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Bu araştırma Yüzüncü Yıl Üniversitesi Bilimsel Araştırma Projeleri Başkanlığı tarafından TDK-2017-5915 numaralı proje olarak desteklenmiştir.

KABUL VE ONAY

Van Yüzüncü Yıl Üniversitesi Sağlık Bilimleri Enstitüsü, Protetik Diş Tedavisi Anabilim Dalında Diş Hekimi Lana Bahram KHİDHER tarafından hazırlanan *"Cad/Cam Restorasyonlarında Farklı Basamak Genişliklerinin Dayanım Üzerine Etkisinin İncelenmesi"* adlı tez çalışması aşağıdaki jüri tarafından DOKTORA TEZİ olarak OY BİRLİĞİ ile kabul edilmiştir.

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Tez hakkında alınan jüri kararı, Van Yüzüncü Yıl Üniversitesi Sağlık Bilimleri Enstitüsü Yönetim Kurulu tarafından onaylanmıştır.

Prof. Dr. Şemsettin DEDE
Sağlık Bilimleri Enstitüsü Müdürü

ETİK BEYAN

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VAN YÜZÜNCÜ YIL ÜNİVERSİTESİ
SAĞLIK BİLİMLERİ ENSTİTÜSÜ MÜDÜRLÜĞÜ'NE

Doktora tezi olarak hazırlayıp sunduğum *""Cad/Cam Restorasyonlarında Farklı Basamak Genişliklerinin Dayanım Üzerine Etkisinin İncelenmesi""* başlıklı tezim; bilimsel ahlak ve değerlere uygun olarak tarafımdan yazılmıştır. Tezimin fikir/hipotezi tümüyle tez danışmanım ve bana aittir. Tezde yer alan deneysel çalışma/araştırma tarafımdan yapılmış olup, tüm cümleler, yorumlar bana aittir. Bu tezdeki bütün bilgiler akademik kurallara ve etik ilkelere uygun olarak hazırlanıp, bu kural ve ilkeler gereği, çalışmada bana ait olmayan tüm veri, düşünce ve sonuçlara atıf yapılmış ve kaynak gösterilmiştir.

Yukarıda belirtilen hususların doğruluğunu beyan ederim.

Öğrencinin Adı Soyadı: Lana Bahram KHIDHER

Tarih:

İmza:

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DEDICATION

From bottom of my heart, I am dedicating my Ph.D thesis to whom I love and never forget.

My Dad and Mam,

My Hasband,

And to my three kids:

Aryaz, Danaz, Artos

Lana Bahram Khidher Mawlood

May 2019 - Van

ABSTRACT

KHIDHER L.B. The Evaluation of The Influence of Different Finishing Line Depth on Strength of Cad/Cam Restorations, University of Van Yüzüncü Yıl, Institute of Health Sciences, Faculty of Dentistry, Department of Prosthodontics, A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy; PhD Thesis,Van, 2019. The aim of this study is to evaluate the effects of different shoulder finishing line depth (0.5 mm, 1.0 mm and 1.5 mm) on fracture strength of coping design as one type of CAD/CAM restorations. Using Lithium disilicate (IPS e-max CAD; Ivoclar Viva dent) and Feldspathic block (CEREC blocks; Sirona) materials for milling of three type of design according to the finishing line depth (FLD), which was done with Cerec inLab software program (Version, 4.2.0.57192) with 120 µ cement film thicknesses. A total of 72 specimens of coping design were prepared as monolithic crown on 72 novel nickel chrome dies. Each with a diameter of 8 mm and height of 6 mm as they were used to support the restoration. 12 specimens of coping design for each material and finishing line depth where prepared, to be in three groups according to FLD. Panavia V5 resin cement system where used as a luting agent for fixation of each coping restorations. For the measurement of fracture resistance value, each sample where subjected to fracture test with a universal test machine.It was found that Lithium disilicate crowns with 1.5 mm thickness of marginal design showed the maximum mean value of fracture strength of about 2721 ± 967 N among all the groups, whereas, the minimum mean valueof fracture strength was recorded with Feldspathic one with 1296.7 ± 642 N at the same depth of shoulder finishing line (1.5 mm). Kruskal –Wallis and Mann-Whitney testsas well as Annova test were performed to compare all groups with different P values. Concluded that the effect of different depth of finishing line on the fracture strength of CAD/CAM restoration material was evedent with variable results wich was related to different factors. As it is clear from the results of the present investigation. Lithium disilicate crown material seems to be increased their strength to fracture as the finishing line depth where increased. While in case of Feldspathic restorations, the strength where increased from 0.5 mm to 1.0 mm depth of finishing line restorations, but the strength were decreased, when the marginal depth increased to be 1.5 mm.

Key words: CAD/CAM, Shoulder, Finishing line, Fracture resistance, All ceramic

CONTENTS

ABBREVIATIONS

µm	: Micron
2D	: Two-Dimension
3D	: Three-Dimension
ANSI	: American National Standards Institute
CAD	: Computer Aided Design
CAI	: Computer Aided Impression
CAM	: Computer Aided Machine
CEREC	: Chair side economic reconstruction of esthetic ceramic
CNC	: Computer Numerical Control
CR	: Crown
CTE	: Coefficient of Thermal Expansion
DXF	: Drawing Exchange Format
FDP	: Fixed Dental Prosthesis
FEA	: Finite Elements Analysis
FLD	: Finishing Line Depth
FPD	: Fixed Partial Denture
FSC	: Feldspathic Ceramic
GPa	: Gega Pascal
HA	: Hydroxyl Apatite
HT	: High Translucency
IGES	: Initial Graphics Exchange Specification
IOS	: International Organization for Standardization
LED	: Light Emitting Diode
LITH	: Lithium disilicate
Mg	: Magnesium
mm	: Millimeter
N	: Newton
NEDO	: New Energy and Industrial Technology Development Organization
Ni	: Nickel
PC	: Polychromatic

PFM	: Porcelain-Fused-To-Metal
SIO	: Silicon Dioxide
SLA	: Stereolithography
ß	: Beta
Std	: Standard deviation
STEP	: Standard for Exchange of Product model data
TCP	: Tricalcium Phosphate
TTCP	: Tetracalcium Phosphate
YO	: Yttrium Oxide
YTZP	: Yttrium-stabilized Tetragonal Zirconia Polycrysals
Zr	: Zirconia
ZrO	: Zirconia Dioxide

FIGURES

TABLES

1. INTRODUCTION

As the recent development and progress of science in various aspects. In respect to digital technology, that had infiltrated most areas of daily life, including most fields of medicine. Nevertheless, it had increasingly being introduced into the most field of dentistry. Computer-aided design/computer-aided manufacturing (CAD/CAM) solutions as apart from chairside practices becoming available for creation of crowns, inlays, fixed partial dentures, implant abutments, and other dental prostheses. In fact, CAD/CAM dental resolutions is considered as a sequence of digital devices and software for almost all-automatic design and creation of dental restorations (Tapia et al., 2015).

In contrast to the past when the strong material was associated with poor esthetic restoration, the choice of clinicians nowadays is becoming very simple and easy when selecting CAD/CAM materials, in order to achieve an excellent esthetic with strong materials (Abdul-Azim et al., 2015).

Recently applications of various materials through CAD/CAM system for tooth colored restoration have been quite widely practiced in dental clinic. Such as ceramics (esthetic ceramic, high-strength ceramics, and zirconia), hybrid ceramics then CAD/CAM composites, fiber reinforced resin, polymers, and metals, etc (Li et al., 2014; Alghazzawi, 2016). In fact, throughout using such materials one may fabricate many things, starting from single copings, crowns, temporaries, surgical guides, dentures, orthodontic appliances, and complex full arch (Porto et al., 2016).

In parallel with increasing demands for more esthetic, wholesome and healthy life, more attribution to biocompatibility of restoration material will remain the need and request of both patients and the dentist. That’s why, at present, dental ceramics in dentistry evidently become quite widely used, practiced and applied (Hussain, 2008 ; Miyazaki and Hotta, 2011).

Actually, the fracture resistance of all ceramic materials including glass ceramic in particular was and still is the main concern and worry of the dentists especially during their practical uses and application of such materials (Kern, 2009). Recently, clinical information and background knowledges about ceramic crown preparation had got much more concern and attention (Schultheis et al., 2013; Belli et al., 2016). However, fractures remain the main problem that facing patients with ceramic restoration throughout clinical follow up processes (Ɵilo et al., 2014).

Other authors showed that, the stress concentrated at the marginal collar of fixed dental prostheses (FDP) can be repaired by increasing the crown thickness, especially at the depth of the finish line, which are then becomes a more essential matter for the durability of all-ceramic restorations due to their brittle natures, and opposed to the metal ones, which existing a ductility character at the marginal areas (Zimmermann et al., 2017). Meanwhile, many researchers proclaimed that the design of the finishing line of prepared tooth is one of the factors that play an important role in marginal adaptation and fracture resistance of crowns (Beuer et al., 2008; Ozer et al., 2015).

Still, others suggest that adequate marginal and internal fit, as well as high mechanical strength, and selection of reliable luting cement, are the most important factors, in improving the prognosis of the prosthetic restoration, for example, a crown (Ahlholm et al., 2018).

The present investigation was carried out in order to declare and evaluate the important of the effect of finishing line depth on the strength of the two-selected restoration material. The used materials were Lithium disilicate and Feldspathic ceramic materials made by CAD/CAM system. Actually, these two materials are the most widely spread and commonly used in dental clinic (Sakaguchi and powers, 2012).

The restorations were applied as coping design on nikel chrome dies made by CNS. The only difference was in finishing line depth of the prepared designs. The chosen finishing line depth applied for this study were 0.5 mm, 1.0 mm, and 1.5 mm depth of shoulder finish line. The results have been discussed in detail, the illustrations of the statistical estimation of the outcome results were compared and contrast.

Undoubtedly, these finding will reduce the existing gap of the knowledge in this line, meanwhile, may well be followed by more detailed studies and investigations on this line of prosthodontic restorations for the other materials that have been and will be used as direct or indirect restorations for the defected teeth in dentistry in coming years and future.

2. GENERAL INFORMATION

2.1. CAD/CAM System

2.1.1. Introduction and history of CAD /CAM system

The term "CAD/CAM" in dentistry is nowadays applied as a synonym for prosthetic restorations, which are produced by "milling technology". CAD /CAM is the shortening of Computer Aided Design /Computer Aided Manufacturing; represent the process in which digital images or copy of objects are formed as it is used for designing and fabrication of prototypes or definite products by Computer Numerical Control (CNC) (Beuer et al., 2008; Sakaguchi and Powers, 2012).

Pioneers who played a part in the generation of today dental CAD/CAM systems were Dr. Duert and his friends; they were foremost in the scope of dental CAD/CAM system (Miyazaki et al., 2009). In term of 1980, they had started with fabrication of crown restoration. A serious of steps using an optical impression of the abutment tooth in the oral cavity were applied, then designing an optimal crown with a considering of functional movement, and then milling a crown. Numerically controlled milling double machine have been used, and finally Sopha system were developed (Karaalioğlu and Yeşil Duymuş, 2008).

The significant evolution of dental CAD/CAM system appeared in 1985 by a Swiss Dentist (Mormann) and Electrogenic Engineer (Dr.Brandestini) (Figure 1). Both are researcher from University of Zurich. They were developers of the CEREC 1 (Sirona) machines (CEREC system), and it was known by computer–assisted CERamic REConstruction that were widely recognized by CEREC (Kern, 2009; Kaur and Datta, 2006). They tried to get new technology in a dental office at the chairside of patients through directly measuring the prepared cavity using an intra-oral camera that was followed by designing and carving of an inlay restoration from a ceramic block, using a compact machine set at chair-side (Çelik et al., 2013).

Figure 1. CEREC1 prototype in 1985

However, metal allergies had become a problem, especially in Northern Europe, and a transition to allergy-free titanium was proposed, since the precision casting of titanium was still difficult at that time. In nineteenth years Dr. Andersson the developer of Procera system (Noble bio care), attempted to produce titanium copings by spark erosion and inserted CAD/CAM technology into the process of composite veneered restorations. This was the first application of CAD/CAM in a specialized procedure as a component of a total processing system (Miyazaki et al., 2009).

Many teams carried out researches organized by industry, academia and the government as one of a large-scale research and developmental project of NEDO (New Energy and Industrial Technology Development Organization) in order to produce acommercial system. In the University of Minnesota in United States and by Dianne Rekow who was also aiding efforts in creation such system. Some groups in Japan, such as Yoichi Uchiyama's group at Hokkaido University as well as Takashi Miyazaki's group at Showa University, were also making researches and developments in cooperation with different companies. Research and development was progressed by these collections which resulted in CAD/CAM systems becoming available commercially (Ueda and Yamaguch, 2017).

In the term of concept, the development of chairside digital impression with digital intraoral photography do offer accuracy and speed (Pradies et al., 2015).

As well as, the ability to indefinite storage of the captured information without any material constraints (Mobaleghi et al., 2016). Thus a quickly and easily handover of the digital images were performed from dental office to the laboratory and vice versa (Lowe, 2008) (Table 1).

The evolution of this system was actually an innovation in dentistry, as it will allow fabrication of ceramic restorations in the same day. Meanwhile proclaimed and hastily spread CAD/CAM term to the dental profession. CAD /CAM restorations provide a clinically precise digital impression. It captures the marginal detail and tooth structure to the proposed restoration's finish line for the master model and die(s). Since then, many studies have confirmed the importance of accurate and precise dental restorations using CAD/CAM technology (Pradies et al., 2015; Jonathan et al., 2014).

CAD/CAM dentistry does improve the method of clinicians' providence of indirect restorations to patients, with fabrication of adequately precise and accurate design of tooth restorations. Later on, the increase chairside productivity and improve clinic- laboratory communication through developing a processing center network, with satellite digitizer globally for production of all ceramic frameworks. A number of international companies today have introduced such systems to the market (Miyazaki et al., 2009; Lowe, 2008).

Nevertheless, as computer technologies have become more powerful, CAD/CAM systems also have become more progressed. These systems can now enable dentists to harness the power of computers to design and fabricate aesthetic and durable chair-side restorations (Michael et al., 2007).

A rapid evolution of this technology especially optical one as new intraoral digitizer is now commercially worldwide available. The application of CAD/CAM system is looking forward to shift quickly as well as intraoral scanner, which had been available for practice in clinic at present. So eventually digital dentistry is a waited to be a keyword for future of dentistry (Zarina et al., 2017).

Good marginal integrity, with high mechanical strength of selected restorative material according to the specific indication, as well as, the luting cement are the most important factors in improving CAD/CAM restoration prognosis specially in prosthetic restorations (Ahlholm et al., 2018).

Table 1. Timeline development of some CAD/CAM systems.

Year	System/Scientist	Company/Place
1970	Dureit and Preston	University of Southern California, USA
1980	Mörmann and Brandestini	University of Zurich, Switzerland
1984	Sopha system	Sopha bioconcept.
1985	Cerec 1	Sirona Dental Systems
1993	Procera	Nobel Bio Care, Yorbia Linda, CA
1994	Cerec 2	Sirona Dental Systems
2000	Cerec 3	Sirona Dental Systems
2001	Cerec InLab	Sirona Dental Systems
2002	Lava	3M ESPE, St. Pauel, MN
2008	E4D	Planmecca, E4D
2014	Cerec 4	Sirona Dental System

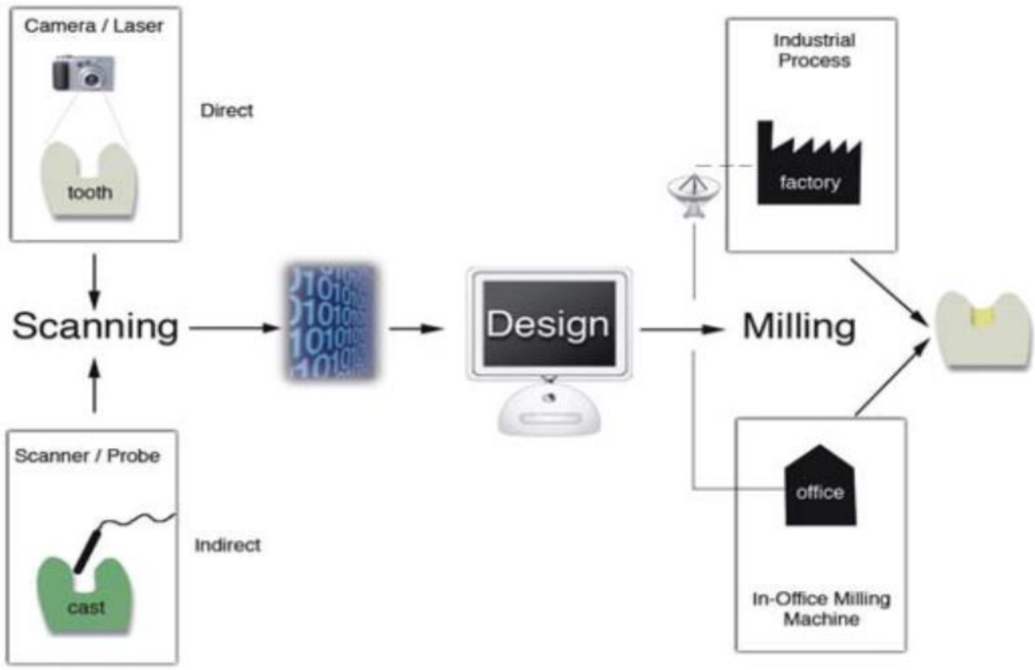

Figure 2. CAD /CAM processes

2.1.2. CAD/CAM systems composition

CAD/CAM systems functionally composed of three major unites (Michael et al., 2007):

First, (CAI) Computer aided impression (Scaning) , (Data Collection Unites):

It is referred to computer surface digitization tool that transforms geometry to digital data then can be processed by the computer. Data collection tools that measure three dimensional the relation of jaw, tooth structures, then transform them into digital data software, so when the data is obtained from the site of the preparation they will convert them to realistic impression (Kalpana et al., 2015) (Figure 2).

A. Intraoral scanner

Intra oral scanner: which save the records of the prepared tooth, directly from patients' oral cavity, allowing them to instant designing and production of the dental restoration. The scanning process is done with either LED based or laser based scanner device which are considered to be a very correct scanning means (Parasher and Tarun, 2014). Therefore, it minimizes the dental clinical steps, obtaining a digital impression with reducing discomfort and the feel of gagging reflex. As an example Sirona CAD/CAM system has CEREC omnicam as intraoral scanner for scanning of oral structures as well as implant abutment (Kalpana et al., 2015; Kern, 2009) (Figure 3).

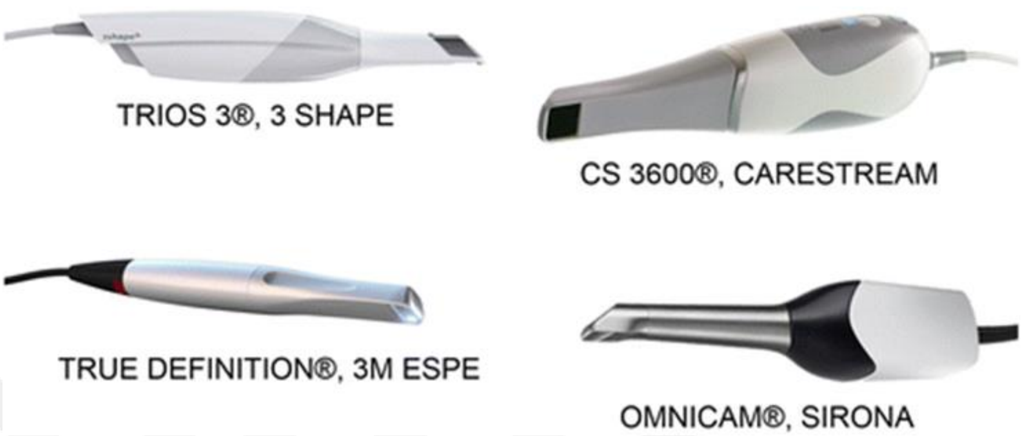

Figure 3. Examples of Intra oral scanners

B. Laboratory scanner:

The collection of the data is made either from the die stone model or instantly from the impression records (depending on the system).

There are more than one laboratory scanners:

a) Optical scanner / 3D scanner

They use a light source "laser" which have been angled next to the sensor, this angulation permits the coordination to determine 3-D information of the examined typical in a sort of mechanism (Beuer et al., 2008; Miyazaki et al., 2009) (Figure 4).

Figure 4. Optical scanner

b) Mechanical scanner

This is another scanning means; the model of stone is scanned by using of fine ball "contact probe which is very fine to allow the capturing of all fine details of the prepared tooth. Mechanical scanners are considered to be very accurate" and it involves more scanning period to construct the fundamental 3D model. Procera Scanners from Nobel biocare is an instance of mechanical scanner in dental clinics characterized by a high scanning accuracy (Miyazaki et al., 2009) (Figure 5).

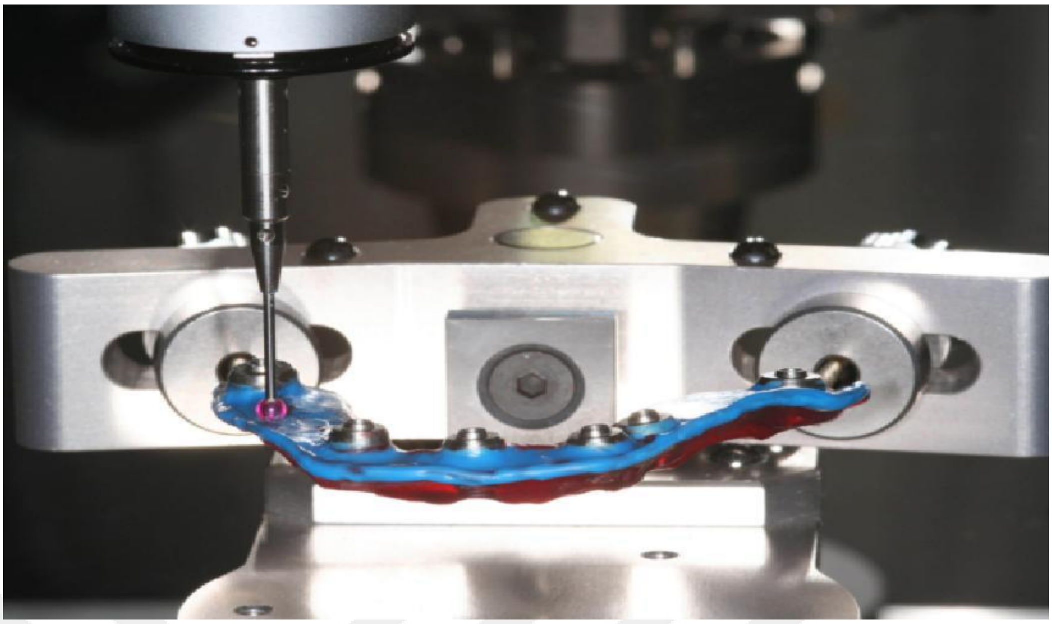

Figure 5. Mechanical scanner

Second: (CAD) Computer aided design: (3D software program)

It is the stage of designing of virtual restoration, using software data, which in term computing the millings parameters for fabrication of the restoration. It is provided by the manufacturers for designing of variety of oral restorations (Kalayci and Bayindir, 2015).

Every Company has its particular software program that can be consumed to fabricating numerous dental restorations with 3D technology (Beuer et al., 2008)(Table 2). The CAD software design has a previous loaded library providing various designs of crowns, and bridge frameworks, inlays besides onlays, with full anatomical crowns. Innovative software programs can manufacture supplementary types of dental restorations, for example; abutments of implant, frameworks of removable partial prosthesis, as well as, orthodontic appliances (Ueda and Yamaguchi, 2017).

Once the information is uploaded to the software program of CAD/CAM system, the laboratory actions will be achieved successfully. Initially, a substantial die, will be formed, and then heeled by die sectioning steps, and the marginal line will need to be evident. In conclusion, the final design of the selective dental restoration with their detailed information have been described.

Table 2. Some example of software file format for standard computer aided design.

Format	License Source
Auto CAD DXF(Drawing Exchange Format) Auto CAD DWG(drawing)format	Autodesk Inc.
IGES (Initial Graphics Exchange Specification) format	ANSI American National Standards Institute
STEP (Standard for Exchange of Product model data/ISO 10303)	International Organization for Standardization (IOS)

The CAD software system begins with planning a request of a model restoration, that were installs on a prepared tooth, in relation to the marginal design with points of contact to the opposing dentition. Then the clinician can regulate the restoration; fissures, cusps, etc. (Alghazzawi, 2016; Ueda and Yamaguchi, 2017).

In former times, all companies had fabricated closed software design that is compatible with their private individual system, but so they are not suitable for others. Nowadays, manufacturers have been founded to produce open source information of software programs, which give a permission of the uses of variable scanner devices with different CAD systems.

Regarding to each individual company, which is considering to have its own private confidence, to protect updates of their software programs by the others (Miyazaki et al., 2009). The previous two-phase digital impression and design software called CAD phase.

Third: (CAM) Computer aided machine: (Milling Device):

In the CAM phase, prosthetic restoration is manufactured from a solid block of selected material. In this stage, milling process is carried out through computerized electrically driven diamond disc or bars (Yeshwante et al., 2016 ; Alghazzawi, 2016).

Milling center in the clinic or dental laboratories produce restoration directly from the digital impression and restoration designed data, which have been milled different materials such as composite, feldspathic porcelain, leucite-reinforced ceramic, lithium disilicate ceramic, and zirconia in order to get final restoration (Ahlholm et al., 2018).

Milling devices are distinguished by the number of milling axes that affect the level of geometric complexity, which can be produced (Miyazaki et al., 2009).

Three-axis devises; with this type of milling process, three degree of movement(x,y,z) in three spatial directions are present. They have no capability of milling divergences and/or convergences. Three-axis device can turning the material block that were used for milling by 180 degree through milling process, example of three axis device: CEREC in Lab (Sirona) (Kalpana et al., 2015).

Four axis devices adding an ability to rotate the blocks of selected material infinitely so enable the fabrication of prosthesis having a large vertical height difference. For example, Zeno cad (Wieland-IMes) (Kalpana et al., 2015) (Figure 6).

Five axis devices add the ability to rotate the milling spindle, so very complex geometries could be milled throughout this device, eg; iTero system (Sakaguchi and Powers, 2012).

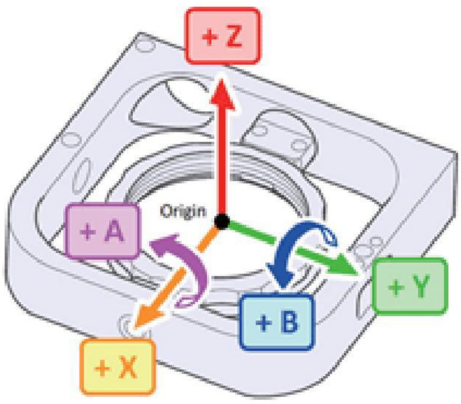

Figure 6. Illustration of five axis in milling device

Milling variants

A) Dry processing

Dry processing application is mainly used with zirconia oxide blanks and low degree of pre-sintering blocks, which offers several advantages such as less investment costs for a milling device and there is no moisture absorption by the die of ZrO_2 mold, as a result no any initial drying times for the ZrO_2 frame prior to sintering.

In contrast, the disadvantages of the lower degree of pre-sintering that leads to increase shrinkage of the frameworks. However, some manufacturers offer the options of milling resin materials with this type of milling process (dry milling) (Beuer et al., 2008).

B) Wet milling

It is a process of milling that performed by diamond or carbide cutter which are protected by using a spray of cool liquid in order to prevent overheating of the milled material. This type of milling process is used for metals or glass ceramic materials to avoid any damage of material throughout heat development (Beuer et al., 2008) (Figure 7).

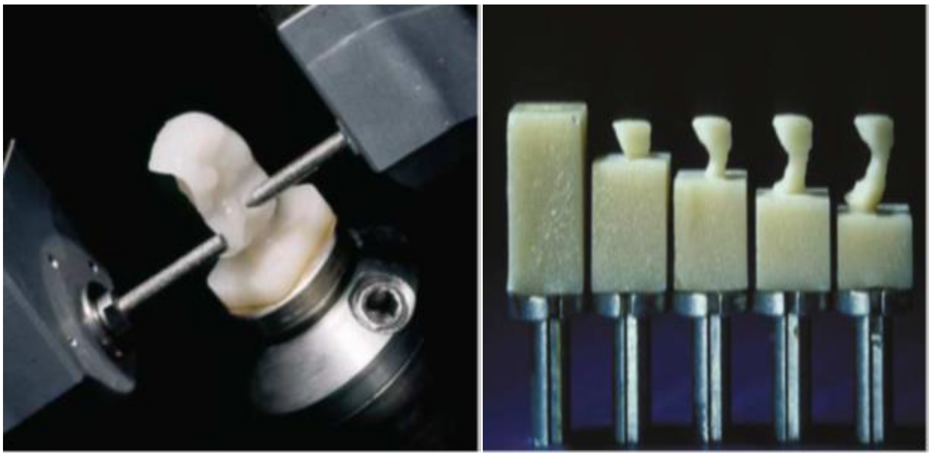

Figure 7. Milling process of ceramic block

2.1.3. CAD/CAM production concepts

Depending on the location of the components of the “CAD/CAM systems”, three various production concepts are present:

1. Chairside production (Office System).
2. Laboratory production.
3. Centralized production center.

1- Chairside CAD/CAM production

In which the company has its own scanner with milling units, e.g.; Sirona, and Planmeca. The whole CAD/CAM systems components are located in the dental clinic. Production of dental restorations can be done at chairside with some laboratory procedures. Here the digitalization instrument consist of an intra-oral camera, which will replaces the conventional impression material and commercially offered by Cerec system (Sirona) through selecting appropriate materials, the dentist can fabricate the restorations and seat it in the oral cavity within a single appointment (Beuer et al., 2008) (Table 3).

2- Laboratory production

With this system, the scanning of a stone cast or die of the prepared tooth (conventional impression) will be send by the dentist to a dental lab (e.g.; Cerec-in Lab) where as a master cast is fabricated. Most of this system produces copings which require dental technicians treatment in order to add esthetic material e.g. porcelain for getting an individualization and characterization of the restoration (Miyazaki et al., 2009).

Table 3. Some popular in Lab CAD/CAM system.

Name of the system	Scanning method	Restoration products
Dux (Titan)	Contact probe	Titanium substructures
Denti CAD	Contact probe	Ceramic ;inaly,onlay ,crown ,veneer
Cerec in -Lab	Conact probe	Ceramic ;inaly,onlay ,crown ,veneer
Decim	Laser	Ceramic coping
Cicero	Laser	Ceramic crowns
Lava	laser	Ceramic coping
Everest	Optical Scanner	Ceramic coping

3. Centralized production

In this system dental laboratory, use a network connection for fabrication of frameworks of high strength material. Therefore, as the informations set produced in the dental laboratory then will be send to the fabrication center through internet connection for fabrication of the restoration with CAD/CAM devices. Procera system provided the first application of this type of restoration production system (Beuer et a., 2008; Yeshwante et al., 2016).

Some examples of CAD/CAM system:

Procera all ceram system

This system was produced in 1994. It was the first system which obtain the out-sourced fabrication through an internet link connection. In this system, the master die have been scanned then the data will be sent to the processing center. Following the manufacturing process, the coping will be return back to the lab for veneering (Mantri and Bhasin, 2010) (Figure 8).

Figure 8. Procera digital processing device

The iTERO

This system was developed in 2007, as one of the first digital impression system for conventionally manufactured crown and bridges. It employs parallel confocal imaging and captures 3D digital impression, a device projects red laser light to the teeth surface so the reflected light transforms to be a digital data using an analog to digital converter. These scanners are combined with a monitor in order to get 3-D colored model of both arches. However, in this system the scanning is performed without using of coating powder (Zarina et al., 2017). In fact, iTERO system, milling the models is done with a five access-milling machine for fabrication of copying or full coverage restoration (Lowe, 2008; Taneva et al., 2015) (Figure 9).

Figure 9. iTero intraoral digital scanner

LAVA chairside oral scanner (LAVA, 3M ESPE):

Actually, it was introduced in February 2008. It includes a mobile cart with a touch screen display. It has also a scanner with a camera at the end, that consists of light-emitting diodes (LEDs) and lens systems (Zarina et al., 2017). Using an active wave front sampling to capture the images at video rates. Then the scanned data are sent wirelessly to the dental laboratory. In this system, there is availability to create CAD/CAM copying design (Farah and Brown, 2009) (Figure 10).

Figure 10. LAVA system

The E4D dentist

The E4D Dentist system had introduced in 2008. In this case, there is a use of high-speed laser beam combined with a camera to get a serious of 3-D scans of the tooth. E4D Dentist comprises a laser scanner, called Intra Oral Digitizer. In some cases, not all, laser utilization allows scanning of different surface, types and colors without the need of a contrast agent (powder). There is no need to widely opening of patient’s mouth during scanning process; because of the small scanner device in this system. As well as, in this system, detection of finishing line is done automatically then it marks on the screen device. However, in this system milling machine will manufacture the restoration which is selected from the chosen blocks of ceramic or composite in the dental office (Zarina et al., 2017; Patill et al., 2018) (Figure 11).

Figure 11 . E4D Dentist system

CEREC system

An acronym for Chair side economic reconstruction of esthetic ceramic is Cerec (Kaur and Datta, 2006). The first sort of such system introduced was the CEREC 1 in 1987 and then improved to Cerec 2 in 1996. Nevertheless, the advanced 3-D Cerec 3 has been forwarded in 2000. Currently designed restoration is transmitted to milling unit for fabrication with C4 model produced in 2014 as CEREC SW4.2.4. (Zarina et al., 2017; Patill et al., 2018).

The CEREC bluecam has a blue Light Emitting Diode (LED). The camera system do works by active triangulation techniques, which are used to take multiple pictures, as it is stitched together to create 3-D model of the teeth. This system gives the dentists the choice of either implementation in office through fabrication of the restoration in the same day or sending the digital image directly to the laboratory. Full contour crowns could be created in 6-12 minutes within milling. In fact, the earliest models of Cerec system was produced inlays and onlays only, but the newly model, are able to manufacture of veneer, single full crown as well as bridge and implant restorations. The important of this system appears through is its ability to provide long-lasting, tooth-colored prosthetic restorations in a single appointment (Mörmann, 2006; Mantri and Bhasin, 2010; Kalayci and Bayindir, 2015) (Figure 12).

Cerec systems have several advantages over other systems; a) Preparation of restoration may be made in one visit, so it will save both patients and clinician times.b) It may not need interim restoration, so eliminate patient’s potential discomforts. c) As the thermal expansion of tooth structure is similar to the thermal expansion of Cerec materials (all ceramic), meanwhile no contraction and expansion of restoration material with eating hot and cold food will be evident, as in case of metal restorations (Michael et al., 2007). In spite of the postoperative sensitivity with CAD/CAM restorations is between 0% to 13% that have been described and most of them was impermanent (Michael et al., 2007). d) Finally, x-ray can penetrate CEREC materials so enhancing the dentist to adequate examination of the tooth structure under the restorations (Kaur and Datta, 2006).

Figure 12. Cerec system with milling device.

The precision of the digital impression act as a foremost factor that has a guidance on the fit of dental restoration. So in the first generation of CEREC system the occlusal surface of restored teeth required selective adaptation. As it provided with a standard form of occlusal surface and the occlusal relationship was not taken in account. However, the new version of CAD/CAM system with CEREC 4.4 software permit the reconstruction of the occlusal morphological design based on the occlusal surface of the arch. That is, mean more accurate results in comparison to the previous version (Bohner et al., 2016).

It has been reported that regardless the data acquisitions are carried out either precisely in the patient's mouth (intra-oral) or indirectly from an impression and fabricating a master cast (extra-oral). Clinical parameters, (e.g. saliva, blood, movements of the patient….etc.), might effect on the reproduction of restored teeth (Yeshwante et al., 2016).

Chairside CEREC (Sirona) and E4D technology machines become a very popular method in prosthetic dentistry for creating good impressions. Reports of more than 10 years follow up studies for each system have showed quit well out comes by improving each technological enhancement (Sakaguchi and Powers, 2012).

Currently there are several sorts of CAD/CAM systems in the markets, and when comparing and contrasting these systems, it will be evident and clear that CEREC C4 and E4D Dentist devices can offer the options of in-office design and milling. However, they also allow for designing and milling by technicians in dental laboratory. In contrast, the iTero and Lava COS devices are reserved as their production of digital impression. It requires design and milling at the dental laboratory or milling center. So, it is clear that all of these systems produce models from their digital files, whereas the In-office milling system allows same-day restorations (Dwivedi et al., 2017).

2.1.4. CAD/CAM system classification

1) Close system. 2) Open systems.

According to data sharing, closed systems exhibit all CAD/CAM procedures; including data collection device, computer generated design, and restoration manufacturing by a same company. Furthermore, all the steps are unified into one system, and there is no exchangeability between other different systems from other companies. In contrast, in the open systems allow the acceptation of the original digital data by CAD software and CAM devices from other companies (Beuer et al., 2008).

2.1.5. The ideal properties of conventional impression

The following points should be considered:

1. The impression for prosthetic restorations should be accurate at the time of impression procedure and should not be distorted prior to a master model and die(s) fabrication.
2. Dimensional stability of impression material.
3. Short chairside time of impression procedure.
4. Biocompatibility of impression material.
5. Appropriate working and setting time for the given procedure.
6. Adequate tearing strength of impression material.
7. Adequate followability property of impression material.
8. Hydrophilic property.
9. Ease of removal and elastic recovery, so that any deformation during removal of the impression is reversed.
10. Acceptable smell, taste and texture of impression material.
11. Ease of storage is needed of impression (Lowe, 2008).

Dental Impression is regarded as one of the most important and critical tasks in conventional dental treatment process. In good conditions, the difficulty in impression procedure will be slightly diminished.

The difficulty of oral impression for prosthetic restoration is affected by many factors such as:

- General health condition of the patient.
- Oral care degree of the patient before the clinical treatment.
- The area of the marginal line after removal of the affected tooth structure (sub gingival or supra gingival).
- Bleeding condition of gingival tissue.

The intraoral scanner is a modern technology that is greatly related to reduce the difficulty of conventional impression process. Nevertheless, because intraoral scanners cannot scan the hidden marginal line behind the gingiva; therefore, it is necessary to ensure that the cervical collar of the abutment tooth is in a visible condition.

However, in case of conventional impression technique, when using any impression material, the marginal line cannot be seen directly in some cases ; because of the overhanging of gingival tissue and bleeding, therefore, gingival retraction and hemostasis are sufficiently performed then an impression material will flow to the gingival pocket, so the shape of the marginal design will be change.

While in case of digital impression finish line, geometry cannot be measured by an intraoral scanner if it is not directly visible. That is why it is regarded as one of the major disadvantage of intra oral scanning process (Ueda and Yamaguchi, 2017).

2.1.6. The clinical performance of CAD/CAM restorations

- **Hardware and software systems:** The accuracy of digital impression devices, milling process and their selective software program as a digital techniques play an important role in efficiency of the result (Michael et al., 2007).
- **Selective adhesion system:** The efficiency of luting agent which create a force-locked linking between the restoration material and underling tooth and/or implant structure (Kern, 2009).
- **Finishing performance:** accurate finishing performance with their appropriate occlusion.
- **Operators induced variability:** clinical skills and expertise with CAD/CAM system (Palin and Burke, 2005).

2.1.7. The advantages of using CAD/CAM technology

1- Applications of new materials (High strength materials) that are expected to be used for prosthetic dental restoration which have been difficult in processing them with conventional technologies. Therefore, the challenges in application CAD/CAM processing system leading to successful uses of ceramic as well as metallic materials.

2- Because of increasing demands of esthetic in every dental clinic, CAD/CAM system provides a patient with restoration that have a natural appearance. As ceramic blocks are available in a wide range of tints with their identical translucent properties.
3- Time is important matter for both patient and dentist.
4- Reduced laboratories production time.
5- Impression free dentistry, offers many advantages for patients who often experience of irritation, sensitivity and/or difficulty during conventional impression process. As well as there is diminished chance of bacterial invasion, decreased pulpal stress resulting from excessive cleaning, drying or trauma. So decreased the need for an additional tooth manipulation saving patients discomfort.
6- Owing to the creation of full arch of precisely parallel preparation, the computer can help to calculate and build the coping design adequately, and then can be cemented to prepared tooth. Therefore, it results in developing of simple but high performance measuring equipment.
7- Scanning the teeth and viewing the image on a computer screen will enhance the dentist to review the preparations and impressions, then makes immediate adjustments to the preparation or/and retake the impression if it is necessary, prior sending to the millings unit or a laboratory. This review in seeing a preparation multiple times and its normal size on a screen resulted an improvement in preparations.
8- Providing a supplemental tool for dental laboratories with development of CAD/CAM system.
9- With ceramic restoration wears well be in the mouth even for posterior region, it cause minimal wear to opposing teeth in comparison to the conventional restoration with amalgam or composite.
10- Another benefit include the possibility to storing of all scans on computer, whereas the conventional stone models occupy space while can chip or fracture if stored improbably (Almustafa, 2016; Boujoual et al., 2018; Miyazaki et al., 2009;

Prajapati et al., 2014; Mobaleghi et al., 2016; Karaalioğlu and Yeşil Duymuş, 2008).

