COMPARATIVE EVALUATION OF FRACTURE STRENGTH OF
CAD/CAM ANTERIOR FPD FRAMEWORK MADE WITH
ZIRCONIA AND PEEK CEMENTED USING RESIN CEMENT
– AN IN-VITRO STUDY.

A Dissertation submitted to
THE TAMILNADU Dr.M.G.R. MEDICAL UNIVERSITY
in partial fulfilment for the degree of
MASTER OF DENTAL SURGERY

BRANCH – I
PROSTHODONTICS AND CROWN & BRIDGE
2017-2020
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Jeevitha Mani

Post Graduate Student
PURPOSE OF THE STUDY:

Introduction of Zirconia in dentistry has expanded the possible application of metal free ceramic restoration with great success and reliability. Among the clinical complications of Zirconia FPD’s, crown/connector fractures are reported most commonly. As PEEK (Polyetheretherketone) is high performance polymer, with low modulus of elasticity resulting in shock absorbing effect which makes it less prone to fracture. Fracture strength of Zirconia is well known, hence this study aimed to evaluate the fracture strength of PEEK and compare it with Zirconia.

AIM AND OBJECTIVE:

This study aimed to comparatively evaluate the fracture strength of Computer Aided Designing, Computer Aided Manufacturing, 3-unit anterior Zirconia and PEEK framework.

MATERIALS AND METHOD:

Prefabricated prepared teeth model for 3-unit anterior FPD in relation to 21,22 & 23 was obtained and scanned using 3 Shape, Trios intraoral scanner and a metallic die was milled using base metal alloy. The metallic die was scanned using the same Intra oral scanner (3 shape, Trios). Five, 3-unit CAD/CAM Zirconia (Group A) and five, 3-unit PEEK (Group B) frameworks were fabricated and cemented to the metallic die using resin cement. A universal testing machine was used for the fracture strength evaluation. The load was applied to the specimen at a crosshead speed of 0.5mm/min until catastrophic failure occurred. This was repeated for all the FPD framework and the fracture strength mean value was recorded and statistically analyzed through Unpaired Student t-test.

RESULT:

The mean fracture strength of CAD/CAM Zirconia is 1862 N ±18.8149 N and the mean fracture strength of CAD/CAM PEEK is 2563 N ±19.7231 N. Fracture strength of CAD/CAM PEEK framework was higher than that of CAD/CAM Zirconia framework. The values were statistically significant by 1% (p value < 0.01).

CONCLUSION:

Since PEEK showed a significantly higher fracture strength value compared to Zirconia, it could be an alternative metal free, esthetic material for replacing missing anterior teeth.

KEYWORDS: Fixed partial denture, Zirconia, Polyetheretherketone, Fracture strength
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LIST OF ABBREVIATIONS

1. CAD/CAM - Computer Aided Designing, Computer Aided Manufacturing
3. FPD - Fixed Partial Denture
4. HPP - High Performance Polymer
5. PAEK - Polyaryletherketone
6. PEEK - Polyetheretherketone
7. PSZ - Partially Stabilized Zirconia
8. Y-TZP - Yttria-Stabilized Tetragonal Zirconia Polycrystal
10. ZrO₂ - Zirconium Oxide
11. ZTA - Zirconia Stabilized Alumina
Introduction
INTRODUCTION

A missing tooth is a common condition in clinical dentistry. The replacement of missing tooth in the anterior region is challenging because of the soft and hard tissue, esthetic, phonetic, functional, and occlusal requirements. The prosthetic options for replacement of missing anterior teeth are Resin-bonded Fixed Partial Dentures, Conventional Fixed Partial Dentures (FPDs), Removable Partial Dentures, and Implant-supported Fixed Prosthesis. The demand for esthetics in fixed prosthodontics has led to development of new materials. The permanent materials most commonly used for restoration of anterior teeth are Metal ceramic and All ceramic. Metal-ceramics cause “graying” of the gingival margin because of metal show through and have the potential to cause allergic or toxic reactions within the soft or hard tissues\(^1\). Use of these materials, have resulted in the development of metal free alternatives that is All ceramic restoration and more recently PEEK to restore the missing anterior teeth.

All ceramic crown like IPS Empress & e-max provide good esthetics but lack strength when used for FPD’s. Zirconia crowns has been used since 1960’s. Yttria-stabilized Tetragonal Zirconia Polycrystal (3Y-TZP) has been used for its high strength and good reliability. All ceramic crowns can be Monolithic or Bilayered. Bilayered restorations are used to replace teeth in esthetic region where the core is fabricated using Alumina, Zirconia, Zirconia toughened Alumina, Magnesium Aluminate Spinel and Lithium silicate. Once the core is fabricated, veneering porcelain are applied to the core to create the final esthetic restoration. The most common failure of these bilayered crowns and bridges are fracture of the veneering ceramic from its core\(^2\). Before the advent of silanation, all-ceramic FPD failures were also attributed to a lack of adhesion to the underlying tooth substance. Silanation provided a means by which a chemical bond between etched porcelain and the
tooth could be achieved. Monolithic crowns are made up of alternative ceramics like monolithic lithium disilicate which showed lower fracture strength than those made of monolithic Zirconia. Fabricating mono-block restorations from pure Zirconia (full contour Zirconia crowns) could increase the mechanical stability, expand the range of indications and also provide a higher reliability and sustain loading². But from the esthetic point of view, they are still inferior to their lithium disilicate in spite of adequate staining. Therefore, their indication range is limited to posterior single crowns and short span FDP’s.

PEEK is a viable alternative to Zirconia full contour crowns, which could not only be able to resist occlusal loading but also provide good esthetics when used for an anterior esthetics. Polyetheretherketone (PEEK) is a sulfonated aromatic high-temperature thermoplastic material with very high mechanical strength. It is highly inert, resistant to chemical erosion, exhibits bone like flexibility and withstands high temperature. It is also non-allergic and has low plaque affinity. PEEK is widely accepted as a biomaterial and is an excellent substitute of bone⁴. Apart from physiological properties, its esthetic properties such as proximity to natural teeth color, radiolucency, rigidness and light weight makes it the perfect choice for dental restorations.

PEEK is used widely in CAD/CAM manufacturing for dental implants, provisional abutments, implant-supported bars, framework for removable prostheses, and fixed dental prosthesis⁵. When used in Fixed partial denture the PEEK framework is layered with microfilled veneering composite resin. At first the opaque paste of selected shade is applied on the framework and then light cured for 10 minutes, followed by layering with deep dentin shade and subsequently with dentin body and incisal shades with periodic curing after each application⁶.

