COMPARATIVE EVALUATION OF THE MARGINAL FIT AND INTERNAL FIT OF METAL LASER SINTERED CROWNS WITH DIRECT AND INDIRECT SCANNING TECHNIQUES:

AN INVITRO STUDY

Dissertation submitted to

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

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BRANCH I

PROSTHODONTICS AND CROWN AND BRIDGE AND IMPLANTOLOGY

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THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

CHENNAI

DECLARATION BY THE CANDIDATE

I hereby declare that the dissertation titled **"COMPARATIVE EVALUATION OF THE MARGINAL FIT AND INTERNAL FIT OF METAL LASER SINTERED CROWNS WITH DIRECT AND INDIRECT SCANNING TECHNIQUES: AN INVITRO STUDY"**is a bonafide and genuine research work carried out by me under the guidance of **Dr. R. SRIDHARAN, M.D.S.,** Professor and Head, Department of Prosthodontics and Crown and Bridge and Implantology, Chettinad Dental College & Research Institute, Kelambakkam, Kanchipuram District.

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This is to certify that the dissertation titled **"COMPARATIVE EVALUATION OF THE MARGINAL FIT AND INTERNAL FIT OF METAL LASER SINTERED CROWNS WITH DIRECT AND INDIRECT SCANNING TECHNIQUES: AN INVITRO STUDY"** is a bonafide and genuine research work done by **Dr. D.JENEFER SHEKINA** under my guidance during the study period 2017-2020.This dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY** in partial fulfillment for the degree of **Master of Dental Surgery in the Branch I - PROSTHODONTICS AND CROWN AND BRIDGE AND IMPLANTOLOGY.** It has not been submitted (partially or fully) for the award of any other degree or diploma.

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To

Dr.D.Jenefer Shekina
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Chettinad Dental College and Research Institute

Sub: Your proposal submitted for EC approval – Reg.

The previous Institutional Human Ethics Committee reviewed the proposal titled "A comparative evaluation of the marginal and internal fit of laboratory fabricated metal lazer sintered crowns using direct and indirect methods of scanning : An Invitro study with teeth model "on 16.10.2017 and has been approved as submitted.

Member Secretary
IHEC, C.A.R.E

Guide: Dr.R.Sridharan

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D. This approval is valid for three years or the duration of the project whichever is less

E. Any changes in the study procedure / site/ investigator should be informed to the IHEC

F. **A report of the project has to be submitted to the IHEC after completion of the study.**

ABSTRACT

INTRODUCTION:

CAD/CAM technology has evolved in dentistry and provide almost accurate restorations and prosthesis which is done by digitalized mechanical scanning. The scanners could be optical, laser, or contact scanners. The marginal and internal fits of restorations fabricated by CAD/CAM technology are better as compared with the restorations fabricated by the lost wax technique.

AIM:

To evaluate the marginal and internal fit of laboratory fabricated metal laser sintered crowns using direct and indirect methods of scanning.

MATERIALS AND METHODOLOGY:

A typhodont model in which a mandibular first molar tooth is prepared with a shoulder finish line. An intraoral scanner for direct scanning and laboratory scanner for indirect scanning technique is used for the fabrication of Metal Laser Sintered crowns. The marginal and Internal fit of the crowns are evaluated with two groups and compared with stereomicroscope.

RESULT AND CONCLUSION:

The results did show better marginal and internal fit in crowns fabricated by the direct method; however, the crown fabricated by the indirect method has more discrepancy, but was in the clinically acceptable limit.

KEYWORDS: CAD/CAM, Intraoral Scanners, Extra oral Scanners, MLS Crowns.

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LIST OF ABBREVIATIONS

S.NO	ABBREVATION	EXPANSION
1.	CAD	Computer aided designing
2.	CAM	Computer aided Manufacturing
3.	MLS	Metal Laser Sintering
4.	DMLS	Direct Metal Laser Sintereing
5.	FPD	Fixed Partial dentures
6.	EAT	Extraoral Scanners with active triangulation
7.	IAT	Intraoral Scanners with active triangulation
8.	ICT	Intraoral Scanners with Confocal Laser

INTRODUCTION

Prosthodontics has evolved with advancements over years in replacing the missing teeth and restoring the mutilated regions in the oral cavity. One such advancement is the Computer Aided Designing and Computer Aided Manufacturing (CAD/CAM) of crowns and fixed partial dentures. Dental technology has also evolved with Computer Aided milling of Metal Laser Sintered Crowns. Revisiting the history is very important before understanding the advancements.