2.1.8. Disadvantages and limitation of CAD/CAM systems

1. One of the primary considerations in a CAD/CAM system is the length learning time for practitioner needs; may range between a few days to several months.
2. Lack of the clinician's confidence in using a computerized system is another problem, which is potential for the dental.
3. The capital costs of CAD/CAM systems for production of this quality of restorations.
4. The color matching of the patient tooth with shade of selected ceramic may be a challenge to the clinicians initially.
5. Most of CAD/CAM system depends on marginal design in digital impression digitization, making it a challenging when the preparation margins have been place sub gingival.
6. The dentist may need to budget for monthly fees for technical support and software up gradation since CAD/CAM systems is an ever-sophisticated technology. Upgrades and updates are to be contemplated (Lowe, 2008; Davidowitz and Kotick, 2011; Prajapati et al., 2014).

2.1.9. Restorations with CAD/CAM technology

- Inlays
- Onlay
- Crowns (permanent and interim)
- Endo Crowns
- Veneers
- Fixed partial dentures
- Implant abutments
- Surgical guides
- Partial denture
- Complete Dentures
- Maxillofacial prosthesis (Kalpana et al., 2015).

2.1.10. Materials used for CAD/CAM systems

Metals: Nowadays, titanium, titanium alloys, as well as nickel chrome alloys are processed using dental milling devices.

Resin materials: this type of materials used for crown and FPD frameworks as provisional or interim prostheses, like Paradigm MZ100 (3M ESPE, St. Paul, Minnesota, USA).

Silica-based ceramics: These sorts of blocks are presented by quite a lot of CAD/CAM systems in order to fabricate different prostheses; inlays, onlays, veneers, partial crowns, and full crowns.

Lithium disilicate ceramic and Glass ceramics blocks are useful samples for chairside production.

Infiltrated ceramics: these are fabricated in a porous, chalky conditions after that infiltrated with lanthanum glass. The whole blocks for infiltration ceramics originate from the Vita In-Ceram system (Vita) and are available in three different types:

- **A- Vita In-Ceram Alumina (Al_2O_3):** Used for crown coping restoration for anterior and posterior region.
- **B- Vita In-Ceram Zirconia (70% Al_2O_3, 30% ZrO_2):** Suitable for customizing copings crowns in the anterior and posterior region, especially for discolored abutment teeth.
- **C- VITA In-Ceram Spinell ($MgAl_2O_4$):** present with high translucent property so it is recommended for the production of highly esthetic restoration anterior crown copings, in particular on avital abutment as well as in young patients.

Aluminum Oxide (Al_2O_3): with this high quality of ceramic, the grounding process has been done initially, followed by sintering in high temperature (1520°C). Fabrication of copings or full crowns in anterior and posterior regions, as well as three-unit FPD for anterior teeth can be obtained with aluminum oxide blocks.

Yttrium stabilized zirconia oxide (ZrO_2, Y-TZP): Zirconia dioxide is a high-performance type of oxide ceramic with excellent mechanical properties. It is present with high flexural strength and fracture toughness value compared with the other dental ceramics. However, it is recommended for using this material, as framework for crowns and FPDs, and it is appropriate for individual implant abutment (Zarina et al., 2017).

2.2. Tooth Preparation Design

The main goal of this procedure is to make a place for the new restoration (prosthetic crowns and conventional bridge) as it includes the removal of the structure of teeth. However, the importance of tooth structures preservation guides to the development of less invasive and ultra conservative dentistry, through production and continuous introduction of new metal free restorative material and new adhesive cement. This will offer more clinical reliability, through enhanced adequate mechanical and physical properties of these restorative materials (Tsitrou et al., 2010). Meanwhile tooth preparation for crown restoration is an essential and former stage to confirm good biological, mechanical and aesthetic performance of the last restoration. Therefore, the following points should be considered:

1. Amount of tooth reduction.
2. Finish-line form.
3. Preparation taper.
4. Line angle.
5. Surface texture.
6. Retention and Resistance.

2.2.1. Tooth reduction:

In order to form indirect restorations a substantial sufficient tooth structure should be lessened throughout tooth reduction procedure. The restoration types will adjust the number of tooth structure reduction that is required, which is regularly (0.5 mm - 2mm) for full coverage restorations. These considerations that can influence tooth reduction amount, for instance; the place with the alignment of the tooth, situation of the gingival margin, occlusal relationships, aesthetical requirement, the tooth morphology and the position of smile line (Ricketts and Bartlett, 2011).

The metal casts are too mush firm, whatever thin sections was present with 0.5 mm marginal depth of the restoration is adequate for construction any metal dental restorations; this is regarded as one of the most conservative full coverage crown restoration (Shillingburg and Herbert, 2012). Nevertheless, because of its opaque color, it is just used for posterior region of the oral cavity. So porcelain material used to glued to the metal crowns if it is used in all aesthetic zones, the requirement of the tooth reduction is about; (1.5 mm – 2 mm). This range of thickness is necessary; because of the metal framework should be enclosed with layer of porcelain, then a thin layer of aesthetic ceramics have been added which enhance to inform a natural appearance. Previously, all ceramic crowns porcelain jacket crowns require extensive tooth reduction; (2 mm) to give a space for a bulky restoration in order to, resist the mastication forces (Almustafa, 2016).

On the other hand, the amount of the tooth reduction depends on the thickness of the selective restorative material, aesthetical and structural durability are obtained with a minimum thickness when using new ceramic materials, which not require the presence of metal substructure (Sannino et al., 2014). Although, statistically significant difference between the amount of tooth structure loss for full coverage restorations had not been evidence in zirconia full coverage preparations compared to PFM and Lithium disilicate glass-ceramic full coverage crown in Ebrahimpours MSc thesis, but statistically significant more preservative preparation tooth structure with zirconia full compared to PFM and Lithium disilicate glass-ceramic full coverage crown preparations (Ebrahimpour, 2017).

2.2.2. Finish line preparation

Tooth preparation for each crown restoration needs the choosing of a suitable finish line. The form of marginal design will guides the restoration seating, the thickness of luting cement material, marginal gap, and cementation process. Each type of dental restorations; all metal, porcelain fused to metal, or all ceramic, suggest their marginal design of finish line that have been used.

Most frequently used, marginal designs are: knife-edge, chamfer, deep chamfer, shoulder and shoulder with bevel (Shillingburg and Herbert, 2012) (Figure 13).

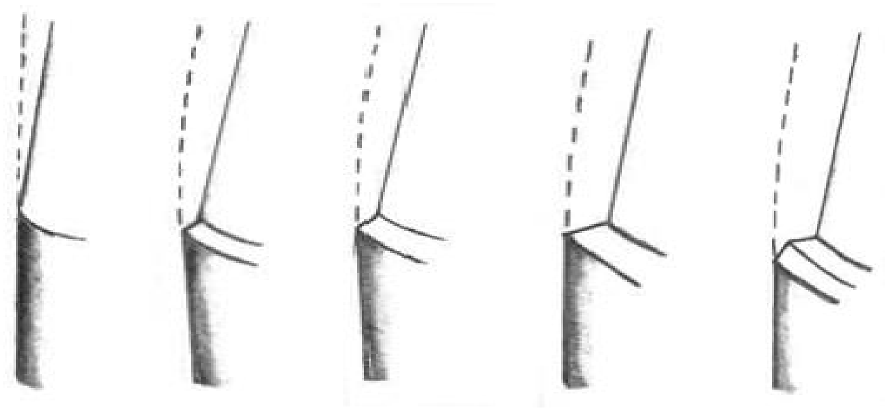

Figure 13. Types of finishing line.

Micro-leakage as a consequence of inadequate fit and cement dis-solution may be related to many problems, like pulpal inflammation, plaque retention leading to periodontal disease as well as secondary caries.

Many authors examined the effect of the marginal design of finishing line on the occupation of indirect restorations in their researches (Table 4). Variable marginal preparation design of finishing line (knife edge, chamfer and shoulder), have been demonstrated to evaluate their effect on the fracture resistance of restoration material and specially when fabricated with CAD/CAM system.

As consequence of the information acquired from these studies, shoulder and chamfer preparation finish lines have been recommended for all ceramic restorations (Al-Joboury and Rasheed, 2015). Therefore, in case of root-canaled teeth, which were compromised coronally, endocron preparation has been suggested with slight shoulder marginal design (Beuer et al., 2008). Nevertheless, the previous study contradicted the resulting data of another study that a shoulder, or heavy chamfer finish lines have been recommended resulting in the best marginal fit (Al-Zubadi and Al-Shamma, 2015). Therefore through reviewing different studies, related to the most preferable marginal design that have been used (Table 4).

Table 4. Some research on different finishing line types and thickness related to the fracture strength of restoration.

Names of researchers / year	Preferable Finishing line
Rammelsberg et al.,2000	Chamfer FL had better resist fracturing than shoulder FL especially for posterior teeth.
Che et al., 2004	Shoulder FL is preferable than chamfer one.
Di-lorio et al., 2008	Shoulder FL is preferable than chamfer one.
Beuer et al., 2008	Shoulder FL is preferable than chamfer one.
Jalalian and Aletaha, 2011	Chamfer FL better resist to fracture than shoulder FL.
Cortellini et al., 2015	Using Knife edge/Chamfer FL / no effect of FL on fracture strength.
Ahmadzadeh et al., 2015	Using Shoulder and chamfer FL / no effect of FL on fracture strength.
Olio et al., 2016	As the marginal thickness increase, resistance to the fracture will increase.
Zhang et al., 2016	As the marginal thickness increase, resistance to the fracture will increase.
Hatice Özdemir, 2018	Shoulder FL is preferable than chamfer one.

However, no significant different statistically between shoulder and chamfer finishing line have been considered with CEREC composite resin crown when it was used for preparation of interim crown restoration (Kelvin et al., 2016).

Regarding, the location of the finish line which can be located even: Supra gingival, with-gingival margin or sub-gingival. The supra-gingival one are recommended (Ann et al., 2014). Since they have the less impacts on periodontal tissue, which are considered in areas where aesthetical recommendation are not of importance, and the core of the preparation tooth located supra-gingivally. Therefore supra-gingival marginal preparation of each tooth with an adequate finish-line has a variety of advantages such as protecting periodontal tissues, due to the simplicity of preparation and easy to remove and clean any extra luting cement materials, finally, simple to check and follow up the integrity of the dental restoration (Nugala et al., 2012).

The equi-gingival finish line: It believes to be used in situation, which enhances the accumulation of plaque, so leading to patient suffering from gingival inflammation followed by gingival recession. Although, restorations with smooth margins and highly polished materials present with CAD/CAM chains (Khuller and Sharma, 2009; Nugala et al., 2012). The sub-gingival finish line used in certain situations with the need of aesthetical and restorative considerations with selective patients (Nugala et al., 2012).

The evolution in dental materials, adhesive dentistry and resin cement, frequently required where aesthetic demands have been increased (Aycan, 2018). Especially in cases of patients suffering from problems with discoloration teeth, wherever the need of perfect teeth preparation in the anterior region. Therefore, well-fitting should be controlled to ensure the periodontal structure conditions. Even, though in patients with a short length of clinical crown, preparation with such design of finishing line positioned can increase the length of the prepared tooth. Therefore, retention and resistance form will be improved (Almustafa, 2016).

Restoration of tooth with an extensive carious problems and/ or subgingival tooth fracture, for providing a ferrule for endocron restoration (Sreedevi et al., 2015). When considering the sub-gingival finish line, never be exceed the half of gingival pocket (0.5 mm- 1 mm) with the biological respected (Nugala et al., 2012).

Figure 14. Some types of fixed restoration.

2.2.3 Retention and resistance form of restoration

Retention is a property of preventing dislodgement of restorations within their path of insertion. Whereas, resistance is a form of prevention the removal of the restoration by any type of oblique or horizontal forces.

For any indirect restoration to resist their dislodgment and removal, appropriate occlusal-cervical dimension of the tooth in relation to the tapering measurement have been regarded as one of the important factors (Blair et al., 2002). There is a respective relationship between the tapering degree of final preparation and the resistance to dislodgement of their restoration prosthesis. As it is considered as the primary retention or resistance form of a crown restoration (Shillingburg and Herbert, 2012).

Secondary retention form as well as secondary resistance form may existed in areas with poor primary retention, as in patients with short clinical crowns, through adding pins and grooves to the existed preparation, and present in case of using new adhesive cement with high quality, adequate quantity and a new technology with digital impression using CAD/CAM systems. The retention and resistance form of a dental restoration are related to the longevity of survival rate of each restorations (Sharma et al., 2012).

2.2.4. Preparation taper

Convergence angle: refers to the angle between two opposing axial surfaces, and it is an important characteristic factor, which enhance the retention and resistance form. Formerly in 1923, Prothero et al reported that a tapering degree of 2-5° was the optimum need when preparing each tooth for single restoration. Nevertheless, it was not exposed to be in scientific revisions until 1950s, when others operated variable tapering angles. They found that the retention of crowns by application of tensile forces, and their conclusion did support the tapering degree of a range between 2° and 5° following the recommendation of Prothero (Almustafa, 2016).

Although clinically it was very difficult to achieve and measure the tapering angle, so the mean convergence of tapering angle of the preparation clinically were ranged between 5° and 12° (Sharma et al., 2012). Therefore, it has also been found that when tooth in posterior regions were prepared, they have greater tapering degree in comparison with the teeth in anterior and premolar regions. This may be probably related to the adversity in entrance and clinicians' assessment, keeping away from damaging neighboring tissue as well as closest tooth (Almustafa, 2016).

2.2.5. Surface texture

Following finalization of the preparation procedure, the surface roughness of the prepared tooth should be smoothed in order to be present without any undercuts or revers beveling specially at the margin, which can improve marginal fit of the restoration and enhance the adequate digital impression. However, others have shown that surface roughness may help in increasing the retention form of the crown restoration with a certain type of new adhesive cement (Ricketts and Bartlett, 2011; Nejatidanesh et al., 2015).

After the tooth preparation have been completed and the tissue will be retracted to visualize the tooth margins, the tooth should be dried up and be ready for scanning. Although in some scanning system there is a use of an oxide powder on the prepared tooth to remove optical high light reflect from the surface of the preparation and to enhance to scan with adequate quality of measurement. The Scanner device use either a serious of static images or a stream of video images to capture the geometry of the tooth preparation as well as their surrounding structure in the oral cavity including neighbor teeth and or opposite dentition (Sakaguchi and Powers, 2012).

2.3. Ceramics:

2.3.1. Introduction and history

The origin of Ceramic word is keramos (Greek word) which means potter's clay, it is a man-made material which was resulted from mixing and burning of different metallic and nonmetallic elements. Metal oxide is the main component of ceramic which is produced by an oxygen unions with metals elements such as; aluminum, calcium, titanium magnesium, potassium, Lithium sodium, tin, zirconia, and non-metal elements such as silicon, fluorine, boron (Tutal et al., 2015).

Ceramics came to be used in dental clinics to serves such purposes; to watchful practitioners in dentistry to the truth of the using ceramics, since former time, performed the adoption of 'high technology' versus 'craft art'. The reinforcement concept of improved ceramics is a second purpose, which are solving specific problems and increasing the proficiency of the restoration. As well as providing a gentle background to the science of ceramics (Kelly and Benetti, 2011). As one go back to the history it become evident that ceramic have been used in dentistry for more than 100 years (Gracis et al., 2015). A French dentist De chement invented the first porcelain tooth material in 1789 to be introduced to dentistry. In 1808 ceramic teeth "terrametallic" patented by Italian dentist Fonzi that were held in place using platinum pins or frame. As developed and improved version of platinum teeth in 1837. In 1903, Charles Land presented the first ceramic dental crown (El – Dessouky, 2015). In contrast, first commercially available dental ceramic crown was, introduced in 1963 by Vit Zahnfabic (Raghavan, 2012).

In general, ceramic restorations have been limited to anterior regions prior to the production of monolithic Lithium disilicate and zirconia restorations. So nowadays, these types of restorations have no limitation of where they can be used as a restoration in the oral cavity (Helvey, 2013). At present study Feldspathic and Lithium disilicate ceramic blocks are used as an examples of ceramic material made by CAD/CAM manufacturing system, however the clinical success of such materials have been well documented by many authors and dentists. (Yalim and Türker, 2012; Çetindağ and Meşe, 2016; Zimmermann et al., 2017).

2.3.2 Ceramic composition

There are 3 basic components in the structure of the ceramics that are used in dentistry; feldspar (75-85%), quartz (Silica, sand) (12-22%) and kaolin (3-5%) (Anusavice et al., 2013b).

- Feldspar material consists of the combination of potassium alumina silicate; (K2OAl2O36SiO2) and sodium alumina silicate; (Na2OAl2O36SiO2).Which gives transparency to porcelain. As they melted in firing process, a yellow feature of them is a result of their combination to kaolin and quartz (Karadağ, 2018).
- Quartz is made of silicon dioxide which protects the form of porcelain material from shrinkage during firing process and stabilize their performances. (Saint-Jean, 2014).
- Kaolin (Al2O32SiO22H2O) is an aqueous aluminum silicate structure. It gives a shape to the porcelain clay and gives opaque property to the porcelain restorative materials (Anusavice et al., 2013b).
- Other compounds, such as potassium oxide (K2O), magnesium oxide (MgO), barium oxide (Ba2O), sodium oxide (Na2O) are glass-modifying agents. They are used to decrease the melting point of glass material. And as the ceramics used in dentistry need to be highly resistant to flow during firing, these compounds are used in order to decrease the melting degree through sintering process (Anusavice et al., 2013b).
- The viscosity and hardness of ceramic can be increased with aluminum oxide (Al2O3).
- Heat-resistant components such as titanium (Ti), iron (Fe), manganese (Mn), copper (Cu), cobalt (Co) and nickel (Ni) are used to give a color to porcelain. (Karadağ, 2018).
- Opacification agents such as titanium oxide, and zirconia oxide are also used. (Saint-Jean, 2014)

2.3.3. Classification of dental ceramic

Commercially the availability of quite many types of dental ceramic, each having it is own specific physical properties, clinical use and production method make the classification of ceramic in dentistry becomes a very difficult task. Due to vast modification and because of continuous improvement made in ceramic production and in its composition. As a consequence dental ceramic have been categorized in distinctive ways in literatures (Raghavan, 2012).

Nevertheless, the general idea of some classification of ceramic in dentistry has been outlined down below:

1. **Microstructural classification**: (Raghavan, 2012).

   Class 1: Glass/based system; mainly silica.

   Class 2: Glass/ based system; mainly silica with filler, as they are usually crystalline; for example leucite to be:

   A. Low to moderate leucite-containing feldspathic glass.

   B. High leucite ;approximately 50%, containing glass, glass ceramic.

   C. Lithium disilicate glass-ceramic.

   Class 3: is a crystalline-based system with glass fiber , mainly alumina.

   Class 4: is a polycrystalline solid for e.g.; alumina and zirconia.

2. **Based on their application in dentistry** : (Sakaguchi and, Powers, 2012):

   A. All-Ceramic crown, including veneers, onlays, inlays and that are used in fixed partial prosthesis.

   B. Ceramics used for metal-cermic crowns.

   C. Ceramic used as orthodontic brackets, dental implant abutments, and ceramic teeth for complete removable dentures.

3. **Based on firing temperature**: (Lino Carracho, 2011) :-

   A. High fusing greater than 1300 C^o .

   B. Medium fusing 1100 C^o -1300 C^o .

   C. Low fusing 850 C^o -1100 C^o .

   D. Ultra-low fusing less than 850 C^o.

4. **Based on the composition (Schmalz and Arenholt-Bindslev, 2009) as illustrated** (Figure 15).

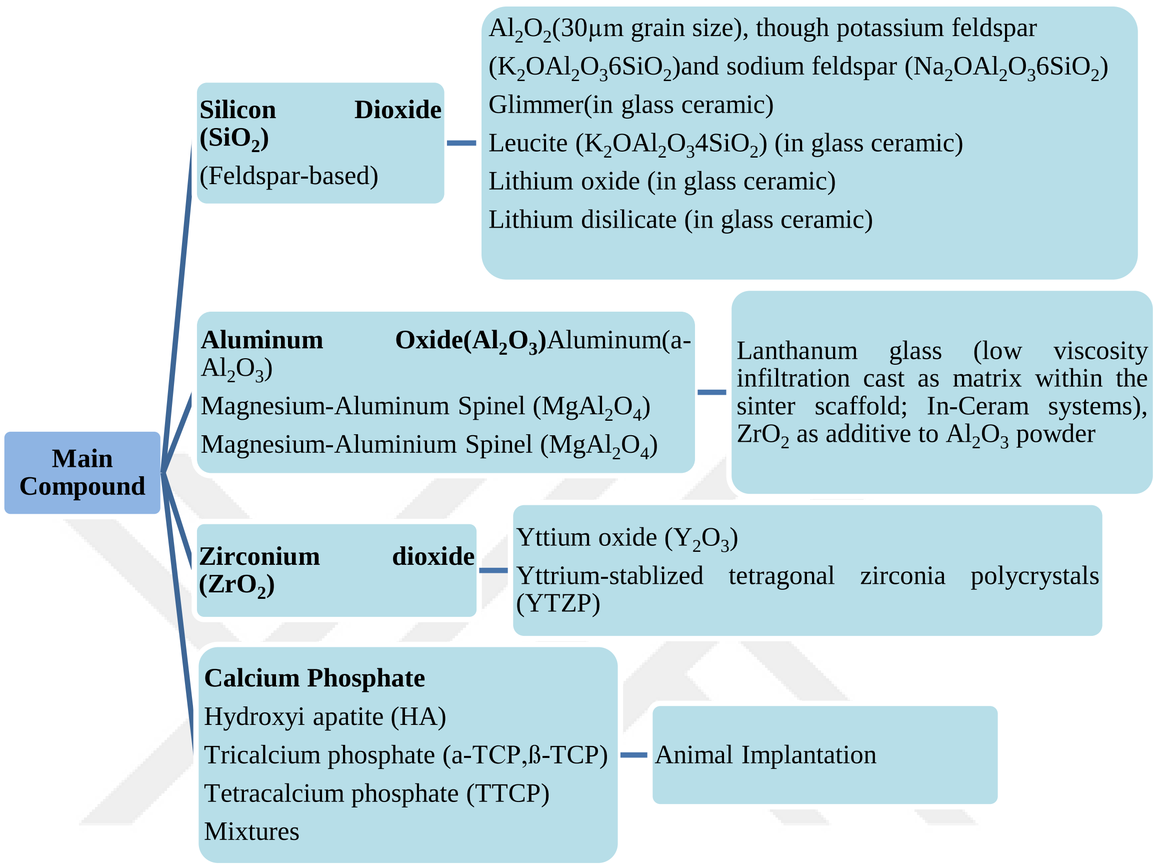

Figure 15. Classification of dental ceramic according to composition.

2.3.4. Ceramic properties

Ceramic become quite popular and widely used in dentistry (Thompson and Rekow, 2004), as they are highly advantageous (Al Mously et al., 2014). It is considered as a choice material, because of their low cost and availability (Li et al.,2014). However common important characteristics of restoration with ceramic system are their proportion of glassy phase with their amount of porosity, and both of them influence the optical and mechanical properties of the final restoration (Denry and Holloway, 2010). Mechanical properties of different ceramic material and tooth Structure have been referred to by (Guess et al., 2011) (Table 5).

2.3.5. Mechanical properties of dental ceramics

An improvement in all-ceramic restorations through increasing the mechanical property of the material is one of the main goals of dental clinicians (Danzer, 2014). However the relation between the mechanical properties of dental ceramic, and its clinical performances may influenced by a lot of variables (Ertürk et al., 2015). Some of these properties, are strength and fracture toughness. Which have been regarded as, the first parameters need to be understudied by the clinical potentiality and the limits of a ceramic material in dentistry (Lino Carraco, 2011).

Stress is defined as the internal reaction of the material to the extrinsic forces. Therefore leading to elongation, compression, shear, torsion or bending and in brittle material as it increased resulted in fracture of the material (Powers and Wataha, 2013). There are different type of stress; compression, tension or shearing ,twisting moment, bending moment (Sakaguchi and, Powers, 2012) .In general dental ceramic present with week tensile strength in related to the compressive strength that explain its reaction at the tip of the cracks by deformation and fracture of the restoration (Güler et al.,2012). Therefore, tensile strength is considered more meaningful compared to compressive strength when testing this property in brittle dental material such as, ceramics (Danzer, 2014).

Strain is defined as the amount of deformation (change in the length) per original length of the material body when subjected to the external forces or load which usually reported as a percentage (Anusavice et al., 2013b).

Elastic limit is described as the maximum stress that the material can resist without any permanent deformation means illustrate the elastic behavior of the selected material (Homaei et al., 2016). Whereas the yield strength of any material is defined as the amount of the stress at which the material deform permanently; plastic manner. Both are regarded as the most important properties through its definition of transitional grade from elastic to plastic behavior (Johansson et al., 2014).

Strength in dental material is referred to the ultimate stress value necessary to cause the fracture or plastic deformation of such material (Anusavice et al., 2013).

As they affected by the size of flaws, and the defects if it was present on the surface of the selected ceramic material (Burke, 1999).

The fracture toughness is defined as the mechanical resistance of the material to crack propagation and the resulting catastrophic failure. (Duan and Griggs, 2015). Unlike strength, which depends on the size of the initiating cracks present on the surface of that particular specimen (Nordahl et al., 2015). Fracture toughness is thus considered a more meaningful property than strength when validating a material's suitability for structural components (Hussain, 2008 ; Alkadi and Ruse, 2016).

In spite of the presence of adequate statistical design (De Jager et al., 2005), still cracking as well as fracture of brittle ceramic components have been recorded (Pieger et al., 2014). Through reviewing and well discussing the theory of different type of stress and their consequences, by Danzer in 2014, the methods of increasing the material strength, in order to, prevention of an unexpected failure of components.

Different stress categories include (Danzer, 2014):

- **A.** Hidden stresses: Caused by thermal strain discrepancy, by contacting
- **B.** Component's quality and their surfaces and edges.
- **C.** Appropriate handling of ceramic materials.

2.3.6. Factors related to the fracture and fatigue of ceramic restoration

In fact they come under different chatagories such as: (Weyhrauch et al., 2016; Lameira et al., 2015; Zahran, 2013 ; Türkoğlu et al., 2010)

- **Factors related to the restoration, which are:**
  - Composition of ceramic materials.
  - Finishing and glazing
  - Crown dimension and geometry
  - Core/veneer thickness
  - Different ceramic mechanical and physical properties.
  - Internal fit of the restoration.

- **Factors related to the oral environment:**
  - Oral fluid
  - Change in temperatures
  - Occlusal forces.
- **Factors related to the supporting structure** (Ayad, 2008):
  - Modulus of elasticity
  - Preparation characters
- **Factors related to the luting agent**:
  - Adhesion mechanisms
  - Cement layer thickness.
  - Mechanical properties of selected cement material.
  - Efficiency of bonding between cement and ceramic.
  - Efficiency of bonding between cement and supporting structure.

Actually, it have been referred to that, material thickness has a primary important effect on fracture resistance of ceramic restoration (Miyazaki and Hotta, 2011; Zhang et al., 2016). In fact, the strength of restoration material is one of the preferred parameters applied by dentist in order to select clinical indication of the needed restoration (Zimmermann et al., 2017). They pointed out that fracture resistances of all ceramic restoration are affected by the following four parameters which are restoration design (Whitton et al., 2008), tooth preparation, cementation (Cubas et al., 2011) and material thickness.

2.3.7. Indications and contraindications of ceramic restoration:

Ceramic restorations are considered as the best, in resembling the appearance of natural teeth (Awada and Nathanson, 2015). Therefore, it is indicated where predictable performance and esthetic needs (Anusavice et al., 2007). While the contraindication of using such type of restoration is, first; the limited inter-occlusal distance; in case of deep overbite and, short clinical crowns as well as in patients with supra erupted of the opposing tooth (Conrad et al., 2007). Second one is areas of heavy occlusal forces, especially in cases with para-functional habits such as, bruxism due to brittle nature of ceramic material. Third, is in the patient with inability of maintenance of dry field with cementation process. The fourth contra indication is tooth with deep sub-gingival preparation which is not considered as an absolute contra indication (Al Dehailan, 2009).

2.3.8. Advantage and disadvantages of ceramic restorations:

Indirect all-ceramic restoration requires at least two appointments to be achieved as well as additional fees, making them to be more expensive. Brittleness of ceramic material needs appropriation with adequate thickness to avoid fracture of restoration in the future. Then wearing of the opposite dentition as well as repairing of the fractured restoration is difficult. All these factors regarded to be the main disadvantage of ceramic restorations (Al Dehailan, 2009; Addreescu et al., 2017).

Nevertheless, in spite of presence of disadvantages of ceramic restoration, still they do exhibit many great noticeable advantages such as realistic appearance, biocompatibility and well tolerated by surrounding periodontal tissue, as well as if they well polished and glazed, reduce the dental plaque adherence, and color stability is regarded as one of the important advantage of ceramic restorations (Aboushelib et al., 2016 ; Tiu et al., 2015).

Table 5. Mechanical properties of different ceramic material and tooth structures. (Guess et al.,2011).

Mechanical properties of different all-ceramic systems according to manufacturer's instructions						
Material	Modulus (GPa)	Hardness (GPa)	Toughness (MPa $m^{1/2}$)	Strength (MPa)	CTE°C Xx 10^{-6}	Firing(°C)
porcelain						
Vitablocks (feldspathic)	45	NA	NA	154	9.4	780-790
Lava Ceram	78	5.3	1.1	100	10.5	810
IPS e.max ceram	60-70	5.4	NA	90	9.5	750
IPS e.max ZirPress (flour-apatite	65	5.4	NA	110	10.5-11	900-910
Glass-ceramic						
Dicor	75	3.4	1.4	290	9.8	850
Empress esthetic (Leucite)	65-68	6.2	1.3	160	16.6-17.5	625
IPS e.max Press (Lithium disilicate)	95	5.8	2.75	400	10.2-10.5	915-920
IPS e.max CAD (Lithium disilicate)	95	5.8	2.25	360	10.2-10.5	840
Alumina						
In-ceram Alumina	280	20	3.5	500	7.2	2053 melting point
Procera Alumina	340	17	3.2	695	7.0	1600
Zirconia						
Cercon	210	12	9	1300	10.5	1350
IPS e.max Zir CAD	210	13	5.5	900	10.8	1500
Lava	210	14	5.9	1048	10.5	1480
DSC Zirkon	210	12	7	1200	10.4	1500
In-Ceram YZ	210	12	5.9	>900	10.5	2706 melting point
Procera Zirconia	210	14	6	1200	10.4	1550
Prettau Zirkon Zirkonhzahn	210	12.5	NA	1000	10	1600
Tooth						
Dentin	16	0.6	3.1	-	11-14	-
Enamel	94	3.2	0.3	-	2-8	-

2.3.9. Chairside CEREC CAD/CAM materials

CEREC means; Chairside Economical Restoration of Esthetic Ceramics or Ceramic REConstruction. According to this description, this system is mainly based on chairside treatment which is very comfortable to the clinician and the patient when completing the restoration process in a single appointment (Franklin, 2015). Some of these are referd to down below as:

- **Esthetic ceramics:(Feldspathic)**

Feldspathic ceramic:

Are available in market with a brand name of Vitabloc Mark II (Vident) and CEREC Blocs (Sirona Dental), which contains a glass phase that allowing them to be etched and adhesively bonded for better retention.

Vita Mark I (VitaTM Mark I, Vita Zahnfabrik, Bad Sackingen, Germany): They were introduced to dental markets as first CAD/CAM restorative materials in 1985 .These blocks were contain fine grains of feldspathic ceramic, having a flexural strength of 120 MPa. That was used for veneer, onlay, and inlay restorations. Whereas Vita Mark II introduced in 1991, present with flexural strength (100 MPa -160 MPa), which was considered suitable for monolithic anterior crowns as well as inlays, onlays veneers fabrications. CEREC Blocs entered the market in 2007 (Fasbinder, 2009), as they manufactured by Vita Zahnfabrik. However, there are two types of CEREC Blocs: One is CEREC Bloc C in monocolor that is highly translucent and used especially for inlays and partial crowns production. The other one is CEREC Bloc PC; polychromatic which is suitable for producing of posterior crown restorations. They are available in 6 shades and 3 chroma; degree of color. (T) For translucent one, (M) for medium one, and (O) for opaque color (Büyükbayram et al., 2016).

- **Esthetic ceramics (leucite-reinforced)**

Pro CAD:

ProCAD (Ivoclar-Vivadent, Schaan, Liectenstein), introduced as a first leucite-reinforced glass-ceramic blocks for CAD/CAM system in 1998. Nine shades presents with either high translucency ;(HT) or low translucency ;(LT). The structure of this material when examined, it was similar to the heat pressed ceramic Empress TM; (Ivoclar Vivadent) (Şen ve Tuncelli, 2017).

Express CAD:

It was introduced in 2006. Express CAD has 45% leucite with particle size about 1-5µm that resists the machining damages. As they recommended for single tooth restoration, it has three forms: polychromatic, high and low translucency (Susic et al., 2017).

Paradigm C:

Introduced in 2006, as a new material, by 3M ESPE that was a glass ceramic block made out of a two phase leucite-reinforced ceramic. The indications of this material were the same like Paradigm MZ100, which present with six different shades (Fasbinder, 2009).

- **High strength ceramics**

IPS e.max:

Is a Lithium disilicate glass-ceramic blocks used for CAD/CAM restorations. It was introduced in 2006. It has flexural strength (350-450 MPa) which is higher than leucite reinforced dental ceramics (Fasbinder, 2009).

Lithium disilicate-based glass-ceramics, in order to extend the indication range of glass-ceramics beyond to the anterior teeth, that showing significantly higher strength and fracture toughness compared with the leucite type glass-ceramics.

This material demonstrates significantly higher crystal content (up to 70 %) compared with that of leucite glass-ceramics. Therefore, the high degree of interlocking crystals, which exhibits strength of 350 MPa and a fracture toughness of 2.5 MPa. This material (IPS e.max Press, Ivoclar Vivadent AG) suitable for fabricating crowns and frameworks for three-unit bridges, using the well-established press technique. These products are subsequently coated with a fluoroapatite glass-ceramic in order to resemble the optical properties of natural teeth (Li et al., 2014). The reliability of this material was shown by several in vitro and in vivo studies (Alghazzawi et al., 2012; Baladhandayutham et al., 2015 ; Sağlam, 2017).

Nevertheless, it shows preferable machining properties. In its intermediate stage, the material has a bluish color and exhibits very low chemical durability. However, these properties change significantly during the crystallization process at 850 °C in which the Lithium meta silicate is transformed into a durable Lithium disilicate glass-ceramic with a selected dental color. Solid-state reactions significantly improve the chemical durability of the material and impart the tooth-like optical properties (Ritzberger et al., 2010).

- **Composite resin (final restoration)**

Paradigm MZ100 (3M ESPE):

It was introduced in 2000 as resin based composite with 85% zirconia silica ceramic by weight. It is an aesthetic material with improvement in their physical properties as well as clinical performance. The indications of this material were veneers, crowns, inlays and onlays (Gracis et al., 2015).

- **Composite resin (temporary restorations)**

Vita CAD-temp (vident):

It is highly cross-linked microfilled polymers, which is available as big size of blocks, in order to be used for preparation of multiple units of fixed prosthetic restorations. It comes with four shades (Fasbinder, 2009).

2.4. Dental Cements

All indirect dental restorations for adhesion to the tooth surfaces do require choosing correct dental luting cements. It is one of the important steps of prosthetic restorations, as it will result in the long-term success of the restorations (Ladha and Verma, 2010).

Loss of the retention of prosthetic dental restoration generally lead to a failure of the crown and/or fixed partial denture (Paul, 2015). 'Luting' a word was originated from a Lutum; which is a Latin word meaning mud. The luting cement will create a link between a restoration and prepared tooth surface. It will bond them together with different form of surface attachment either; mechanical, chemical, or micromechanical even may be through combination of them. Whereas, the Bond term means attraction reaction between two different surface which may be through a chemical or physical interaction. However Cement; is a common term of joining medium that enhance the adhesion or micromechanical locking between several surface to be connected together (Paul, 2015).

As Malment and Scransky in 2001 stated that, "A luting agent might not only attach a restoration to a tooth but also act as a physical shield to mask the weak qualities of dentin and other low modulus materials which is used as cores" (Malament and Socransky, 2001).

With a significant progress in development of bonding techniques, that expected to be a field of great interest in dentistry in the near future. Increase of both the strength of ceramic through reduced fracture rate and survival rate of ceramic restorations is evident. Cementing with resin luting agents which provide a chemical bond between the cement and the tooth surface together with the salinization of the glass material have been well developed (Davidson, 2001).

Some of an over view of luting cements have been summarized according to the date of their production in (Table 6).

Table 6. List of development of luting agent in dentistry

Cement	Year
Zincoxide euginol	1875
Zinc phosphate	1880
Silicate cement	1940
Zinc Polycarboxylate	1968
Glass-ionomer cement	1969
Composite resin cement	1975
Resin cement	1986
Resin modified glass ionomer cement	1990
Poly–Acid Modified composites (compomer)	1993
Self-etching	2000
Self adhesion resin cement	2004

The cement properties generally include (Gresnigt et al., 2016):

1. Its biocompatibility to teeth structure and its surrounding soft tissue.
2. Having adequate mechanical properties involving; high bonding, tensile, shear and compressive strength to the underlying tooth and/or implant structure.
3. Sufficient physical property as adequate resistance and retention strength, low solubility and viscosity, good working and shot setting time and radiopaque character.
4. Having good marginal sealing properties to prevent or reduced marginal leakage.
5. Should not be soluble in water or oral fluid and should not absorb water (Rosenstiel et al., 1998; Rickman and Satterthwaite, 2010).

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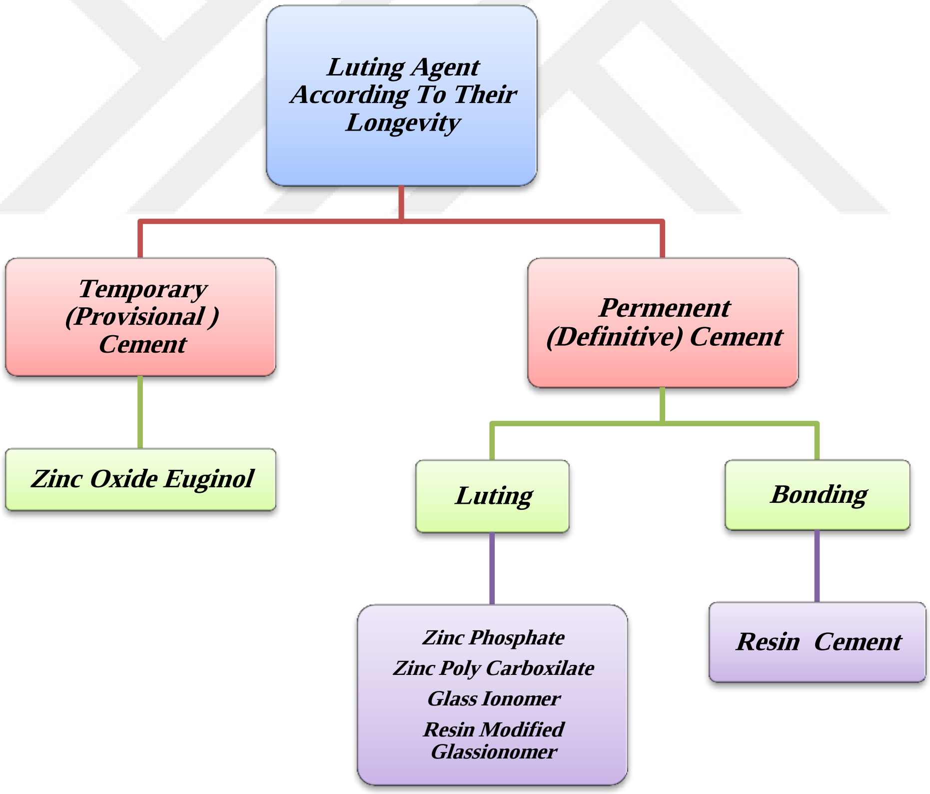

Figure 16. Classification of luting agent according to their longevity

2.4.1. Types of cement

- **Zinc phosphate cement:**

- Have a long-term successful rate with a history of more than a century.
- This type of luting agent will provide retentive seal through mechanical bonding .in fact the surface area of tooth structure, tapering and length of preparation design show a critical role in success of such restoration fixed with zinc phosphate cement.
- Zinc phosphate cement produced by mixing of liquid (phosphoric acid) and powder (zinc oxide and magnesium oxide).
- It has moderate compressive strength (62-101) MPa and low tensile strength (5-7) MPa (Paul, 2015; Alakhras, 2011).

