were investigated, the LRF Block samples show Emax. CAD and Empress showed higher light transmittance values than CAD material samples.

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