Studies evaluating the mechanical properties of PEEK are limited in literature. Till date there only few studies regarding the fracture strength of PEEK. An in-vitro study on
“Fracture strength of three-unit implant supported fixed partial denture with excessive crown height fabricated from different materials” where they compared Zirconia and PEEK material in posterior tooth region\(^7\). There is no scientific information available regarding the fracture strength of anterior FPD framework made with Zirconia and PEEK.

This study aimed to comparatively evaluate the fracture strength of three-unit anterior CAD/CAM FPD framework made with Zirconia and PEEK cemented to metal die with resin cement. The Null hypothesis of the present *in-vitro* study is that there would be no significant difference in fracture strength of CAD/CAM anterior FPD framework made with Zirconia and PEEK.
Aim & Objectives
AIM AND OBJECTIVES

AIM

Aim of this study is to comparatively evaluate the fracture strength of CAD/CAM anterior three unit FPD framework made with Zirconia and PEEK.

OBJECTIVES

1. To evaluate the fracture strength of CAD/CAM anterior three-unit Zirconia framework bonded with resin cement to metal die

2. To evaluate the fracture strength of CAD/CAM anterior three-unit PEEK framework bonded with resin cement to metal die

3. To compare the fracture strength of CAD/CAM anterior three unit FPD framework made with Zirconia and PEEK.
GENERAL REVIEW

ZIRCONIA

Zirconium is an elemental metal with an atomic number of 40. Zirconium oxide has been in use since 1960. The word Zirconium is derived from Persian word “Zargun” which means golden in color. Pure Zirconia is a polymorphic material that present in three phases depending on the temperature, Monoclinic (from room temperature to 1170°C), Tetragonal (from 1170°C to 2370°C) and cubic (temperatures above 2370°C). Out of these three phase, it is in tetragonal phase, the ceramic with improved mechanical properties is obtained.

When cooled after sintering, this material undergoes volume expansion of 3% to 5%, which is related to the transition from tetragonal to monoclinic phase. Hence pure Zirconia cannot be used without stabilization. Many stabilization oxides such as Calcium (CaO), Magnesium (MgO), Yttrium (Y₂O₃), or Ceria (CeO₂) can be added to Zirconia to stabilize the tetragonal phase at room temperature. The addition of varying amounts of stabilizer allows the formation of partially or fully stabilized Zirconia. A fully stabilized Zirconia is obtained by adding sufficient amount of stabilizing oxides such as 16mol% of MgO, 16mol% of CaO or 8mol% Yttria (Y₂O₃) and they have a cubic phase. Partially stabilized zirconia is obtained when same oxides are added in smaller amount, that is 2 to 3 mol% Yttria and they have a multiphase structure.

Of the all-ceramic materials available, Yttria-stabilized tetragonal zirconia polycrystal (Y-TZP) exhibit the greatest fracture strength in dental restorations. The most attractive property of 3Y-TZP is that it undergoes “transformation toughening”. This mechanism is primarily responsible for preventing the crack formation and propagation. Crack formation occurs when stress is applied to the surface of PSZ. Energy is created by the stress and this stimulates a phase transformation from the tetragonal to the monoclinic crystalline structure.
in the material leading the fracture. This phase shift results in volumetric expansion which places pressure on the crack, making it harder to propagate and contributes to PSZ’s toughness and fracture resistance. The discovery of PSZ’s transformation toughening expanded its use to the machining industry due to its mechanical properties such as favorable chemical and dimensional stability, mechanical strength and toughness, and Young’s modulus similar to stainless steel alloys.

In 1969, orthopedics research and development began to look at zirconia as a potential replacement for titanium and alumina ball heads in Total Hip Replacements. Such use as a biomaterial launched studies to investigate its biocompatibility and potential cytotoxic properties.

In vitro studies since 1990’s has demonstrated the biocompatibility of Zirconia when implanted into bone or muscles of various animal species. Those studies have confirmed ZrO₂ is not only non-cytotoxic, but creates less inflammatory infiltrate, micro vessel density, and vascular endothelial growth factor expression than titanium. Some caution was given to the utilization of ZrO₂ in an acidic environment, such as the oral cavity, due to the release of zirconium and yttrium ions. Further investigations have determined that the ion release was due to zirconium hydroxide, which is eliminated after sintering and allowing the safe application of solid zirconia’s use in dentistry.

Although PSZ had been used as a ceramic biomaterial in medicine starting in the 1970s, its utilization in dentistry did not start until the early 1990s. Zirconia-toughened alumina (ZTA) and yttrium stabilized tetragonal zirconia polycrystals (3Y-TZP) slowly became popular in dentistry. 3Y-TZP is widely used now a day. It has a fracture toughness from 5 to 10MPa and a flexural strength of 900-1400MPa, exhibits better fracture resistance compared to all other dental ceramics.
The use of 3Y-TZP in dentistry has been made possible by CAD/CAM technology and a milling machine’s ability to cut a zirconia block into the desired final form\textsuperscript{10,11,12}. Milling of zirconia is done in one of three block states: green, pre-sintered and fully sintered. The green state describes the zirconia in a chalk-like form by which the 3Y-TZP powder has been added to a binder and condensed by cold isostatic pressing into the form of a block. This block can then be pre-sintered, where heat is applied slowly, eliminating the binder and enhancing the hardness and machinability. A final heat treatment develops the definitive mechanical properties and dimension of the 3Y-TZP.

The fabrication of a full contour restoration or coping can be completed in two ways using CAD/CAM technology: soft milling or hard milling. Soft milling involves either machining an enlarged form of the final product from a homogenous green block or a partially sintered block. 3Y-TZP shrinks 20-25\% during the sintering process, this shrinkage must be accurate to assure an accurate fit. Hard milling is machining of the final product from a fully sintered zirconia block. The drawback of hard milling is the wear and tear on the milling tools and potential for incorporation of unwanted defects in the zirconia during machining.

The properties that favor its use in dentistry are biocompatibility, low thermal conductivity, resistance to corrosion and aesthetics. Previously Y-TZP crowns have been used only for posterior restorations since they were less translucent and was available in only opaque white color. For anterior restoration the Y-TZP core material is veneered with alternative ceramic for better esthetics(bilayered).

The strength of the core material in Y-TZP crowns is excellent but the fracture of the veneering material occurred most often which lowered their success rates. To overcome this monolithic crowns were introduced. Previously monolithic crowns were made up of glass-
ceramics like lithium-disilicate and have shown improved strength and indicated for both anterior and posterior restorations. Recently Y-TZP materials with improved translucency (by altering the microstructure) and color options have been introduced making the monolithic Y-TZP restoration a possible treatment option. Monolithic crowns offer other advantages such as reduced production time, improved cost-effectiveness, requires a minimally invasive tooth preparation. Restorations made from Y-TZP materials can likely be made thinner than glass-ceramic restorations as the strength of Y-TZP exceeds that of glass-ceramics. Nevertheless, all monolithic or full countered Zr are used only in posterior crown & FPD’s only due to their inferior esthetic properties.