For a century there is metal casting technology in arts and industries. It has its origin in the ancient Egypt or China, where the wax replicas were made, investing material surrounding the replica, it was let to harden, wax was melted and burn out was carried for production of accurate molds followed by melting of metal and pouring it in the mold. These ideas lead to the metal casting technology. In the literature, Dr. Swasey (1890) was the one who first introduced the technique of making solid gold inlay. Pressure casting method for the production of gold inlays was given by Dr. Philbrook (1896). After a decade, Dr. Taggart (1907) discussed his paper on casting technique and machine before New York Odontological Group. His improved casting technique was a success though it was not original. It was the incorporation of ideas of Martin’s (1891) formation of pattern by using wax and Philbrook’s (1896) casting of alloy by pressure technique.

After this for a long period of time the casting technology has been used in producing accurate casts.[1]

Metal restorations which was fabricated by conventional lost wax technique has its own disadvantages. The fit of Crowns are affected by the dimensional properties of the casting metal and the investment material. The marginal fit and Internal fit of the restorations is an important criterion for the success and longevity of the prosthesis. Marginal and Internal fit is nothing but the accurate adaptation of the restoration or the crown on to the abutment teeth. Insufficient adaptation of the crowns results in cement solubility and plaque retention, which eventually causes secondary caries in the abutment tooth and also inflammation of the periodontal structures. Marginal discrepancy is the distance or the gap from the internal surface of the restoration at the margin to the finish line of the abutment tooth. The acceptability of this discrepancy is dependent on the size and location of the tooth. Therefore, the fit of any restoration is as important as replacing the missing region in the mouth. To overcome these disadvantages various other techniques came into existence.[2]

To name a few

1.DMLS

2.CAD/CAM Milled Restorations

CAD/CAM Milled Restorations are milled from blocks of base metal alloy, ceramic, zirconia, or resin as an alternative to the conventional lost wax technique. Dental CAD/ CAM systems underwent enormous development in 1980s.[3]

There were three pioneers, in particular, who contributed to the development of the current dental CAD/CAM system – Duret and Preston, Mormann et al, and Andersson and Oden.

In dentistry before two decades there was introduction of CAD / CAM for the ceramic inlays and onlays. After this introduction there was Procera system (Nobel BiocareAB, Goteborg, Sweden) in 1991. This was introduced for individual dental restorations. CEREC (Sirona Dental Systems LLC, Charlotte, NC) for use of CAD/ CAM in- office chair side. For 8 years, Palleson and van Dijken valuated the CAD/CAM ceramics and established it as successful and agreeable.[2] Simultaneously, there was launch of metal powders in CAD models and 3D printing technology. Although CAM and 3D printing hve different processes they were used equally.[1]

Milling of dental restorations from a block of base material, such as metal, is proposed as an alternative for fabricating restorations. This technology assures results of higher accuracy and structural homogeneity. Requisition of converting data into control signals, prepared tooth surface digitalisation for computer assisted milling to produce milled restorations with accurate fit. In dentistry the CAD/CAM has faced many problems, due to the shapes of prepared teeth and dental restorations cannot be detailed with regular geometric methods because the degrees of freedom are unlimited in number. While using CAD/CAM technology, data acquisition has to be done with the digital mechanical scanning of the parts of cast or by point-based optical systems.[4]

CAD/CAM restorations can be fabricated by two different techniques. That is,

- Additive
- Subtractive

Shamseddine et al concluded that the subtractive computer-aided design and computer-aided manufacture patterns resulted in a better fit of pressed lithium disilicate crowns by decreasing margin discrepancies. The fabrication of crowns with printing technology such as the ProJet DP 3000 has the potential for high-quality production with consistently more accurate crown margin adaptation and increased output, in which case printing could replace milling and hand waxing for crown production on the bases of decreased turnaround time, lower cost, and fewer restoration remakes.