- **Zinc polycarboxylate cement:**

These cements as a water bases cement type used permanently for retention of crowns and bridges. These kinds of cements are not as solid as zinc phosphate cement, but they are fewer irritating to the pulp. The main things of zinc poly carboxylate cements are moderate viscosity, moderate strength, fitness to bond to enamel, and mild acidity. Mixed polycarboxylate cements appears to be very viscous (thick), nevertheless it flow readily when used to the surfaces to be cemented. The compressive strength of poly carboxylate cement is not as much of glass ionomer cement; however, it provides clinically satisfactory retention for well-fitting restorations. These cements are slightly acidic (low pH) when first mixed, although the acid is softly dissociated. Histologic results are like to those of zinc oxide-eugenol cements, but further reparative dentin is complying with the zinc polycarboxylate. Zinc poly carboxylate cements bond well to sand blasted gold alloys, while clinical studies have not appeared better-quality retention with these cements. Some characters of this type are:

- It was invented since 1968.
  It was first cement exhibit chemical bond to the tooth structure.
- It is produced from mixing of liquid (polyacrylic acid) and powder (zinc oxide and magnesium oxide).
- Compressive strength (67-91) MPa and low tensile strength (8-12) MPa.

- Because it may undergo plastic deformation under loading after setting the use of zinc poly carboxylate cement is confined to single crown or short fixed bridge, so it has limited use in general (Paul, 2015).

➢ **Glass ionomer cement:**

These kinds of cements are water-based cements used for last cementation of crows and bridges. Minimum requirements are explained by the American nation standards Institute- American Dental Association (ANSI-ADA). The value of compressive and tensile strengths of glass ionomer cements are the same as those of compomer, high hybrid ionomer, and zinc phosphate cements. The cement has the nonirritating values of zinc polycarboxylate cements. On the other hand, a calcium hydroxide based is suggested for pulpal protection when the ionomer cement is benefit from a deep cavity. Because of fluoride incorporated in the powder, the cement has an anti-cariogenic effect as it is leached out. Retention of glass ionomer cements is primarily micromechanical, while some chemical bonding occurs.

- It has a character of fluoride release
- Its role is to adhere to the tooth structure by ionic bond formation between tooth – cement.
- It can be produced through mixing of liquid (polyacrylic acid and tartaric acid) and powder (alum inosilicate and fluoride)
- It has moderate compressive strength (85-126) MPa and low tensile strength (6-7) MPa (Paul, 2015).

➢ **Hybrid ionomer cement:**

The second types of cements (resin modified glass ionomer cements) are water-based cements designated for permanent cementation of alloy crows and bridges to tooth arrangement and core buildups, cementation of posts, and bonding of orthodontic appliances. There are more than one inventions are not mentioned for cementation of lower-strength all-ceramic inlays, onlays, or crowns for the reason that their water sorption, which leads to leads expansion and can reason cracking of the ceramic rebuilding. Hybrid ionomer cements can be used for cementation of zirconia all-ceramic crowns and bridges.

The cost for compressive and tensile strength of hybrid ionomer cements are the same as those of glass ionomer cements. Hybrid ionomer cements have no considerable solubility when checked by lactic acid erosion. The fracture toughness is larger than that of other water-based cements but lower than that of resin cements. Fluoride release is similar to the glass ionomer cements. The first pH is about 3.5 and step-by-step rises. These cements have least postoperative feeling. The bond ability to moist dentine is 14MPa and is much higher than that of most water based cements.

- **Resin modified glass ionomer cement:**

- It is formed by replacing some of polyacrylic acid in conventional glass ionomer liquid with polymerizable functional methacrylate monomers
- It has higher compressive and tensile strength than conventional glass ionomer cement type.
- Will bond to the tooth structure chemically by ionic bond and hybrid layer bond. (Alakhras, 2011).

- **Zinc oxide eugenol:**

Cements are oil based cements obtundent (sedative) influence on the pulp and are mainly suitable for cementation on arranged teeth with exposed dentinal tubules the adding of strengthening agent to zinc oxide eugenol cements has developed in permanent luting cements. Temporary cements are not so strong but are useful for short-term cementation of temporary stainless steel crowns and permanent restorations. Zinc oxide non-eugenol cement are additionally oil based cements used for little term cementation of temporary acrylic crowns and finished cast restorations. They are weak and certainly prepared for the casting.

The moderate strength and how acidic quality of the zinc oxide–eugenol cements are important properties. The permanent zinc oxide-eugenol cements are not as forceful as other cements but have been appeared to be clinically productive for last cementation of crowns and bridges that have suitable retention. The temporary cements are not stronger, a described feature for cementation of impermanent crowns or for temporary cementation of finalized crowns and bridge restorations that must be separated without difficulty.

The pH of the zinc oxide-eugenol cements is neutral. For the reason that the sedative quality of these cements, they do not need a protective varnish or cavity liner. Retention is the product of micro-mechanical interlocking of the restoration and ready tooth.

- **Resin-based cements:**

The introduction of Maryland bridge (rochette) by Shembish et al 2016 resulted in development and progression of resin based luting material (Hussain, 2008).

Resin cements have the ability of sealing the small cracks of an intaglio surfaces of ceramic restorations, so improve their ceramic strength. Ceramic-resin bonding agent successfully achieved with a pretreatment of (silica-based) ceramics with acid etching, which is followed by salinization.

Some studies in 2003 showed that using resin cements in the dental treatment increase the retention to be a double in cases with indirect dental restoration when compared with the zinc phosphate and the conventional glass ionomer cement (Zidan and Ferguson, 2003).

2.4.2. Types of resin cements

1- Esthetic resin cements:

These cements are tooth-colored or translucent resins existing in a difference of shadows, and they are used for bonding of all-ceramics and indirect composite restorations. These cements involve a bonding agent for adhesion to tooth arrangement and divide primers for bonding to ceramic substrates. These cements present with medium to high strong point as well as with a little film thickness. The radiopacity is necessary, for cementation of an inlay (Figure 17).

The latest investigation suggests that the microfilled resin cements have more wearing resistance than hybrid resin cements. Light-cured the resin cements with an extended effective period, while exposure to sun or flurescent light can initiate polymerization process. High bond strengths of esthetic resin cements to tooth structure and ceramic substrates (Jetti et al., 2015).

2- Adhesive resin cements:

These types of cement are used for bonding of most alloy and ceramic restorations; including implant-supported crowns, veneers and bridges, as well as indirect resin restorations. Adhesive resin cements have radiopaque character therefore, requiring less film thickness. However, little working period is associated with this type of cement.

3- Self-adhesive resin cements:

Self-adhesive resin cements remove the need for split primers for bonding to tooth, alloy, or ceramic substrates. These cements bond to tooth structure and other things with low to medium bond strengths. They usually are not as solid as esthetic and adhesive resin cements. Properties determined after these cements are light activated are commonly higher than when they are self-cured.

4- Temporary resin cements:

These types of cements are used for temporary cementation of crowns. Removed the problem related to the potential infection of teeth by their eugenol content. Temporary resin cements are generally simple to combine and clean up and have low-to-medium compressive strength (Figure 16,17).

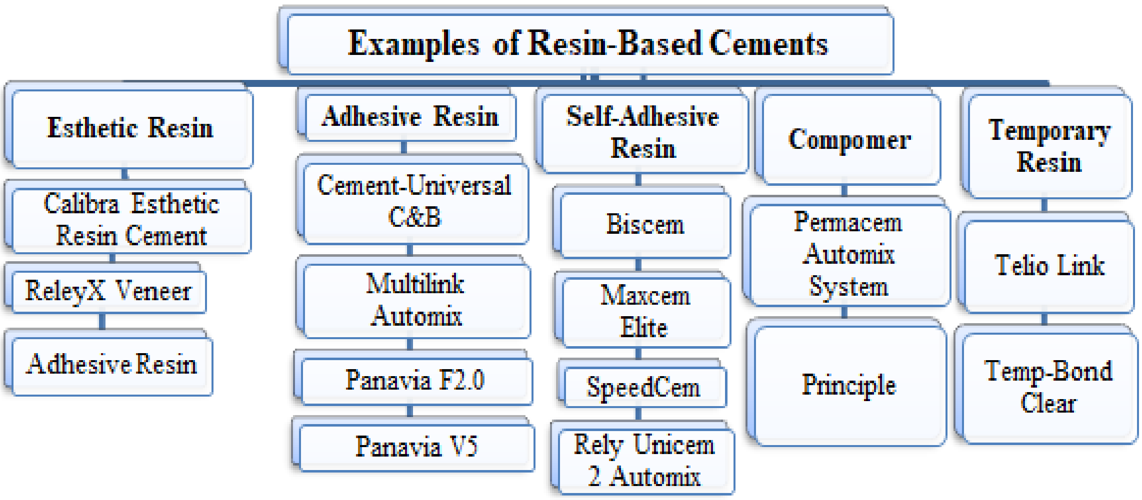

Figure 17. Classification of resin based cement

3. MATERIAL METHOD

3.1. Devices and Materials

The procedures and materials that have been used with in the present project which is under the title of “the evaluation of the influence of different finishing line depth on strength of CAD/CAM restorations” have been carried out and performed within the scientific laboratory and prosthodontic department of Faculty of Dentistry/Van Yüzüncü Yıl University, Republic of Turkey.

All the row materials and the tools of the laboratory that have been used in the present study were listed, illustrated and tabulated down below in (Figures 18-42) and (Tables 7 and 8).

Whereas only for die material fabrication the used Computer Numerical Control machine (CNC) was from a private shop in industrial area of Van city (Figure 18).

Figure 18. CNC machine

Table 7. Materials used in this project

	Name of Material	Name of Country and Factory That Made The Machine
1.	IPS e.max®CAD	Ivoclar Vivadent, LIGHTENSEIN LT A2/C14
2.	CEREC Blocks	Sirona Dental Systems ,GERMANY
3.	Panavia v5 adhesive resin cement system	Kuraray Noritake Dental Inc.Japan
4.	KaVo Basic study model	KaVo Dental GmbH, Biberach, GERMANY
5.	50 mikron Al2O3 kum Korox,Bremen, GERMANY	Korox, Bremen, GERMANY
6.	Dental wax	Q Wax Dental Wax
7.	Auto polimarized acrylic resin	Self-curing cold cur acrylic ,IMICRYL,Turkey

Table 8. Names of equipments used in the present study

	Names of Equipment	Name of Country and Factory That Made The Machine
1.	Cerec AC with Omnicam, CAD Units	Sirona Dental systems GmbH, Bernsheim GERMANY
2.	Cerec MC XL, CAM units	Sirona Dental systems GmbH, Bernsheim GERMANY .model:6092162 /D3439
3.	Programat EP 3000	Ivoclar Vivdent,Schaan,LIECHTENSTEIN
4.	Sand blasting Machine	Rotaks-Dent/Istnbul,Turkiye
5.	Dental Microscope	Leica M320 for dental
6.	Shimadzu Autograph-X Universal test machine	Shimadzu Corporation, Kyoto,JAPAN
7.	Led curing unit	Elipar Freelight 2, 3M ,USA,
8.	Incubator	Mermmert 30-750

Two materials have been selected to be used in the current investigation. Feldspatic Ceramic (CEREC Bloc ceramic for CEREC (Sirona) with 14 A2C CEREC Block C) and Lithium disilicate glass ceramic blocs (IPS e.max CAD (Ivoclar-Vivadent) /LT A2/C14) (Figure 19) have been used in the present in-vitro study (Table 7, 8).

Figure 19. Shows the Lithium disilicate and Feldspathic blocks used in the present project.

They were chosen to fabricate posterior single full-contorted flat coping crown. Milled by CAM (Sirona Dental Systems, CEREC MCXL, GmbH, Bensheim, Germany) (Figure 12). A digital impression was taken using CEREC 4 software (Version,4.2.0.57192).

3.2. Specimens Preparation:

Preparation of seventy two die models were obtained from nickel chrome material for the present study, by the aid of computer numerical control machine (CNC), in order to simulate a mandibular 1st molar tooth as a novel design. Preparation samples were standardized with a height of 6 mm and 8 mm occlusal diameter. The preparation angle of the entire wall was set up to 6 degree.

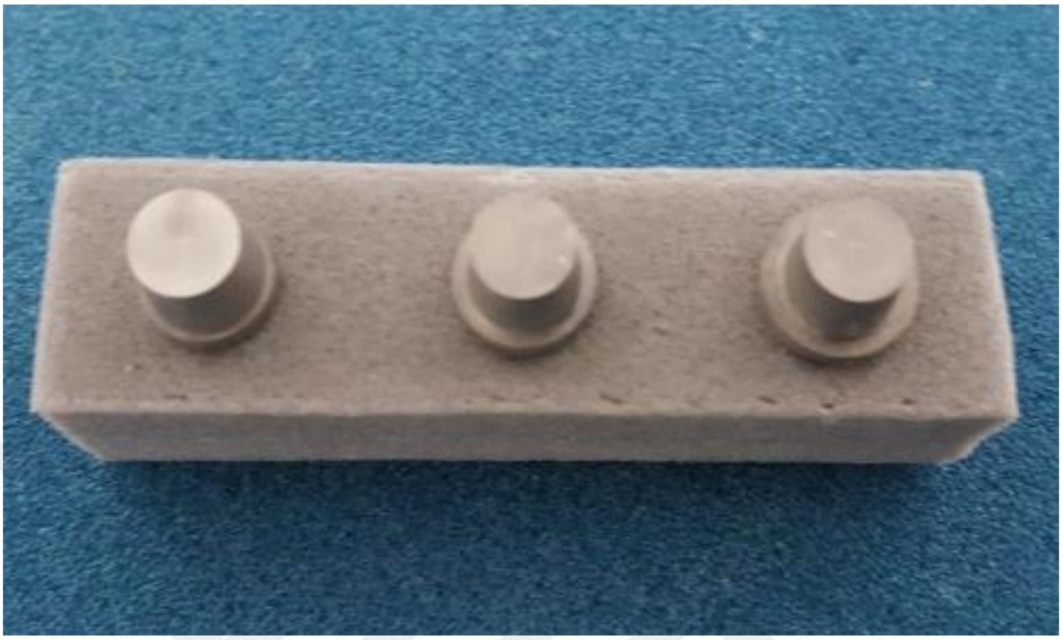

Figure 20. Sample of die specimen with three different finishing lines

In the present in vitro investigation all samples were prepared with a circumferential, each one with 94 degree axiogingival internal line angle shoulder finish line with different depths. Using a computer numerical control machine (CNC) shoulder finish line, designs were prepared with 3 different depth of 0.5 mm, 1.0 mm, 1.5 mm (Figure 20). Each group of twenty–four (24) specimens was divided to two sub groups. Twelve (12) specimens for each of the two materials for every group of three finishing line depth that were used in the present project.

3.3. Imaging and Coping Crown Fabrication:

One specimen from each group of standard die (0.5 mm,1.0 mm and1.5 mm) have been chosen, in order to be fixed in the KaVo Basic study model (KaVo dental GmbH, Biberach, Germany) by wax (QWAX DENTAL WAX) in the region of the first mandibular molar.

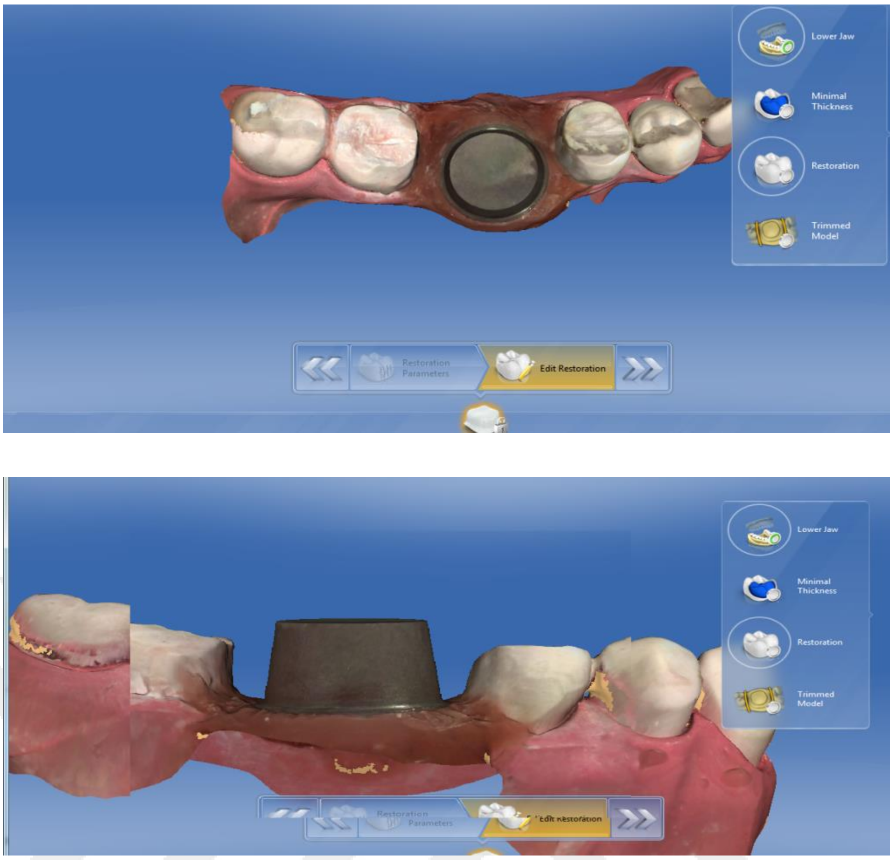

Figure 21. Two digital images of die specimen

Feldspatic Ceramic (CEREC Bloc ceramic for CEREC (Sirona) with 14 A2C CEREC Bloc), and Lithium Disilicate glass ceramic blocs (IPS e.max CAD (Ivoclar-Vivadent)/ LT A2/C14) have been chosen as the model material for the glass–ceramic crown in the present study. All materials were milled using a CAM machine (Sirona Dental Systems. CEREC MCXL, GmbH, Bensheim, Germany) (Figure 21).

Then after a digital impression was taken by using CEREC 4 software (Version,4.2.0.57192). An optical impression of each type of master die was made with CEREC intraoral scanner (CEREC Omincam) from each chosen study model. The coping crowns were then fabricated. Later, it finalized to be even and line up with its selected master die in order to precise their position (Figure 21).

Figure 22. CEREC imaging device used in this project

The restoration parameter applied was 120 μm for spacer (Renne et al., 2015). Whereas the radial wall thickness was entered to be only 2mm, as the occlusal wall thickness, for each one of the sets. All coping crowns were fabricated by the repetitive machining of the same design for each type of blocks; Feldspathic one (n=12) for very selective one of the three finish line (0.5 mm and 1.0 mm and 1.5 mm) Lithium disilicate (n=12) for every finish line depth (0.5 mm,1.0 mm and 1.5 mm).

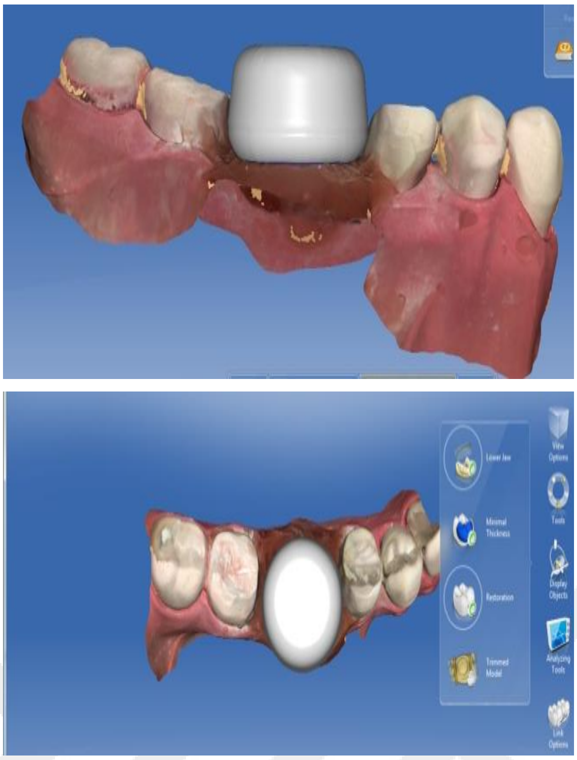

Figure 23. Digital images of coping design

The used CAD files of each design were imported into a milling machine (Sirona Dental Systems, CEREC MCXL, GmbH, Bensheim, Germany) (Figure 22).

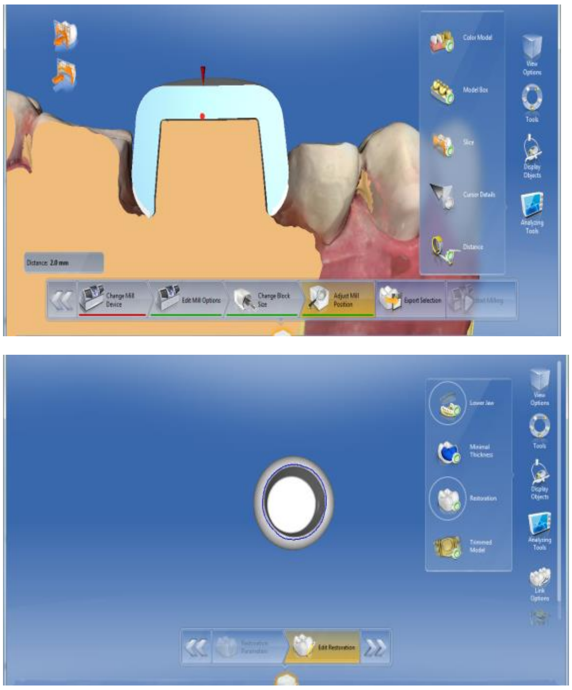

Figure 24. Sagittal and inner view of one coping sample

However, the period of milling procedure to be completed was at least 15 min for each one of restoration material; (Feldspathic and Lithium disilicate blocks).

The CAD/CAM crowns had been fabricated in accordance to the manufacturer's instructions, to produce optimum sequels.

All monolithic crowns were manufactured in such a way to produce the same shape and size to ensure standardization of specimen parameters (Figure 25).

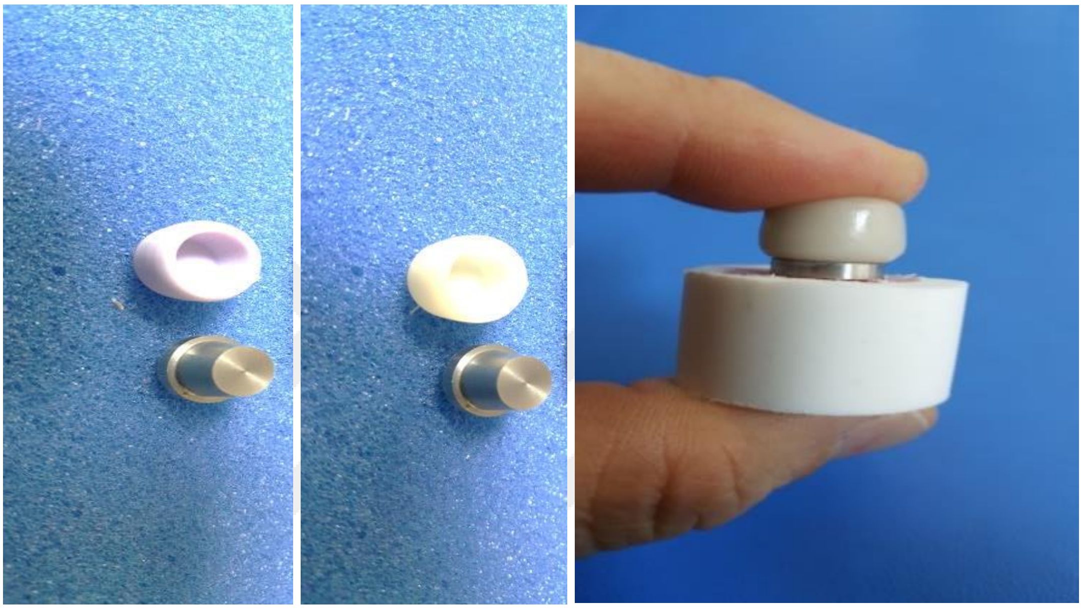

Figure 25. View of coping crown on nickel chrome die

Figure 26. Pre and post sintering of Lithium disilicate crowns

Figure 27. View of measurement of the depth of finishing line

For every completed prepared crown measuring and rechecking of collar depth, wall thickness, height and diameter were carried using dial caliper.

A dial caliper was used to measure and check the depth of collar and wall thickness of each completed crown (Figure 27).

Figure 28. View of all 72 samples

Following milling, and cleaning procedure all restoration crowns were examined thoroughly for defects, cracks or voids using a compound dental micro scope with 2.5x magnification (Dental Microscope Leica M320 for dental) (Figure 29,30). Any defected specimen or doubtful ones has been discarded and excluded from the experiment, then after replaced with new ones (Magne et al., 2015).

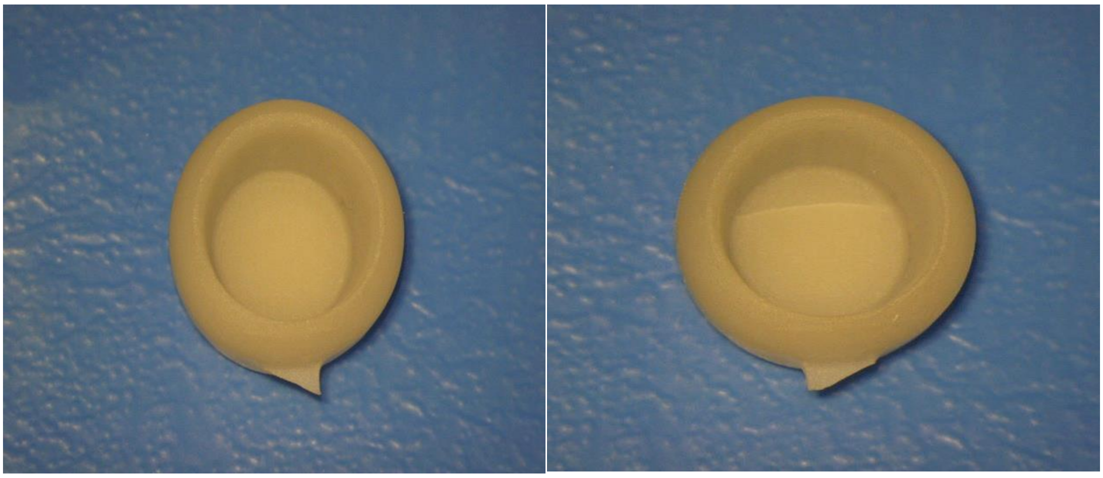

Figure 29. View of sound crown in relation to the defected one

Figure 30. Leica dental microscope

The crown fitting surfaces and the dies were well cleaned with 70% alcohol. Then after they were dried with air blast in order to remove any leftover of the Cerec powder or dust particles.

Figure 31. Evaluation the position of each coping crown

Finally, all the examined restoration were placed and arranged on a firing tray (Figure 32). They were sintered in a furnace for 25 min at 830^0C temperature for Lithium disilicate copings groups.

Figure 32. Programat EP300

3.4. Arrangement of the Set Groups

All seventy two coping crowns was divided in to two groups each with thirty – six as explained in the following Twelve crowns of each of feldspatic and Lithium ceramic sets were seated on every one of die specimen with their identified finishing line depth (0.5 mm,1.0 mm and 1.5 mm) (Table 9).

Group A = 0.5 mm shoulder finishing line depth and their Feldspathic coping crown (n=12), numbering from no.1 to no.12 with Lithium disilicate coping crown (n=12), numbering from no 13 to no. 24.

Group B = dies with 1.0 mm shoulder finishing line depth, and their Feldspathic group coping crown (n=12) numbering from no.25to no 36, Lithium disilicate coping crowns (n=12) numbering from no.37 to no 48.

Group C = dies with 1.5 mm shoulder finishing line depth and their Feldspathic coping crowns (n=12) numbering from no.49 to no. 60, Lithium disilicate group coping crowns (n=12) numbering from no.61 to no.72 (Figure 28).

Table 9. Illustrate working plan of the 72 ceramic specimen dealt with during the present investigation.

Group* No.	Group symbol for crown depth	Group Symbol for ceramic type	Type of Ceramic material	Depth of The Crown Wall
1.	A	F1	Feldspathic glass ceramic	0.5 mm
2.		L1	Lithium disilicate ceramic	0.5 mm
3.	B	F2	Feldspathic glass ceramic	1.0 mm
4.		L2	Lithium disilicate ceramic	1.0 mm
5.	C	F3	Feldspathic glass ceramic	1.5 mm
6.		L3	Lithium disilicate ceramic	1.5 mm

* Each group composed of 12 ceramic specimens.

Prepared teeth were assigned into six groups of twelve each according to crown type and the depth of coping collar. (Table 9), as follows**:**

1. **Group F1:** Shoulder finishing line with feldspathic glass ceramic, and a depth of 0.5 mm.
2. **Group L1:** Shoulder finishing line with Lithium disilicate ceramic, and a depth of 0.5 mm.
3. **Group F2:** Shoulder finishing line with feldspathic glass ceramic, and a depth of 1.0 mm.
4. **Group L2:** Shoulder finishing line with Lithium disilicate ceramic, and a depth of 1.0 mm.
5. **Group F3:** Shoulder finishing line with feldspathic glass ceramic, and a depth of 1.5 mm.
6. **Group L3:** Shoulder finishing line with Lithium disilicate ceramic, and a depth of 1.5 mm.

3.5. Surface Treatment and Cementation Process:

Pre cementation process each die were embedded and mounted in self-acrylic resin (Epovia, Cray valley) in a one inch diameter PVC tube (Figure 31). The die was placed in such away to be 2mm above the surface of the resin.

Figure 33. View of controlling the adequate positioning of each die in acrylic resin using bubble level tool

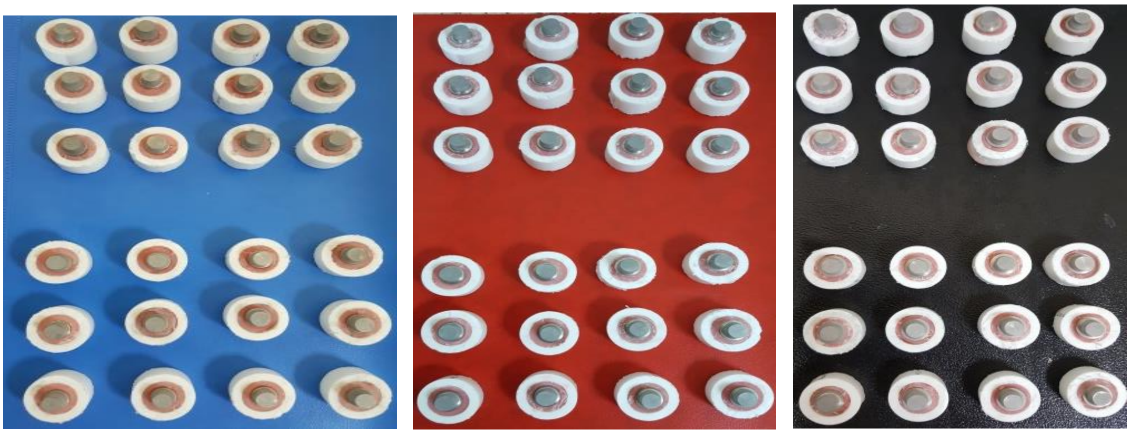

Figure 34. All 72 Die samples; Blue one (0.5 mm), Red one (1.0 mm), Black one (1.5 mm)

According to the manufactures instruction of Panavia V5 brochure the surface of each die was roughened by sandblasting from distance of 10 mm at 2.5 bar (Cortellini et al., 2015). The abutments were air-abraded with alumina particles coated with silica 50 nm for 20 seconds with sandblasting machine (Korox Bremen, Germany) then cleaned and dried.

The cementation surfaces of each coping crowns were etched with hydrofluoric acid gel 5% (Ivoclar Vivadent) with small brush for 20 seconds. The inner surfaces then thoroughly rinsed with water and dried.

Figure 35. Acid etching process of each sample

Then, one coat of CLEARFIL™ CERAMIC PRIMER PLUS which contains the adhesive monomer MDP and MPS silane monomer was applied on the cemented surface of coping crowns and on the die surfaces, leaved for 20 sec and dried.

Figure 36. Panavia V5 adhesive cement system

Resin cement (Panavia V5, kuraray noritake Dental Inc., Okayama, Japan) was injected to the inner surface with an applicator tip provided with in cement kit, according to the manufacturer’s recommendations.

The coping crowns were cemented and initially seated on their metal dies using standardized constant pressure of 1kg was applied for cementing of CAD/CAM coping crown using customized metallic appliance for 5 minute (Elsaka, 2014).

Excess cement was well removed from the margins by Tack-curing method with dental explorer through application of light from dental device LED curing unit (Elipar S10, 3M ESPE, Seefeld, Germany). Later on, each specimen was cured again for 40 sec from each side to ensure that the polymerization was completed.

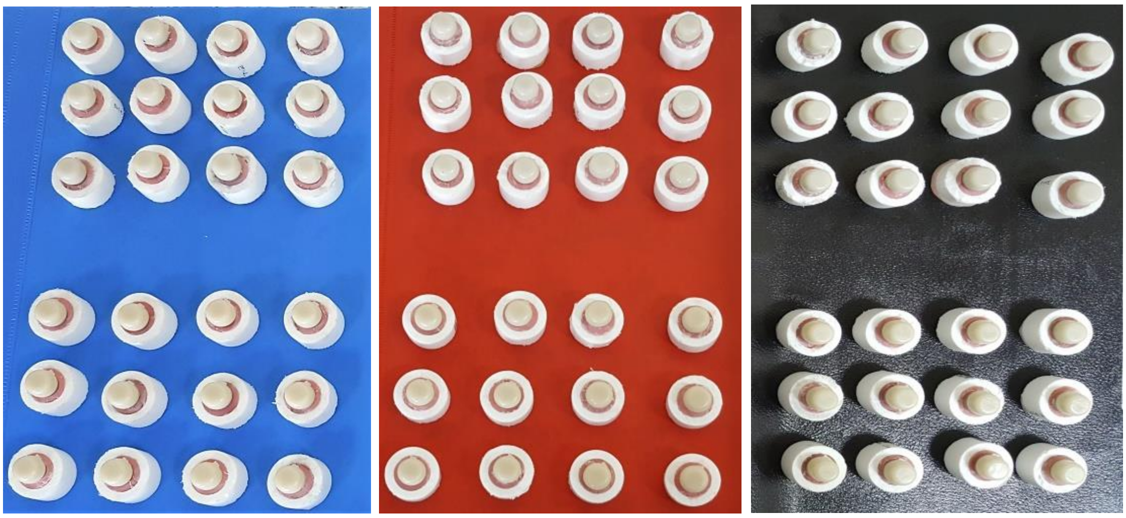

Figure 37. All 72 samples after cementation

All Cementation procedures were performed at room temperature according to the manufacturer's instructions. After cementation and before starting the experiment the specimens were place in distilled water for at least 24 hours in incubator prior to fracture testing.

3.6. Fracture Tests:

The samples were mounted in a universal testing machine (ShimadzuAGS-x, Japan) (Figure 39). Then after each spacimen was placed and fixed in matrix to maintain identical loading position during the fracture strength test. Bubble level tool was used to level the crown surface to the floor in order to control the parallelism, and ensure centralized location of fracture load on each of the sample spacimen on the center of occlusal surface of each crown.

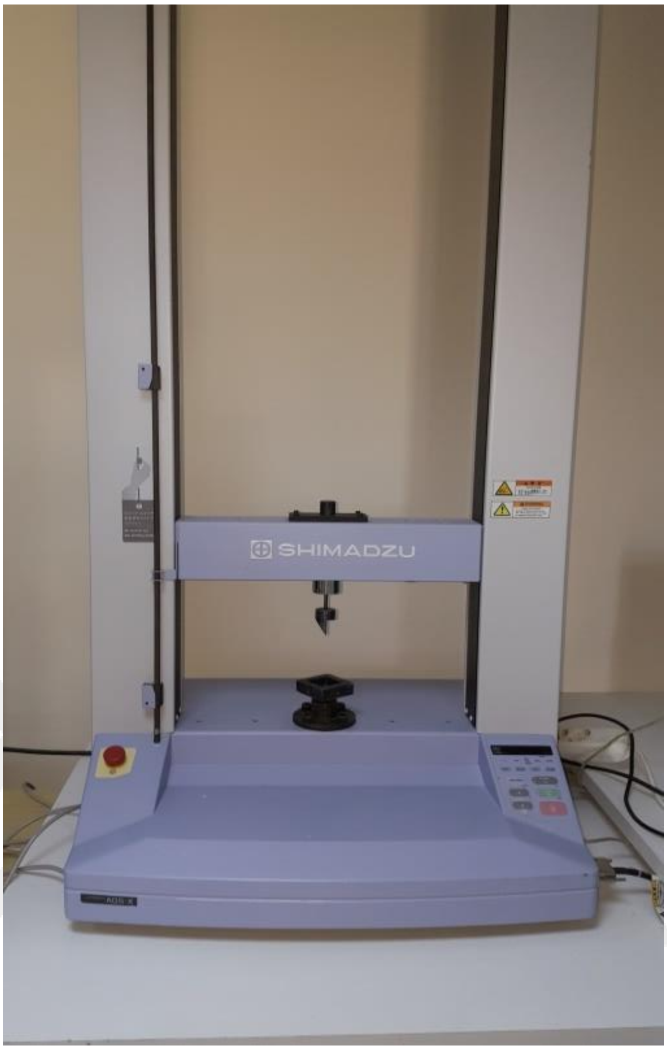

Figure 38. Universal test machine

A total of 72 sample specimens were tested in 6 groups (n=12 for each group). On the bases of the three selected finish line depth of crown shoulder margin (0.5 mm,1.0 mm,1.5 mm) and ceramic type of material- (feldspathic glass ceramic, and 2- Lithium disilicate ceramic) (Table 9).

Fracture load test have been performed in the scientific Laboratory of Prosthodontic Department /Faculty of Dentistry/Van Yüzüncü Yil University.

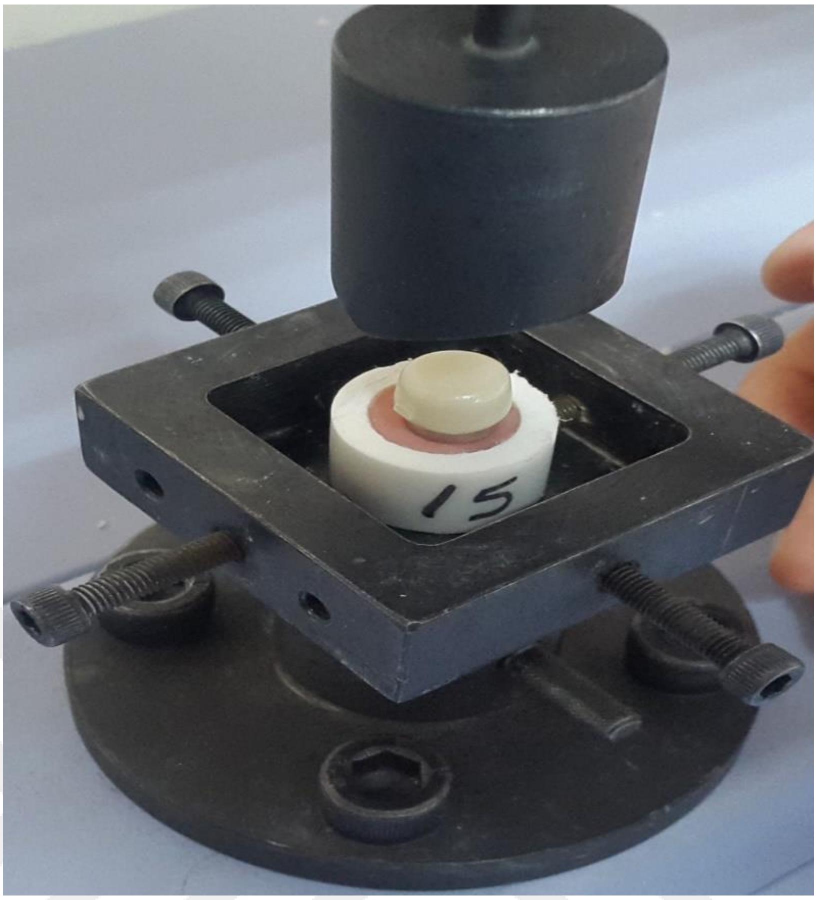

Figure 39. View of one sample positioned in fracture machine test

The load was applied at a straight angle in reference to the long axis of the restoration center using a stainless hexagonal steel road on the center of each occlusal surface of the coping crown, with a crosshead-speed of 1.0 mm/min.