**PEEK**

Polyetheretherketone (PEEK) is a synthetic, aromatic, semi crystalline, linear, radiolucent, rigid, sulfonated aromatic, high-temperature thermoplastic tooth colored polymeric material. It belongs to the family polyaryletherketone (PAEK). In 1978 it was developed by a group of English scientists. After which PEEK was commercialized for industrial applications. At the end of 1990s, PEEK became an important high-performance thermoplastic material for replacing metal implant components in vertebral surgery.

Introduction of carbon fiber reinforced PEEK (CF/PEEK), a new composite material was used for fracture fixation and femoral prosthesis in artificial hip joints. It is synthesized from aromatic dihalides and biphenolate salts via nucleophilic substitution. PEEK are amorphous and produced in three viscosity grades (high, medium and low) based on the same basic formula (- C6H4—O-C6H4—O- C6H4—O-)n. Aromatic rings make PEEK resistant to mechanical forces and thermal and oxidative attacks, which made PEEK an attractive biomaterial for medical use, especially due to its ability to be sterilized by radiation, heat, steam, gamma and ethylene oxide without structural damage.
PEEK can be modified either by pre-polymerization (by adding functional monomers) or post-polymerization (modifications by chemical processes such as sulphonation, amination and nitration. For example, its properties can be altered to suit the biological demand by addition of others materials such as carbon fibers (carbon fiber reinforced/ CFR-PEEK) and ceramic micro-particles fillers (Bio-HPP). For example, the modulus of elasticity of PEEK is about 3.6 GPa, by reinforcing it with carbon fibers (CFR-PEEK), the modulus value can be increased up to 18 GPa to match that of cortical bone. Similarly, BioHPP (High Performance polymer) which contains about 20% ceramic filler particles with grain size 0.3μm to 0.5μm dispersed in PEEK polymer matrix. Due to the very small grain size of the ceramic particles, constant homogeneity can be produced which accounts for the excellent mechanical properties of these materials.

Tensile properties of PEEK are also analogous to those of bone, enamel and dentin, making it a suitable restorative material. From the biomechanical point of view, PEEK materials can be considered superior to other implant biomaterials due their young’s modulus value being in closest proximity to bone than any other material. In recent years, PEEK is modified at the nano-level to improve its bioactivity and Osseo conductive properties. They flex iso-elastically with bone which may result in homogeneous distribution of load, minimal stress shielding effect and prevention of stress concentration.

Their close proximity to natural teeth color imparts good aesthetic properties and make them suitable for use in anterior segments of jaw. Kistler et al., in their research works have shown that Bio HPP is extremely resistant to abrasion and has excellent color stability and anti-discoloration properties. Their insolubility in water and the low reactivity to other materials makes them particularly suitable for use in patients with metal allergies.
PEEK materials are also amenable to CAD-CAM technology. PEEK dental implants are radiolucent in nature and their radiolucency can of considerable benefit to patients who has to undergo MRI scan as it will result in fewer artifacts during imaging. The versatility of this material in the medical field in long-term implantation includes artificial cranial plates, components of finger and knee joints, and intervertebral bodies (spine implants). It has been used in the field of orthopedic surgeries since the 1980s. Its use in dentistry started after its wide acceptance in the medical field.

In dentistry, PEEK has been explored as a material in a number of applications including dental implants, provisional abutments for implant-supported prosthesis, implant supported bars, removable partial dentures\textsuperscript{17} and fixed dental prostheses. Furthermore, different dental PEEK presentations allow the manufacture process of dental prostheses by both milling and lost wax techniques.

Despite having desirable mechanical properties for dental prosthesis, PEEK does not meet the aesthetic requirements because of their opaque nature and unaesthetic color it cannot be used as a milled monolithic restoration. It can however be used as a core material on which layering can be done with suitable veneering composite after treating the surface in some ways.

To improve the adhesion of PEEK to veneering resins and cements, the PEEK surface requires treatment since it has low surface energy\textsuperscript{18,19}. Sandblasting is one efficient method for modifying the surface morphology of materials like metals and polymers. Other options for surface morphology modification are grit blasting with 50 micron or 150-micron alumina particles with or without silica coating, tribochemical silica-coating and chemical attack. Due to the high resistance of PEEK to chemical agents, 9.5% hydrofluoric acid (HF) is not effective for altering surface morphology. Manufacturer’s instructions suggest that chemical
attack on the PEEK surface is possible with 40% HF or 40% sulfuric acid, 30–50% nitric acid, formic acid, and chlorosulfonic acid. These substances are highly toxic and considered as high risk for dental office use. It has been observed that etching with sulfuric acid for 60–90 sec can exhibit shear bond strength to resin composite cements as high as 15.3 ± 7.2 MPa after being stored in water for 28 days at 37°C. Etching with Piranha acid along with a bonding agent have shown to produce tensile bond strength to composite resin as high as 23.4 ± 9.9 MPa. The above mentioned data’s and studies suggest that PEEK can be used under resin-composite as a coping material.

Next is the inner surface treatment which has to be done for better adhesion to tooth surface. Till date no established protocol was developed force cementing single crowns or fixed dental prosthesis using a PEEK infrastructure. The manufacturer’s recommended cementation protocol is to produce roughness using diamond burs on the inner surface followed by acetone degreasing prior to luting system application; however, this protocol is difficult to standardize.

The mechanical properties of PEEK are similar to dentin and enamel and hence PEEK can have advantage over alloy and ceramic restorations. CAD-CAM makes it possible to produce dental prostheses chair-side\textsuperscript{20}. Three-unit PEEK fixed partial denture manufactured via CAD-CAM have a higher fracture resistance than pressed granular or pellet-shaped PEEK dentures.

The fracture resistance of the CAD-CAM milled PEEK fixed dentures is 2354N much higher than those of lithium disilicate glass-ceramic (950N), alumina (851N), zirconia (981-1331N). The abrasive properties of PEEK are excellent and are competitive with metallic alloys. Considering good abrasion resistance, mechanical attributes and adequate bonding to composites and teeth, a PEEK fixed partial denture can be expected to have a
good survival rate. There are no clinical data on PEEK’s abrasion with other materials such as metal alloys, ceramics, dentin or enamel.

Other properties are,

Table 1: PROPERTIES OF PEEK

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<tr>
<td>Flexural modulus</td>
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Review of Literature
Ahmed (2010) evaluated the influence of different surface treatment and luting agent to zirconia ceramics. The surface treatments included airborne particle abrasion, silica coating, silica coating followed by silane application. He concluded that silica coating and silane application improved tensile bond strength compared to silica coating or airborne particle abrasion.

Florian Beuer et al., (2011) did a study to evaluate the in-vitro performance of full-contour zirconia single crowns. He concluded that the polished full-contour showed significantly higher light transmission than the other groups. Polished full-contour exhibited significantly less contact wear at the restoration and higher contact wear at the antagonist. Glazed full-contour zirconia also showed contact wear at the antagonist compared to veneering technique. Conventional veneered crowns showed significantly lower load-bearing capacity.

Yu-sung Choi et al., (2012) did an in-vitro study to evaluate the fracture strength of zirconia restoration veneered with various ceramic materials. Various ceramic materials used are zirconia coping veneered with feldspathic porcelain by layering technique, the glass ceramic heat pressed on zirconia coping and CAD/CAM fabricated glass ceramic by sintering technique. They concluded that the zirconia crowns veneered with CAD/CAM generated glass ceramic by the sintering technique are superior than the other materials tested.
Taek-ka kwon et al., (2013)\textsuperscript{24} conducted a study to compare the fracture strengths of two computer-aided design/computer-aided manufacturing (CAD/CAM) zirconia crown system: Lava and Digident. The results obtained in this study demonstrated that Digident CAD/CAM system provided a core with lower flexural strength than did the Lava CAD/CAM system which showed poor fracture strength where crowns including both the veneering porcelain and the core fractured completely.

Deborah Pacheco et al., (2015)\textsuperscript{25} conducted a study to evaluate the fracture strength of aged monolithic and bilayered zirconia based crowns. For this Yttria tetragonal zirconia polycrystal (Y-TZP) monolithic crowns of 1.5mm thickness and bilayered crowns of 0.8mm coping and 0.7mm porcelain veneer was fabricated and tested. It was reported that the monolithic zirconia crowns present higher fracture strength than bilayer veneered zirconia crowns after aging.

Tonino traini et al., (2015)\textsuperscript{26} conducted a study to evaluate the fracture strength of zirconia and alumina ceramic crowns and also the mechanism of failure through fractographic analysis of single all-ceramic crowns supported by implants. They reported that the metal ceramic restorations have higher fracture strength than PEEK. They also stated that the sandblasting procedure of zirconia core showed to be effective for improving adhesion at the interface between zirconia and ceramic.

Niklas Nordahl et al., (2015)\textsuperscript{27} conducted a study to evaluate the fracture strength of ceramic monolithic systems of different thickness. Strength of high-translucent (HTZ), low-translucent (LTZ) zirconia and glass-ceramic (LDS) crowns. HTZ and LTZ crowns were
made with thickness of 0.3 mm, 0.5 mm, 0.7 mm, 1.0 mm, and 1.5 mm, and LDS crowns of 0.1 mm and 1.5 mm thicknesses. According to this study, there is no difference in strength between crowns made of high or low-translucent zirconia. Strength of the crown made of zirconia crowns was significantly greater than that of lithium disilicate crowns. The load at fracture decreased from thicker to thinner within the same material for all groups.

Vahideh Nazari et al., (2016) conducted a study to compare the fracture strength of three-unit implant supported fixed partial dentures with excessive crown height fabricated from three different materials. Materials include zirconia nickel-chromium alloy (Ni-Cr) and polyetheretherketone (PEEK). In this study all the above mentioned materials are capable of withstanding the bite force in molar region with excessive crown height. They also concluded that metal ceramic restorations have higher fracture strength than PEEK.

Regina Furbino Villefort Rocha et al., (2016) conducted a study to evaluate the effect of surface treatment and bonding of the Polymer Polyetheretherketone (PEEK) to Human dentin. The various surface treatment includes silica coating, sandblasting with 45 micrometer Al2O3 particles, etching with 98% sulfuric acid for 5, 30 and for 60 seconds. It was concluded that none of the tested surface treatments was able to improve adhesion between PEEK and resin cement.

Sung Joon Kwon et al., (2017) did a comparison study on mechanical properties of translucent zirconia and lithium disilicate. Crowns made of 5Y-ZP, 3Y-TZP and lithium disilicate were used in this study. They stated that 5Y-ZP has a flexural strength and translucency parameter intermediate to 3Y-TZP and lithium disilicate. Both short and long
Long-term bond strength of 3Y-TZP and 5Y-ZP were similar to lithium disilicate. 5Y-ZP demonstrated no measurable material wear and opposing enamel wear similar to that of all other materials tested.

Fahad Bakitian et al., (2017)\textsuperscript{31} conducted a study to evaluate the fracture strength of veneered translucent zirconium oxide crowns with different porcelain thickness. 0.5mm thickness of zirconium oxide coping and 2.5, 2.0, 1.0, 0.8, 0.5 and 0.3mm thickness of porcelain was tested in this study. It was stated that Fracture strength of micro-veneered crowns with a layer of porcelain (0.3 mm) is lower than that of traditionally veneered crowns.

Mohammed M Gad et al., (2018)\textsuperscript{32} did a study to evaluate the effect of zirconium oxide nanoparticles addition on the optical and tensile properties of poly methyl methacrylate denture base material. They concluded that the addition of nano-ZrO\textsubscript{2} increased the tensile strength of the denture base acrylic. Increase in strength was directly proportional to the nano-ZrO\textsubscript{2} concentration. But PMMA translucency reduced as the nano-ZrO\textsubscript{2} increased.

Deyar Jallal Hadi Mahmood et al., (2018)\textsuperscript{33} conducted a study to evaluate the Fracture load of colored and non-colored high translucent zirconia three-unit fixed dental prosthesis frameworks. They conclude that the coloring of translucent zirconia FDP frameworks using brush infiltration technique may decrease fracture load. Coloring with immersion infiltration technique does not appear to affect fracture load. Fracture mode does not appear to be influenced by coloring.
Carlos Lopez et al., (2018) evaluated the effect of thermomechanical and static loading on the load to fracture of metal-ceramic, monolithic and veneered zirconia posterior fixed partial dentures. They concluded that all tested groups demonstrated clinically acceptable load to fracture values and zirconia monolithic group exhibited the highest fracture resistance values among the zirconia groups independent of the type of pre-loading. They also stated that Thermomechanical loading did not affect the load to fracture of veneering ceramic or the total fracture of the metal-ceramic and veneered zirconia groups, but it reduced the load to fracture of the monolithic zirconia group.

Paul Weigl et al., (2018) conducted an in-vitro study to evaluate the performance and fracture strength of thin monolithic zirconia crowns. Crown with thickness of 0.2 mm and 0.5 mm were milled from zirconia for the study. He concluded that 0.5 mm thick monolithic crowns possessed sufficient strength to endure physiologic performance and fracture strength of the 0.2 mm cemented crowns showed too low for clinical application.