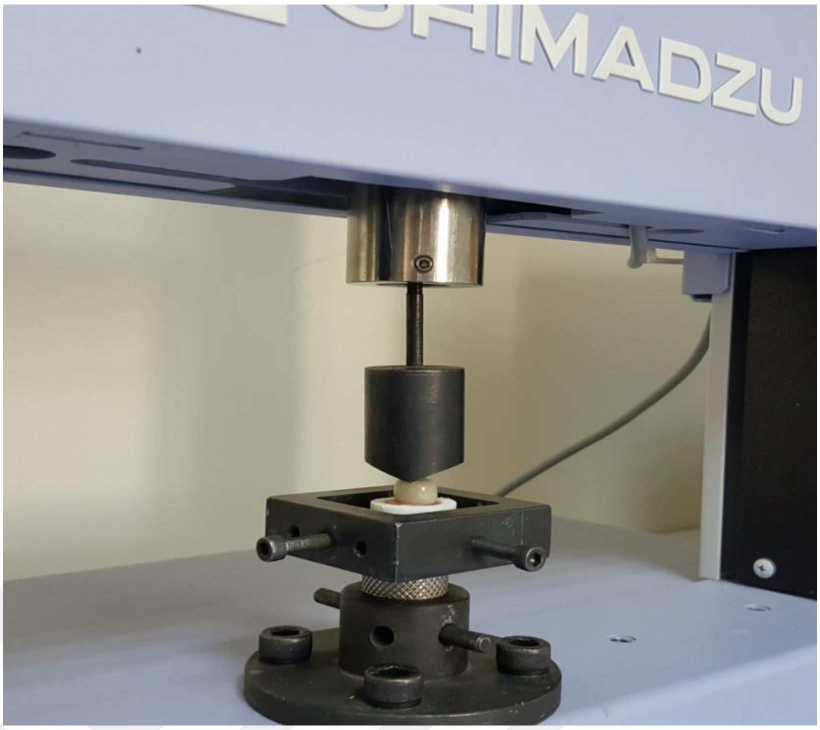

Figure 40. Showed sample during fracture process

The procedure (load application to the long axis of the spacemen) where carried out until catastrophic failure occurred using low speed video recorder to ensure and determined the exact fracture with load magnitude.

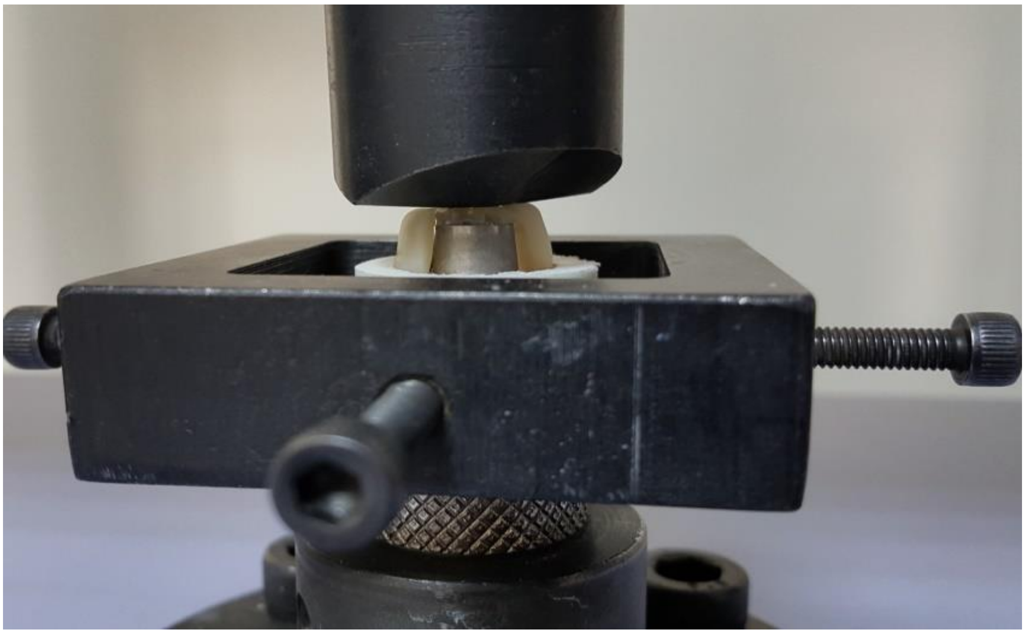

Figure 41. Showed sample after fracture.

Catastrophic failure was determined as the appearance or exhibition of visible cracks, load drops or acoustic events of chipping or fracture.

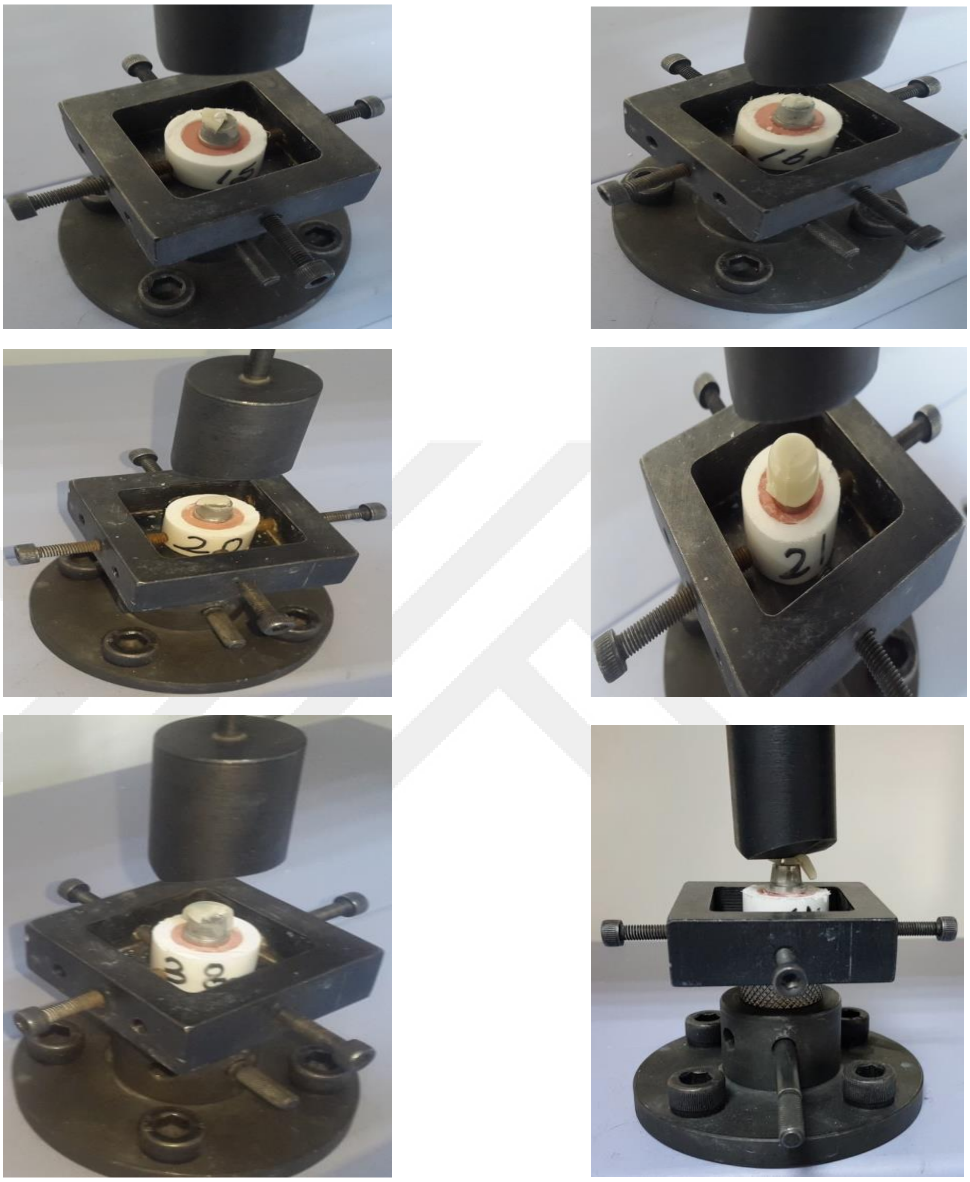

Figure 42. Different fractured mode of coping crowns

Statistical Analysis

Descriptive statistics for the studied variables (characteristics) were presented as median, mean, standard deviation, minimum and maximum values. Kruskal-Wallis and Man- Whitney U tests were performed to compare groups. Bonferroni comparison test was used to determine different groups. Statistical significance level was considered as 5% and SPSS (version: 23) statistical program was used for all statistical computations.

Alternatively, Kruskal-Wallis test were used to determine if there are statistically significant differences between two or more groups of an independent variable. The test was used to determine different groups and the statistical significance level was considered as 5%. Also, the SPSS (version: 23) statistical program was used for all statistical computations.

The fracture strength values were analyzed with the one-way ANOVA; in order to verify whether statistically significant differences were found among the experimental groups. Bonferroni comparison test was used to determine the different groups. Ultimately, the analyses level of significance was set at $\alpha=0.05$. Accordingly, Microsoft Excel 2010 has been used to determine the figures.

P-value were applied to compare the fracture load strength between the two material having same finishing line depth and within the same material having different finishing line thickness. Finely the comparison were made between Lithium di silicate restoration and Feldspathic ceramic with different finishing line depth of each. Nevertheless, P can take any value among 0 and 1. Values close to 0 point out that the detected modification is improbable to be due to chance, while a P value close to 1 means aproposal of no change among the groups other than chance. Statistical program was used for all statistical computation. A statistical test were performed in order to determine any relation and difference between the two materials (feldspathic glass ceramic, and Lithium disilicate ceramic), in respect to applied force and finish line depth, (0.5 mm, 1.0 mm, and 1.5 mm).

The coefficient variance was also calculated for each one of the six group of the specimen according to equation C.V= standard deviation/mean x 100%.

4. RESULT

Results of the present investigation have been tabulated in (Table 10) .The unit value used for fracture strength was in Newton .Two materials has been used Lithium disilicate (LITH) and Feldspathic ceramic (FSC) throughout the current study. The data represents the outcome results of each of the three depth of finishing line concerned (0.5 mm, 1.0 mm, and 1.5 mm). The absolute minimum value of the whole fracture strength data was only 513 N that recorded for Feldspathic ceramic with 1.0 mm depth of finishing line where as the maximum strength value of 4518N found with Lithium 1.5 mm finishing line depth.

The range of variation of FSC was as follow; 1873N, 2028N, and 1296 N for 0.5 mm, 1.0 mm, and 1.5 mm finishing line respectively. Whereas the range of variation of LITH was 1527 N, 2489 N, and 2721N for 0.5 mm, 1.0 mm and 1.5 mm depth of finishing line. The result shows that the mean value of fracture strength for FSC unlike LITH was not linear when it plotted against depth of finishing line. All the outcome results of primary and row data that have been achieved throughout the current investigation were dealt with statistically as well (Figure 43).

The detail of statistical analysis outcome for the concerned variable in this project are presented as median, mean, standard deviation, minimum and maximum value, Co-efficient of variant and p-values which have been illustrated in (Table 11,12).

In respect to feldspathic crown, the results are shown in (Table 13 and Figure 43). However these tables and figures illustrate minimum, maximum and mean strength value in respect to the three finishing line depth that were taken in consideration throughout present project. However, as far as Lithium disilicate crown is concerned, the result of present investigation are tabulated in (Table 14 and Figure 44). It represent the concerned related variance in respect to the three finishing line depth the minimum, maximum and mean values of strength at each of the three thickness (0.5 mm,1.0 mm and 1.5 mm) .

Table 10. Fracture strength value in Newton of both materials used (Feldspathic and Lithium disilicate) according to the depth of finish line (0.5 mm, 1.0 mm, 1.5 mm).

NO.of sample	FSC 0.5mm/N	LITH 0.5 mm/N	FSC 1.0 mm/N	LITH 1.0m/N	FSC 1.5 mm/N	LITH 1.5 mm/N
1	1543.5	1275	1716	4334	1297	1972
2	1654	1616.5	1779	1338	1239.5	3539
3	1501	834.2	2346	1639.5	2979.5	4518
4	1227	941	1422	1695.5	651.7	2897
5	2337	1172.5	2773	4172	847.2	2737
6	3233	1160.5	2977	2744	2134	1454
7	1868	1681	1952.5	1820	1116	3360
8	1995	865.6	513	1430.5	1015	3783
9	2090.5	3173	2408.5	2504	903.5	2882
10	1824.5	1482	1730	2580.5	984	1892
11	1365.5	2277	1674	1671	1261	2195
12	1837.5	1855	3046.5	3940	1132.5	1424.5
Mean	1873	1527	2028	2489	1296.7	2721

Table 11. Statistical measurement (median, mean, standard deviation, minimum and maximum value as well as co-efficient of variance and P value.*LITH=Lithium disilicate/*FSC=feldspathic *FLD= finishing line depth.

Item number	Material with FLD in mm.	Median	Mean	Minimum	Maximum	Std. Deviation	Coefficients Of variation	P-Value
1	FSC_0.5 FSC_1.0	1831 1865	1873 2028	1227 513	3233 3046	530 724	0.0028 0.0036	0.097
2	FSC_1.0 FSC_1.5	1865 1124	2028 1296	513 651	3046 2979	724 642	0.0036 0.0049	0.314
3	FSC_0.5 FSC_1.5	1831 1124	1873 1296	1227 651	3233 2979	530 642	0.0028 0.0049	0.589
4	LITH_0.5 LITH_1.0	1378 2162	1527 2489	834 1338	3173 4334	674 1100	0.0057 0.0044	0.917
5	LITH_1.0 LITH_1.5	2162 2809	2489 2721	1338 1424	4334 4518	1100 967	0.0044 0.0035	0.029
6	LITH_0.5 LITH_1.5	1378 2809	1527 2721	834 1424	3173 4518	674 967	0.0057 0.0035	0.445
7	FSC_0.5 LITH_0.5	1831 1378	1873 1527	1227 834	3233 3173	530 674	0.0028 0.0057	0.952
8	FSC_1.0 LITH_1.0	1865 2162	2028 2489	513 1338	3046 4334	724 1100	0.0036 0.0044	0.065
9	FSC_1.5 LITH_1.5	1124 2809	1296 2721	651 1424	2979 4518	642 967	0.0049 0.0035	0.407

Table 12. Continuation of statistical measurement (median, mean, standard deviation, minimum and maximum value as well as co-efficient of variance and P value.*LITH=Lithium di silicate/*FSC=feldspathic *FLD= finishing line depth.

Item number	Material with FLD in mm.	Median	Mean	Minimum	Maximum	Std. Deviation	Coefficients of variation	P-Value
10	FSC_0.5 LITH_1.0	1831 2162	1873 2489	1227 1338	3233 4334	530 1100	0.0028 0.0044	0.368
11	FSC_0.5 LITH_1.5	1831 2809	1873 2721	1227 1424	3233 4518	530 967	0.0028 0.0035	0.281
12	LITH_0.5 FSC_1.0	1378 1865	1527 2028	834 513	3173 3046	674 724	0.0057 0.0036	0.457
13	LITH_0.5 FSC_1.5	1378 1124	1527 1296	834 651	3173 2979	674 642	0.0057 0.0049	0.321
14	FSC_1.0 LITH_1.5	1865 2809	2028 2721	513 1424	3046 4518	724 967	0.0036 0.0035	0.183
15	LITH_1.0 FSC_1.5	2162 1124	2489 1296	1338 651	4334 2979	1100 642	0.0044 0.0049	0.627

Table 13. Fracture strength value (Newton) in respect to feldspathic restoration with different marginal thickness of 0.5 mm, 1.0 mm, and 1.5 mm.

Finishing line depth of FSC in mm	Mean /N	Minimum/N	Maximum/N
FSC 0.5	1873	1227	3233
FSC 1.0	2028	513	3046
FSC 1.5	1296	651	2979

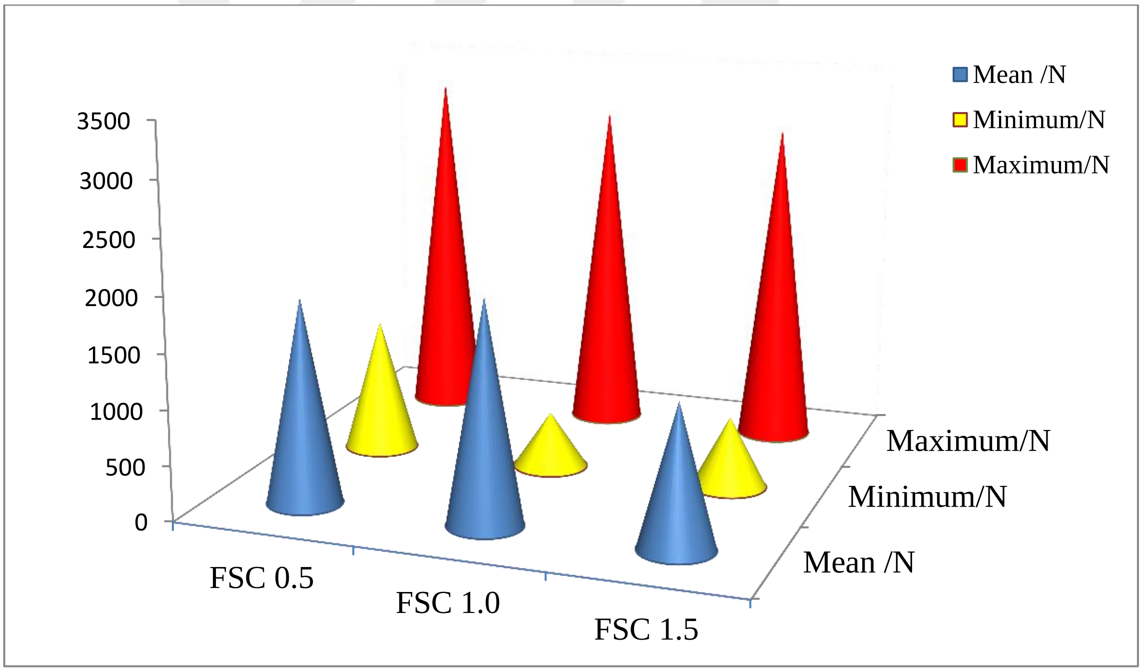

Figure 43. The relation between mean minimum and maximum value of Feldspathic restorations with the three finish line depth

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Table 14. Fracture strength value (Newton) in respect to Lithium disilicate restoration with different marginal thickness of 0.5 mm, 1.0 mm, and 1.5 mm.

Finishing line depth of LITH in mm	Mean /N	Minimum/N	Maximum/N
LITH 0.5	1527	834	3173
LITH 1.0	2489	1338	4334
LITH 1.5	2721	1424	4518

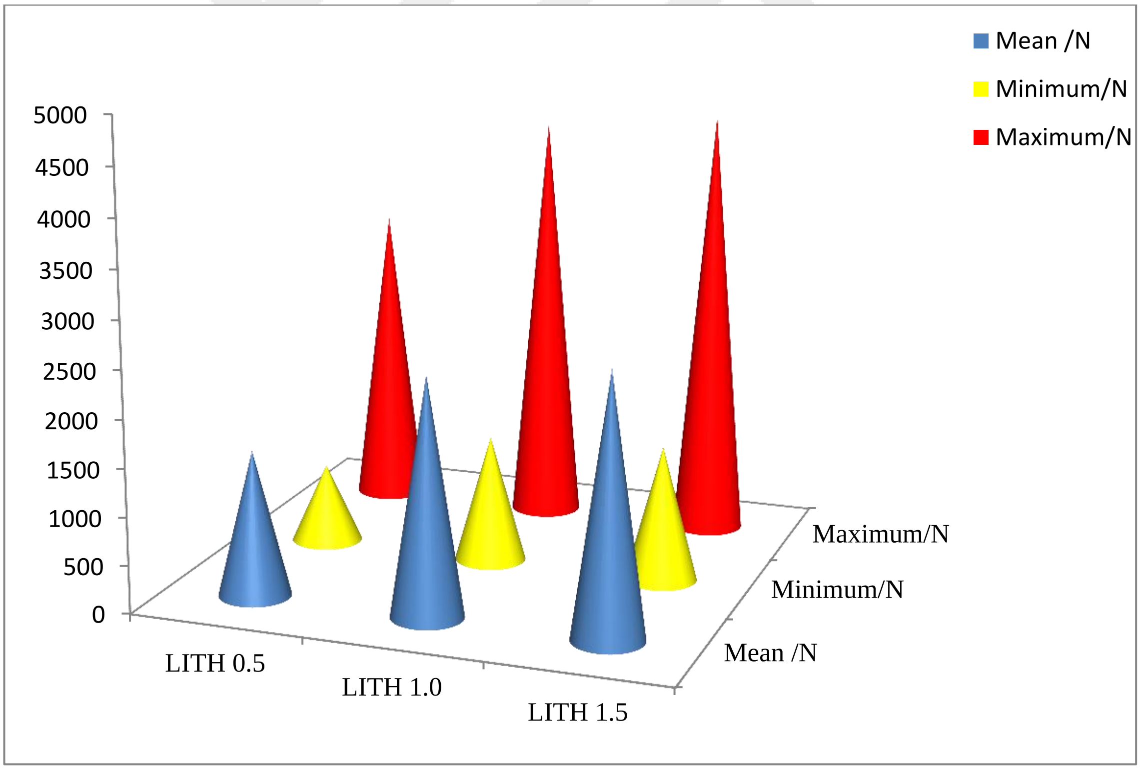

Figure 44. The relation between mean minimum and maximum value of Lithium disilicate restorations with the three finish line depth.

In respect to the finishing line 0.5 mm for both materials (LITH and FSC) used in the present experiment (Figures 48) shows the difference in the mean and median fracture strength values of the two materials used as it was only 346 N(1873- 1527 =346) and 453 N (1831-1378 = 453) respectively. In fact, values was higher, in general in case of Feldspathic restoration in comparison to Lithium disilicate whenever considering 0.5 mm finish line depth. However, when taking 1.0 mm finishing line depth as constant for comparing both materials the difference between their fracture strength values was 461 N (2489-2028 = 461) and 297 N (2162-1865=297) for mean and median respectively but in other way round. A higher value recorded with Lithium disilicate indicating that Lithium disilicate is stronger than feldspathic in case of 1.0 mm depth of finish line. Nevertheless, in case of Lithium disilicate and Feldspathic with1.5 mm depth of finishing line the difference become much wider as it exceed 1400N and1600N for mean and median values respectively, as illustrated in (Figure 48). The results clearly indicate that parcel out values of fracture resistance of Lithium with 1.0 mm finishing line depth in contrast to Feldspathic with depth of finishing line 0.5 mm was much higher when applying mean and median values as it was 636 N and 331N respectively. However, as the depth line of Lithium increases to 1.5 mm, the strength of CAD/CAM material had also increased as well. Different values of 848N and 1078N in estimating mean and median categories was obtained through out present investigation.

In general, Lithium disilicate in this comparison appears to be stronger than Feldspathic in cases, 1.0 mm and 1.5 mm .However the result shows completely different outcome whenever 0.5 mm depth line taken in consideration for both materials. While, Feldspathic did reflect stronger fracture strength in comparison to Lithium dislicate in case of 0.5 mm depth of finishing line (Table 15 and figure 15). The point that should be refer to here is that the result indicates that Feldspathic with depth of 1.5 mm need less power to fracture in comparison to Lithium 0.5 mm whenever using the difference in values of mean and median in comparison (Table 11,12).

Table 15. The statistical estimation of fracture strength value of LITH coping crowns with 0.5 mm FLD in relation to the three finishing line depth of FSC coping crowns.

Finishing line depth in mm	Mean /N	Minimum/N	Maximum/N
LITH 0.5	1527	834	3173
FSC 0.5	1873	1227	3233
FSC 1.0	2028	531	3046
FSC 1.5	1296	651	2979

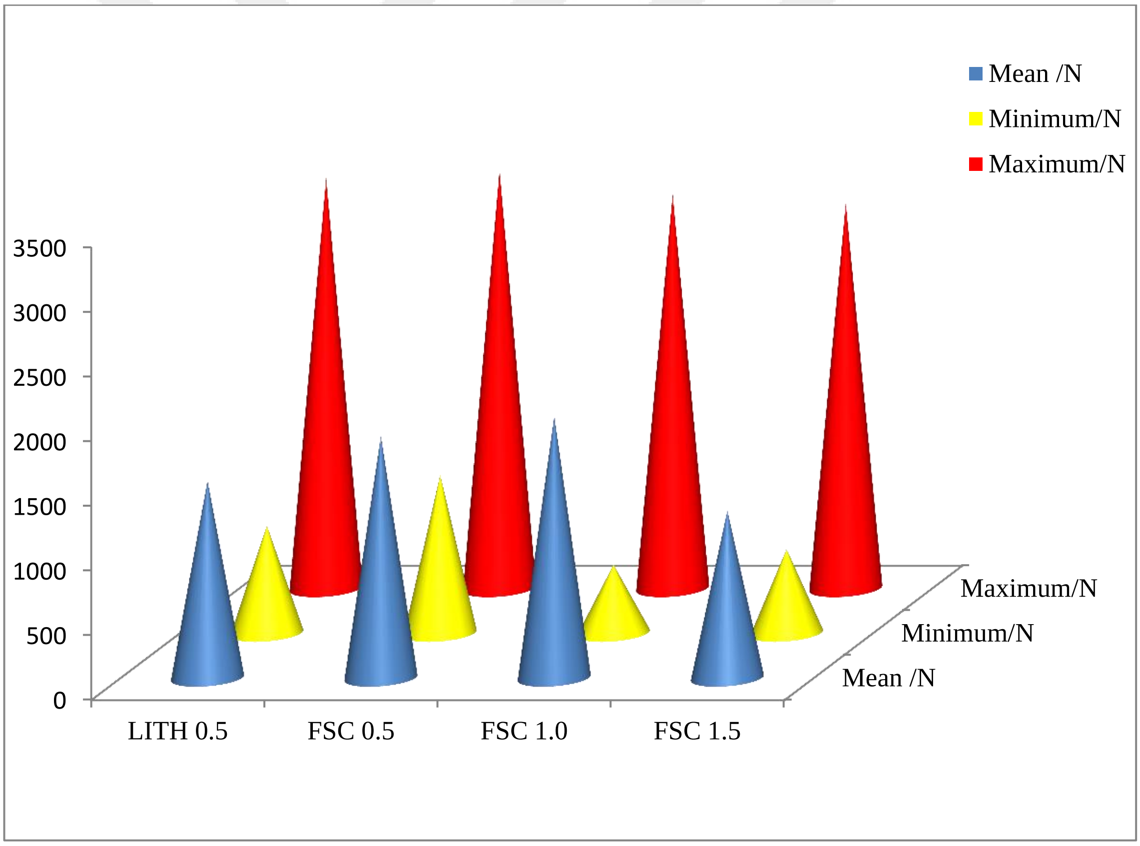

Figure 45. Mean, minimum and maximum value in Newton (N) of fracture strength of LITH 0.5 mm and the three finish line of FSC.

Table 16. The statistical estimation of fracture strength value of LITH coping crowns with 1.0 mm FLD in relation to the three finishing line depth of FSC coping crowns.

Finishing line depth in mm	Mean /N	Minimum/N	Maximum/N
LITH 1.0	2489	1338	4334
FSC 0.5	1873	1227	3233
FSC 1.0	2028	531	3046
FSC 1.5	1296	651	2979

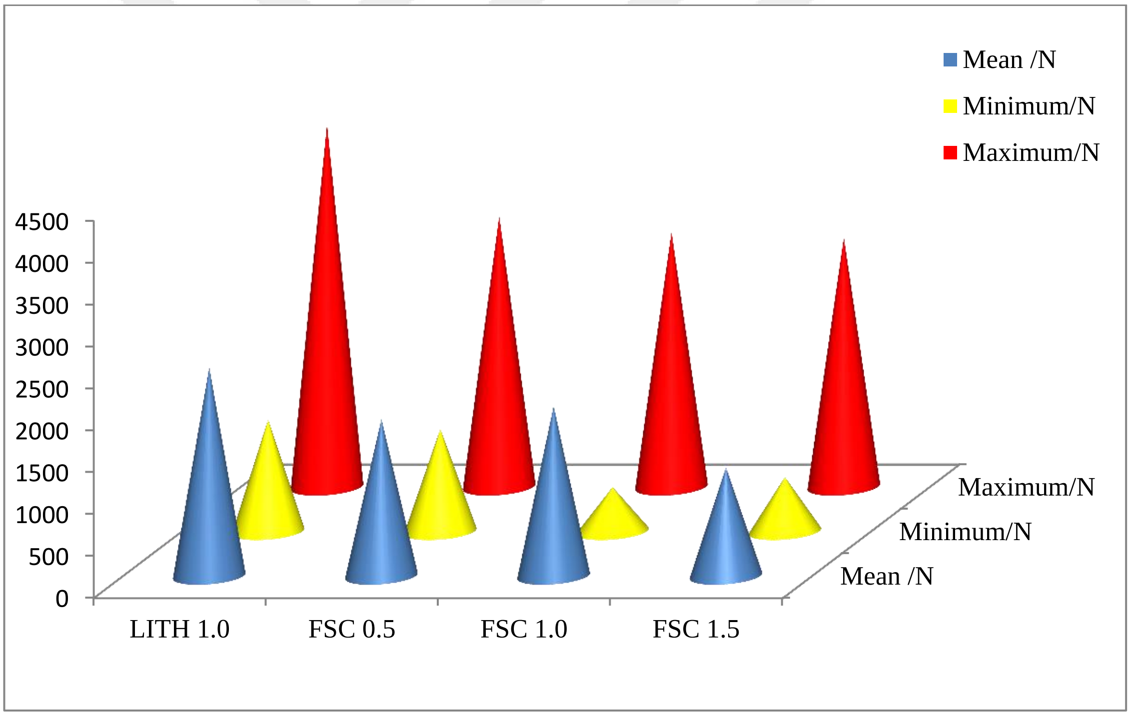

Figure 46. Mean, minimum and maximum value in Newton (N) of fracture strength of LITH 1.0 mm and the three finish line of FSC .

Table 17. The statistical estimation of fracture strength value of LITH coping crowns with 1.5 mm FLD in relation to the three finishing line depth of FSC coping crowns.

Finishing line depth in mm	Mean /N	Minimum/N	Maximum/N
LITH 1.5	2721	1424	4518
FSC 0.5	1873	1227	3233
FSC 1.0	2028	531	3046
FSC 1.5	1296	651	2979

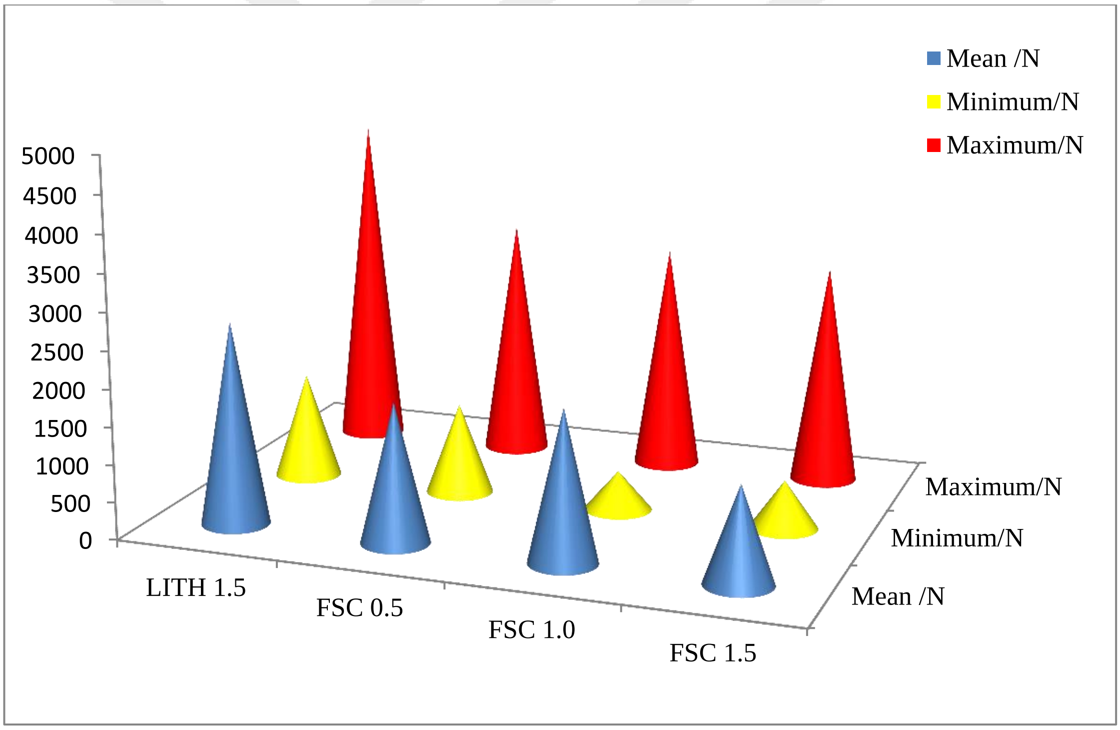

Figure 47. Mean, minimum and maximum value in Newton (N) of fracture strength of LITH 1.5 mm and the three finish line of FSC.

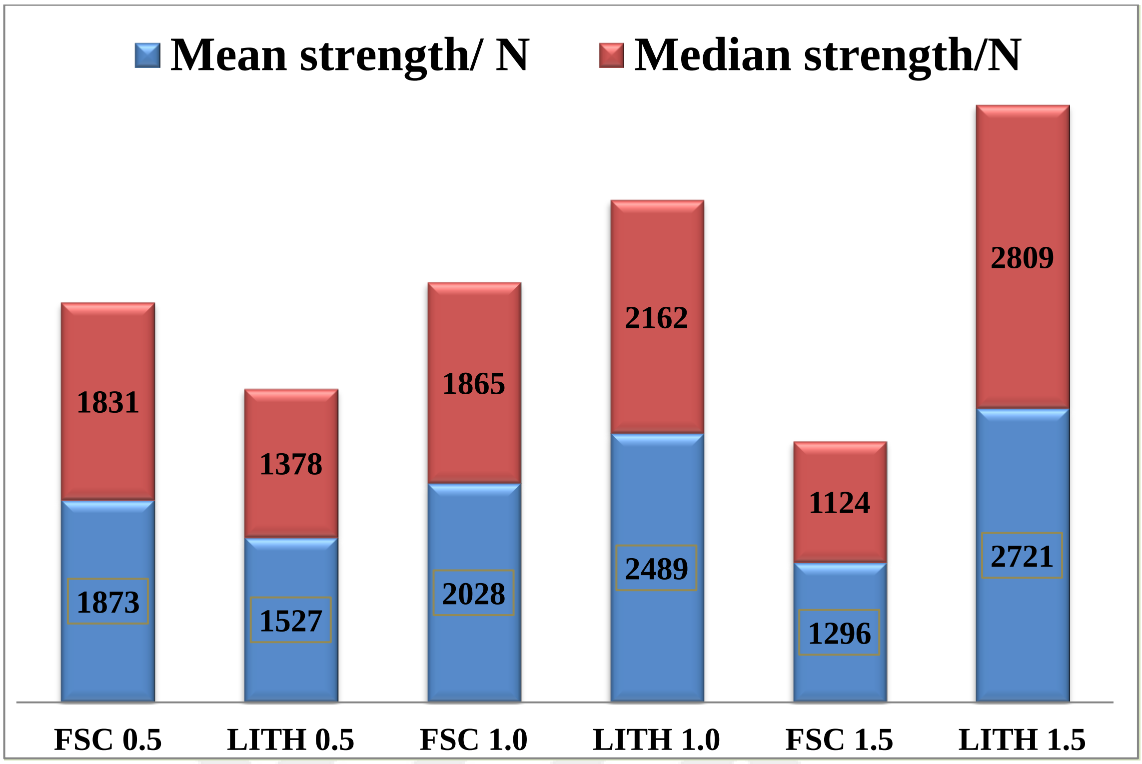

Figure 48. Variation between mean and median strength for the six samples

Values of mean and median obtained from fracture strength of the CAD/CAM material was shown in (Figure 48) it reflect that both parameters have the same trend ,but with different segments , in general values obtained from mean was less than that obtained from median calculation (Table 18) .

Values of standard deviation of all results are summaries and illustrated in (Figure 49). It shows that the value of standard deviation varied from 674 N to 1100 N in respect to Lithium as the figures was observed to be higher in 1.0 mm depth line where as the range of standard deviation in case of Feldspathic was between 530 N and 724 N, in fact its appear that the range was much wider (more than double) in case of Lithium when compared with that of Feldspathic.

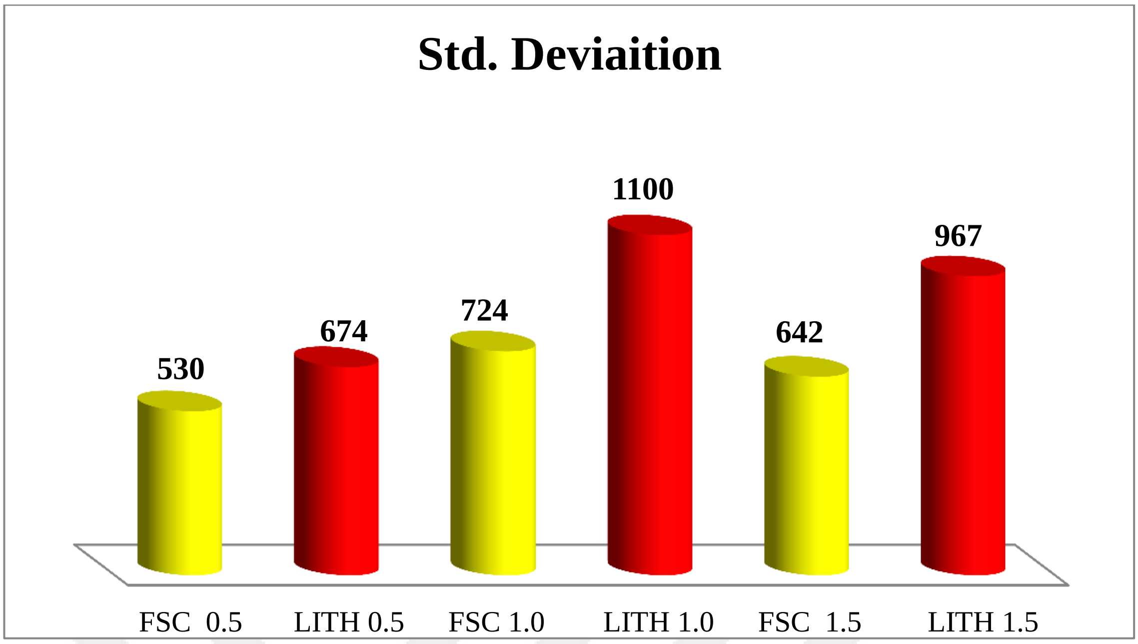

Figure 49. The Std. Deviation of FSC and LITH of three different finishing lines

As far as standard deviation is concerned the estimated number for both material used in the present investigation (Lithium disilicate LITH and Feldspathic ceramic FSC) each with 0.5 mm,1.0 mm and 1.5 mm depth of finishing line were performed and illustrated in (Tables 11-18 and Figure 43-50).

Table 18. The mean and median strength value of the two materials used in the present study.