Abdullah Saeed Alayad et al., (2018) evaluated the influence of various Y-TZP thicknesses and veneer firing cycles on the strength of two ceramic veneers. For this Y-TZP cores of 0.5, 1.0, and 5.0 mm thickness were prepared followed by sintering. The two ceramic system are Vita VM9 and e.max. The results of this study showed that in bilayered zirconia specimens, different zirconia thicknesses (0.5, 1.0, 5.0 mm) and veneer firing cycles for Vita VM9 and e.max ceramics failed to show any significant influence on their biaxial flexural strengths.
Saadet Saglamatsu et al., (2018)\textsuperscript{37} did a study to evaluate the fracture resistance of zirconia, titanium and ceramic reinforced polyetheretherketone implant abutments supporting CAD/CAM monolithic disilicate ceramic crown. The ceramic reinforced PEEK abutments had the potential to withstand maximum anterior occlusal forces and also showed better fracture pattern than zirconia abutments. He concluded that ceramic reinforced PEEK abutments may be an alternative to zirconia abutments with a titanium base for single-implant restorations in the anterior region.

Zainab M Jassim et al., (2018)\textsuperscript{38} did an in-vitro study to evaluate and compare the fracture strength of monolithic crowns fabricated from five different all ceramic CAD CAM material. Materials tested include lithium disilicate, zirconia, reinforced composite, hybrid dental ceramics. The highest fracture strength was recorded by monolithic crowns fabricated from zirconia followed by reinforced composite, zirconia reinforced lithium disilicate, and then the hybrid dental ceramics.

Ami Amelya et al., (2019)\textsuperscript{39} evaluated the load bearing capacity of posterior CAD/CAM implant supported fixed partial dentures fabricated with different esthetic material. The esthetic materials include polyetherketoneketone, zirconia veneered with fluorapatite, lithium disilicate and monolithic zirconia. They concluded that zirconia based implant supported FPD had superior load bearing capacity compared PEKK based implant supported FPDs.

Burak Yilmaz et al., (2019)\textsuperscript{40} did a study to evaluate failure of high performance polymers and new generation cubic zirconia when used for implant-supported fixed, cantilevered prosthesis. They concluded that the load-to-failure values of HPPs and Zr were
lower when Ti bases were used. New generation cubic Zr and all HPPs had lower load-to-failure values and PEKK with Ti base had lowest load-to-failure value.

Yadav et al., (2019)\textsuperscript{41} did an in-vitro study to evaluate the effect of liners on the shear bond strength of veneered zirconia block. It was stated that lithium disilicate liner obtained the maximum SBS. Maximum adhesive failures were found with lithium disilicate liner, and silicon dioxide-based liner group showed cohesive failure.

Mohamed Younis et al., (2019)\textsuperscript{42} did a study to evaluate the effect of various Plasma Gases on the Shear Bond Strength between Unfilled Polyetheretherketone(PEEK) and Veneering Composite following Artificial Aging. It was concluded that the nitrogen surface treatment had the highest mean shear bond strength. Mode of fracture, was 100\% adhesive failure. Plasma surface treatment can be an alternative method to the traditional protocol of bonding veneering composite resin to unfilled PEEK material.

Sergio Alexandre Gehrke et al., (2019)\textsuperscript{43} did a study to evaluate the fracture strength of zirconium oxide three-unit fixed partial denture framework supported by dental implants in acceptable and reduced interocclusal space. They concluded that short crowns due to reduced interocclusal spaces does not reduce the mechanical resistance of FPD framework but there may be accumulation of more energy within the small crowns.

Shimoe S et al., (2019)\textsuperscript{44} did a study to evaluate the Influence of various airborne-particle abrasion conditions on bonding between zirconia ceramics and an indirect composite resin material. They concluded that airborne-particle abrasion improved the
bond strength between zirconia and composite and particle size of airborne particle abrasion and jet pressure were not an influencing factor.

**Shiro Rikitoku et al., (2019)** did a study to evaluate the influence of SiO2 content of polyetheretherketone (PEEK) on flexural properties and tensile bond strength to resin cement. They concluded that The TBS improved with increasing concentration of SiO2 in PEEK moreover PEEK with 20% TiO2 and the sample with 40 wt.% SiO2 exhibited the highest flexural strength.

**Rodrigo Alessandretti et al., (2019)** did a study to evaluate the Fracture Load and Failure Mode of CAD-on Ceramic Structures. In this study specimens were CAD-on trilayer structure composed of Y-TZP infrastructure, fusion glass-ceramic and lithium disilicate-based glass-ceramic, YLD- bilayer structure composed of Y-TZP infrastructure and fluorapatite layering ceramic, LDC- monolithic lithium-disilicate glass-ceramic and YZW-monolithic Y-TZP Zr Translucent. They reported that All monolithic structures (LDC and YZW) fractured catastrophically. Most of the CAD-on specimens (85%) also fractured catastrophically and 15% failed by chipping. All YLD specimens (100%) failed by chipping. The CAD-on group had the highest number of fragments, followed by YZW, LDC and YLD

**Saleh Zidan etal.,(2019)** did a study to evaluate the mechanical properties (flexural strength, fracture toughness, impact strength, and hardness) and fracture behavior of heat-cured denture base acrylic resin when impregnated with different concentrations(0,1.5%, 3%, 5%, 7%, and 10%) of Yttria-stabilized zirconia (ZrO2) nanoparticles. They concluded that the incorporation of ZrO2 nanoparticles to PMMA resin significantly improved the
mechanical properties like flexural modulus, fracture toughness flexural strength, and surface hardness, with an optimum concentration of 3–5 wt% zirconia.

Salem RST et al., (2019) conducted a study to investigate the shear bond strength of various primer/resin cement systems to monolithic zirconia under different levels of storage. Primer/cement system includes Z-PRIME Plus/DUO-LINK (Bisco), Clearfil Ceramic Primer Plus/PANAVIA SA (Kuraray), and Single Bond Universal Adhesive/RelyX Ultimate (3M ESPE). They concluded that the methacryloyloxydecyl dihydrogen phosphate-containing resin cement is recommended to provide a durable bond for monolithic zirconia.

Hang-ying Jin et al., (2019) did a study to evaluate and compare BioHPP and titanium as a framework veneered with composite resin for implant-supported fixed dental prostheses. It was concluded that the bond strength of BioHPP with the composite resin was greater than that of titanium. CAD-CAM BioHPP frameworks exhibit good fracture resistance and marginal fit. Hence BioHPP may be a suitable alternative to metal as a framework to be veneered with composite resin.

Mendes F et al., (2019) did a study to evaluate the bonding strength of luting cement to zirconia-based ceramic under different surface treatments. Surface treatment includes wear with diamond bur, blasting with glass beads, wear with a medium-roughness milling machine, primer application on the surface without treatment, wear with diamond +Primer, blasting with glass beads+Primer and wear with diamond+Primer: PMA treatment plus primer application. He stated that mechanical preparation using diamond bur followed by
primer application significantly improved the bond strength between the ceramic and the luting cement.
Materials & Method
MATERIALS AND METHOD

MATERIALS

- 3 unit prepared tooth model (Figure 1)
- Intra oral scanner - TRIOS 3Shape, Germany (Figure 2)
- A metal die of anterior 3 unit prepared teeth (Figure 4 & 5)
- 5 numbers of Anterior 3 unit CAD CAM Zirconia framework - VITA In-ceram YZ; VITA Zahnfabrik, Bad Sackingen, Germany (Figure 6)
- 5 numbers of Anterior 3 unit CAD CAM PEEK framework- Bio-HPP; Bredent GmbH &Co.KG, Senden, Germany (Figure 7)
- Dual cure resin cement - Maxcem Elite, Kerr manufacturing& Co, USA (Figure 9)
- Universal Testing Machine – Servo Controlled, Model - F 100 (Figure 10)
METHOD

FABRIATION OF PREPARED TOOTH MODEL:

A Prefabricated three unit anterior FPD gypsum model was obtained from Bredent company. The model was digitally designed with a 6° taper in relation to 21,22,23 (Figure 1).

FABRICATION OF METALLIC DIE:

The model was scanned using Trios 3 Shape, intraoral scanner (Figure 2) and the STL file was exported to graft 3D Healthcare solution, for metallic die fabrication. To simulate the oral condition, the metallic die was digitally designed such that the teeth are in 30-degree angulation to that of the floor, so that the given load is subjected to cingulum (Figure 3). If not the force given will be subjected to the incisal edges of crown. Metallic die was 3D printed with cobalt chromium base metal alloy. The outer surface of the metallic die was sandblasted with Al₂O₃ for better bonding and to avoid the adhesive failure (Figure 4 & 5).

FABRICATION OF CAD/CAM ZIRCONIA AND PEEK FRAMEWORK:

The metallic die was scanned using Intra oral scanner (3 Shape, TRIOS). Total of 5 CAD CAM 3-unit PEEK and Zirconia framework was fabricated. The framework was digitally designed using Exocad Dental DB 2.2 Valletta software (Figure 6 & 7). The connector between central incisor and lateral incisor had a height of 4.96mm, width of 3.12 and an area of 11.09mm and the connector between the lateral incisor and canine had a height of 4.93mm, width of 3.18mm and an area of 11.52mm (Figure 8). The framework was cemented to the metallic die using dual cure resin cement (Figure 9). The metallic die along with the framework was subjected to load to evaluate the fracture strength.
FRACTURE STRENGTH EVALUATION:

Universal testing machine (Servo Controlled, Model - F 100) was used for the fracture strength evaluation (Figure 10). All samples were subjected to compressive axial loading with a 5mm diameter spherical head mounted in a computer-controlled universal testing machine at a crosshead speed of 0.5 mm/min. The load was applied to the lingual fossa of the framework until catastrophic failure occurred (Figure 11). Catastrophic failure was defined as exhibition of visible cracks, load drops and acoustic events of chipping or fracture. This was repeated for all samples and the values was recorded and statistically analyzed.

This study was approved by the Institutional Review Board (IRB number:2018-MDS-Br-1-VEN-15/APDCH).
Figure 1: PREPARED TOOTH MODEL

Figure 2: 3SHAPE TRIOS INTRAORAL SCANNER
Figure 3: SCHEMATIC REPRESENTATION OF 30° TILT OF METAL DIE
Figure 4: METTALIC DIE FRONT VIEW

Figure 5: METTALIC DIE SIDE VIEW
Figure 6: CAD/CAM THREE UNIT ZIRCONIA FRAMEWORK

Figure 7: CAD/CAM THREE UNIT PEEK FRAMEWORK
Figure 8: DESIGN OF THE CONNECTOR

Figure 9: RESIN CEMENT
Figure 10: UNIVERSAL TESTING MACHINE

Figure 11: LOAD APPLICATION
Result
RESULT

The present *in-vitro* study was conducted to comparatively evaluate the fracture strength of three-unit CAD/CAM anterior FPD framework made with Zirconia and PEEK. All the samples in Group A (Zirconia) and Group B (PEEK) were subjected to compressive axial loading with a 5mm diameter spherical head mounted in a computer-controlled universal testing machine at a crosshead speed of 0.5 mm/min and the force at which the material fracture were noted with the load displacement curve. The values were tabulated as follows,

Table 2: FRACTURE STRENGTH OF ZIRCONIA AND PEEK FRAMEWORK

<table>
<thead>
<tr>
<th>S.NO</th>
<th>ZIRCONIA (GROUP A)</th>
<th>PEEK (GROUP B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1890 N</td>
<td>2500 N</td>
</tr>
<tr>
<td>2</td>
<td>1790 N</td>
<td>2600 N</td>
</tr>
<tr>
<td>3</td>
<td>1880 N</td>
<td>2550 N</td>
</tr>
<tr>
<td>4</td>
<td>1890 N</td>
<td>2610 N</td>
</tr>
<tr>
<td>5</td>
<td>1860 N</td>
<td>2555 N</td>
</tr>
</tbody>
</table>
Graph 1: LOAD DISPLACEMENT CURVE (ZIRCONIA SAMPLE 1)

Graph 2: LOAD DISPLACEMENT CURVE (ZIRCONIA SAMPLE 2)
Graph 3: LOAD DISPLACEMENT CURVE (ZIRCONIA SAMPLE 3)

Graph 4: LOAD DISPLACEMENT CURVE (ZIRCONIA SAMPLE 4)
Graph 5: LOAD DISPLACEMENT CURVE (ZIRCONIA SAMPLE 5)

Graph 6: LOAD DISPLACEMENT CURVE (PEEK SAMPLE 1)
Graph 7: LOAD DISPLACEMENT CURVE (PEEK SAMPLE 2)

Graph 8: LOAD DISPLACEMENT CURVE (PEEK SAMPLE 3)
Graph 9: LOAD DISPLACEMENT CURVE (PEEK SAMPLE 4)

Graph 10: LOAD DISPLACEMENT CURVE (PEEK SAMPLE 5)
Graph 11: FRACTURE STRENGTH OF ZIRCONIA FRAMEWORK

Graph 12: FRACTURE STRENGTH OF PEEK FRAMEWORK
Figure 11: FRACTURED CAD/CAM THREE UNIT ZIRCONIA FRAMEWORK
Figure 12: FRACTURED CAD/CAM THREE UNIT PEEK FRAMEWORK
Statistical Analysis
From the data obtained the mean values for group A and Group B were calculated. Statistical analysis was done with Non parametric Unpaired Student t-test to compare the mean value of fracture strength between the CAD/CAM Zirconia framework (Group A) & CAD/CAM PEEK framework (Group B).