Material	Mean strength/ N	Median strength/N
FSC 0.5	1873	1831
LITH 0.5	1527	1378
FSC 1.0	2028	1865
LITH 1.0	2489	2162
FSC 1.5	1296	1124
LITH 1.5	2721	2809

The variation of the mean strength and median strength of both materials with different marginal thickness is shown down below. Nevertheless; (Figure 51) illustrate the results of the six samples taken in consideration throughout present investigation.

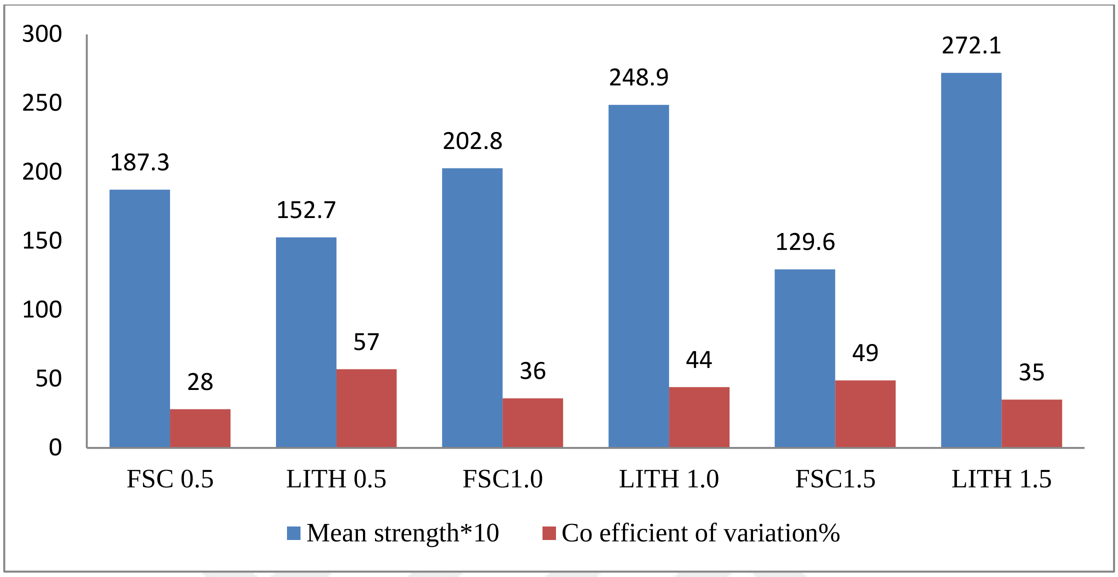

Figure 50. Showing mean strength of used materials (Lithium and Feldspathic) and the co-efficient variance of the three finishing line.

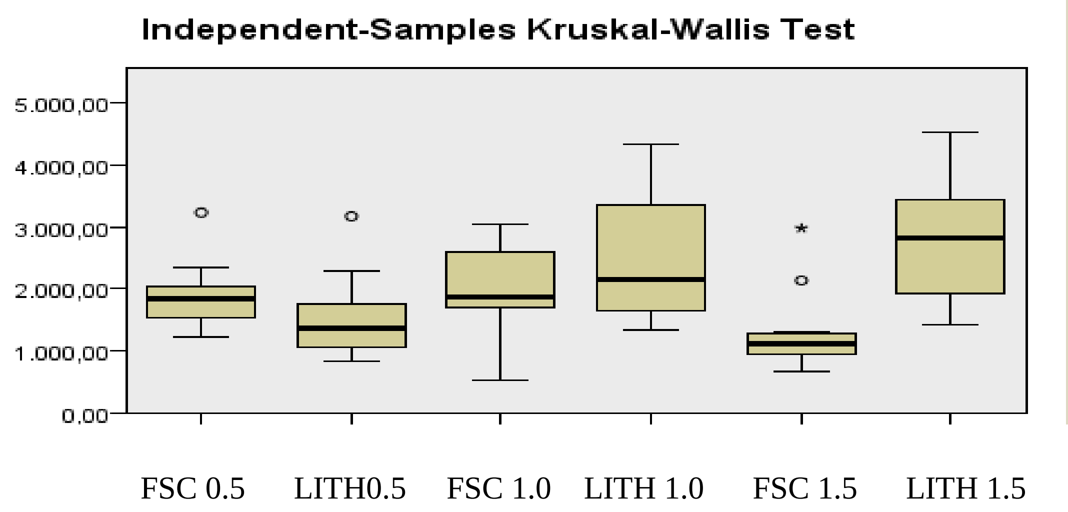

Figure 51. Illustrate the result of different strength of both materials in accordance to different finishing line.

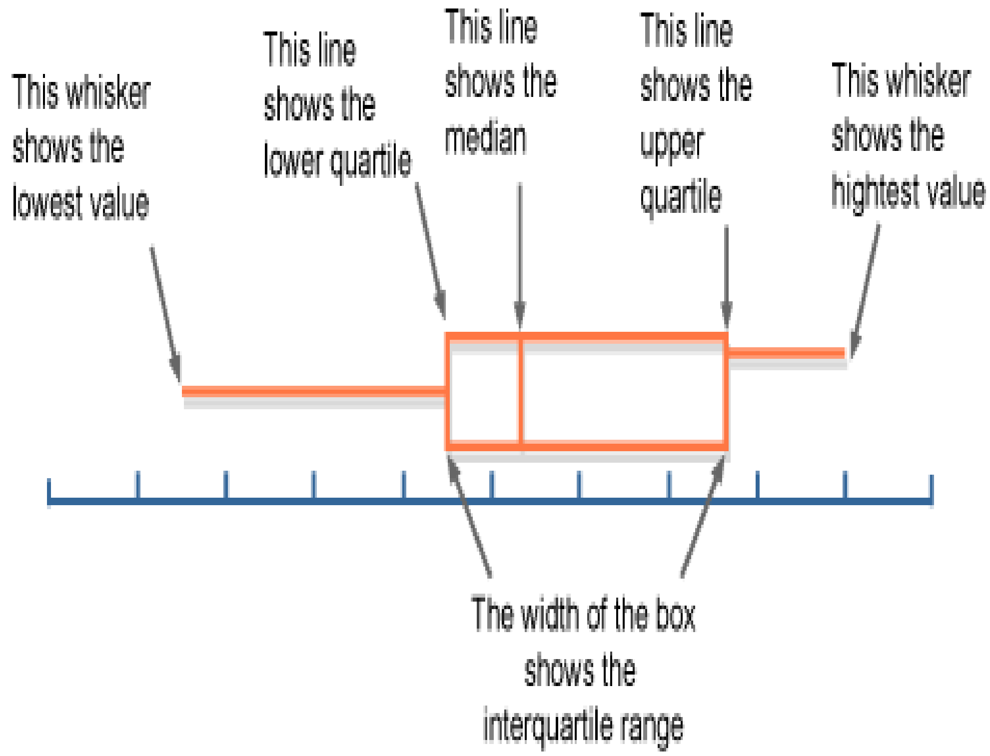

Figure 52. Illustration of independent samples of kruskal-wallis test.

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Outliers:

When collecting data, often a result is collected this seems "wrong". In other words, it is much higher or much lower than all of the other values. Such points are known as "outliers".

Lower quartile: it is the first quartile Q_1.

Upper quartile: it is the third quartile Q_3.

The difference $Q_3 – Q_1$ is called interquartile range (IQR).

Upper outlier data value is > 1.5 IQR

5. DISCUSSION

The duration of dental restoration was and still is one of the main goals of clinician and dentists to be achieved. However, changes in life style in all aspects (increase consumption of acid drink, carbonate and sticky food), as well as increasing the average of caries teeth which have become a major dental problem, all these did and still do contribute in increasing demands and requests for direct or indirect restoration (Gupta, 2016).

Miyazaki and Hotta in 2011 had pointed out the foremost reasons and suggestions for restoring or replacing missing teeth through summarizing it, as repairing one or more than one of these issues; aesthetic, mastication function, speech, occlusal stability, periodontal splinting, filling of competence, orthodontic retention, protection of weekend teeth and restoring occlusal vertical dimension.

Whenever one reviews the literature on fracture strength of restoration, it became clear that all CAD/CAM ceramic crowns besides reflecting excellent esthetic appearance will also go through successfully for restoring posterior as well as anterior teeth (Silva et al., 2017). However, clinical success of both Lithium disilicate and feldspathic material (both of which used in the present study) have been demonstrated through several previous studies (Reich and Schierz, 2013; Otto 2015). Even though fracture possibility of ceramic restorations, still remain the main concern and worry of the dentist, in spite of all known positive properties of ceramic material (Campos et al., 2015).

The objective of the present in vitro study is to investigate the effect of different marginal thickness on fracture strength of ceramic CAD/CAM restoration. Using 0.5 mm, 1.0 mm, and 1.5 mm 90-degree shoulder finishing line as a single variation among the samples to compare the effect of these marginal collar design measurements on fracture strength of two CAD/CAM restoration materials that were chosen (FSC and LITH). Almost all previous studies on the sequence of the value on the fracture strength had shown that to be generally around 1000 N (Sagsoz et al., 2016), however higher values close to 4000N have also been recorded (Güleç, 2017).

Seventy two specimens of ceramic have been prepare to be used in the present investigation 36 feldspathic glass ceramic and 36 Lithium disilicate ceramic to be ready for fracture strength test with three shoulder finishing line depth of 0.5 mm,1,0mm and 1.5 mm .12 specimens for each of the two materials used were prepared for each depth of finishing line to making the total of 36 for each materials.

The result of the present investigation showed that the standard deviation of fracture load was relatively high between all selected group (Figure 49), especially, in Lithium disilicate with 1.0 mm shoulder finishing line which represented with the highest value of about 1100 N, but it is decreased to be 967 N in same material with 1.5 mm, and 674 N in Lithium disilicate with 0.5 mm shoulder finishing line, but in Feldspathic the standard deviation was 642 N, 724 N, 530 N for 1.5 mm, 1.0 mm, 0.5 mm shoulder depth of finishing line respectively. For that reason several aspect of this study should be discussed

The recorded values in the present study for median fracture strength of FSC were found to be 1831 N, 1865 N and 1124 N for finishing line depth of 0.5 mm, 1.0 mm and 1.5 mm respectively. In contrast, 1378 N, 2162 N and 2809 N was recorded in respect to LITH, here the value increased as finish line depth increased. In general, it appears that the fracture strength value was higher with LITH in comparison to the sequence for FSC apart from 0.5 mm depth of finish line (Table 18 and Figure 48).

The concerned studied variables were represented as median, mean, standard deviation, minimum and maximum value, co-officiant of variants and P-values, the outcome results of the statistical analysis of this investigation are illustrated in detail within (Table 11, 12).

In order to apply the statistical methods for the outcome results of any experiments, one should examine the data and finds out those results in numbers, which are either quite close with each other or otherwise. When they are close to each other, means they are parametric, therefore the type of statistical analysis methods that should be applied will be generally A-NOVA or T-Test. Such methods depend on finding out the mean of data, which is in fact, an arithmetic mean value. This can be estimated as following calculation: Total of all observed data divided by the number of observation, as following example:

Data: A, B.C, D, and E

NO. Of observation = 5

The mean = (A+B+C+D+E)/5

However, if the outcome results were not close to each other or non-parametric other statistical methods will be applied to achieve the analysis outcome such as Kruskal Wall and Man–Witny method .In non-parametric data arithmetic mean should be replaced by the median value in order to be used in statistical calculation. In fact, median value will be calculated and achieved after rearrangement of the resulted data ascendingly or descendingly. Then after the extreme number or numbers will be omitted to achieve the median value as following example: if the obtained data were 30 , 3, 65, 20 It will be rearranged as: 3, 20, 30, 65 Then when omitting the two extreme numbers (3 and 65) the result will be (20+30)/2=25 That represent the median value.

In the present project, because the results come out not so close to each other, in other word they were close to non-parametric distribution. Nevertheless, both mean and median values were calculated and applied for statistical analysis of the outcome results. In fact, both values were found out to be quite close to each other in both parametric (mean) and non-parametric (median) tests (Table 18).

When taking mean value in consideration results of the present study indicates that fracture strength value increases by a value of about 155 N as the finish line depth raise up from 0.5 mm to 1.0 mm depth in case of FSC. In contrast, when using median values in consideration, still the difference can be observed with same trend and the increased value was about 34 N. Therefore, it can be proposed that as the finish line depth increases the strength of material will also increase regardless applying arithmetic mean or median values (Figure 48).

In fact, such proposal or phenomena can be observed from the results when considering the other two depth of finish line (1.0 mm and 1.5 mm). The difference of the strength in case of FSC was about 732 N and 741 N when using mean and median values (Figure 48).

At last when comparing the results of Feldspathic ceramic coping with finish line depth 0.5 mm with that of 1.5 mm using mean and median values of fracture strength, the difference did appear to be 577 N and 707 N respectively reflecting an inverse relationship with thickness of finishing line in case of feldspathic (Figure 48).

In summary, the trend of difference shows that as the depth line increases, the value of fracture strength decrease. This was quite evident in case of 1.0 mm to 1.5 mm depth and 0.5 mm in comparison to 1.5 mm finish line in FSC.

In contrast the relationship was found to be opposite in case of 0.5 mm and 1.0 mm FSC as it was found from the obtained results of present investigation, regardless using the obtained value from mean or median (Figure 44,45).

However, all these recorded variation statistically found to be not significant when considering the outcome results in respect to LITH.It becomes evident that as the depth increases, the mean value of fracture strength also increased, the values were 1527 N, 2489 N, and 2721 N for 0.5 mm, 1.0 mm and 1.5 mm depth line respectively. This trend of increase can also be noticed when considering median values as well.

Actually the parcel out mean value of fracture strength between 0.5 mm and1.0 mm finish line depth was 961 N for LITH, whereas a strength value of 783 N was recorded when median value have been considered, however the difference between the other two sets (1.0 mm and 1.5 mm) was 647 N for mean and 232 N for median.

In contrast, when the marginal thickness of Lithium raised up to 1.5 mm, the different in the mean and median value of the two elements was 693 N and 903 N respectively. Nevertheless, the strength increased when finishing line depth increased, meanwhile in this case, Lithium appears to be stronger than feldspathic restoration.

Finally, the sequence of difference between 0.5 and 1.5 mm was much more as the parcel out value exceeded 1000 N for both mean and median measurement.

Therefore, a clear positive relationship between depth of finishing line and the fracture strength was found and recorded throughout the present project for Lithium disilicate, as shown in (Figure 44 and Table 14). This was reflected in maximum and minimum value as well as in mean value.

As a matter of fact ,in case of the constant finishing line depth the present result showed clearly the influence and effect of material type on the fracture resistance of CAD/ CAM restoration, particularly when 1.5 mm depth line were considered .

When one focus on (Table 15 and Figure 45). It became evident that the fracture strength value of Lithium with depth of finishing line 0.5 mm was less than strength of feldspathic with 0.5 and 1.0 mm finish line depth. Regardless taking mean or median value in consideration as in both cases quite close different results was found 500 N and 487 N .In other word feldspathic with 1.0 mm depth line appears to be stronger than Lithium of 0.5 mm depth of finish line.

Actually as the Lithium one depth line increases to 1.0 mm (Figure 46, Table 16) in comparison to constant depth line of 1.5 mm of feldspathic. The recorded different values were found to be 1193 N and 1038 N for the mean and median values respectively.

However the trend of the increase value of fracture strength in case of Lithium jumps to 2809 N and 2721 N and the different with that of 0.5 mm raises up to 1431N and 1184 N as the finishing line depth expanded to 1.5 mm (Table 17 and Figure 47). Therefore, clearly results indicate that Lithium disilicate showed to be stronger in one hand and as the depth line value increases it become much more stronger this was evident in the present results.

It’s clear that feldspathic with1.5 mm marginal thickness reflects the least mean strength 1296 N and least median strength 1124 N among all feldspathic samples, whereas same material with 1.mm marginal thickness showed the highest mean strength 2028 N and highest median value of 1865 N. Conversely, LITH with 0.5 mm depth of finish line showed the least mean strength of 1527.7 N and least median strength of

1378N. In contrast, LITH with 1.5 mm marginal thickness had the highest mean strength of 2721 N in parallel, highest median strength value was 2803 N.

Therefore, it is quite clear from the outcome results that the strength value with Lithium is more than double of that of feldspathic when both materials have the same marginal thickness (1.5 mm).

It was found that minimum value was at 0.5 mm depth of finishing line for both material used whereas the maximum value of standard deviation were recorded at 1.0 mm depth of finishing line.

Nowadays, in parallel with huge invasion of modern technology to almost all aspects of our life style, in order to assist, accelerate, and ease getting any things or to achieve the needs as soon as possible, throughout applying modern and advanced technological methods (Dwivedi et al., 2017). However, during 20th century both dental material and dental technology as well as manufacturing dental devices have been progressed remarkably (Rajan et al., 2015). At present time of days , application of computer aided design and computer aided manufacturing CAD/CAM system do ease the fabrication of implant and crown frameworks using different materials in prosthetic dentistry (Lan et al., 2016). So progressively become one of these applied sciences that used in different part of dentistry (Rocca et al., 2018).

Actually, CAD/CAM unit is still not so cheap to purchase and use. Nevertheless, it is expected an expansible development in the utilization of such technology in prosthodontics dentistry in the near future (Yeshwante et al., 2016).

However, the performances of restorations which is the outcome of CAD/ CAM systems that have been quite well developed recently, particularly during last decades as it has dramatically progressed to inform their role in superior clinical results which is becoming quite evident (Davidowitz and Kotick, 2011;Sakaguchi and Powers, 2012; Dwivedi et al., 2017).

Others in 2016 proved that the differences in fitness of CAD/CAM restorations are related to the gap parameters from the digital design and related to the actual properties of the CAD/CAM system (Brenes et al., 2016). Therefore, it is possible to fabricate restoration with an appropriate marginal fit as they expected from the conventional one having clinically acceptable results (Abdul-Azim et al., 2015). Limited number of clinical studies and the diversity of the results between the different CAD/CAM systems and the variety of protocols does not allow definitive conclusion.

Several advantages can be drawn from including CAD/CAM dental technology, 3-D scanning and the use of mill materials for all-ceramic restorations. Even though clinical studies have shown that marginal fit of CAD/CAM restorations is compared to conventional restorations the fabrication of dental restorations is still a complex task that requires experience, knowledge and skills (Azuma et al., 2017).

Incorporation of new systems and materials bring many concerns regarding system implementation, capabilities and mechanical properties of the different materials. One of the biggest problems that still remain in CAD/CAM dental systems is the accuracy of each step in the CAD/CAM chain, from digital impression to the milling step (Mormann, 2006).

Nevertheless Mou et al in 2002 ,have referred to that, improvements in the Cerec 2 and Cerec 3 systems over Cerec 1, overcame some problems associated with resolution and milling precision and thus increased the accuracy of the marginal fit of Cerec restorations. However, the active triangulation principle remains a feature of both Cerec 2 and Cerec 3. In fact, Mormann, in 2006 showed that the internal gap for a Cerec 2 anterior crown has been reported as 141 ± 21. Thus, internal fit remains a weak point of Cerec restoration because the internal configurations of these restorations are based on images scanned from the Cerec camera, and the distal shadow problem seems to be unavoidable (Mou et al., 2002).

However since for the best of our knowledge the evaluation and comparison have not been performed yet, so it is not available, meanwhile in the present study C4 was applied as a more advanced form of CAD/CAM generation. Using computer aided manufacturing is dependent on the calibration of hardware with software in the workflow. Furthermore, the virtual configuration of the die spacer between the tooth and the restorations is essential for the accuracy of the marginal adaptation, as it has to be calibrated for each one of the systems (Miyazaki and Hotta, 2011).

Taneva et al 2015 referred to that although there are no universal standard for defining models accuracy still in orthodontics generally accepted that the measurement accuracy up to 0.1 mm is adequate for clinical dental purpose so it does not compromise diagnostic value of model. In fact throughout the present work although great concerned were given in preparing monolithic restoration as accurate as possible however still if any variation occurred, may will not exceed 0.1 mm, which is found to be acceptable clinically.

In accordance with many dental researchers who pointed out clearly the longer-term survival rate of CAD/ CAM single restoration (Nejatidanesh et al., 2015; Belli et al., 2016). They were found that such clinical technology do assist both patients and clinicians to get much more realistic and esthetic appearance as well as good strength. Ultimately, enhance the dentist to carry out more investigations in this line of research (Bohner et al., 2016).

The increasing necessity of patients and dentist for highly aesthetic and strong metal-free restoration, lead to greater attention to this aspect of science which had increased and further development on all ceramic systems which already have been quite well improved and progressed (Conrad et al., 2007).

As a matter of fact, so far, there is no material to be ideal in all aspects to the natural structure of teeth, nevertheless physical and biological properties of ceramic have exhibited a significant improvement throughout last few decades (Danzer, 2014). Recent development in all ceramic crowns for aesthetic and durability is the result of such progress. Farther scope of research in future on dental ceramic can be directed to be stronger and much better ceramic restoration outcomes. Definitely, a huge progress in the field of dental ceramics is expected and will appear in the lines of form, function and aesthetic with improvement in their physical and mechanical properties (Al Dehailan, 2009).

As many authors confirm that, there are four main factors, which have been identified to effect on the fracture resistance of all ceramic restorations, they include material thickness, tooth preparation, restoration design, and cementation (Schultheis et al., 2013). The ideal combination of these factors will result in an increased fracture resistance of all CAD/CAM restoration material (Rekow, 2006; Zimmermann et al., 2017).

In accordance of recommendations of many dental researchers on preparation design of all CAD/CAM ceramic restoration that 360 degree shoulder or chamfer preparation is considered to be an appropriate marginal preparation geometry for all ceramic restoration, this marginal preparation (finishing line) should be without any divergence (reverse bevel), which making a preparation border hardly detected by CAD/CAM scanner device (Beuer et al., 2008).

While the effect of various preparation designs on the fracture resistance of zirconia crown copings have been dealt with in detail by Beuer et al., in 2008, they concluded that in spite of limitation of their investigation, still they showed that shoulder preparation immerged as the most recommended design for both mechanical and periodontal points of view (Beuer et al., 2008).

As a matter of fact different type of marginal design have been applied for dental restorations, nevertheless, the three known type of finishing line (knife edge, chamfer, shoulder) is shown in (Figure 12). These three types have been already applied and used throughout in vivo and in vitro investigations (Reich et al., 2008; Di-lorio et al., 2008).

However during the end of last century Doyle et al 1990 have reevaluate the effect of finishing line on surface fracture resistance of almost all ceramic crowns. They showed that the strongest Dicor crown restoration was that which was prepared with 1.2 mm shoulder finishing line, in contrast chamfer-finishing line produces the weakest restoration when cemented to metal dies. (Doyle et al., 1990) quoted from (Al-Makramani et al., 2011).

Accordingly Di-lorio et al., (2008) in their invitro study on the effect of margin design on the fracture resistance of Procera All ceram crowns clearly showed the presence of relationship between the finishing line depth of zirconia cores and their resistance to fracture, however Di-lorio, and his friend stated that shoulder margin could improve the biomechanical performance of posterior single crown restoration. Their reports indicates that the load of fracture for procera (alumina based) crown with shoulder finishing line was significantly higher than chamfer preparation.

Cho and his friend in 2004, have carried out a comprehensive study on the effect of finishing line variants on marginal accuracy and fracture strength of ceramic optimized polymer fiber–reinforced composite crowns (FRC). In their in vitro study, they evaluated the fracture strength of Ceromer FRC crown with respect to various types of finish lines. Their result indicates that marginal adaptation of crown with shoulder finish line was significantly better than that of crown with chamfer finish line, before and after cementation. In their study they had used four metal dies with only two depth of finish line (0.9 mm and 1.2 mm) for chamfer one and (1.2 mm) depth for shoulder, as well as round shoulder. They reported that the mean fracture load of all crowns regardless of finish line design was 1646N. In contrast to the present outcome result, which was between the mean fracture resistance value of LITH coping crowns 1527 N and mean fracture strength of FSC restorations 1873 N both with the same 0.5 mm depth of shoulder finishing line.

Jalalian and Alataha in 2010 reviewed and studied also the effect of two marginal designs (chamfer and shoulder) on the fracture resistance of all ceramic crowns. As a matter of fact, it is known that one of the major problems, one might face in ceramic restoration process is the probability of fracture, against the occlusal and lateral forces .However they carried out an in vitro study, in order to estimate the effect of the two marginal design on the fracture resistance of all ceramic restoration. The result of their investigation was that fracture resistance of chamfer samples and shoulder samples were 610.18 N and 502 N respectively. Statistically significant different between the two groups was observed; they showed presence of a clear relationship between fracture resistance and marginal design of alumina cores. It showed less value when compared to the present result values, in spite of selecting shoulder finishing line. They had predicted from their results that chamfer margin could improve the biomechanical action of posterior single crown alumina restoration. They related the reasons of that, to the strong unity of chamfer margin, as they concluded that design with a chamfer margin present with more fracture resistance of restoration material than that of shoulder margin one. Meanwhile they showed that good fitness on the occlusal surface would increase the strength resistance against fracture.

Jalalian and others in 2011 had furthermore studied the effect of preparation design on the fracture resistance of zirconia coping crowns with CAD/CAM systems. The purpose of their in vitro study was mainly to compare the effect of two marginal designs (chamfer and shoulder) on the fracture resistance of zirconia coping restoration. They found that fracture resistance of chamfer margin was more than shoulder one, as the strong unity of chamfer margin has a curved and round internal angle, therefore it reflects more marginal fitness, so it will spread the load. Such case does not appear in a shoulder margin. Finally, the conclusion of their results indicates clearly that marginal design has an effect on fracture resistance. Such finding may be compared and contrasted with undergoing investigation. As a matter of fact, the results of the present project indicate that Lithium disilicate has a greatest strength value in finishing line depth 1.5 mm in comparison to 0.5 mm and 1.0 mm finishing line depth as it had increased linearly. But, such phenomena was not evident with feldspathic material as the strength was increased from a restoration with 0.5 mm to 1.0 mm, but it is decreased in restoration with 1.5 mm depth of finishing line (Table 11,12). This led to assume that assorted results come with various materials.

Although this phenomena was not evident statistically through Al Makramani et al in 2011 work, they urged and explained the reasons, to be due to less stress concentration on the axial wall in shoulder one compared to chamfer margin. However, strength of ceramic restorative material has been dealt with in detail by others, as they studied the resistance load to fracture of Turkom Cera in Ceram and Procera All-Ceram. In their investigation all ceramic coping cemented to extracted teeth using resin luting cement have been evaluated. They found that there is no influence of finishing line design on the fracture of Turkom Cera ceramic coping, in fact they declared and reported no evident of significant difference between shoulder and chamfer margin (Malament and Socransky, 1999; Al Makramani et al., 2011).

Nevertheless, many other authors showed no effect of different finishing line design on the fracture resistance of Dicor crown luted with resin cement (Malament and Socransky, 1999). As it was reported in their investigations, the effect of finishing line form and luting agent on the fracture strength of Dicor crown (glass ceramic crown). In accordance with, Bernal et al in 1993, they have state that no any difference in the fracture strength in relation to the type of finishing line used was detected throughout their study.

The strength of all ceramic restoration in relation to the different finishing line recently seems to be the concern of most clinicians in different parts of the world as Cortellini and others from Brazil in 2014. They reported that pressed Lithium disilicate crown might not require invasive finish line preparation, since finish line type does not impair the strength of restoration material. Their study on durability of Lithium disilicate crown bonded on abutment with knife edge and large chamfer finish line after cyclic loading. No significant fracture strength found with Lithium disilicate ceramic crowns bonded on the teeth with knife edge finish line in comparison to that bonded to teeth with large chamfer one of marginal design. They evaluate the effect of fracture strength of Lithium disilicate crown in relation to two type of finishing line, as there were adhesively bonded to their abutment ,the mean result of fracture strength of Lithium disilicate crowns with knife edge group was of 1655 N ± 353 and with a chamfer group was 1618 N ± 263. Hence, they concluded that there is no effect of finishing line design when using Lithium disilicate material as a restoration. However, the value in general was less, in comparison to the present investigation outcomes. As the value was about 1378 N ± 674 in preparation design of margin with 0.5 mm shoulder finishing line depth, while the value increased to 2809 N ± 967 in 1.5 mm group of finishing line depth with the same material. Finally, they stated that clinical studies should be carried out on the longevity of Lithium disilicate FDP that should reported on the association between incidence of failure and finish line type employed.

Conversely, to the previous research of Cortellini et al in 2014, Zhang and his colleges in 2016 found that marginal thickness of prosthetic restoration has more significant effect on fracture strength of restoration material. They used glass simulated dental crowns as a novel restoration with chamfer design of finishing line with 0.8 mm and 1.2mm depth in comparison.

Kelly in 2011 had put forward a number of proposal and recommendations for dentists; all of which are in relevant to investigations on all ceramic restorations. As in vitro investigations, using of the die material with elastic modulus similar to dentin, so preparation of the teeth or dies according to clinical guidelines and use of all-ceramic crowns with clinically relevant dimensions.

To evaluate maximum resistance of CAD/CAM restoration to fracture, different die material have been used to be resemble to tooth form and shape (Zahran, et al., 2008; Sağsoz, et al., 2016). But it seem that it is impossible to achieve standardization similar to that of natural teeth because of their different size and mineralization percentage of each teeth, anatomical configuration, pulpal size variation with different age stages and internal cracks. As well as there are few other parameters that have their effect on the results of investigations in case of using natural teeth, such as storage process of extracted teeth and the extraction conditions of selected teeth (Burk, 1999).

Therefore, all these factors are playing a major role in the possibility of the tooth fracture throughout fracture testing procedure (Kwon et al., 2013).

Since, the selection of the die material may influence the maximum loading force on restoration material to resist fracture of the prosthesis, as Nemane and his friends from India in 2015 have stated, that Gavelis GR et al in 1981 showed that most significant source of variation between the results of previous in vivo studies seems to be from casting variability.

Nowadays, it is clear that the preparation design is one of the main factors that affect the fracture of ceramic restoration. In present study, shoulder finishing line was selected rather than chamfer finishing line as recommended by Nemane et al (2015), they suggested that the occlusal seat of the restoration will be effected by different finishing line design and they found that the preparation of tooth structure with shoulder finishing line present more adequate seating in comparison to chamfer or feather finishing line. However, they used a stainless steel die material with a diameter of

10mm, height of 6mm, and tapering degree of 5 degree using full cast metal crown as a restoration in their investigation (Nemane et al., 2015).

In fact most of all-ceramic restorations are subjected to fractures during their function in oral cavity (Al-Joboury and Al-Rasheed, 2015; Dibner and Kelly, 2016), so in order to minimize these common clinical complications, many dental studies have been carried out in in vitro on CAD/CAM restorations (Cho et al., 2011; Anusavice et al., 2013).

As many studies reported that, the occlusal force during mastication and swallowing process is about 40 N, even though it reaches the maximum value in posterior regions with a range between 150 N and 665 N. While the occlusal forces in patient with removable partial denture is between 65 N and 235 N .In cases with complete denture ,the force of occlusion in molar and bicuspid region are 100 N , but with incisors are 40 N. As a general, it becomes higher in male and younger cases (Sakaguchi and Powers, 2012). However, the present investigation reflects values higher than those of clinical values in both selected materials and with various depth of selected finishing line.

In the present investigation, although the experimental condition was different from Kellys advices, since the elastic modules of the die material that was used approached (218 GPa). However, in this figure (this experiment) was almost 20 folds higher than that of natural dentine structures with elastic module which was only 12 GPa. In the current study, metal (nickel- chrome) was used as a die material in order to get closer standardization of the results that cannot be achieved by using natural teeth as die of underlying restorations as there had been referred to, previously.

Considering, other factors, which effect on the result of in vitro fracture tests, by using, die material having higher elastic module than that of dentin which is resulted in false true result in comparison to that of in vivo investigations. But because the inner surface of all ceramic restoration shows higher share strength when underling die material present with elastic modulus near the dentine, vice versa results appear when using metal die. It shows lower share strength due to stable form of underling metal die.

Therefore, the tooth structure under the restoration will be subjected to many deformations, which should be considered in evaluating the strength value of restoration material (Yuce et al., 2012).

In the current study, all underlying defect factors that may affect on the result of the test have been excluded, rather than finishing line differences. So the value for evaluation of fracture strength in present study a part from finishing line difference, no effect of any other factors have been considered, such as fracture of underlying die material or deformation of supporting structure. So present results reflect maximum value of fracture strength of LITH and FSC, which were 4518 N and 3233 N respectively.

In fact, although Sağsoz et al in 2016 have shown type of die material do not effect on fracture strength of CAD/CAM restoration, however, when Lithium disilicate material used for their investigation. The mean fracture strength value of monolithic crown were 595 N ,606 N, and 578 on resin die ,nickel-chrome die ,and dentin respectively which found out to be less than present minimum fracture strength value as it was 834 N with 0.5 mm depth of finishing line using same material. However, Aksan in his specialty thesis in 2017 found out the maximum mean fracture strength of monolithic Lithium disilicate crowns with undelaying titanium abutment as787.80 ± 120.95 N in comparison to titanium based zirconia abutment with 623.93 ± 97.44 N, whereas Bio HPP hybrid abutments was 602.93 ± 121.03 N (Aksan, 2017). In contrast, the present investigation figures were higher in respect to both the median and mean value of Lithium disilicate coping crowns with all the three different finishing line depth of 0.5 mm 1.0 mm and 1.5 mm

Whereas Sakoguchi and his college's in 2013 referred to that crown cemented on resin die do reflect more fracture resistance than that cemented over metal die regardless the type of restoration material. Other authors documented that even though natural teeth restoration could not be achieved, neither by using metal nor resin dies (Kowon et al., 2013).

Even though, the strength of all ceramic restoration does not depend only on the fracture resistance of used material. Others like Yeğin in 2017, in here PhD thesis evaluate the stress distribution of different restoration material to the underlying structure. When, she select Lithium disilicate material as a monolithic crown restoration using Finite element analysis method, she concluded that the restorative material type do not affect the stress distribution on underling implant component, especially in case of monolithic restoration with Lithium disilicate material that reduce the stress on underlying implant and bone structures, resulted in a fracture strength of mean value of 2891.88 N ± 410.12 and when comparing with present results, it seems to be close to Lithium disilicate coping design used in this study with a finishing line of 1.5 mm which presented with mean fracture strength of about 2721 N ± 967, as see in (Table 11).

Accordingly, Jager et al 2005 studied the influence of design parameters on the finite elements analysis (FEA), they determine the stress distribution through CAD/CAM produced ceramic crowns, they reported and recommended that cement layer thickness with different finish line should be as thin as possible, meanwhile they refer to that complete ceramic crown may increase the resistance and longevity of restoration. They also stated that for full ceramic crown in posterior region, specific design roles should be followed. They showed that FEA utilizing CAD/CAM data could be used as a successful tool for developing a design guideline for all ceramic restoration.

When reviewing the relevant literatures, it become clear that quite many researchers have called for farther work and research to be carry out to investigate the seating pressure applied and it is impact on different types of CAD/CAM restoration through using various type of luting cements with distinct viscosities (Dwivedi et al., 2017).

In fact, pulp necrosis after crown placement, have been stated to be a significant factor, for the failure of restoration process (Decerle et al., 2014). The prediction of cement micro fracture under crowns using 3-D FEA techniques have been dealt by (Kamposiora et al., 2001) in order to, test the effect of crown margin type, cement type, cement thickness, loading direction and loading magnitude on the stress level and distribution with in luting cement, which might lead to micro fracture .they found out that stress at the margin of crown with chamfer marginal configuration were higher than those with shoulder margin. They also reported that stress under oblige stressing were greater than that of under axial stressing, meanwhile cement thickness minimally affected stress level and distribution.

On the other hand, other authors' conclusion was that chamfer margin design could cause greater stress near the margin Komsara et al., in 2000. Ultimately, the cement does face a risk of micro fracture, and then increase the possibility of crown failure. In contrast, they propose that glass ionomer and composite resin cement possess more mechanical properties to resist micro fracture in comparison to others.

In order to evaluate the effect of different thickness on marginal adaptation of all ceramic restoration to be sustain for a long period in the oral cavity in case of having appropriate mechanical, biological, and esthetical properties, as it was referred by Jalalian et al (2014), who stated that increasing marginal core thickness can decrease the marginal gap in all ceramic crown.

While regarding the marginal gap, as they increased, decreasing in the fracture strength of the restoration have been happened (Maghrabi, 2010). In fact the acceptable marginal gap clinically is 120° regardless using conventional impression method or by the aid of different CAD/CAM system in digital impression method (Renne et al., 2015).

An in vitro study of Habekost et al in 2007 on tensile bond strength and flexural modulus of resin cement showed that the mechanical properties of resin cement can influence the fracture resistance of teeth restored with ceramic inlay, they concluded that cement with higher elastic module had showed better resistance to restoration failure. It was shown that the use of resin cement with a feldspathic ceramic has been considered as an essential factor for the success of restoration, due to some reasons that could contribute to such achievement, transmission of the force from restoration to the underlying resin cement and may increase crack riding that caused by acid etching their by avoiding crack propagation of restoration material, that indicate generally cement with high flexural module will have better resistance to fracture.

While, in case of using resin die, quite many references indicate that it may be quite close to natural teeth in their elastic module sequence as it (11.5 GPA) in hybrid resin composite die, as an example in comparison to elastic modules of natural teeth which is in arrange of (5.2-19.3 GPa) which was shown by Bindl and his friends in 2006. They examined the fracture strength of Lithium disilicate and feldspathic ceramic as a monolithic crown restoration with thickness of 1.5 mm as a uniform thickness of both occlusal and lateral wall using three different cement as a luting agent that present with different elastic module and resulted that Lithium disilicate crowns mean fracture resistance value were 2082 N when cemented with zincphosphate one and the value were increased to be 2389 N as they cemented with adhesive resin cement (Panavia F2). The same were happened in mean fracture strength of feldspathic once luting by zincphosphate in comparison to resin one, which was increased from 1270 N to 2392 N (Bindle et al., 2006).

In the present study, Panavia 5 resin cement were used which has a high flexural module that enhance increasing resistance of restoration to fracture as Lithium disilicate and feldspathic ceramic were used with the finishing line thickness were 1.5 mm the mean fracture strength were 2721 N and 1296 N respectively .

Therefore with the development and improvement of adhesive bonding technique resin cement, can seal small crack of intaglio surface of ceramic restoration and improve ceramic strength, ceramic-resin bonding is successfully achieved through pretreatment of silica based ceramic with acid etching following by silanization (Nejatidanesh et al., 2015). As the elastic modulus of feldspathic ceramic is 45 ± 0.5 mm GPa after milling, the elastic modulus of Lithium disilicate is 95 ± 5 GPa after crystallization and as the elastic property of ceramic material are influenced by the composition and processing method, so these differences influence the stress concentration at the bonding interface between tooth and restoration. The lower elastic modulus of the restoration resulted in higher stress concentration at the bonding interface (Anusavice et al., 2013).

Furthermore, the cement thickness also regarded to be one of the important factor that influence the duration of restoration as well as fracture strength of CAD/CAM restoration, as Vurgeç from Ataturk university in his uzman thesis (specialist) in 2016, when he compare the fracture strength of three different material with their different cement thickness using resin cement, the conclusion was that the fracture strength will increase the group of 50 µm cement and decreased when used 200µm cement thickness.

Regarding the selection of adequate cement material present with good bonding strength property which is having a major role in successful of the final restoration as well as the surface treatment of applied material prior to the cementation. As they have an importance in good adhesion Çakır in 2017 in his thesis concluded that best result was obtained from using silane and adhesion both rather than using one of them (Çakır, 2017).

In dentistry, tooth fracture against the occlusal and lateral forces, was and still is one of the main problems facing ceramic restoration prosthesis in clinical practice (Øilo et al., 2016), have carried out an in vitro study, in order to compare and contrast the load at fracture of monolithic and bilayer zirconia crowns, with and without a cervical zirconia collar. They obtained result of significant difference in the load at fracture and fracture modes, among the tested groups. They found out that restoration with cervical zirconia collar needs higher load to fracture, in comparison to core veneer design, in contrast the load was lower than the monolithic crowns as they were present with highest value of fracture strength among their groups of about 6517 N. Finally, according to their results they reported that crown wall thickness as well as marginal crown design does effect on the fracture of crown restoration (Anusavice et al., 2013 ; Øilo et al., 2016). Same result was concluded from Kara specialist thesis in 2016 as she compared between monolithic and veneering restoration, and she proposed ceramic restoration with monolithic crown rather than bilayer one as their were presented with higher resistance to fracture (Kara, 2016).