Table 3: STATISTICAL RESULT

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>ZIRCONIA</th>
<th>PEEK</th>
<th>t - Test</th>
<th>P - Value</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1 MEAN  ±SE</td>
<td>N2 MEAN  ±SE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>5</td>
<td>1862.00</td>
<td>18.8149</td>
<td>5</td>
<td>2563.00</td>
</tr>
</tbody>
</table>

** - P<0.01 – Statistically significant at 1 percent level.

Graph 13: MEAN VALUES OF FRACTURE STRENGTH OF ZIRCONIA AND PEEK FRAMEWORK
Inference
INFERENCES

Statistical analysis was done with Non parametric Unpaired Student t-test to compare the mean value of fracture strength between the CAD/CAM Zirconia framework (Group A) & CAD/CAM PEEK framework (Group B). The values obtained for PEEK (Group B) was higher than the values obtained for Zirconia (Group A). It is statistically significant by 1%. (p value <0.01).

- The highest fracture strength value for Zirconia was 1890 N.
- The highest fracture strength value for PEEK was 2610 N.
- The mean fracture strength value for Zirconia was 1862 N ±18.8149 N.
- The mean fracture strength value for PEEK was 2563 N ±19.7231 N.
Discussion
DISCUSSION

Fixed Prosthodontics is a branch of Prosthodontics concerned with the replacement or restoration of teeth with artificial substitutes that are not removed from the mouth. A Fixed Partial Denture (FPD) is a restoration that is luted or otherwise securely retained to natural teeth/tooth roots/dental implant abutments that furnish the primary support for the prosthesis.

Rehabilitation of teeth with crowns has increased greatly over the last three decades. The final crown or FPD is fabricated from All-ceramic, Porcelain Fused Metal, or All-Metal. All restorations are liable to failure during function. Failure of the fixed partial denture could be biologic, aesthetic, mechanical or a combination. Restoration failures are often a multifactorial phenomenon. A number of different factors may be responsible for the mechanical failure of restorations\(^\text{53,54}\) and factors may also vary depending on the type of fracture that has occurred.

Despite rapid advancements in the development of newer and stronger ceramic systems metal-ceramic restorations still remain the ‘gold standard’ in prosthodontics since their introduction in the 1960s. Metal-ceramics crowns are prone to mechanical fracture, especially fracture of veneering porcelain. Eliasson \textit{et al}\(^\text{51}\) reported a survival rate of 97\% for metal-ceramic restorations after a period of ten years in clinical service. A systematic review by Goodacre \textit{et al}\(^\text{52}\) revealed that the fracture of veneering porcelain is the most common complication associated with metal-ceramic prostheses. Metal-ceramic crowns had advantages of strength and disadvantage of esthetics which was overcome with the evolution of materials and techniques. Evolution of all ceramic crowns was initially not well accepted due to failure rates. With technological and material advances in Zirconia core, all ceramic crowns were demonstrated comparable mechanical properties to that of metal ceramic crowns in 2012\(^\text{55}\) and 2009\(^\text{56}\)
Fracture strength of restorative materials is important to predict both the clinical service and failure rates. Fracture strength is defined as the ability of a material to resist failure and is designated specifically according to the mode of applied load, such as tensile, compressive, or bending. Fracture strength is also known as the breaking strength. It is the stress at which a specimen fails via fracture. The final recorded point is the fracture strength.

The aim of the present study was to comparatively evaluate the fracture strength of CAD/CAM framework made of Zirconia & PEEK of same thickness. The null hypothesis of the present study was that there would be no significant difference in fracture strength of CAD/CAM three unit FPD framework made of Zirconia (Group A) and PEEK (Group B).

To avoid operator-based errors, all the procedure mentioned in methodology was performed by single operator.

Kelly recommended few guidelines for a clinically relevant in vitro load to-failure test protocol for all-ceramic restorations which was followed in this study. This includes designing the prepared teeth and cementing the crowns with reliable and most commonly used luting cement. The teeth preparation was digitally designed according to clinical guidelines for all ceramic anterior teeth with 6° taper. If tooth preparation was done in a typodont model manually exact taper and accurate dimension reduction cannot be achieved. Following this, the metallic die and the Zirconia and PEEK framework was also digitally designed for standardization. The crowns were cemented using dual cure resin cement which is the most common luting cement used for the cementation of the all ceramic crowns.

The mean fracture strength of CAD/CAM Zirconia is 1862 N +18.8149 N and the mean fracture strength of CAD/CAM PEEK is 2563 N +19.7231 N. Fracture strength of CAD/CAM PEEK framework was significantly higher than that of CAD/CAM Zirconia.
discussion

framework. Hence the results support the rejection of the null hypothesis because significant
differences were observed.

Maximum bite force is usually highest in the molar region. Unilateral measurement of
maximum bite force in the molar region averages between 216 and 890 Newton in healthy
adults with natural teeth. With the transducer placed on the anterior teeth the measured force
is about 40% of the unilateral force recorded in the molar region, and with the transducer in
the premolar region it is about 70%. Maximum occlusal forces up to 909 N have
been recorded in the molar region. Thus, the maximum mean forces for anterior teeth are
around 500 N. It is necessary that the prostheses should bear at least twice this load. This is
because the restorations placed in the oral cavity undergo a decrease in strength over time of
approximately 50% of the initial value, so when they are placed in the mouth, must have an
initial value of strength of about twice of the majority of forces that on average develop in the
that areas. So the threshold of 1000 N is very important and has been widely verified that
both Zirconia and PEEK FPD framework exceed this limit. Hence both Zirconia and PEEK
can be used as a framework material in anterior Fixed Partial Denture.

In a study done by Zahran et al., result shows that the mean fracture loads of
Zirconia crowns were 1459 N. In a study done by Manoharan et al., the mean fracture load
of Zirconia group was 2077 N. In a study by Wael Att et al., the mean fracture strength of
Zirconia ranged from 1522 N to 1702 N. An in vitro study by Dornhofer et al. showed a
mean fracture strength of 2527 N. A Study by Stiesch-Scholz et al. showed a mean fracture
strength of 1265 N. Study by Tinschert et al. the mean fracture value of Zirconia was greater
than 2000 N and a study by Rountree et al. showed a mean fracture strength of 1816 N.
From the above mentioned studies *in vitro* studies, the mean fracture load of Y-TZP based all-ceramic FPDs is reported to be in the range of 1200 N to 2600 N. The fracture strength of Zirconia framework obtained in this study also ranges within these values.

Different values are obtained in different studies. The reason is that, in some studies procedures for artificial aging (thermal and mechanical cycles) were implemented while in other studies it was not. The artificial aging procedures are intended to simulate conditions which are to establish the patient’s mouth that is continuous mechanical stresses and temperature changes of some significance that in time lead to a substantial decrease in the strength of the prostheses.

All Zirconia-ceramic framework fractured involving the whole thickness of the ceramic crown. This is the expected mode of fracture for all ceramic material\(^6\). Unlike Zirconia, PEEK framework did not fracture completely instead formation of a visible crack at the connector region was noted which could be due to the high flexural strength of the material.

Regarding comparison between Zirconia and PEEK, there are two studies regarding the fracture strength of three unit FPD made of PEEK. Both the study has investigated the fracture strength in posterior region. Vahideh Nazari et al in 2016 compared the fracture strength of bilayered Zirconia and PEEK framework veneered with composite. He concluded that at given load the fracture that occurred in zirconia involved both framework and veneering material where as in PEEK only the veneering material fractured and the framework remained intact which supports this study.

Other study by Bogna Stawarczyk et al in 2013 who investigated the fracture strength of PEEK three-unit FDPs before veneering and showed a mean fracture load of 1383N. However, the PEEK substructure that they used was PEEK whereas in the present study BioHpp PEEK was used which would have been the reason for increased fracture strength.
The fracture strength of PEEK three-unit FDPs on molars found in a manufacturer’s material brochure (Scientific Documentation, Invibio), reports an *in vitro* fracture resistance of 2055 N, which is closer to the values obtained in this study.

However, the connector area, type of cement, thickness of the coping material will also influence the fracture strength of the framework. The strength of an all-ceramic restoration depends not only on the fracture resistance of the material, but also on a suitable preparation design with adequate material thickness. Frameworks for all-ceramic crown and bridges by CAD/CAM have been based upon empirical machine guidelines rather than clinical scientific data. Most of all CAD/CAM systems, the frameworks of the crowns are design to arbitrary thicknesses of 0.4 to 0.6 mm\(^2\)\(^{67,68,69,70,71,72}\). Appropriate veneering porcelain thickness and support to minimize internal stress, reduce mechanical failures, and optimize esthetics of the veneering porcelain.

Connector is that part of fixed partial that unites the retainer and pontic. The connector is definitely the weak point of the entire restorations and its size should be adjusted in height and width in order to allow long-term survival of the restoration. In fact, in several studies it was shown that the failure of the restoration is almost always due to a fracture that begins at the gingival portion of the connector.

Study of Studart et al\(^{80}\) based on the evaluation of some fatigue parameters of the prostheses, found that the size of the connector should be at least 5.7 mm\(^2\), 12.6 mm\(^2\) and 18.8 mm\(^2\) for the bridges respectively of 3, 4 and 5 units. Filser et al\(^{78}\) recommended a minimum connector size of be 6 to 9 mm\(^2\) and according to Oh et al\(^{79}\) the connector should be 6 mm\(^2\) for three unit Fixed Partial denture. From all these studies is clear that the connector should not be less than 6.25 mm\(^2\) or more. This is valid for 3-unit posterior bridges. The connector area designed in this study fall in the above mentioned values.
In summary, both Zirconia and PEEK can be used for replacing anterior tooth. And also based on the findings in the current study PEEK seem to be interesting alternative for use as core material for restoration of anterior tooth region. Clinical studies with long term follow-up are however, necessary to assess the clinical performance.
Limitation
LIMITATION

Limitation of this *in-vitro* study are as follows,

- Number of samples used in the study were limited
- The study did not evaluate the type of fracture occurred in the framework
- The study did not evaluate the type of failure occurred in the framework
Summary
SUMMARY

The present *in vitro* study was conducted to comparatively evaluate the fracture strength of CAD/CAM 3 unit anterior FPD framework made of Zirconia and PEEK cemented using resin cement.

Anterior three-unit prepared teeth gypsum model in relation to 21, 22 & 23 was obtained from Bredent company. The model was scanned using Trios 3Shape intra oral scanner and the STL file was exported for metal die fabrication. The metal die was given a 30° tilt to that of the floor, so that the force given are subjected to cingulum. The metal die was scanned with Trios 3Shape intraoral scanner and a five, three-unit CAD/CAM Zirconia framework in Group A and five, three-unit CAD/CAM PEEK framework in Group B was fabricated. The framework was cemented to metal die with dual cure resin cement. The framework was subjected to load test in universal testing machine (Servo Controlled, Model - F 100). The force was subjected to cingulum with 5mm diameter spherical ball tip mounted in a computer controlled universal testing machine at a crosshead speed of 0.5mm per minute. The force was gradually increased until a catastrophic fracture occurred. The point at which the material failed was recorded in a load displacement curve for each sample. This was repeated for all samples.

On statistical analysis using Non parametric Unpaired Student t-test to compare the mean value of fracture strength between the CAD/CAM Zirconia framework (Group A) & CAD/CAM PEEK framework (Group B).

- The mean fracture strength value for Zirconia (Group A) was 1862 N +18.8149N.
- The mean fracture strength value for PEEK (Group B) was 2563 N +19.7231 N.
The values obtained for PEEK (Group B) was higher than the values obtained for Zirconia (Group A) and this was found to be statistically significant by 1% (p value <0.01). Thus, the null hypothesis of this study is not validated, because the present study had revealed that there was a statistically difference in the mean fracture value between two groups.

In summary, both Zirconia and PEEK can be used for replacing anterior tooth. And also based on the findings in the current study PEEK seem to be interesting alternative for use as core material for restoration of anterior tooth region. Clinical studies with long term follow-up are however, necessary to assess the clinical performance.
Conclusion
CONCLUSION

The following conclusion were drawn based on the results obtained in the present *in-vitro* study, which was conducted to comparatively evaluate the fracture strength of 3 unit CAD/CAM framework made up of Zirconia and PEEK cemented using resin cement.

- The mean fracture strength of CAD/CAM Zirconia framework is **1862N**.
- The mean fracture strength of CAD/CAM PEEK framework is **2563N**.
- PEEK is a reliable material to be used as framework for Fixed Partial Denture.
REFERENCE


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Urkund Analysis Result

Analysed Document: MD - Copy.docx (D61662824)
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Submitted By: jeevithamanib4u@gmail.com
Significance: 5 %

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This Ethical Committee has reviewed the research Protocol submitted by Dr. JEEVITHA MANI, Post Graduate Student, Department of Prosthodontics, under the title “Comparative evaluation of fracture strength of CAD/CAM anterior FPD framework made with Zirconia and PEEK cemented using resin cement - An in-vitro study” Ref no.: 2018-MDS-BrI-VEN-15/APDCH under the guidance of Dr. A. Ponsekar Abraham M.D.S., for consideration of approval to proceed with the study.

This Committee has discussed about the Material being involved with the study, the Qualification of the investigator, the present norms and recommendations from the Clinical Research Scientific body and comes to a conclusion that this Research protocol fulfils the Specific requirements and the Committee authorizes the proposal.

Principal