When non-metallic crowns undergo fracture, the fracture typically originates from flaws or defects in the intaglio surfaces. Subcritical crack growth follows, which is enhanced in the aqueous environment. Ceramic materials are particularly susceptible to the tensile stresses, and mechanical resistance is also strongly influenced by the presence of superficial flaws and internal voids. This phenomenon may be influenced by different factors such as marginal design of the restoration, residual processing stress, magnitude and direction and frequency of the applied load, elastic modulus of the restoration components, restoration–cement interfacial defects, and oral environmental effects (Al-Joboury and Al-Rasheed, 2015).

The introduction of computer-aided design/computer-aided manufacturing CAD/CAM technology in dentistry enabled dentists to use new treatment modalities and changed the design and application limits of all-ceramic restorations as the demand for esthetics in the posterior region of the mouth has increased. Recent monolithic restorations have provided functional, biocompatible, and esthetic demands with superior mechanical properties than conventional porcelain restorations. The strength of an all ceramics restoration depends not only on the fracture resistance of the material, but also on a suitable preparation design with adequate material thickness. It was proposed that both shoulder chamfer and deep chamfer finishing lines are considered to be adequate for the fracture strength of all-ceramic restorations (Al-Joboury and Al-Rasheed, 2015).

Koştur in 2016 in her PhD thesis confirmed that the fracture strength will increase with increasing thickness of restoration when she compare the different between three different material (Hibrid ceramic, Resin ceramic and zirconia) with three different thickness (0.5, 1.0, 1.5 mm). Furthermore, Zimmermann and his friend in 2017 proposed the same hypothesis when they work on Lithium disilicate and feldspathic material in their investigation when they evaluated the maximum fracture load needed to fracture of the restoration in related to the thickness of material, when they used 0.5 mm, 1.0 mm and 1.5 mm thickness as whole thickness from the margin to the occlusal wall making a comparison between 4 types of CAD/CAM crowns (Lithium disilicate and Feldspathic were among their group). Over SAL die material with elastic module of 2.5 GPs, and shoulder finishing line where designed for the margin which was increased their depth as the thickness of the restoration material were increased and adhesively cemented over the die. Resulted in maximum fracture strength of crowns made by Lithium disilicate one with 1.5 mm thickness with about 1240.8 N and 634.8 N for Feldspathic with the same thickness while the others present with less value of facture strength to be less than 1000 N. So in comparison with the present result which were less than mean value of fracture resisistance of the present investigation of both materials, as the restoration thickness were 2.0 mm as a hole. Rather than Sorrentino and other authors in 2016 when they evaluate the occlusal thickness of CAD/CAM monolithic crown in related to the fracture strength in posterior region and even it was 0.5 mm can resist the occlusal forces with clinical acceptable value in case of using zirconiua material.

In general almost all previous experiment were carried out using 1.5 mm thickness or less for either occlusal or wall of their restoration(Magne et al.,2015; Zimmermann et al.,2017) and, the outcome results was generally below 1000 N. Anyhow, during the present investigation the chosen thickness used was 2 mm for occlusal and wall thickness ,such thickness (2 mm) was also proposed and applied by Vichi et al in 2000 for Lithium disilicate. Vichi et al in 2000 had performed a comprehensive study on the influence of ceramic and cement thickness on the masking of various opaque posts .They demonstrate that whenever ceramic thickness was 1.0 mm all other variables were visually detectable whereas for thickness of 1.5 mm color difference decrease and most variance could only be detected through laboratory instrument, however for ceramic thickness of 2.0 mm. No detection of any clinical relevant deference was recorded, therefore in the present investigation on CAD/CAM restoration that involve full coverage crown, inlay, onlay, endocrown and implant restoration, a wall thickness of 2.0 mm were applied throughout the present experiments which was the need of masking of underling supporting structure (vital tooth structure, tooth with root canal restoration and posted tooth and or implant abutment).

Shahrbaf et al (2014) concluded that teeth restored with crown of flat occlusal preparation design do reflect the highest fracture strength. They used maxillary second premolar as it was prepared for all ceramic restoration with a standard preparation of anatomical tooth reduction, and a Novel design with a flat occlusal design, they used feldspatic CAD/ CAM material as a restoration with CEREC 3 CAD/ CAM system.In accordance to that, the present investigation also revealed the same phenomena when a restoration on a novel flat occlusal surface of nickel-chrome dies made by using feldspathic and Lithium disilicate with CEREC 4 CAD/CAM system, resulting high value of fracture resistance of both materials than what was expected. As well as Abdullah and Ibraheem (2017) in their investigation concluded that the shoulder margin preparation with flat occlusal restoration provide a better in compared to the deep chamfer (Abdullah and Ibraheem, 2017).

Regarding the coverage angle Zhang et al in 2016 found that the marginal thickness has more significant effect on the fracture strength of restoration material than the coverage angle (when they used chamfer finishing line with a depth of 0,8 mm and 1.2 mm) as well as adhesively bonded crown have highest fracture resistance value than conventional cementation procedure.

The point that should be referred to from the present results is the recording and observing of higher value of fracture strength, as matter of fact values exceeding 4000N was observed ,meanwhile maximum recorded value for Lithium throughout the present study was 4518 N at 1.5 mm depth line whereas in case of feldspathic material the value did not exceed 3233 N .this indicate that the type of material have its effect on the load of fracture strength as it has been referred to by many other authors (Zahran et al., 2013).

As Güleç in her uzman (specialist) thesis is in 2017 she conclude that material with high elastic modulus and high mechanical property have higher fracture strength which is about 3098,4 N ±667,7 with IPSe-max in comparison to Vita Enamic one with a fracture strength of 1978.71 N ±364.05 and the same result of our investigation with a mean fracture strength of Lithium disilicate with 1.0 mm and 1.5 mm to be 2489 ±1100 N and 2721 ±967 N while with a feldspathic one with same thickness are 2028 ± 724 N and 1296 ± 642 N.

However, clinically crown failure due to fracture as reported by (Øilo et al., 2014) is start from crack initiation from the margin of the restoration. Whereas, in most in vitro studies reports indicate that fracture occurred due to frictional effect between the applied force and surface of restoration materials. In order to produce a condition resemble to the oral cavity, many authors proposed the use of an adjective (elastic or aluminum foil) between the applied surface and restoration surface that is as they mentioned will cause the spread of the force along the surface.

Therefore, when placing a piece of rubber layer or aluminum foil which was act as stress barrier between the applied force and the restoration surface (Rammelsberg et al., 2000). In the present investigation, the resistance force was increased unexpectedly to more than 5000 N, when placing such barrier material. Hence ,such proposal was neglected throughout the present experiment .Mean while the fracture test were performed using a destructive applicant (rhombohedral pyramid diamond tip), till the fracture resulted, without any adjustment between applied load and the crown surface , however still high value of strength were observed in comparison to the previous studies.

Otherwise, many authors declared that further clinical investigation are requested and necessary to verify the previous hypotheses. Nevertheless, results of the present investigation come in accordance to the previous studies. Since the mean value was ranged from 1378 N to 20721 N using 90 degree shoulder finishing line regardless to the marginal thickness used(0.5 mm,1.0 mm,1.5 mm) for both used material (Table 11, 12).

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So, the results of the present investigations shows that shoulder finishing line 1.5 mm for Lithium disilicate material is more adequate to the fracture strength in respect to all other ceramic restoration. Anyhow, the mean value of fracture strength varied with thickness variation, in case of feldspathic greatest value was with 1.0 mm depth line

(Figure 43 and Table 13). Nevertheless, the value increased linearly from 1855 N to the maximum mean value of 2721 N for Lithium when contrasting 0.5 mm, 1.0 mm, and 1.5 mm 90 degree shoulder finishing line (Table 14 and Figure 44). In fact, whenever comparing and contrasting values of fracture strength of the two material used in the present study, it can be deduce that adequate and greatest value were found in case of Lithium with 1.0 mm as well as the peak was in 1.5 mm. Actually, no significant different value have been recorded between the two material; feldspathic and Lithium in case of practicing 0.5 mm marginal finishing line, as the fracture strength value were 1831 N and 1378 N for feldspathic and Lithium respectively, and present with highest value of fracture strength of FSC in related to the LITH which may be due to adequate bond strength of FSC to the underling metal die in the present of Panavia V cement material. .

The outcome of the present results have been illustrated and tabulated in the form of graphes and tables, using both mean and median values however, the results in both case seem to be close, similar and have the same trend (Figure 49). The estimated values of standard deviation of both materials in respect to all finishing line applied in this study is shown in (Figure 49) as well as, the effect of finishing line on the fracture resistance of the two material groups dealt with in this project (when it is expressed as mean and median) shows clearly that there is an influence of finishing line depth on forces needed to fracture particularly in Lithium. Mean and median load of the two material used are shown (Figure 48).

The present study shows clearly the influence of different finishing line depth on fracture strength particularly in Lithium. However, the effect was not evident clearly in case of feldspathic material since the following outcome of the result appeared as followings for the depth line 0.5 mm,1.0 mm,and 1.5 mm the mean value of fracture strength was 1831 N,2165.8 N and 1296.7 N respectively, that’s mean more suitable finishing line for this material is 1.0 mm rather than 0.5 mm and 1.5 mm finishing line. In contrast, a quite clear liner relationship between finishing line depth and the fracture resistance was evident in case of using Lithium disilicate. All these factors confirm the result of the present investigation with high value of fracture strength of used such materials.

6. CONCLUSION

1. The maximum fracture strength mean value in case of Lithium disilicate crowns were presented with 1.5 mm shoulder finishing line of 2721±967 N and decreasing to be 2489±1100 N with 1.0 mm finishing line depth, then the minimal fracture strength value in the same type of material are present with 0.5 mm shoulder finishing line with 1527± 674 N. Therefore, give a result of increasing the strength of such material linearly as the finishing line depth increased.
2. The maximum mean value of fracture strength in case of feldspathic ceramic was presented with 1.0 mm depth of finishing line was 2028± 724 N , Followed by 1873±530 N to be a mean value of fracture strength feldspathic with 0.5 mm depth of finishing line specimens and the absolute minimum mean value was found with 1.5 mm depth of shoulder finishing line, as it was only 1296 ±642 N .In conclusion the increasing was linearly from 0.5 mm to 1.0 mm, and decreased in case of 1.5 mm conversely.
3. In comparison between the two material the resulted data in general gave a maximum fracture strength value to Lithium disilicate material with 4518 N which is present with elastic modulus of 95 ± 5 GPa ,whereas the minimum fracture strength value comes with feldspathic restoration with 513 N that have elastic modulus of 45±0.5GPa.So concerning the mean and median fracture strength value of both material with the three different finishing line ,they were in the limitation of clinical occlusal force.
4. Both types of CAD/CAM material (Lithium disilicate and Feldspathic) are considered as promising prosthodontics restoration alternative to the previous metal ceramic restorations in posterior region, in addition to their esthetical and biomechanical properties, they were presented with a good mechanical properties that can withstand the occlusal forces in the oral cavity.
5. In relation and comparison to the previous studies, present work indicates and supports other investigation suggestion that different material can be used in evaluating the effect of different finishing line depth on fracture strength of

strength of different CAD/CAM materials as well as various cement material to be used as a luting agent on different die structure in the future dental studies.

Limitations of the study and recommendations for future research

Within the limitations of this study and advanced innovation in the field of digital dentistry, future study could be modified to provide a more precise, accurate answer to researcher questions. Therefore, the study could be conducted with extracted human teeth or on implant abutment that would be a better simulation of a clinical setting.

Researches should be carried out to consider the accuracy of diverse types of digital impression systems and further materials in order to be compared and contrasted

To allow and support analysis of survival and endurance of the restoration and assessing with the satisfaction of the patient and dentist is important to be considered in the long term. The audit showed that, at Prosthetic Clinic of Dental Faculty of Van Yüzüncü Yıl University, both dentists and dental students are acceptable with feldspathic and Lithium disilicate restoration, this was monitored by a high standard and quality of the impression ensuring in dentists and patients being highly contented with the final CAD/CAM outcomes.

7. ÖZET

Khidher LB. CAD/CAM Restorasyonlarında Farklı Basamak Genişliklerinin Dayanım Üzerine Etkisinin İncelenmesi, Van Yüzüncü Yıl Üniversitesi Sağlık Bilimleri Enstitüsü, Diş Hekimliği Fakültesi Protetik Diş Tedavisi Anabilim Dalı, Doktora tezi, Van 2019. Bu çalışmanın amacı CAD/CAM sistemi ile üretilen koping dizaynın farklı basamak genişliklerine (0.5 mm, 1.0 mm ve 1.5 mm shoulder) sahip olan restorasyonların kırılma dayanımının etkisinin incelenmesidir.

Bilimin çeşitli alanlarındaki son gelişmeler dijital teknolojide kendini göstermiş, ve bu teknoloji tıbbın birçok alanı dahil günlük yaşamımızın birçok alanında kullanılmaya ve hatta diş hekimliğinin çoğu alanında da giderek yoğun bir şekilde ilgi görmeye başlamıştır.

Hasta başı uygulamalarının bilgisayar destekli tasarım/bigisayar destekli üretim CAI CAD/CAM çözümleri; inley, kron, köprü, implant abutmenti ve diğer dental protezlerinin yapımında yaygın bir kullanım alanı bulmaktadır. CAI CAD/CAM sisteminin, dental restorasyonların otomatik olarak tasarlanmasında ve üretilmesinde kullanılan bir dizi dijital cihaz ve yazılımdan oluştuğu düşünülebilir.

Dayanıklı materyallerin kullanıldığı restorasyonların, zayıf estetik görünüme sahip olduğu düşünüldüğü eski dönemlerin aksine günümüzde CAI CAD/CAM materyalleri ile hem dayanıklı hem de üstün estetiğe sahip restorasyonların üretimi mümkün hale geldiği için diş hekimlerinin seçimi oldukça kolaylaşmıştır.Son zamanlarda diş renginde restorasyonlar üretebilmek için çeşitli materyallerin CAI CAD/CAM sistemiyle birlikte kullanılması dental kliniklerde oldukça yaygın hale gelmiştir. Örneğin seramikler (estetik seramikler,yüksek dayanımlı seramikler ve zirkonya), hibrit seramikler ve CAI CAD/CAM kompozitleri, fiberle güçlendirilmiş rezinler, polimerler, metaller vb.

Ancak tam seramik materyallerin ve cam seramiklerin kırılma dayanımları göz önünde bulundurulduğunda diş hekimleri bu gibi materyalleri klinik uygulamada kullanmaktan kaygı duymaktadırlar. Son zamanlarda seramik kron hazırlığı ile ilgili klinik ve temel bilgiler çok daha fazla dikkat ve ilgi çekmiştir. Bununla birlikte klinik

takipler, seramik restorasyon kullanan hastalarda karşılaşılan en büyük sorunun meydana gelen kırıklar olduğunu göstermektedir. Zimmermann ve arakadaşlarının yaptığı çalışma 2017, sabit protezlerde marjinal bölgede görülen streslerin, kron kalınlığının özelliklede basamak genişliğinin arttırılmasıyla azaltılabileceğini göstermiştir.

Marjinal alanlarda esneklik (duktilite) gösteren metallere göre kırılgan yapısı olan tam seramik restorasyonların dayanıklılığı için bu daha önemli bir konudur. Bunun yanı sıra çoğu araştırmacı, kesilen dişin basamak tasarımını kronların marjinal uyumunda ve kırılma direncinde önemli faktörlerden biri olduğunu bildirmiştir. Diğer araştırmacılar ise protetik restorasyonların prognozunu iyileştirmede yüksek mekanik dayanıklılığın yanı sıra yeterli marjinal ve internal uyum ve iyi bir yapıştırıcı siman seçiminin en önemli faktörler arasında olduğunu öne sürmektedir .

Bu araştırma, basamak genişliğinin, seçilen iki restorasyon materyalinin dayanımı üzerindeki etkisinin önemini değerlendirmek amacıyla yapılmıştır. Materyal olarak CAI CAD/CAM sistemi kullanılmak üzere lityum disilikat ve feldispatik seramikler tercih edilmiştir. Bu iki materyal dental kliniklerde en yaygın kullanılan materyallerdir. Bu materyallerin kullanımları ve uygulamaları araştırılmış ve sonuçlar mevcut projede sunulmuştur. CNC de elde edilen nikel krom day üzerinde kronların üretimi için kor tasarımları yapılarak, sadece basamak genişlikleri arasında farklılıklar olacak şekilde uygulama yapıldı. Belirlenen shoulder basamak genişlikleri sırasıyla; 0.5 mm, 1.0 mm ve 1.5 mm'dir. Sonuçlar detaylı bir şekilde elde edilen istatistiksel verilere göre tartışılmıştır. Elde edilen bulgular araştırılan konu hakkındaki bilgi eksikliğine ışık tutacağı gibi, diğer dental metaryaller ile daha detaylı çalışmaların yapılabilmesinde imkan sunacaktır.

Dişlerin kron harabiyeti, klasik tedavi yöntemleriyle bir dereceye kadar restore edilebilmekte ve fazla madde kaybı nedeniyle oluşan eksiklikler sabit protetik uygulamalarla giderilebilmektedir. Böylece hastada kaybedilen estetik, fonetik ve çiğneme ihtiyaçlarının sağlanması mümkün olmaktadır.

Diş hekimliğinde, hızla artan materyal bilgisi, bu bilgilere dayalı in vitro uygulama gereksinimini arttırmaktadır. Ağız içinde kullanılan materyallerin stres koşullarında değişimleri, restoratif materyallerin seçimine, bunların özelliklerine, ve klinik gereksinimlerinin kombinasyonuna bağlıdır. Oral kavitede kullanılan bir materyalin buradaki kuvvetlere dayanabilmesi için yeterli dirençte olması gerekirlidir.

Bilgisayar simulasyonları yoluyla kontrollü üretimden elde edilen başarılı sonuçlar, diş hekimliği alanındaki restorasyonların da bilgisayar destekli olarak üretilmesi fikrinin oluşmasını sağlamıştır ve bilgisayar destekli dental tasarım (CAI CAD-Computer Aided Design) geliştirilmiştir. Hem çalışma yöntemlerinin kolaylaştırılması hem de daha yeni ve daha iyi materyallerin kullanılabilmesi için CAI CAD/CAM sistemlerinin kullanımı oldukça önemlidir.

Diş hekimliğinde, estetik ihtiyaçların karşılanması için geliştirilen tam seramik restorasyonların yapımında farklı metodlar kullanılmaya başlanmıştır. Bilgisayar ve otomasyon teknolojisinin ilerlemesi ile birlikte diş hekimliğinde restorasyon yapım yöntemleri değişmektedir. Özellikle bilgisayar tasarımla üretimde yüksek kalitede materyallerin kullanılabilmesi ve ortaya çıkan düşük maliyet tedavide yeni olasılıklara imkan tanımıştır. Böylece geleneksel ölçü alma yöntelerin kullanılması yanında, bilgisayar destekli tasarım CAD ve bilgisayar destekli üretim CAM adı verilen CAI CAD/CAM sistemler, gelişmiştir.

CAM (Computer Aided Manufacturing – Bilgisayar Destekli Üretim); ölçülen ve planlanan veriler kullanılarak bilgisayar yardımıyla üretimin yapılması anlamını taşır. Diş hekimliğinde restorasyonların otomatik olarak yapımı ilk olarak, CAI CAD/CAM sisteminin kurucusu olarak kabul edilen Francois Duret tarafından 1971 yılında gerçekleştirilen sistemle gündeme gelmiştir .

CAI CAD/CAM sistemleriyle ilgili çalışmalar, 1979 yılında Heitlinger ve Rodder tarafından, 1980'de ise Moermann ve Brandestini tarafından gerçekleştirlmiştir. İlk dental CAI CAD/CAM sistemi, 1983 yılında, Fransa'da Garanciere konferansında sunulmuştur. Klinik ortamında hazırlanan, herhangi bir laboratuar işlemine tabi tutulmadan şekillendirilen ve ağızda uygulanan ilk kuron protezi 1985'te yapılmıştır.

Geleneksel ölçü yöntemlerini ortadan kaldırmak, yapılacak restorasyonun doğal anatomisine, fonksiyonlarına ve preparasyonuna göre bilgisayar yardımıyla tasarım yapmak, masa başında yüksek kalitede restorasyon üretebilmek (mekanik direnç, yüzey kalitesi, kenar uyumu) ve daha iyi bir estetik sağlamak amacıyla CAI CAD/CAM sistemleri geliştirilmiştir.

Procera, Cercon, Cicero ve Cerec gibi çesitli CAI CAD/CAM sistemleri, inley, onley, kuron ve sabit parsiyel protezlerin yapımı için geliştirilmiştir. Cerec sistemleri hem laboratuvarda hem de ofiste kullanılabilen sistemlerdir. Kullanıcıların tasarım üzerinde yapabildikleri değişimler, farklı CAI CAD/CAM sistemlerinde farklı oranlardadır; daha güncel olan birçok sistemde diş hekimi tasarımın hemen her özelliğini değiştirme gücüne sahipiken, ilk sistemler kullanıcının yapacağı değişimlere neredeyse hiç izin vermemiştir.

Bunun yanında optik veri transferi birimleri gibi, tasarıma ait yazılımlar da ilgili sisteme özeldir ve farklı sistemler arasında yazılım uyumu gözlenmez. Restorasyonun tasarımının tamamlanmasıyla, CAD yazılımı sanal modeli CAM birimine iletir ve restorasyonun üretimi başlatılır. Günümüzde kullanımda olan çoğu sistemde genellikle su soğutması altında, metal veya seramik blokların, çeşitli şekil ve boylardaki elmas disk ve çeşitli frezler ile aşındırılması yoluyla istenen restorasyonlar elde edilir.

Seramik, silikat yapısında topraksı bir materyal olup kelime olarak Yunancada "çömlek" anlamını taşıyan, "keramos" kelimesinden türevlenmiştir. Seramik, inorganik ametaller için kullanılan genel bir isimdir. Bu grup, silikatlar, camlar, nitritler, metal oksitler ve çimentoları da içermektedir. Birbirleri içinde çözünmeyen elementlerin düşük ısıda eriyerek şekillendiği seramik materyali ise porselen olarak tanımlanır.

Diş hekimliğinde ise porselen terimi için dental seramik kavramı da kullanılabilmektedir. 1965 yılında, Mc Lean ve Hughes, esası %40-50 oranında alümina kristalleri ile güçlendirilmiş jaket kron yapımını geliştirerek günümüzde kullanılan tam porselen yapıların temelini oluşturmuşlardır.

Parsiyel kuronlarda (inley, onley, laminate, rezin bağlantılı kuronlar), tam kuronlarda, konvansiyonel köprülerde, post-core' larda, implant sistemlerinde, ve çene-yüz protezlerinde kullanılabilir.

Tam seramik restorasyonlarda başarısızlığın nedenleri:

- Hekime ve laboratuara bağlı olanlar:
- Seramik restorasyonda diş desteğinin yetersiz olması.
- Hatalı yüzeyler oluşturan seramik kalınlığındaki ani değişimler.
- Seramiğin düzensiz biçimde pişirilmesi ve kondensasyonu kritik noktalarda mekanik kusurlara yol açar. Termal şok ile meydana gelen mikro çatlaklar ve aksiyolingual kenardaki büyük hava boşluğu kırıklara sebep olur.
- Düzeltilmeyecek derecede maloklüzyona sahip bireylere restorasyonun uygulanması.
- Dişleri sıkma (Bruksizm) gibi aşırı basınç oluşturan, mandibulanın parafonksiyonel hareketlerinin varlığı
- Travmatik zararlar.

Tam seramik restorasyonlarda dayanıklılığı etkileyen parametreler:

- Hekim,laboratuar ve materyale bağlı olanlar:
- Destek diş dokusu ve preparasyonun şekli.
- Restorasyonun uyumu ve formu.
- Siman özellikleri.
- Materyalin mekanik özellikleri.
- Oklüzal temaslar sebebiyle oluşan stres dağılımı.
- Yapım tekniği.
- Materyalin kalınlığı.
- Isısal hareketler sebebiyle biriken stresler.

Vitrifikasyondan sonra cam yapısı nedeniyle seramikler tamamen kırılgandır. Kayma ve dislokasyon oluşmaz. Sıkıştırma dayanımı yüksek olduğu için teorik olarak basma kuvvetlerine karşı dirençleri fazladır. Çekme ve makaslama kuvvetlerine karşı direnici ise oldukça azdır. Normal bir porselenin içinde küçük düzensizlik, çatlak ve pörözite mevcuttur. Bu yüzey bozuklukları düz hattan sapma gösteren çatlaklara sebep olabilir. Bu yarıklar gerilimin yoğunlaşmasından kaynaklanır. Plastik deformasyon ile metallerde bu gerilim giderilebilir fakat porselenler oldukça kırılgan materyaller olduğundan gerilim boşalması imkansızdır.

Eğer malzeme bir çekme gerilimi altında değilse yoğunlaşmış gerilim, porselen gövdesinin dayanıklılığını kolayca aşacağından çatlağın derinliği artar. Çatlağın derinliği arttıkça gerilim yoğunluğu da artar ve kolayca kırılgan bir yapı meydana gelir. Bu durum seramik gövdelerde çokça oluşan patlayıcı bir kırılmayı açıklar. Öte yandan sıkıştırma kuvveti altında çatlak kendiliğinden büyümediği için gerilime çok daha iyi bir şekilde direnç gösterir.

Stres (Gerilim): Bir maddeye uygulanan kuvvet sonucunda bu etkiye karşı birim alanda meydana oluşan tepkiye stres denir. Basınç ve stresin birimleri aynı olmasına rağmen basınçta temel olarak sıkışma tipi kuvvetlerin varlığı söz konusudur. Uygulanan kuvvet sonrasında sıkışma (compressive stress), gerilme (tensile stress) ve makaslama (shear stress) olmak üzere üç farklı şekilde stres meydana gelebilmektedir.

Strain (Gerinim): Üzerine kuvvet uygulanan bir cisimde bir deformasyon meydana gelir. Cismin bir strese maruz kalması sonucu cismin her birim uzunluğunda oluşan değişim gerinim olarak ifade edilir.

Oral kavitede protezin yapısını meydana getiren materyallerde yorulma oluşur ve kırılma ya da aşınma buna bağlı olarak gerçekleşir. Dolayısıyla araştırmacılar, protez yapımında tercih edilen materyallerin aralarındaki ya da iç yapılarındaki farklılıkların tespiti ve yorulmaya karşı dayanıklı olan materyallerin belirlenmesi için laboratuarda yorulma testleri üzerine yoğun olarak çalışmaktadırlar.

Temel materyal özelliklerinin elde edilmesi ya da kullanım ömürlerinin arttırılması ve özel tasarımların değerlendirilmesine yönelik verilerin sağlanması amacıyla testler uygulanmaktadır. Bunlardan birisi de oklüzal yüzeye yükleme yapılabilen çiğneme simulatörü test cihazları ile gerçekleştirilebilir.

Cam ve seramikler kırılgan materyaller olduklarından dolyı, yapımları sırasında önceden oluşmuş defektler içerebilirler. Bunlar çatlak gelişimi için zemin hazırlar. Kritik stresin derecesi ve çatlakların boyutu bu materyallerin kırılma direncini belirler. Kırılma değerinin altındaki değerlerde çatlaklar korunabilir fakat bu değeri aşan streslerde katastrofik bir çatlak gelişimi gerçekleşir. Özellikle silika içeren camlar ve bu materyaller durgun bir yorulmaya maruz kalmaktadırlar. Bunun yanında, çatlaklar daha stabil bir şekilde de meydana gelebilir. Çeşitli kristalin seramiklerde döngüsel yorulma etkileri gözlenmektedir. Materyal her ne kadar plastik özelliği taşımasa da, döngüsel stres uygulaması esnasındaki başarısızlık süreçleri, benzer stres değerlerinde statik yorulmaya göre daha az olmaktadır.

Kuron preparasyonlarında başarıyı belirleyen en önemli aşama dişlerin kesimidir. Kesim aşamasında genel kuralların yanı sıra işlemi kolaylaştıran ve daha iyi sonuç elde edilmesini sağlayan ayrıntılar bilinir ve uygulanır ise başarıya ulaşmak daha olası hale gelecektir. Kuron kenarları dişeti seviyesine göre dişetinin altında, dişeti seviyesinde ve dişetinin üzerinde olabilir. Kuron kenarları estetik açıdan doğal dişin mukoza içersinden çıkış görüntüsü (emerge profile) elde edilmek istenilen, özellikle ön bölgelerde veya diş renginin koyu olduğu ve restorasyon ile renk değişikliği hedeflenen olgularda**.** Hazırlanma şeklinde anatomik sınırları izlemek önemlidir. Aksi halde rahatsız olan dişetinde ilerleyen dönemlerde boyutsal değişiklik olacağından kenar açıklığı problemi ile karşılaşılabilir. Tüm seramik restorasyonların başarısında biyouyumluluk, estetik, doğal görünüm ve düşük plak birikimi gibi özelliklerin yanında bir diğeri de klinik olarak uzun ömürlü olmasıdır. Restorasyonun uyumu direkt olarak dişin preparasyonu ve restorasyon yapımı için kullanılan sistemin hassasiyeti ile ilişkilidir. Basamaklı preparasyonlar basamak tabanı ile dişin dikey duvarı arasındaki açıya göre iki ana grupta sınıflanabilirler: geniş açı yapan şev (chamfer), dik açı yapan omuz (shoulder).

Özdemir ve Aladağ (2018), diş preparasyonu ve marjinal basamak dizaynının protetik restorasyonlarda kullanılan materyallerin kırılma dayanımında önemli rol oynadığını ve olduğunu belirlemişlerdir. Preparasyon sırasında oluşturulan basamak, çiğneme kuvvetinin dişe dengeli dağılmasını sağlarken, kronun statik dayanıklılığını da arttırır.

Bu amaç doğrultusunda, restorasyonları tasarlayıp üretmek için CAI CAD/CAM (Cerec AC) sistemi kullanıldı. Feldspatik cam seramik (Cerec Blocs), lityum disilikat (e.max CAD) materyalleri kullanılarak 120 µ siman film aralığında 12'şer adet örnek ile 6 araştırma grubu oluşturuldu. Restorasyonların alt yapı dayanakları olarak 72 adet nikel krom metal day, 12'şer adet örnek üç farklı basamak genişliklerinden hazırlandı (0.5 mm, 1.0 mm ve 1.5 mm). CAI CAD/CAM sistemi ile kırılma dayanımı testi için, üretilen restorasyonlar, koping olarak kullanılan daylar üzerine PanaviaV rezin simanla simante edildi. Tüm örnekler universal test cihazında dayanımları ölçülmek üzere kırılma testine tabi tutuldular.

Bulgular: (F1 Grubu) 0.5 mm basamak genişliğine sahip feldispatik cam seramikten üretilen materyaler ortalama olarak 1873 N kırılma dayanımına sahipiken (L1 Grubu) 0.5 mm basamak genişliğine sahip Lityumdisilikat materyaller 1527 N ortalama kırılma dayanımı göstermiştir.

(F2 Grubu) 1.0 mm basamak genişliğine sahip feldispatik cam seramikten üretilen materyallerin ortalama kırılma dayanımı. 2028 N iken (L2 Grubu) 1.0 mm basamak genişliğine sahip Lityumdisilikattan üretilen materyalerin ortalama kırılma dayanımı 2489 N bulunmuştur.

(F3 Grubu) 1.5 mm basamak genişliğinde feldispatik cam seramikten üretilen materyallerin ortalama kırılma dayanımı 1296 N olarak bulunuriken (L3 Grubu) 1.5 mm basamak genişliğind Lityumdisilikattan üretilen materyallerin ortalama kırılma dayanımı 2721 N dur. Sonuçlar istatistiksel olarak (Annova, Mann-Whineytest, ve Kruskal-Wall's) testi ile test edilmiştir.

Tüm kırılma dayanımı verilerinin mutlak minimum değeri, 1.0 mm basamak genişliğine sahip feldspatik cam seramik için kaydedilmiş olup, 513 N' dur. Maximum dayanım değeri ise basamak genişliği 1.5 mm olan lityum disilikattan elde edilen seramik materyal için bulunan 4518 N' dur.

Çalışmada Lityumdisilikat materyallerin 1.5 mm basamak genişliğında kırılma dayanımın ortalama değeri, 2721±967 N olarak bulunmuş iken 1.0 mm basamak genişliğinde 2489±1100 N'ye düşmüştür, 0.5 mm basamaklı genişliğinde ise minimum kırılma dayanımın değeri 1527±674 N olarak tespit edilmiştır. Sonuç olarak, basamak genişliklerinin artması, lityum disilikattan üretilen materyallerin kırılmaya dayanımını doğru orantılı olarak artırmıştır.

Feldspatik cam seramikten 0.5 mm basamak genişliklerinde üretilen materyallerin ortalama kırıma dayanımı 1873 ± 530 N olarak bulunurken 1.0 mm basamak genişliklerinde Feldspatik cam seramikten üretilen materyallerinki ortalama 2028 ± 724 N olarak bulunmuştur, 1.5 mm basamak genişliklerinde Feldspatik cam seramikten üretilen materyallerde ise 1296 ± 642 N kırılma dayanım değeri ölçülmüştür. Sonuç olarak, kırılma dayanımı artış 0.5 mm basamak genişliklerinden 'den 1.0 mm basamak genişliklerinde doğru orantılı olarak artarken 1.5 mm genişliğinde dayanım kuvvetinde azalma tespit edilmiştir.

Tartışma ve sonuç:

Dental restorasyonların hastalar tarafından uzun süre kullanılması diş hekimlerinin her zaman ana hedeflerinden biri olmuştur. Ancak, hayat tarzındaki değişiklikler beslenme alışkanlıklarını etkilemiş, asitli içecek, yumuşak-yapışkan gıda tüketiminin artması sonuç olarak dental çürüklerin büyük bir problem olarak karşımıza çıkması direkt ve indirekt restorasyonların kullanımının artmasına neden olmuştur.

Yaşamımızın hemen hemen tüm alanlarına girmiş olan modern teknoloji ile birlikte, ileri teknoloji yöntemlerini kullanarak en kısa sürede, kolay ve hızlı bir şekilde ihtiyaç duyduğumuz ürünlerin elde edilmesini sağlanmaktadır.

Bu gelişmelere paralel olarak özellikle 20. yüzyıl boyunca, dental materyaller ve teknolojideki gelişmeler ile dental cihaz üretiminde dikkat çekici ilerlemeler kaydedilmiştir. Günümüzde CAI CAD/CAM sistemi uygulaması ile protetik tedavilerde farklı materyaller kullanılarak implant ya da kron alt yapısı üretmek artık daha kolaylaşmıştır. Bu sistem günümüzde dijital dişhekimliği adı ile diş hekimliğinin farklı bölümlerinde kullanılan uygulamalı bilimlerden biri haline gelmeye başlamıştır. Ancak yinede yakın gelecekte protetik tedavilerde bu teknolojinin kullanımında büyük oranda bir gelişme beklenmektedir.

Bu gelişmeler doğrultusunda, son zamanlarda geliştirilen CAI CAD/CAM sistemleri ile üretilen restorasyonların performansı özellikle son 10 yılda çarpıcı bir şekilde ilerleme kaydetmiş ve klinik başarıdaki rolleri hakkında önemli kanıtlar elde edilmiştir.

Bunun sonucu olarak, son birkaç on yıllık süreçte dental CAI CAD/CAM tekniği üzerine yapılan araştırmalarda büyük ve hızlı bir artış olmuştur. Bu yeni teknoloji önümüzdeki yıllarda indirekt dental restorasyonların üretilmesinde geleneksel teknik ve materyallerin yerini alma potansiyeline sahip olabileceklerdir. Bununla birlikte her yeni teknoloji gibi CAI CAD/ CAM sistemler'de yüksek maliyete sahiptir.

Nitekim, dişlerin doğal yapısı göz önünde bulundurulduğunda her açıdan ideal olabilecek hiçbir materyal yoktur, yine de bu konuda seramiklerin fiziksel ve biyolojik özellikleri son yıllarda önemli ölçüde geliştirilmiştir. Tam seramik kronlarda estetik ve dayanıklılık üzerine elde edilen başarılar bu gelişmelerin bir göstergesidir. Gelecekte dental seramikler üzerine daha kapsamlı çalışmaların yapılması daha dayanıklı ve iyi seramik restorasyonların üretilmesine imkan sunacaktır. Şüphesiz, önünümüzdeki yıllarda dental seramikler alanında büyük bir ilerleme kaydedilecektir. Geliştirilmiş fiziksel ve mekanik özellikleri ile birlikte dental restorasyonlarda form, fonksiyon ve estetik çizgide beklenen başarıyı sağlayacaktır.

Bu çalışmanın ana amacı, CAI CAD/CAM den iki farkli materyal (feldspatik cam seramik ve lityum disilikat ile üç farklı tam basamak (0.5 mm,1.0 mm ve 1.5 mm) genişliğinde üretilen koping kronlardaki kırılma dayanımı üzerine olan etkisinin incelenmesidir.

Mevcut araştırmanın sonucunda kırılma dayanımın standart sapmasının, seçilen tüm grup arasında (0.5 mm, 1.0 mm, ve 1.5 mm) basamak genişliğinde lıtyum disilikatta sırasıyla 1100 N (1.5 mm), 967 N (1.0 mm) 674 N (0.5 mm) iken feldspatik cam seramikte bu oran 1.5 mm 642 N ,1.0 mm 724 N ve 0.5 mm 530 N olmuştur. Bu nedenile çeşitli parametrelerde (day,materyalliğin özelliği siman çeşitiliğine ve siman aralığın etkisi v.b) tartışılmalıdır.

Feldispatik restorasyonlar için mutlak kırılma dayanımı varyasyon aralığının 500 N civarında olduğu saptanırken, kaydedilen en düşük değer 0,5 mm'lik basamak genişliğindedir. Kaydedilen en yüksek değer ise 1.0 mm basamak genişliğindedir. Buna karşılık, lityum disilikat, yaklaşık 700 N olduğundan daha geniş bir varyasyon aralığı sergilemiştir ve bunun için kaydedilen maksimum değer, 1.5 mm basamak genişliğindedir. Bu nedenle basamak genişliği LITH ta 700 N'yi aştığı için FSC'ye kıyasla daha geniş bir varyasyon aralığı gösterdiği sonucuna varılırken, en az varyasyon FSC'de gözlenmiştir.

Bu çalışmada FSC'nin kırılma dayanımı için kaydedilen değerlerin sırasıyla 0,5 mm, 1,0 mm ve 1,5 mm'lik basamak genişliği için 1831N, 2165N ve 1296N olduğu bulunmuştur. Buna karşılık lityum disilikatta sırası ile basamak genişliği arttıkça 1378N (0.5 mm), 2487N (1.0 mm) ve 2721N (1.5 mm) değerlerde artmıştır. Genel olarak, kırılma dayanıklığı değerinin, 0,5 mm basamak genişliğinde farklı olarak, FSC dizisine kıyasla daha yüksek olduğu görülmektedir.

Bununla birlikte, sonuçların birbirine yakın olmaması veya parametrik olmaması durumunda analiz sonuçlarına ulaşmak için Kruskal Wall ve Man-Witny gibi diğer istatistiksel yöntemler uygulanacaktır. Parametrik olmayan verilerde, aritmetik ortalama, istatistiksel hesaplamada kullanılmak için ortanca(medyan) değer ile değiştirilmelidir.

Bu araştırmada, sonuçlar birbirine çok yakın çıkmadığından, başka bir deyişle parametrik olmayan dağılıma yakın olduklarından, sonuçların istatistiksel analizi için hem ortalama hem de medyan değerleri hesaplanmış ve uygulanmıştır. Her iki değerlerinin tablo 12 ve 13 'deki hem parametrik (ortalama) hem de parametrik olmayan (medyan) testlerde birbirine oldukça yakın olduğu görülmektedir.

Birçok araştırma sonucuna göre yazarın onayladığı gibi, tüm seramik restorasyonların kırılma direncine etki ettiği tespit edilen dört ana faktör vardır, bunlar malzeme kalınlığı, restorasyon hazırlama yöntemi, restorasyon tasarımı ve simantasyon olarak sıralanabilir (Schultheis ve ark., 2013). Bu faktörlerin ideal kombinasyonu, tüm CAI CAD/CAM restorasyon materyallerinin kırılma direncinin artmasına neden olacaktır (Rekow, 2006; Zimmermann ve ark., 2017).

Çeşitli preperasyon dizayının zirkon kullanarak üretilen restorasyonlar dan kırılma dayanımı üzerine geniş bir şekilde etkisinin olduğu bildirilmiştir. Tam basamağın restorasyonun mekanik dayanımı ile dişeti için uyumlu bir marjinal preparasyon geometrisinin dişeti sağlığı açısındanda kullanılması önerilmiştir.

Bununla birlikte, geçen yüzyılın sonunda, Doyle ve arkadaşları (1990), basamak genişliğinin hemen hemen tüm seramik kronların yüzey kırılma direnci üzerindeki etkisini yeniden değerlendirmiştir ve 1.2 mm tam basamaklı olarak dicor kronlardan üretilen ve metal day üzerine simanta edilen restorasyonların ayni materyallerin üzerine chamfer dizaynlı basamak restorasyonlara göre kırılma dayanımı daha yüksek olarak bulmuştur (Doyle vd, 1990 Al-Makramani vd 2011)'den alıntılanmıştır.

Buna göre Di-lorio ve ark., (2008), marjnal tasarımın Procera All ceram kronlarının kırılma direncine etkisi konusundaki laboratuvar çalışmalarında, Alumina kronların basamak genişliği ile kırılma direncinin arasındaki ilişkinin varlığını açıkça göstermiştir. Ancak Di-lorio ve arkadaşları, tam basamağın arka tek kron restorasyonunun biyomekanik performansını artırabileceğini belirtmiştir.

Cho ve arkadaşları fiberle güçlendirilmiş seramik içerikli kompozit kronların marjinal netliği ve kırılma dayanımı üzerine çeşitli basamak sınırlarının etkisini kapsamlı bir şekilde incelemişlerdir. Bu invitro çalışmada Ceromer/ FRC kronların kırılma dayanımı çeşitli basamak sınırları ile değerlendirilmiştir. Çalışma sonuçlarına göre shoulder basamaklı kronların marjinal adaptasyonu, chamfer basamaklı kronlara göre daha iyi çıkmıştır. Bu çalışmada dört adet metal day ve iki farklı basamak genişliği (0.9 mm ve 1.2 mm) ve shoulder, chamfer basamak tipi oluşturulmuştur. Çalışma sonucu basamak tasarımına bakılmaksızın ortalama kırılma yükü 1646 N bulunmuştur (Cho ve ark., 2004). Mevcut çalışmanın aksine shoulder tipi aynı basamak genişliğine sahip (0.5 mm) kronlarda ortalama kırılma dayanımı LITH için 1527 N, ve FSC için 1873N bulunmuştur.

Jalalian ve Alataha 2010'da tam seramik kronların kırılma direnci üzerine iki marjinal tasarımın (chamfer ve shoulder) etkisini araştırıp incelenmişlerdir. Bununla birlikte bu araştırmacılar tam seramik restorasyonların kırılma direncine iki marjinal tasarımın etkisini incelemek için çalışmışlardır. Çalışma sonucu kırılma direnci chamfer basamaklı örneklerde 610.18 N, shoulder basamaklı örneklerde ise 502 N çıkmıştır. İstatiksel olarak iki grup arasında fark önemli bulundu, Alumina korların marjinal tasarımı ile kırılma direnci arasındaki ilişki oldukça net çıkmıştır. Shoulder basamak sınırı seçilmesine rağmen sonuç mevcut değerlere göre kıyaslandığında düşük çıkmıştır. Bu sonuca göre chamfer basamak tasarımının posterior tek alumina kronlarda biyomekanik özellikleri arttırdığı öne sürülmüştür. Bu arada kırılmaya karşı dayanım direnci okluzal yüzeyin iyi uyumu ile de artacağı bu çalışmada gösterilmiştir.

Jalalian ve arkadaşlarının (2011) de yaptıkları çalışma, CAI CAD/CAM sistemi ile üretilen zirkonya kopinglerin kırılma direncine preparasyon tasarımının etkisi üzerinedir. Bu invitro çalışmanın amacı iki basamak tasarımın (chamfer ve shoulder) zirkonya kopinglerin kırılma direnci üzerine etksini karşılaştırmaktı. Çalışma sonucunda chamfer basamaklı restorasyonların kırılma direnci daha iyi bulundu, bunu da chamfer basamağın eğimli yuvarlak iç açısına dolasıyla marjinal uyumun daha iyi olmasına ve böylece gelen kuvvetleri daha iyi yaymasına bağladılar. Böyle bir durum shoulder basamakta gözlemlenmemektedir. Sonuç olarak marjinal tasarım kırılma direncini etkilemiştir. Bu bulgu, yürütülmekte olan araştırma ile karşılaştırılabilir. Nitekim bizim çalışmamızın sonuçlarında en yüksek dayanım değeri 1.5 mm basamak genişliğine sahip lityum disilikatlarda gözlemlenmiş, basamak genişliği 0.5 mm'den 1mm' e çıktıkça doğrusal olarak artmıştır (Tablo 10,11). Fakat feldspatik restorasyonlarda basamak genişliği 0.5 mm'den 1mm'e çıktıkça dayanım artmış, 1.5 mm basamak genişliğinde ise azalmıştır.

Al makramani ve ekibinin 2011 de yaptıkları çalışmada her ne kadar istatiksel olarak bu sonuç görülmese de açıklamayı şu şekilde yapmaktadırlar; chamfer basamakla kıyaslandığında shoulder basamakta aksiyal duvarlara daha az stres yoğunlaşmış olabilir. Bununla birlikte seramik restoratif materyallerin dayanımı da detaylı bir şekilde ele alınmış, Turkom Cera ve Procera all-Ceram'ın kırılma dirençleri incelenmiştir. Araştırmalarında bu seramik kronlar çekilmiş dişlere rezin siman ile yapıştırılmıştır.

Araştırma sonucunda basamak tasarımının Turkom Cera kronlarının kırılma dayanımı üzerine bir etkisinin olmadığını tespit etmişler, shoulder ve chamfer basamak tasarımının arasında önemli bir farklılık olmadığını rapor etmişlerdir.

Bunun yanında,bir başka çalışmada rezin simanla yapıştırılan Dicor kronların kırılma direnci üzerinde basamak tasarımının etkisinin olmadığı savunulmuştur (Malament ve Socransky,1999). Önceki çalışmalarla birlikte Dicor kronların kırılma dayanımında basamak sınırının ve yapıştırma ajanının etkisi gösterilmiştir. Buna karşın, Bernal vd 1993 yılında yaptıkları açıklamada, basamak sınırının tipine göre kırılma dayanımında bir fark gözlemlenmediği belirtilmiştir.

Son zamanlarda, farklı basamak sınırları ile ilişkili olarak tam seramik restorasyonların dayanımı hakkında dünyanın farklı yerlerindeki bir çok klinisyende endişe oluştuğu görülmektedir. Cortellini ve arkadaşlarının (2014) yaptığı çalışmaya göre preslenerek hazırlanmış lityum disilikat kronlar için invasiv basamak sınırı oluşturmaya gerek olmayabilir çünkü basamak sınır tipi dayanımı etkilememektedir. Yükleme siklusunden sonra knife edge ve geniş chamfer basamak sınırına sahip abutmentler üzerine yapıştırılmış lityum disilikat kronların kırılma dayanımı üzerine olan çalışmaları sonucunda önemli bir farklılık olmadığı tespit edildi.

Cortellini ve arkadaşlarının 2014 yılında yaptığı daha önceki araştırmaların aksine, Zhang ve arkadaşları 2016'da protetik restorasyonların marjinal kalınlıklarının kırılma dayanımı üzerinde daha önemli bir etkisinin olduğunu söylemişlerdir. Çalışmalarında yeni bir restorasyon materyali olarak cam içerikli dental kron kullanılmış ve chamfer tipi basamak genişliği 0.8 mm ve 1.2 mm ile kıyaslanmıştır.

İki farklı basamak tipine ilişkin lityum disilikat kronların kırılma dayanımının değerlendirildiği çalışmada abutmentlere adezivle yapıştırılmış örneklerin ortalama kırılma dayanımı sonuçları knife edge basamaklı gruplarda 1655 ± 353 N, chamfer basamaklı gruplarda 1618 ± 263 N bulunmuştur. Bu sonuca göre lityum disilikat restorasyon materyali olarak kullanıldığında basamak tasarımının etkisinin olmadığı ortaya çıkmıştır. Bununla birlikte genel olarak elde edilen değerler, mevcut çalışma sonuçlarımıza kıyasla daha azdır. Shoulder 0.5 mm basamak genişliğinde bu değer 1378

N ± 674 iken, basamak genişliği 1.5 mm'e çıktığında bu değer 2809 N ± 967'a yükselmiştir. Sonuç olarak, başarısızlık oranları ve basamak tipleri arasındaki ilişkiyi belirlemek için klinik çalışmalar takip edilmeye devam edilmelidir.

Day materyalinin seçimi, protezlerin kırılma direncinde restorasyon materyaline yüklenen maksimum kuvvetleri etkileyebilir, Nemane ve arkadaşlarının 2015'te yaptıkları çalışmada belirttikleri gibi, Gavelis GR ve arkadaşlarının (1981) yaptığı önceki invivo çalışmalarının sonuçları arasındaki varyasyonun en önemli nedeninin döküm değişkenliğinden kaynaklı olduğu ortaya çıkmıştır.

Günümüzde, basamak tasarımının seramik restorasyonun kırılma oranlarını etkileyen ana faktörlerden biri olduğu açıktır. Bu çalışmada Nemane ve arkadaşlarının (2015) önerdiği üzere chamfer basamak yerine shoulder basamak tipi seçildi. Onların çalışmasında restorasyonların okluzal uyumunun farklı basamak tasarımlardan etkileneceği öne sürülmüştür ve chamfer basamak tipine göre diş kesiminde shoulder basamak tipi daha fazla yüzey alanı sağladığı görülmüştür. Ekip bu çalışmalarında paslanmaz çelik day kullanmışlar, çapını 10mm, yüksekliğini 6 mm olarak ayarlamışlardır, kronlarını da full döküm metal şeklinde üretmişlerdir (Nemane ve ark., 2015).

Tam seramik restorasyonlar oral kavitede her fonksiyonda kırılma ihtimali ile karşı karşıyadır (Al-Joboury and Al-Rasheed, 2015; Dibner and Kelly, 2016), dolasıyla kırık gibi komplikasyonları en aza indirmek için CAI CAD/CAM restorasyonları üzerine in vitro çalışmalar yapılmıştır (Cho ve ark., 2011; Anusavice ve ark., 2013a).

CAI CAD/CAM restorasyonlarının maksimum kırılma direncini değerlendirmek için yapılan bir çalışmada, diş yapısına ve şekline benzer, farklı day materyalleri kullanılmıştır (Zahran, ve ark., 2008; Sağsoz, ve ark., 2016). Ancak her bir dişin farklı ebat ve mineralleşme oranları, anatomik konfigürasyonu, farklı yaş evrelerinde pulpal ebat değişimi ve oluşan iç çatlaklar nedeniyle doğal dişlere benzer bir standardizasyon elde etmek imkan sız gibi görünmektedir. Ayrıca, çekilen dişin saklanması ve seçilen dişlerin çekim nedenleri gibi doğal dişlerin kullanılması durumunda incelemelerin sonuçları üzerinde etkisi olan birkaç başka parametre daha vardır (Burk, 1999).

2011'de Kelly tam seramik restorasyonlar üzerine uygun in vitro araştırmalar yapma konusunda bir takım önerilerde bulunmuştur. Elastikiyet modülüsü dentine yakın day materyali kullanmak, örnekleri kesim prensiplerine göre yapmak ve uygun klinik boyutlarda tam seramik kronları üretmek bu öneriler arasındadır.

Bu çalışmanın laboratuar şartları Kelly'nin tavsiyelerinden farklı olmasına rağmen, day materyalinin elastikiyet modülüsü 218 GPa'ya yaklaşmıştır.

Çalışmada elastikiyet modülü 12GPa olan doğal bir dişe göre 20 kat daha yüksektir. Çalışmanın sonuçları çekilmiş dişlerde yakalanamayan standarizasyon sağlansın diye metal day tercih edildilmiştır.

İnvitro kırma testlerinin sonucuna etki eden diğer faktörler göz önünde bulundurulduğunda, invivo çalışmalarla kıyaslandığında day materyali daha yüksek bir elastikiyet modülüsüne sahip olması sebebiyle artı eksi sonuçlar elde edilir. Fakat tam seramiklerin iç yüzeyinden ötürü alttaki day materyalinin elastikiyet modulusü dentine yakın olduğunda yüksek makaslama kuvvetleri oluşurken tam tersine metal day kullanılırsa alttaki metal dayın stabilitesinden kaynaklı daha düşük makaslama kuvvetleri oluşur. Bu nedenle restorasyon altındaki diş yapısında deformasyonlar oluşmakta, bu da restorasyon materyalinin dayanım değerini etkilemektedir (Yucel ve ark., 2012).

Bu çalışmada basamak genişliklerinin farklılıkları haricinde test sonuçlarını etkileyen tüm olumsuz faktörler göz ardı edilmiştir. Dolasıyla sonuç değerleri etkileyecek herhangi bir faktör, alttaki dayın kırılması gibi veya destekleyen yapının deformasyonu gibi olgular görülmemiştir. Sonuç olarak LİTH ve FSC de maksimum kırılma değeri sırası ile 4518 N ve 3233 N çıkmıştır.

Bazı araştırmacılar, CAI CAD/CAM restorasyon materyali olarak lityum disilikat kullandıkları çalışmalarında, day materyalinin kırılma dayanımı üzerinde harhangi bir etki oluşturmadığını söylemişlerdir. Rezin day, nikel-krom day ve dentin kullanılan çalışmalarda monolitik kronların ortalama kırılma dayanım değerleri sırasıyla 595 N, 606 N, ve 578 N çıkmıştır ki bu sonuçlar çalışmadaki 0.5 mm basamak genişliğine sahip kronlarda çıkan en düşük kırılma değerinden 834 N daha azdır

(Sağsoz ve ark., 2016). Aksanın 2017'deki tez çalışmasında monolitik lityum disilikat kronların titanyum abutmentler üzerine yapıştırdığı çalışmada maksimum ortalama kırılma değeri 787.80 ± 120.95 N, titanyum altyapılı zirkonyum abutmentlerde 623.93 ± 97.44 N ve Bio HPP abutmentlerde 602.93 ± 121.03 N değerleri çıkmıştır. Bu sonuçlar basamak genişlikleri 0.5 mm, 1mm ve 1.5 mm olan lityum disilikat kronlarımızdan daha düşük medyan ve ortalama değerlerdir.

Aksine Sakoguchi ve ekibinin 2013 yaptığı çalışmada rezin day ve metal day üzerine kronları yapıştırmış, rezin day kullanılan örneklerde daha yüksek kırılma direnci gözlemlemişlerdir. Yine de diğer araştırmacılar doğal diş yapısını yansıtmadıktan sonra metal ya da rezin day kullanmanın önemli olmadığını vurgulamışlardır (Kowon ve ark., 2013).

Buna göre, tam seramik restorasyonların dayanımı sadece kullanılan materyalin kırılma direncine bağlı değildir. Diğer araştırmacılar gibi Yeğinin de 2017'deki tez çalışması farklı restorasyon materyallerinin alt yapı üzerindeki stres dağılımı üzerinedir. Monolitik lityum disilikat kronlar, sonlu elemanlar analizinde (FEM) incelendiğinde restoratif materyal tipinin alttaki implant parçaları üzerindeki stres dağılımına etki etmediği sonucuna varmıştır. Lityum disilikattan yapılmış monolitik restorasyonların implant ve kemik dokusu üzerindeki stresi azalttığı bulunmuş ve ortalama kırılma dayanım değeri 2891.88 N ± 410.12 ile sonuçlanmıştır. Bu sonuç çalışmamızda basamak genişliği 1.5 mm olan lityum disilikat kronların ortalama kırılma dayanım değerine 2721 N ± 967 sayısal olarak yakın çıkmıştır.

Aynı şekilde, Jager vd. 2005, tasarım parametrelerinin sonlu elemanlar analizi (FEA) üzerindeki etkisini incelemiş, CAI CAD/CAM ile üretilen seramik kronlarda stres dağılımını belirlemiş ve farklı basamak sınırıyla birlikte siman aralığının olabildiğince ince olması gerektiğini böylece tam seramik kronların direncinin ve uzun ömürlülüğünün artabileceğini öne sürmüşlerdir. Ayrıca, arka bölgedeki tam seramik kron için spesifik tasarım kurallarına uyulması gerektiğini belirtmişlerdir. Tam seramik restorasyonlarda bir tasarım rehberi geliştirebilmek için FEA'nın CAI CAD/CAM verilerini kullanarak başarılı bir araç olabileceği gösterilmiştir.

Kron simantasyonu sonrası pulpa nekrozu restorasyon başarısızlığı açısından önemli bir faktördür (Decerle ve ark., 2014). 3D-FEA teknikleri kullanılarak kronların altındaki tahmini siman mikro kırıkları, kron marjinlerinin tipi, siman tipi, siman kalınlığı, yükleme yönü ve yükleme büyüklüğü üzerindeki etkisi test edilebilmektedir (Kamposiora ve ark., 2001). Mikro kırılmaya yol açabilen yapıştırıcı simandaki stres seviyesi ve dağılımı chamfer marjinlerde shoulder marjinlere göre daha yüksektir. Siman kalınlığı stres seviyesini ve dağılımını düşük oranda etkilerken oblik streslerin aksiyal streslerden daha büyük yük oluşturduğu rapor edilmiştir.

Komsara ve arkadaşları 2000, ise chamfer basamak tasarımının daha büyük streslere sebep olduğunu söylemişlerdir. Sonuçta simanlar mikro kırılma riski ile karşı karşıyadır ve bu da kron başarısızlığını arttırır. Buna karşılık, cam iyonomer ve rezin simanının, diğerlerine kıyasla mikro kırılmaya dirençli olması daha fazla mekanik özelliğe sahip olmasıyla mümkündür.

Tam seramik restorasyonların marjinal adaptasyonunda farklı kalınlıkların etkisinin dğerlendirildiği bir çalışmada, Jalalian ve arkadaşları (2014), seramik kronlarda marjinal kor kalınlığının artması ile marjinal aralığın azalabileceğini tespit etmişlerdir.

Marjinal aralığın artmasıyla restorasyon materyalinin kırılma dayanımının azaldığı Maghrabi (2010) tarafından bildirilmiştir. Konvansiyonel ölçü yöntemi yada farklı CAI CAD/CAM sistemi ile alınan dijital ölçü yöntemleri olsun klinik olarak kabul edilebilir marjinal aralık 120°'dir, (Renne ve ark., 2015).

Buna karşın, bu araştırma aynı zamanda farklı marjinal kalınlıktaki monolitik bir restorasyon seçiminde, bir CAI CAD/CAM restorasyon materyali olarak lityum disilikat kullanılması durumunda kırılmaya karşı direncin büyük ölçüde arttığını ortaya koymuştur.

Habekost ve arkadaşlarının 2007 de rezin simanın gerilme bağlanma dayanımı ve esneklik modülusu üzerine yaptığı in vitro bir çalışmada, rezin simanın mekanik özelliklerinin seramik inleyle restore edilmiş dişlerin kırılma direncini etkileyebileceğini göstermişlerdir. Daha yüksek elastik modülüse sahip simanların restorasyon başarısızlığında daha iyi bir direnç gösterdiği bulunmuştur. Feldspatik cam seramiklerde rezin simanın kullanılması restorasyonun başarısı açısından gerekli bir faktördür. Bu nedenle restorasyondan alttaki rezin simana kuvvet iletimi, asit uygulamasına bağlı restorasyon materyalinde oluşan çatlakların ilerlemesini azaltmak için yüksek esneklik modulusune sahip simanların kullanımı daha iyi bir kırılma direnci göstermesini sağlayacaktır.

Bindl ve arkadaşları (2006) hazırladıkları hibrit kompozit dayların elastikiyet modulusunu (5.2-19.3 GPa) doğal dişlerin elastikiyet modulusune (11.5 GPa) yakın hazırlamışlardır. Çalışmalarında uniform bir şekilde kron kalınlığı 1.5 mm olan monolitik lityum disilikat ve feldspatik cam seramik kronlar üretip üç farklı siman ile yapıştırarak kırılma dayanımlarını incelemişlerdir. Çalışma sonucunda lityum disilikat kronlar çinkofosfat simanla yapıştırıldığında ortalama kırılma dayanımları 2082 N, rezin simanla (Panavia F2) yapıştırıldığında 2389 N çıkmıştır. Feldspatik cam seramik kronlarda ise çinkofosfat simanla yapıştırıldığında ortalama kırılma dayanım değeri 1270 N iken, rezin simanda yapıştırıldığında bu değer 2392 N'a yükselmiştir.

Bu çalışmada Panavia 5 rezin siman kullanıldı, lityum disilikat ve feldspatik cam seramik kronlarda basamak genişliğinin 1.5 mm olduğu gruplarda ortalama kırılma dayanım değerleri sırasıyla 2721 N ve 1296 N çıkmıştır.

Adesiv bonding tekniklerinin geliştirilmesiyle seramik restorasyonların iç yüzeyindeki küçük çatlaklar doldurularak seramiklerin dayanımı arttırılabilmektedir. Silika esaslı seramiklerin asitleme sonrası silanlanmasıyla seramik-rezin bağlantısı başarılı bir şekilde artar (Nejatidanesh ve ark., 2015). Feldspatik cam seramiklerin milleme sonrası elastikiyet modulusu 45 ±5 GPa iken, lityum disilikat seramiklerin kristalizasyon sonrası elastikiyet modulusu 95 ± 5 GPa'dır. Seramiklerin elastikiyet özellikleri kompozisyonlarından ve hazırlanma süreçlerinden etkilenmektedir, dolasıyla bu farklılık diş ve restorasyon arasındaki bağlantıda stres birikimini etkiler. Restorasyonların düşük elastikiyet moduluse sahip olması bağlantı arayüzünde yüksek stres yoğunlaşmasına neden olmaktadır (Anusavice ve ark., 2013b).

Tez çalışmasında farklı siman kalınlıkları ile üç farklı materyalin kırılma dayanımını inceleyen Vurgeç Atatürk üniversitesi, 2016, çalışma sonucunda siman kalınlığının 50µm olduğu gruplarda kırılma dayanımının arttığını, siman kalınlığının 200µm olduğu gruplarda ise dayanımın azaldığını tespit etmiştir.

CAI CAD/CAM restorasyonlarının uyumundaki farklılıklar CAI CAD/CAM sistemlerinin dijital tasarımdaki aralık oluşturma parametreleri ile ilgili olduğu 2016'da diğer araştırmacılar tarafından kanıtlanmıştır (Brenes ve ark., 2016). Dolasıyla CAI CAD/CAM restorasyonlarla yakalanan marjinal uyum konvansiyonellerde olduğu gibi klinik olarak kabul edilebilirdir (Abdul-Azim ve ark., 2015). Klinik çalışmaların sayılı olması, farklı CAI CAD/CAM sistemleri arasındaki sonuçların ve protokol çeşitliliği kesin sonuç elde edilmesine izin vermemektedir.

Okluzal ve lateral kuvvetlere karşı meydana gelen kırıklar, klinik pratiğinde seramik restorasyonlarda karşılaşılan ana problemlerden biridir (Qilo ve ark. 2016), yürüttükleri invitro çalışmada, monolitik ve tabakakalı zirkonya kronların kırılma yükünü karşılaştırmıştır. Test grupları arasında kırık tipleri ve kırık yüklerinde önemli farklılıklar elde edilmiştir. Servikal kole kısmında daha yüksek yük oluştuğu gözlemlenmiştir. Monolitik zirkonya kronlarda, alt yapı olarak hazırlanan zirkonya kronlara göre yük dağılımı daha düşük çıkmıştır. Bu sonuçlara göre kronların kırılma yüküne marjinal tasarım etki ettiği gibi kron duvar kalınlıkları da etki etmektedir (Anusavice ve ark., 2013a; Øilo ve ark., 2016).

Metalik olmayan kronlarda görülen kırıklarda, kırık orjini genel olarak kronun iç yüzündeki defektlerden ilerler. Nemli ortamda çatlaklar daha da büyüyür. Seramik materyaller germe streslerine karşı hassastır, dolasıyla yüzeysel defekt ve iç boşluk varlığında mekanik direnç ciddi oranda etkilenir. Bu fenomen, restorasyonun marjinal tasarımı, rezidüel gelişen stresler, uygulanan yükün büyüklüğü, yönü ve sıklığı, restorasyon bileşenlerinin elastikiyet modülü, restorasyon-siman arayüzey defektleri ve ağız içi ortamı gibi faktörlerden etkilenebilir.

Koştur (2016) tezinde üç farklı materyali (hibrit seramik, rezin seramik ve zirkonyum) üç farklı kalınlıkla (0.5 mm, 1.0 mm, 1.5 mm) kıyaslayarak restorasyonların artan kalınlığı ile kırılma dayanımının da artacağını söylemiştir. Zimmerman ve arkadaşları da (2017) lityum disilikat ve feldspatik cam seramikler üzerinde çalışırken aynı hipotezi kanıtladılar, ki bu hipotez Sorrentino ve diğer araştırmacıların (2016) bulduklarından tamamen farklıydı. Buna göre CAI CAD/CAM monolitik kronların kırılma direnciyle ilişkili okluzal kalınlıklarının arka bölgede ve 0.5 mm kalınlıkta bile olsa okluzal kuvvetlere dayanabileceği savunuluyordu.

Genel olarak daha önceki çalışmalarda restorasyonların oklüzal veya yan duvarı için belirlenen kalınlık 1.5 mm veya bunun altındadır (Magne ve diğerleri, 2015; Zimmermann ve diğerleri, 2017) ve çalışma sonucu elde edilen değerler genel olarak 1000 N'nin altında idi. Hatta bazı örneklerde sonuçların 50 N'ye bile düştüğü görüldü. Mevcut araştırmamızda okluzal ve yan duvar kalınlığı 2 mm olarak belirlendi. Bu kalınlık (2 mm), Vichi ve arkadaşları tarafından 2000 yılında, lityum disilikat restorasyonların altındaki diş renklenmelerini kapatmak için estetik amaçla önerildi. Çalışmada uygulanan bu kalınlık, diğer çalışmaların aksine daha yüksek bir direnç değeri göstermiştir. Aslına bakılırsa önerilen bu kalınlığın (2 mm) implant üstü restorasyonlar için de oldukça uygun olduğu söylenebilir.

Shahrbaf ve arkadaşları (2014), dişlerin kronlanmasında düz okluzal preparasyon tasarımı ile en yüksek kırılma dayanımı sonucunu elde etmişlerdir. Maksiler ikinci premolar dişler kullanılan çalışmada standart anatomik diş kesimi ve düz okluzal tabla oluşturularak tam seramik restorasyonlar hazırlandı. Ayrıca bu çalışmada CEREC 3 CAI CAD/CAM sistemi ve feldspatik cam seramik CAI CAD/CAM materyali kullanıldı. Mevcut çalışmada benzer şekilde düz okluzal tablaya sahip nikel-krom daylar, CEREC 4 CAI CAD/CAM sistemi ve feldspatik cam seramik ile lityum disilikat CAI CAD/CAM seramikleri kullanıldı. Çalışma sonucunda her iki materyalden beklenilenden daha yüksek kırılma direnci elde edilmiştir.

Abdullah ve Ibraheem (2017) araştırmalarında, düz oklüzal restorasyon ile shoulder basamak hazırlığının derin chamfer basamağa göre daha iyi sonuçlar verdiğini söylemişlerdir (Abdullah ve Ibraheem, 2017).

Tam seramik restorasyonlar için 3-D CAI CAD/CAM dental teknolojisini kullanmak birçok avantaj sağlamaktadır. Klinik çalışmalar, konvansiyonel restorasyonlara göre CAI CAD/CAM restorasyonların marjinal uyumunun daha net olduğunu gösterse de CAI CAD/CAM ile restorasyonları üretmek hala kompleks bir uğraştır ve deneyim, bilgi ve beceri gerektirmektedir (Azuma ve ark., 2017).

2002 yılında Mou ve ark. Cerec sistemlerindeki gelişmelere değinmişlerdir. Buna göre Cerec 2 ve 3 sistemler, Cerec 1 de görülen çözünürlük ve milleme hassasiyetindeki problemlerin üstesinden gelerek geliştirilmiş ve dolasıyla Cerec restorasyonların marjinal doğruluğu arttırılmıştır. Bununla birlikte, zincirleme çalışma ilkesi hem Cerec 2 hem de Cerec 3'ün bir özelliği olmaya devam etmektedir. Mormann, 2006'da Cerec 2 ile anterior kronlarda internal aralığı 141 ± 21 olarak hesaplamışlardır. Ancak internal uyum, Cerec restorasyonların zayıf noktası olmaya devam etmektedir. Çünkü restorasyonların bu internal konfigürasyonu Cerec kamerasından taranan görüntülere bağlıdır ve komşu dokuların yansıması da kaçınılmaz görünmektedir. Bir çok araştıranın sonucune göre CAI CAD/CAM le üretilen tam seramik restorasyonlar için 360 derece shoulder ya da chamfer basamak hazırlanması gereklidir (Beuer ve ark., 2008).

2017 yılında Güleç tez çalışmasında yüksek elastikiyet modulüsüne ve mekanik özelliklere sahip materyallerin yüksek kırılma dayanımı gösterdiğini tespit etmiş, IPSe-max için yaklaşık 3098,4 N ± 667, Vita Enamic için ise 1978.71 N ± 364 bulmuştur. Çalışmada ise 1mm ve 1.5 mm basamak genişliğine sahip lityum disilikat kronlarda ortalama kırılma dayanım değeri sırasıyla 2489 ± 1100 N ve 2721 ± 967 N, feldispatik kronlar için ise aynı basamak genişliklerinde sırasıyla 2028 ± 724 N ve 1296 ± 642 N çıkmıştır.

Çalışmanın sonuçlarından değinilmesi gereken bir nokta, 4000 N'u aşan kırılma dayanımı değerlerinin elde edilmiş olmasıdır. 1.5 mm'lik basamak genişliğine sahip lityum disilikat kronların maksimum dayanımı 4518 N iken feldspatik cam seramik kronlarda bu değer 3233 N'u aşamamıştır. Birçok araştırmacının da değindiği gibi kırılma dayanımının yükünde materyal tipinin etkisi olduğu, çalışmanın sonucunda da ortaya çıkmıştır (Zahran ve ark., 2013).

Kronlardaki başarısızlığın klinik olarak incelendiği bir çalışmada kırıkların, restorasyonların marjin kısmındaki çatlaklardan başlayıp ilerlediği rapor edilmiştir (Øilo ve ark., 2014). Bir çok invitro çalışmada ise krıkların, restorasyon materyalinin yüzeyi ile kuvvet uygulanan yüzey arasında sürtünme etkisi ile oluştuğu tespit edilmiştir. Ağız içi ortamı taklit etmek için birçok araştırmacı restorasyon yüzeyi ile kuvvet uygulanan yüzey arasına bir bariyer (lastik yada alüminyum folyo) konulmasını tavsiye eder, böylece yüzey boyunca kuvvetlerin yayılacağını düşünmüşlerdir

Bazı çalışmalarda restorasyon yüzeyi ile uygulanan kuvvet arasında stres bariyeri olarak bir lastik yada alüminyum folyo tabakası kullanılmıştır (Rammelsberg ve ark., 2000). Çalışmada böyle bir bariyer kullandığımızda dayanma direnci umulmadık bir şekilde 5000 N'dan da fazla artmıştır. Bu nedenle çalışmada böyle bir uygulama göz ardı edildi. Kırma testi, kırıcı bir uç ile (dörtgen piramit elmas uçlu) kırılma gerçekleşinceye kadar yapıldı. Uygulanan yük ile kron yüzeyi arasında herhangi bir düzenleme yapılmadan bile oldukça yüksek dayanım değerleri elde edildi.

Çalışmada yüksek dayanım değerlerinin çıkmasında bu tür malzemelerin kullanılması gibi tüm bu faktörler de etki etmektedir. Bununla birlikte çoğu araştırmacı önceki hipotezi desteklemek için daha fazla klinik çalışmanın yapılması gerektiğini söylemişlerdir. Çalışmanın sonuçları ise önceki çalışma ile uyumludur. Bu nedenle marjinal kalınlığa (0.5 mm,1.0 mm,1.5 mm) bakılmaksızın her iki materyal lityum disilikat ve feldspatik cam seramik) için ortalama dayanım değerleri 1378 N ile 2721 N arasında değişmiştir.

Çalışmada 1.5 mm basamak genişliğine sahip lityum disilikat kronlarda diğer seramik kronlara göre kırılma dayanımı oldukça iyi çıkmıştır. Ancak feldispatik kronlarda kalınlıkların değişmesi ile ortalama kırılma dayanım değerleri farklı çıkmıştır, en yüksek değer basamak genişliğinin 1.0 mm olduğu grupta gözlemlenmiştir. Lityum disilikat kronlarda basamak genişliği 0.5 mm, 1.0 mm ve 1.5 mm'e arttıkça kırılma değerleri 1855 N' den 2721 N' a doğrusal olarak artmıştır. Bu iki materyalin kırılma dayanım değerleri kıyaslandığında diyebiliriz ki en yüksek ve yeterli değerler 1.0 mm basamak genişliğine sahip lityum disilikat kronlarda, en pik değer ise 1.5 mm basamak genişliğinde elde edilmiştir. Aslında bu iki materyal arasındaki fark önemli bulunmadı;

basamak genişliğinin 0.5 mm olduğu iki grupta kırılma dayanım değeri feldspatik cam seramik ve lityum disilikat kronlar için sırasıyla 1831 N ve 1378 N çıkmıştır.

Elde edilen sonuçlar ortalama ve medyan değerleri kullanılarak tablo ve grafiklerde gösterilmiş, sonuçlar her iki durumda da hemen hemen birbirine yakın çıkmış ve aynı eğilimi göstermiştir. Basamak genişliklerine ilişkin standart sapmada tahmin edilen değerler Şekil 49'de gösterilmiştir.

Basamak genişliğinin, bu çalışmada ele alınan iki malzeme grubunun kırılma direnci üzerindeki etkisi, ortalama ve medyan olarak ifade edildiğinde, basamak genişliğinin özellikle lityumda kırılma için gereken kuvvetler üzerinde etkisinin olduğu açıkça görülmektedir. Kullanılan iki materyalin ortalama ve medyan değeri şekil 48'de gösterilmiştir.

Basamak genişliği 0.5 mm ve 1.5 mm olan Felspatik seramik kronların ortalama ve medyan değerleri kullanılarak kırılma dayanımları kıyaslandığında, fark sırasıyla 577 N ile 707 N olarak görülmüştür. Bu da feldspatik cam seramik kronlarda basamak kalınlığı ile ters bir ilişki olduğunu gösterir.

Özetle, fark eğilimi, basamak genişliği arttıkça kırılma dayanımı değerinin azaldığını göstermektedir. Bu FSC de basamak genişliği 0.5 mm olan grup ile 1.5 mm basamak genişliğine sahip grup ve 1.0 mm basamak genişliğine sahip grup ile 1.5 mm basamak genişliğindeki grup karşılaştırılınca dikkati çekmiştir.

Buna karşılık, ortalama veya medyan değerlerinin kullanılmasına bakılmaksızın, araştırmamızda elde edilen sonuçlarında 0.5 mm ve 1.0 mm basamak genişliğine sahip FSCler arasındaki ilişkinin zıt olduğu bulundu.

Lityum disilikat kronlarda elde edilen sonuçlara bakıldığında elde edilen varyasyonlarda istatiksel olarak bir fark bulunmadı. Basamak genişliği arttıkça ortalama kırılma dayanımı da artmıştır, bu değerler sırasıyla 0.5 mm, 1mm ve 1.5 mm için 1527 N, 2489 N, ve 2721 N'dur. Bu artış eğilimi, medyan değerleri dikkate alındığında da fark edilebilir.

Aslına bakılırsa, 0.5 mm ile 1.0 mm basamak genişliğine sahip lıtyum disilikat kronlar arasındaki kırılma dayanımının ortalama değeri arasındaki fark 961 N, medyan değer dikkate alındığında ise 783 N'lik bir değer kaydedildi. Aynı şekilde diğer iki grup arasındaki fark ise (1.0 mm ve 1.5 mm) ortalama için 647 N ve medyan için ise 232 N olarak bulundu.

Bu nedenle, çalışmada lityum disilikat kronlar için basamak genişliği ile kırılma mukavemeti arasında pozitif bir ilişki bulundu (Şekil 44 ve Tablo 14) Bu, ortalama ve medyan değerlerin yanı sıra maksimum ve minimum değerlerde de izlenmektedir.

Ayrıca 0.5 mm basamaklı FSC ten üretilen restorasyonlar, 0.5 mm basamaklı lityum disilikatlara gelen kuvvete karşı kıyaslandığında daha yüksek değerlere ulaşılmıştır. Fakat istatistiksel olarak anlamlı bulunmamıştır.

Nitekim, çalışmamızda basamak genişliği dikkate alındığında, materyal tipinin CAI CAD/CAM restorasyonlarının kırılma direnci üzerindeki etkisi özellikle de 1.5 mm basamak genişliğindeki kronlar için, açık bir şekilde görülmüştür.

Aslında lityum disilikat kronlarda basamak genişliği 1.0 mm'e yükseldiğinde,1.5 mm basamak genişliğine sahip feldspatik cam seramik kronlarla kıyaslandığında, ortalama ve medyan dğerleri için sırasıyla farklı değerler bulunmuştur (1192 N ve 1037) N. Lityum disilikat kronlarda kırılma dayanım değeri 2721'den 2809 N'a yükseldiği durumda ve basamak genişliğinin 0.5 mm'den 1.5 mm'e yükseldiği gruplarda bu fark 1431 N ve 1184 N'dur. Bu sonuca göre bir yandan lityum disilikatin daha dayanıklı bir materyal olduğu görülürken diğer yandan basamak genişliği arttıkça dayanım gücünün arttığını görmekteyiz.

Feldspatik cam seramik ile ilgili değerlerin her zaman lityum disilikattan daha düşük olduğu açıktır. Buna karşılık, kırılma dayanımının değişkenliği, basamak genişliği 1.0 mm olduğunda daha fazladır. Genel olarak elde edilen değerler bu çalışmada kullanılan her iki materyalde de basamak genişliği arttıkça artmıştır.

Kullanılan her iki materyal için minimum sapma değeri 0.5 mm basamak genişliğinde, maksimum sapma değeri ise 1.0 mm basamak genişliğinde kaydedildi.

1.5 mm marjinal kalınlıktaki feldspatik seramiklerde en düşük ortalama dayanım değeri 1296 N ve en düşük medyan dayanımı 1124 N çıkmıştır. 1.0 mm marjinal kalınlıkta ise en yüksek ortalama dayanım değeri 2028 N ve en yüksek medyan değeri 1865 N çıkmıştır. Aksine Lityum disilikat 0.5 mm marjinal kalınlıktaki kronlarda en düşük ortalama dayanım değeri 1527 N ve en düşük medyan değer 1378 N ve 1.5 mm kalınlıkta ise en yüksek ortalama dayanım değeri 2721 N, en yüksek medyan dayanım değeri 2803 N çıkmıştır. Bu ortalama üzerine, Lityum disilikat kronların Feldspatik cam seramik kronlara göre daha dayanıklı olduğu ortaya çıkmıştır, tüm örnekler arasında 1.5 mm marjinal kalınlığındaki Lityum disilikat kronlarda en yüksek ortalama ve medyan dayanım değeri görülmüştür.

Her iki materyalde aynı marjinal kalınlığa (1.5 mm) sahipken, lityum disilikat kronların dayanım değerinin feldspatik cam seramik kronların dayanımının değerinin iki katından fazla olduğu görülmüştür.

Her örnek için minimum değişkenlik katsayı değeriyle ortalama en yüksek değeri Şekil 5'te kontrol edilerek incelenebilir. Tüm örnekler arasında 1.5 mm basamak genişliğindeki Lityum disilikat kronlar en yüksek dayanıma sahiptir.

Sonuç olarak;

1. Litiyum disilikat seramik kronları söz konusu olduğunda, maksimum kırılma dayanım ortalama değeri, 1.5 mm basamak genişiliği için 2721 ± 967 N olarak bulunmuş ve 1.0 mm basamak genişliğinde ise 2489 ± 1100 N'ye düşmüştür, ardından basamak genişliği 0.5 mm'ye düştüğünde kırılma dayanım değeri de 1527± 674 N'a düşmüştür. Bu sonuca göre lityum disilikat seramik kronlarda basamak genişliği arttıkça, kırılma dayanımı da paralel olarak artar .
2. Feldispatik seramik kronlarda, kırılma dayanımı ortalama değeri 1.0 mm basamak genişliği için 2028 ± 724 N, 0,5 mm basamak genişliği için 873 ± 530 N ve en düşük ortalama değer 1296 ± 642 N, 1.5 mm basamak genişliğine sahip kronlarda bulunmuştur. Sonuç olarak, kırılma dayanımı basamak genişliğinin 0.5 mm'den 1.0 mm'ye artmasına parallel olarak artmış ve basamak genişliğinin 1.5 mm'ye artmasıyla da aksine azalmıştır.

3. İki seramik materyalinin karşılaştırılmasından elde edilen verilere göre 95 ± 5 GPa elastik modülüsüne sahip lityum disilikat seramikler bu çalışmada maksimum kırılma dayanım değeri olarak 4518 N gösterirken, 45 ± 0.5 GPa elastik modulusüne sahip feldispatik cam seramikler ise bu çalışmada minimum kırılma dayanımı değeri olarak 513 N göstermiştir. Bu nedenle, her iki materyalin ortalama kırılma dayanımın değerleri arasında fark çıkmıştır.
4. Her iki tip CAI CAD/CAMmateryali (Lityum disilikat ve feldispat) estetik ve biyomekanik özelliklerine ek olarak, arka bölge için metal destekli restorasyonlara alternatif olarak kabul edilebilir, mevcut çalışmada gösterdikleri mekanik özellikleri ile ağız içinde okluzal kuvvetlere dayanabileceği söylenebilir.

Çalışmanın limitleri ve gelecekteki araştırmalar için öneriler;

Bu çalışmanın sınırlamaları ve dijital diş hekimliği alanındaki modern yenilikler göz önünde bulundurulduğunda gelecekte yapılacak çalışmalar modifiye edilerek araştırmacıların sorularına daha net cevaplar bulunabilir. Bu çalışmada çekilmiş insan dişi (standardizasyon maksimum ölçüde sağlanırsa) ya da implant abutmenti kullanılsaydı klinik şartlar daha iyi simüle edilebilirdi.

Farklı tipte digital ölçü sistemlerinin doğruluğunu incelemek ve daha çok çeşit materyal kullanıp bunlar arasında kıyaslama yapmak için araştırmalar yapılmalıdır.

Restorasyonların uzun süre kalıcılığının araştırılmasını desteklemek ve hasta ile hekimin memnuniyetlerini kıyaslamak, uzun vadede dikkate alınması gereken önemli hususlardandır. Bu inceleme gösteriyor ki, Van Yüzüncü Yıl üniversitesi Diş Hekimliği Fakültesinin Protez Kliniğinde hem diş hekimleri hem öğrenciler, lityum disilikat ve feldspatik cam seramik restorasyonlara aşinadır. Bunun sonucunda ortaya çıkan izlenim yüksek standartta ve kalitede ölçü alımı ve laboratuar çalışması CAI CAD/CAM indirekt restorasyonlarla sağlanan final çalışmalar ile hem hekimler hem de hastalar son derece başarılı sonuçlar almaktadırlar.

REFERENCES

Abdul-Azim T, Rogers K, Elathamna E, Zandinejad A, Metz M, Morton D. Comparison of marginal fit of lithium disilicate crowns fabricated with CAD/CAM technology by using conventional impressions and two intraoral digital scanners. J Prosthet Dent. 2015;114(4):554-9.

Abdullah LS, Ibraheem AF. The effect of finishing line designs and occlusal surface reduction schemes on vertical marginal fit of full contour CAD/CAM zirconia crown restorations, a comparative in vitro study. Int J Dent Oral Health. 2017; 4(1):1-6.

Aboushelib MN, Wang H, Kleverlaan CJ, Feizler AJ. Fatigue behavior of zirconia under different loading conditions. Dent Mater. 2016;32(7):915-20.

Addreescu CF, Ghergic DL, Botoaca O, Barbu HM, Mitariu ISC, Patroi DN. The advantages of high-density polymer CAD/CAM interim restorations in oral implantology. Materiale Plastice. 2017;54(1):32-6.

Ahlholm P, Sipila K, Vallittu P, Jakonen M, Kotiranta U. Digital versus conventional impressions in fixed prosthodontics: A Review. J Prosthodont. 2018;27(1):35-41.

Ahmadzadeh A, Golmohammadi F, Mousavi N. Effect of marginal design on fracture resistance of IPS e.max all ceramic restorations: chamfer versus shoulder finish lines. J Islam Dent Assoc Iran . 2015;27(2):64-9.

Aksan ME. Estetik biohpp zirkonya ve titanyum implant dayanakları ıle desteklenen CAD/CAM monolotik lityum disilikat kronların çığneme simulatatörü ve termal döngü ile yaşlandırılması sonrası kırılma dayanımlarının karşılaştırılması [Uzmanlık tezi]. Ankara: Kırıkkale Üniversitesi; 2017.

Al Dehailan L. Review of the current status of all-ceramic restorations. IU School of Dentistry. 2009;1-20.

Al.Mously H, Finkelman M, Zandparsa R, Hirayama H. Marginal and internal adaptation of ceramic crown restorations fabricated with CAD/CAM technology and the heat-press technique. J Prosthet Dent. 2014;112:249-56.

Alakhras EE. Influence of cement on survival of all-ceramic restorations. [Master Thesis]. USA: Ohio State University; 2011.

Alghazzawi TF. Advancements in CAD/CAM technology: options for practical implementation. J Prosthodont Res. 2016;60:72-84.

Alghazzawi TF. Liu PR, Essig ME. The effect of different fabrication steps on the marginal adaptation of two types of glass-infiltrated ceramic crown copings fabricated by CAD/CAM technology. J Prosthodont. 2012;21:167-72.

Al-Joboury, AI-Rasheed ZM. An evaluation of the influence of different finishing lines on the fracture strength of full contour zirconia CAD/CAM and heat press all-ceramic crowns. J Bagh Coll Dentistry. 2015;27(1):54-62.

Alkadi L, Ruse ND. Fracture toughness of two lithium disilicate dental glass ceramics. J Prosthet Dent. 2016;116(4):591-6.

Al-Makramani BMA, Razaq AAA, Abu-Hasan MI. Advances in ceramics-characterization, raw materials, processing, properties, degradation and healing. In Tech. Strength of a new all-ceramic restorative material “Turkom-Cera” compared to two other alumina-based all-ceramic systems, 2011;(14):259-80.

Almustafa NM. The use of CAD/CAM for fixed partial prostheses.[PhD Thesis]. UK: University of Dundee; 2016.

Al-Zubadi Z, Al-Shamma A. The effect of different finishing lines on the marginal fitness of full contour zirconia and glass ceramic CAD/CAM crowns (an in-vitro study). J Dent Mater Tech. 2015;4:127-36.

Ann S, Kim S, Choi H, Lee JH, Moon HS. Evaluating the marginal fit of zircinia copings with digital impressions with an intraoral digital scanner. J Prosthet Dent. 2014;112(5):1171-75.

Anusavice KJ, Jadaan OM, Upshaw JFE. Time dependent fracture probability of bilayer, lithium disilicate based, glass-ceramic, molar crowns as a function of core-veneer thickness ratio and load orientation. Dent Mater. 2013a;29(11):1132-38.

Anusavice KJ, Kakar K, Ferree N. Which medical and physical testing methods are relevant for predicting the clinical performance of ceramic-based dental prostheses. Clin. Oral Impl. 2007;I8(3):218-31.

Anusavice KJ, Shen C, Ralph ARH. Philip's Science of Dent Mater. India:First South Asia Edition. 12th Ed. Haryana;2013b.

Awada A, Nathanson D. Mechanical properties of resin-ceramic CAD/CAM restorative materials. J Prosthet Dent. 2015;114(4):587-93.

Ayad MF. Effect of the crown preparation margin and die type on the marginal accuracy of fiber-reinforced composite crowns. J Contemp Dent Pract. 2008;9(2):9-16.

Aycan M. CAD/CAM ve konvansıyonel yönetm kullanılarak üretilen farklı retansiyon apareylerinin ve uygulamada kullanılan farklı yüzey pürüzlendirme yöntemlerinin etinliğinin in vitro olarak karşılaştırılması [UzmanlıkTezi]. Gaziantep: Gaziantep Üniversitesi; 2018.

Azuma T, Kumagai T, Sato T, Mashio G, Fujimoto T, Akiyama S, Yokohara H, Hoshino T, Miyake T. Evaluation of machinable lithium disilicate glass ceramic block for CAD/CAM. Dent Mater J. 2017;33(1):1-8.

Baladhandayutham B, Lawson NC, Burgess JO. Fracture load of ceramic restorations after fatigue loading. J Prosthet Dent. 2015;114(2): 266-71.

Belli R, Petschelt A, Hofner B, Hajto J, Scherrer SS, Lohbauer U. Fracture rates and lifetime estimations of CAD/CAM all-ceramic restorations. J Dent Res. 2016;95(1):67-73.

Bernal G, Jones RM, Brown DT, Munoz CA, Goodacre CJ. The effect of finish line form and luting agent on the breaking strength of Dicor crowns. Int J Prosthodont. 1993;6(3):286-90.

Beuer F, Schweiger J, Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. Br Dent J. 2008;204(9):505-11.

Bijelic-Donova J, Sufyan G, Vallittu PK, Lassila LVJ. Mechanical prosperities, fracture resistance, and fatigue limits of short fiber reinforced dental composite resin. J Prosthet Dent. 2016;115(1):95-102.

Bilginer C. Farklı tek seans tam seramik CAD/CAM boklardan hazırlanan kuron protezlerinin kırılma dayanımının incelenmesi [PhD Thesis]. İstanbul: İstanbul Üniversitesi; 2017.

Bindl A, Lüthy H, Mormann WH. Strength and fracture pattern of monolithic CAD/CAM-generated posterior crowns. Dent Mater, 2006;22(1):29-36.

Bindl A, Mormann WH. Marginal and internal fit of all-ceramic CAD/CAM crown-copings on chamfer preparations. J Oral Rehabi. 2005;32(6):441-7.

Blair FM, Wassell RW, Steele JG. Crowns and other extra coronal restorations : preparations for full veneer crowns. BDJ. 2002; 192: 561-71.

Bohner LO, Neto PT, Ahmad AS, Mori M, Lagana DC, Sesma N. CEREC Chairside system to register and design the occlusion in restorative dentistry: a systematic literature review. J Esthet Restor Dent. 2016;28(4):208-20.

Boujoual I. Mbarki B, Andoh A. Application of CAD/CAM in dental medicine: case report, IJAST. 2018;4(11):172-7.

Brenes C, Duqum I, Mendonza G. Materials and systems for all ceramic CAD/CAM restorations. CAD/CAM Inter Magaz Dig Dent. 2016;7(3):1-15.

Burke FJT. Maximising the fracture resistance of dentine-bonded all-ceramic crowns. J Dent.1999;27(3):169-73.

Büyükbayram IK, Çakan EF, Kazak M. Chaırside Cerec system and CAD/CAM materials. Aydın Dent J: 2016;2(3):47-54.

Çakır M. Farklı yüzey ve silanlama tekniklerinin cad/cam materyallerinin bağlanma dayanımına etkisi [PhD Thesis]. İzmir: İzmir Katip Çelebi Üniversitesi;2017.

Campos RE, Soares PV, Versluis A, de O Junior OB, Ambosano GM, Nunes IF. Crown fracture: failure load, stress distribution, and fractongraphic analysis. J Prosthet Dent. 2015;114(3):447-55.

Çelik G, Sarı T, Üşümez A. Bilgisayar destekli diş hekimliği ve güncel CAD/CAM sistemleri. Cumhuriyet Dent J. 2013;16(1):74-82.

Çetindağ MT, Meşe A. Diş hekimliğinde kullanılan CAD/CAM (bilgisayar destekli tasarım/bilgisayar destekli üretim) sistemleri ve tasarım/bilgisayar destekli üretim) sistemleri ve materyaller. Atatürk Üniv Diş Hek Fak Derg. 2016; 26(3):524-33.

Cho HY, Won HY, Choe HC, Son MK. Fracture characteristics of dental ceramic crown according to zirconia coping design. Procedia Eng. 2011;10:1561-66.

Cho L, Choi J, Yi YJ, Park CJ. Effect of finish line variants on marginal accuracy and fracture strength of ceramic optimized polymer/fiber-reinforced composite crowns. J Prosthet Dent. 2004;91(6):554-60.

Comlekoglu M, Dundar M, Ozcan M, Gungor M, Gokce B, Artune C. Influence of cervical finish line type on the marginal adaptation of zirconia ceramic crowns. Oper Dent. 2009;34(5):586-92.

Conrad HJ, Seong WJ, Pesun IJ. Current ceramic materials and systems with clinical recommendations: A systematic review. J Prosthet Dent. 2007;98(5):389-404.

Cortellini D, Canala A, Souza RO, Campos F, Lima JC, Özcan M. Durability and weibull characteristics of lithium disilicate crowns bonded on abutments with knife-edge and large chamfer finish lines after cyclic loading. J Prosthodont. 2015;24(8):615-19.

Cubas GB, Habekost L, Camacho GB, Pereira-Cenci T. Fracture resistance of premolars restored with inlay and onlay ceramic restorations and luted with two different agents. J Prosthodont Res. 2011;55(1):53-9.

Danzer R. On the relationship between ceramic strength and the requirements for mechanical design. J Eur Ceram Soc. 2014;34(15):3435-60.

Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dent Clin North Am. 2011;55(3):559-70.

Davidson CL. Luting cement, the stronghold or the weak link in ceramic restorations. Adv Eng Mater. 2001; 3(10):763-7.

De Jager N, Pallav P, Feilzer AJ. The influence of design parameters on the FEA-determined stress distribution in CAD/CAM produced all-ceramic dental crowns. Dent Mater. 2005;21(3):242-51.

Decerle N, Bessadet M, Eschevins C, Veyrune J, Nicolas E. Evaluation of Cerec endocrowns: A preliminary cohort study. Eur J Prosthodont Rest Dent. 2014;22:1-7.

Denry I, Holloway JA. Ceramics for dental applications: a review. Materials. 2010;3(1):351-68.

Dibner AC, Kelly JR. Fatigue strength of bilayered ceramics under cyclic loading as a function of core veneer thickness ratios. J Prosthet Dent. 2016;115(3):335-40.

Di-lorio D, Murmura G, Orsini G, Scarano A, Caputi S. Effect of margin design on the fracture resistance of Procera all ceram cores: an in vitro study. J Contemp Dent Pract. 2008;9(2):1-8.

Duan Y, Griggs JA. Effect of elasticity on stress distribution in CAD/CAM dental crowns: Glass Ceramic Vs. Polymer-Matrix Composite. J Dent. 2015;23(6):742-9.

Dwivedi TN, Jakhanwal I, Anupama T, Gill GS, Narang A, Bhatheja A. CAD/CAM in prosthetic dentistry: A comprehensive review. Int J Com Heal Med Res. 2017;3(2):56-9.

Ebrahimpour A, Effect of different ceramic crown preparations on tooth structures loss-an in vitro study [MSc thesis]. Canada: University of Tornoto; 2017.

El-Dessouky RA. Marginal adaptation versus esthetics for various dental restorations: A review article. EC Dental Science.2015;2(1):240-6.

Elsaka SE. Bond strength of novel CAD/CAM restorative materials to self-adhesive resin cement: the effect of surface treatments. J Adhes Dent. 2014;16(6):531-40.

Ertürk BK, Çömlekoğlu MD, Çömlekoğlu ME, Güngör MA. Sabit protetik restorasiyonlarda kullanılan güncel tasarım ve üretim yöntemleri. Atatürk Üniv Diş Hek Fak Derg. 2015;25(1):135-43.

Farah JW, Brown L. Integrating the 3M ESPE lava chairside oral scanner C.O.S. in to daily clinical practice. Dent Advis. 2009;12:1-4.

Fasbinder DJ. Materials for chairside CAD/CAM restorations. Compend Contin Educ Dent. 2009;31(9):702-9.

Franklin GSJ. An update on CAD/CAM dentistry[Internet].www.dentallearning.net. 2015;4(2):1-9. [Accessed 2 Augustus 2017].

Gracis S, Thompson VP, Ferencz JL, Silva NRFA, Bonfante EA. A new classification system for all-ceramic and ceramic-like restorative materials. Int J Prosthodont. 2015;28(3):227-35.

Gresnigt MM, Özcan M, Van den Houten ML, Schipper L, Cune MS. Fracture strength, failure type and weibull charecteristics of lithium disilicate and multiphase resin composite endocrowns under axial and lateral forces. Dent Mater. 2016;32(5):607-14.

Guess PC, Schultheis S, Bonfante EA, Coelho PG. All-ceramic systems: Laboratory and Clinical Performance. Dent Clin N Am. 2011;55(2):333-52.

Güleç C. CAD/CAM restorasyonların termomekanik yaşlandırılmasının kırılma dayanımına etkisinin incelenmesi [Uzmanlık Tezi]. Ankara: Gaziosmanpaşa Üniversitesi; 2017.

Güler MS, Şen S, Bayindr YZ, Güler Ç. The investigation of the effects on stress distributions of luting cements having different properties used in a human tooth crown by finite element method. Atatürk Üniv Diş Hek Fak Derg. 2012;22(1):31-9.

Gupta R, Nagpal A, Sharda V, SwainS, Bhadwal M. Prosthodontic rehabilitation-past, present and future. Ann Prosthodont Restor Dent. 2016;2(1):21-5.

Habekost L de V, Camacho GB, Demarco FF, Powers JM. Tensile bond strength and flexural modulus of resin cements-influence on the fracture resistance of teeth restored with ceramic inlays. Oper Dent. 2007;32(5):488-95.

Helvey GA. Classification of Dental Ceramics. Inside Dentistry. 2013;5:63-80.

Homaei E, Farhangdoost K, Tsoi JKH, Matinlinna JP, Pow EHN. Static and fatigue mechanical behavior of three dental CAD/CAM ceramics. J Mech Behav Biomed Mater. 2016;59:304-313.

Hussain S. Textbook of Dental Materials, India: Jaypee Brothers Medical Pub, 1st Ed; 2008.

Jalalian E, Aletaha NS. The Effect of two marginal designs chamfer and shoulder on the fracture resistance of all ceramic restorations, inceram: an in vitro study. J Prosthodont Res, 2010; 55 (2):121-25.

Jalalian E, Rostami R, Atashkar B. Comparison of chamfer and deep chamfer preparation designs on the fracture resistance of zirconia core restorations. J Dent Res Dent Clin Dent Prospects. 2011;5(2):41-45.

Jalalian E, Sadegh M, Masoomi S, Jalalian S, Ziyaei AE. Effect of thickness of zirconia core on marginal adaptation of all-ceramic restorations. J Islam Dent Assoc Iran. 2014: 26(3):158-162.

Jetti RR, Balasubramanian M, Chidambaranathan AS, Srinivasan S. Evaluation of shear bond strength of feldspathic CAD/CAM ceramic with dentin using 2 bonding agents and 2 surface treatments-an in vitro study. J Clin Diagn Res. 2015;9(11):36-9.

Johansson C, Kmet G, Rivera J, Larsson C, Vult Von Steyern P. Fracture strength of monolithic all-ceramic crowns made of high translucent yttrium oxide-stabilized zirconia dioxide compared to porcelain-veneered crowns and lithium disilicate crowns. Acta Odontol Scand. 2014;72(2)145-53.

Jonathan, NG, Ruse D, Wyatt C. A comparison of the marginal fit of crowns fabricated with digital and conventional methods. J Prosthet Dent. 2014; 112(3):555-60.

Kalayci BB, Bayindir F. Güncel dental bilgisayar destekli tasarim/bilgisayar destekli üretim sistemleri. Atatürk Üniv Diş Hek Fak Derg. 2015;25(11):129-36.

Kalpana D, Harish G, Mahesh PC, Swati S, Madhuri V, Brunda K. CAD/CAM in dentistry-A review. International Journal of Research In Dentistry. 2015;5(2):14-21.

Kamposiora P, Papavasiliou G, Bayne SC, Felton DA. Predications of cement microfracture under crowns using 3D-Fea. J Prosthodont. 2001;9(4):201-9.

Kara D.Monolitik ve çift katmanlı zirkonya seramik kuronların kenar uyumlarının ve kırılmadirençelerinin in vitro olarak değerlendirilmesi. [Uzmanlık Tezi] Adana: Adana Menderes Üniversitesi; 2016.

Karaalioğlu OF, Yeşil Duymuş Z. Diş hekimliğinde uygulanan CAD/CAM sistemleri. Atatürk Üniv Diş Hek Fak Derg. 2008;18(1):25-32.

Karadağ G. Cad/Cam İle Üretilen Farkli Yapidaki İnley/Onley Materyallerinin Klinik Performanslarinin Değerlendirilmesi: 1 Yillik Takip. [Uzmanlık Tezi] Kirikale:Kirikkale Üniversitesi;2018.

Kaur I, Datta K. Cerec-the power of technology. J Indıan Prosthodont Soc. 2006;6(3):115-19.

Kelly JR, Benetti P. Ceramic materials in dentistry: historical evolution and current practice. Aust Dent J. 2011;56(1):84-96.

Kelvin Khng KY, Ettinger RL, Armstrong SR, Lindquit T, Gratton DG, Qian F. In vitro evaluation of the marginal integrity of CAD/CAM interim crowns. J Prosthet Dent. 2016;115(5):617-23.

Kern M. CAD/CAM Expands The Scope of Restorative Dentistry, Cosmetic Dentistry. 2009;4:1-5.

Khuller N, Sharma N. Biologic width: evaluation and correction of its violation. J Oral Health Comm Dent. 2009; 3(1): 20-25.

Koştur E. Farklı kalınlıklardaki CAD/CAM zirkonya, hibrit seramik ve rezin nano-seramik onleylerin kırılma dayanıklılıklarının in-vitro olarak karşılaştırılması [PhD thesis]. Ankara: Hacettepe Üniversitesi; 2016.

Kwon TK, Pak HS, Yang JH, Han JS, Lee JB, Kim SH, Yeo IS. Comparative fracture strength analysis of lava and digident CAD/CAM zirconia ceramic crowns. J Adv Prosthodont. 2013;5(2):92-7.

Ladha K, Verma M. Conventional and contemporary luting cements: An overview. J Indian Prosthodont Soc. 2010;10(2):79–88.

Lameira, DP, Silva WAB, Silva FA, Souza GM. Fracture strength of aged monolithic and bilayer zirconia-based crowns. BioMed Res Int. 2015; 1-7.

Lan TH, Liu PH, Chou MMC, Lee HE. Fracture resistance of monolithic zirconia crowns with different occlusal thicknesses in implant prostheses. J Prosthet Dent. 2016;115(1):76-83.

Li RWK, Chow TW, Matinlinna JP. Ceramic dental biomaterials and CAD/CAM technology: state of the art. J Prosthodont Res. 2014;58(4):208-16.

Lino Carracho JFPC.The Influence of Different Surface and Heat Treatments on The Biaxial Flexural Strength of Veneering Ceramics for Zirconia and Strength Reliability and Mode of Fracture of Veneering Ceramics/ Zirconia Core Ceramics. [PhD Thesis]. Portugal: University of Lisbon School of Dentistry; 2011.

Lowe RA. CAD/CAM Dentistry and Chairside Digital Impression Making [Internet].2008.[Accessed 5 December 2016]: https://www.yumpu.com.

Maghrabi AA. Reinforcement of fiber-reinforced composite crowns with variant margin designs. Pak Oral Dent J. 2010;30:264-8.

Magne P, Carvalho AO, Bruzi G, Giannini M. Fatigue resistance of ultrathin CAD/CAM complete crowns with a simplified cementation process. J Prosthet Dent. 2015;114(4):574-9.

Malament KA, Socransky SS. Survival of Dicor glass-ceramic dental restorations over 16 years. part III: effect of luting agent and tooth or tooth-substitute core structure. J Prosthet Dent. 2001;86(5):511-19.

Malament KA, Socransky SS. Survival of Dicor glass-ceramic dental restorations over 14 years: part I. survival of Dicor complete coverage restorations and effect of internal surface acid etching, tooth position, gender, and age. J Prosthet Dent 1999;81(1):23-32.

Mantri SS, Bhasin AS. CAD/CAM in dental restorations: An overview. Annu Esse Dent. 2010;2(3):123-8.

Michael F, Quinn F, O`Sullivan M. Single unit CAD/CAM restorations: a literature review. J Ir Dent Assoc . 2007; 53(1):38-45.

Miyazaki T, Hotta Y, Kunii J, Kuriyama S, Tamaki Y. A review of dental CAD/CAM: current status and future perspectives from 20 years of experience. Dent Mater J. 2009;28(1):44-56.

Miyazaki T, Hotta Y. CAD/CAM systems available for the fabrication of crown and bridge restorations. Aust Dent J. 2011;56:(1):97-106.

Mobaleghi T, Pournasiri E, Emadi M, Mobaleghi R. Advances in technicians on CAD/CAM restorations: A Review. Adv Biores. 2016;7(6):199-204.

Mormann WH. The evolution of the CEREC system. J Am Dent Assoc. 2006;137(9):7-13.

Mou SH, Chai T, Wang JS, Shiau YY. Influence of different convergence angles and tooth preparation height on the internal adaptation of Cerec crowns. J Prosthet Dent. 2002;87(3):248-55.

Nejatidanesh F, Amjadi M, Akouchekian M, Savabi O. Clinical performance of CEREC AC Bluecam conservative ceramic restorations after five years-a retropective study. J Dent. 2015;43:1076-82.

Nemane V, Akulwar RS, Meshram S. The effect of various finish line configurations on the marginal seal and occlusal discrepancy of cast full crowns after cementation – an in-vitro study. J Clin Diagn Res. 2015;9(8):18-21.

Nordahl N, Steyern PV von, Larsson C. Fracture strength of ceramic monolithic crown systems of different thickness. J Oral Sci . 2015;57(3):255-61.

Nugala B, Kumar BC, Sahitya S, Krishna PM. Biologic width and its importance in periodontal and restorative dentistry. J Conserv Dent. 2012;15(1): 12-7.

Otto T, Mormann WH. Clinical performance of chairside CAD/CAM feldspathic posterior shoulder crowns and endocrowns up to 12 years. Int Comput Dent. 2015;18(2):147-61.

Özdemir H, Aladağ L.Basamak Tipi Ve Koniklik Açısının Lityum Disilikat CAM Seramiklerin Baskı Dayanımına Etkisinin Değrlendirilmesi. J Dent Fac Atatürk Uni. 2018;28(4):545-52.

Ozer Z, Kurtoglu C, Mamedov AM, Ozbay E. Influence of crown margin design on the stress distribution in maxillary canine restored by all-ceramic crown: A finite element analysis. J Korean Dent Sci. 2015;8(1):1-8.

Palin W, Burke FT. Trends in Indirect Dentistry:8.CAD/CAM Technology. Dental Update. 2005;32:566-72.

Parasher P, Tarun P. Functioning of chairside CAD/CAM systems. J Adv Med Dent Sci Res. 2014;2(4):38-44.

Patill M, Kambale S, Patil A, Mujawar K. Digitalization in dentistry: CAD/CAM–A review. Acta Sci Dent Sci. 2018;2(1):12-16.

Paul J. Dental cements A Review to Proper Selection. Int J Curr Microbiol App Sci. 2015;4(2):659-69.

Pieger S, Salman A, Bidra AS. Clinical outcomes of lithium disilicate single crowns and partial fixed dental prostheses: A systematic review. J Prosthet Dent. 2014;112(1):22-30.

Porto T, Roperto R, Akkus A, et al. Mechanical properties and DIC analyses of CAD/CAM materials. J Clin Exp Dent. 2016;8(5):512-516.

Powers JM, Wataha JC. Dental materials properties and manipulation. 10^{th} Edition. USA: Linda Duncan; 2013;10:p80-7.

Pradies G, Zarauz C, Valverde A, Ferreiroa A, Martinez-Rus F. Clinical evaluation comparing the fit of all-ceramic crowns obtained from silicone and digital intraoral impressions based on wave front sampling technology. J Dent, 2015;43(2):201-8.

Prajapati A, Prajapati AN, Mody D R, Choudhary A B. Dentistry goes digital: a CAD-CAM way a review article. J Dent Med Sci. 2014;13(8):53-9.

Raghavan RN. Ceramics in Dentistry, Sintering of Ceramics. New Emer Tech. 2012;11;204-24

Rajan BN, Jayaraman S, Kandhasamy B, Rajakumaran I. Evaluation of marginal fit and internal adaptation of zirconia copings fabricated by two CAD/CAM systems: an in vitro study. J Ind Prosth Soc. 2015;15(2):173-8.

Rammelsberg P, Eickemeyer G, Erdelt K, Pospiech P. Fracture resistance of posterior metal-free polymer crowns. J Prosthet Dent. 2000;83(3):303-8.

Reich S, Petschelt A, Lohbauer U. The effect of finish line preparation and layer thickness on the failure load and fractography of Zro_2 copings. J Prosthet Dent. 2008;99(5):369-76.

Reich S, Schierz O. Chair-side generated posterior lithium disilicate crowns after 4 years. Clin Oral Invest. 2013;17:1765-72.

Rekow ED, Harsono M, Janal M, Thompson VP, Zhang G. Factorical analysis of variables influencing stress in all-ceramic crowns. Dent Mater. 2006;22(2):125-32.

Renne W, Wolf B, Kessler R, Pherson KM, Mennito AS. Evaluation of the marginal fit of CAD/CAM crowns fabricated using two different chairside CAD/CAM systems on preparations of varying quality. J Esthet Restor Dent. 2015;27(4):194-202.

Ricketts D, Bartlett D. Advanced operative dentistry. China: Churchill Livingstone Elsevier. 2011.

Rickman LJ, Satterthwaite JD. Considerations for the selection of a luting cement. Dental Update. 2010;37(4):247-56.

Ritzberger C, Apel E, Holland W, Peschke A, Rheinberger VM. Properties and clinical application of three types of dental glass-ceramics and ceramics for CAD-CAM technologies. Dent Mater J. 2010;3(6):3700-13.

Rocca GT, Daher R, Saratti CM, Sedlacek R, Suchy T, Feilzer AJ, Krejci I. Restoration of Severely Damaged Endodontically Treated Premolars: The influence of the endo-core length on marginal integrity and fatigue resistance of lithium disilicate CAD/CAM ceramic endocrowns. J Dent. 2018;68:41-50.

Rosenstiel SF, Land MF, Crispin BJ. Dental luting agents: A review of the current literature. J Prosthet Dent. 1998;80(3):280-301.

Sağlam G. Farklı restoratif materyaller ile üretilmiş endokronların marjinal uyumunun ve kırılma dayanımının değerlendirilmesi. [PhD thesis]. Zonguldak: Bülent Ecevit Üniversitesi; 2017.

Sagsoz NP, Yanikoğlu N, Sagsoz O. Effect of die materials on the fracture resistance of CAD/CAM monolithic crown restorations. Oral Health Dent Manag. 2016;15(3):165-8.

Saint-Jean SJ. Dental Glasses and Glass-ceramics. Advanced Ceramics for Dentistry**:** Elsevier; 2014; 255-277.

Sakaguchi RL, Powers JM. Craig's Restorative Dental Materials, USA: Elsevier Mosby; 2012: 13th Ed.

Sakoguchi K, Minami H, Suzuki S, Tanaka T. Evaluation of fracture resistance of indirect composite resin crowns by cyclic impact test :influence of crown and abutment materials. Dent Mater J Journal. 2013;31:433-40.

Sannino G, Germano F, Arcuri L, Bigelli E, Arcuri C, Barlattani A. Cerec CAD/CAM chairside system. J Oral Implantol. 2014;7(3):57-70.

Schmalz G, Arenholt-Bindslev D. Biocompatability of dental materials. Springer Berlin Heidelberg; 2009: p.184.

Schultheis S, Strub JR, Gerds TA, Guess PC. Monolithic and bi-layer CAD/CAM lithium-disilicate versus metal-ceramic fixed dental prostheses: comparison of fracture load and failure modes after fatigue. Clin Oral Invest. 2013;17(5):1407-13.

Şen N, Tuncelli B. CAD/CAM restorasyonlarının üretimi için kullanılan materyaller. Turk Klinik Dis Hek Bili Derg. 2017;23(2):109-15.

Shahrbaf S, Noort RV, Mirzakouchaki B, Ghassemieh E, Martin N. Fracture strength of machined ceramic crowns as a function of tooth preparation design and the elastic modulus of the cement. Dent Mater. 2014;30(2):234-41.

Sharma A, Rahul GR, Soorya T, Shetty K. Short clinical crowns-treatment considerations and techniques. J Clin Exp Dent. 2012; 4(4): 230-6.

Shembish FA, Hui Tong, Kaizer M, Malvin NJ, Thompson VP, Opdam NJ, Zhang Y. Fatigue resistance of CAD/CAM resin composite molar crowns, Dent Mater. 2016;32(4):499-509.

Shillingburg, Herbert T. Fundamentals of Fixed Prosthodontics. Quintessence Publishing Co, Inc:2012.

Silva LH, Lima E, Miranda RBP, Favero SS, Lohbauer U, Cesar PF. Dental ceramics: a review of new materials and processing methods. Braz Oral Res. 2017;31:131-46.

Sorrentino R, Triulzio C, Tricarico MG, Bonadeo G, Gherlone EF, Ferrari M. In vitro analysis of the fracture resistance of CAD-CAM momolithic zirconia molar crowns with different occlusal thickness. J Mech Behav Biomed Mater. 2016;61:328-33.

Sreedevi S, Sanjeev R, Rekha R, Anna A, Rajamani T, Govind GK. An in vitro study on the effect of post-core design and ferrule on the fracture resistance of endodontically treated maxillary central incisors. J Int Oral Health. 2015; 7(8): 37-41.

Susic I, Travar M, Susic M. The application of CAD/CAM technology in dentistry. IOP Conference Series: Materials Science and Engineering. 2017;200:1-12.

Taneva E, Kusnoto B, Evans CA. Issues in contemporary orthodontics. 3rd ed. Edited by Farid Bourzgui; 2015. Chapter 9, 3D scanning, imaging, and printing in orthodontics.

Tapia L, Lebon N, Mawussi B, Fron-Chabouis H, Duret F, Attal JP. Understanding dental CAD/CAM for restorations–the digital workflow from a mechanical engineering viewpoint. Mater Sci Eng. 2015;18(1):21-44.

Thompson VP, Rekow DE. Dental ceramics and the molar crown testing ground. J Appl Oral Sci. 2004;12:26-36.

Tiu J, Al-Amleh B, Waddell JN, Duncan WJ. Clinical tooth preparations and associated measuring methods: A systematic review. J Prosthet Dent.2015;113(3):175-84.

Tsitrou EA, Helvatjoglu AM, Van Noort R. A preliminary evaluation of the structural integrity and fracture mode of minimally prepared resin bonded CAD/CAM crowns. J Dent. 2010;38(1):16-22.

Türkoğlu P, Bultan Ö, Öngül D. Factors affecting strength of all-ceramic restorations. İstan Üniver Dişh Fak Derg. 2010;44(1):45-53.

Tutal Z, Yamaner ID, Tuncer EB. Dental seramiklerin tarihsel gelişimi. J Dent Fak Ataturk Uni. 2015; 10: 157-66.

Ueda Y, Yamaguchi T. History and current situation regarding dental CAD/CAM systems and future perspectives. Hokkaido J Dent Sci. 2017;38:104-10.

Vichi A, Ferrari M, Davidson CL. Influence of ceramic and cement thickness on the masking of various types of opaque posts. J Prosthet Dent. 2000;83(4):412-7.

Vurgeç OR. Farklı içerikli CAD/CAM freze lamine onaylandı venerlerin iki siman aralığında kırılma dayanımlarının karşılaştırılması. [Uzmanlık Tezi]. Erzrum: Atatürk Üniversitesi ;2016.

Wendler M, Belli R, Petschelt A, Mevec D, Harrer W, Lube T, Danzer R, Lohbauer U. Chairside CAD/CAM materials. Part 2: flexural strength testing. Dent Mater. 2017;33(1):99-109.

Weyhrauch M, Igiel C, Scheller H, Weibrich G, Lehmann KM. Fracture strength of monolithic all-ceramic crowns on titanium implant abutments. Int J Oral Maxillofac Imp. 2016;31(2):304-9.

Whitton A, Qasim T, Ford C, Hu XZ, Bush M. The role of skirt geometry of dental crowns on the mechanics of failure: experimental and numerical study. Med Eng Phys . 2008;30:661-8.

Yalim BB, Türker ŞB. Klinikte tam seramik sistemler. J Dent Fac Atatürk Uni. 2012;5:76-90.

Yeğin E. İmplant üstü kronlarda CAD/CAM ile üretilen farklı materyallerin kırılma dayanımlarının ve implanta ilettiği kuvvetlerin değerlendirilmesi. [Üzmanlık Tezi].Bolu: Abant İzzet Baysal Üniversitesi; 2017.

Yeshwante B, Nazishbaig Babita, Deshpande S, Patil S, Makanikar S, Bhandari S. Dental CAD/CAM: A systematic review. Int J Appl Dent Sci. 2016;2(3):105-9.

Yucel MT, Yondem I, Aykent F, Eraslan O.influence of the supporting die structures on the fracture strength of all-ceramic materials. Clin Oral Invest. 2012;16:1105-10.

Zahran M, El-Mowafy O, Tam L, Watson PA, Finer Y. Fracture strength and fatigue resistance of all-ceramic molar crowns manufactured with CAD/CAM technology. J Prosthodont. 2008;17(5):370-7.

Zahran M. Factors Affecting the Fracture Strength and Fatigue Resistance of Molar Crowns Produced Using a Zirconia-based System . [PhD thesis]. Canada: University of Toronto ;2013.

Zarina R, Jaini JL, Raj RS. Evaluation of the software and hardware in CAD/CAM systems used in dentistry. Int J Prev Clin Dent Res. 2017;4(4):284-91.

Zhang Z, Sornswan T, Rungsiyakull C, Li W, Li Q, Swain MV. Effects of design parameters on fracture resistance of glass simulated dental crowns. Dent Mater. 2016;32(3):373-84.

Zidan O, Ferguson GC. The retention of complete crowns prepared with three different tapers and luted with four different cements. J Prosthet Dent. 2003;89(6):565-71.

Zimmermann M, Eglı G, Zaruba M, Mehl A. Influence of material thickness on fractural of CAD/CAM fabricated ceramic crowns. Dent Mater J. 2017;36(6):778-83.

Ɵilo M, Kvam K, Gjerdet NR. Load at fracture of monolithic and bilayered ziconia crowns with and without a cervical zirconia collar. J Prosthet Dent. 2016;115(5):630-6.

Ɵilo M, Kvam K, Gjerdet NR. Simulation of clinical fractures for three different all-ceramic crowns. Eur J Oral Sci. 2014;122(3):245-50.

ÖZGEÇMİŞ

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EKLER

EK1.Tez Orijinallik Raporu

T.C.
VAN YÜZÜNCÜ YIL ÜNİVERSİTESİ
Sağlık Bilimleri Enstitüsü

DOKTORA TEZİ ORİJİNALLİK RAPORU

Tarih: 12/04/2019

Tez Başlığı / Konusu: CAD/CAM Restorasyonlarında Farklı Basamak Genişliklerinin Dayanım Üzerine Etkisinin İncelenmesi.

Yukarıda başlığı/konusu belirlenen tez çalışmamın Kapak sayfası, Giriş, Ana bölümler ve Sonuç bölümlerinden oluşan toplam 180 sayfalık kısmına ilişkin, 12/04/2019 tarihinde şahsım/tez danışmanım tarafından TURNITIN intihal tespit programından aşağıda belirtilen filtreleme uygulanarak alınmış olan orijinallik raporuna göre, tezimin benzerlik oranı % 17 (on yedi) dır.

Uygulanan filtreler aşağıda verilmiştir:

- Kabul ve onay sayfası hariç,
- Teşekkür hariç,
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- Alıntılar hariç,
-Tezden çıkan yayınlar hariç,
- 7 kelimeden daha az örtüşme içeren metin kısımları hariç (Limit match size to 7 words)

Van Yüzüncü Yıl Üniversitesi Lisansüstü Tez Orijinallik Raporu Alınması ve Kullanılmasına İlişkin Yönergeyi inceledim ve bu yönergede belirtilen azami benzerlik oranlarına göre tez çalışmamın herhangi bir intihal içermediğini; aksinin tespit edileceği muhtemel durumda doğabilecek her türlü hukuki sorumluluğu kabul ettiğimi ve yukarıda vermiş olduğum bilgilerin doğru olduğunu beyan ederim.

Gereğini bilgilerinize arz ederim.

Lana Bahram Khidher
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