Additive manufacturing, commonly known as 3-dimensional (3D) printing, was introduced in the 1980s. Printing technology has gained popularity and is now used in dental restoration pattern fabrication. Printing can produce consistently more accurate crown margins, increase speed and volume of production, and decrease restoration remakes.[5]

DMLS

DMLS is a process of manufacturing complex 3D components without the usage of machining directly from 3D CAD data. It requires three inputs: the material, the energy and the CAD model. Powder based working material is the material used. Chromium cobalt alloy is necessary composition for MLS crowns. Molybdenum, tungsten, silicon, cerium, iron, manganese and carbon are also used for MLS crowns. These crowns are free from beryllium and nickel. The material consists of particle size of 3 to 14 lm. 200 W Ytterbium fiber optic laser (high power laser beam) is mandatory for energy. Melting of alloy powder is done using the energy. CAD model: The data is read by the machine from a CAD drawing. Then the alloy powder is laid down in successive layers and model is built up from cross section series. These layers are joined to create a final shape as it corresponds to the virtual cross section from CAD model. STL file format is the data interface between the CAD software and machine. Using a triangular facet the shape of a part is accurate by STL file. Higher quality surface is produced by smaller facets. To start a DMLS process, tooth preparation impression is made in dental clinic or office after proper treatment plan and routine diagnosis. The impression may be a digital or conventional one. Casting of impression and preparation of model is done in the dental laboratory. Model is scanned and by using CAD design the crown or bridge is designed. Then it is sent to the Central processing unit. It is a laboratory located remotely with the laser sintering equipment. To import the CAD file a special CAM software is used which is in STL format. Further, the parts are sliced into discrete horizontal layers by using the CAM software. When an adequate number of crown copings and bridge frameworks are present the laser starts to produce layer by layer within few hours. Working platform is spread with metal powder. CAD file creates a predetermined path which is used by the high power laser beam to melt a bed of alloy powder. Several dental prostheses are produced by the machine using the metal powder. 3 minutes per crown is the approximate speed.

The DMLS process is carried out by two different methods: the powder deposition and the powder bed method. The difference is in the way of application of each layer of powder. The powder bed method is preferred due to its fast speed. A recoater blade is present in the material dispensing platform which is used to move new powder to the platform. Focused laser beam is needed to fuse the solid part of metal powder by melting 20 µm thickness parts are built layer by layer. Once a layer is built the build piston pushes the platform and the following layer is applied. By this process highly complex geometrics can be created from the 3D CAD data directly. This is done fully automatically without tools, gives good surface quality, higher mechanical properties, greater accuracy and higher resolution. Support material is removed from copings/ bridges/ crowns. DMLS is a best alternative to casting which removes the complicated steps. Full control is achieved over the framework design by the usage of scanning and CAD software. Standardization of coping thickness, pontic design and thickness of cement can be done by this method. Laser sintering is a precise process controlled by computer that enables compatible work quality. It does not involve the possible defects and inclusions that are common in casting method. DMLS gives multiple unit framework which are accurate with improved marginal fit and doesn't suffer distortion like in conventional technique.[1]

AIM AND OBJECTIVES

AIM

The aim of the study is evaluate the Marginal and Internal fit of Metal Laser Sintered crowns and comparing the fit with Direct and Indirect Scanning techniques.

OBJECTIVES

The main Objectives of this study is

1. To evaluate the marginal fit and internal fit of laboratory fabricated MLS crowns using direct scanning technique
2. To evaluate the marginal fit and internal fit of laboratory fabricated MLS crowns using indirect scanning technique
3. To compare the marginal fit and internal fit of laboratory fabricated MLS crowns using direct and indirect scanning techniques.

REVIEW OF LITERATURE

Fransson B et al (1985) measured and compared the fit of two series of metal-ceramic crowns, made by students at the Dental Faculties in Oslo and Gothenburg. The study showed a statistically significant difference in mean film thickness between the two series of crowns with the best fit in the Oslo-series. In both series, the mean film thickness between crown and die was about 80% of that between crown and tooth. [6]

Francois Duret et al(1988) aimed at the clinical practice of dentistry. Setting aside scientific considerations, the practitioner would learn, how the system is used.[7]

J. Robert Holmes (1989) presented the measurements of misfit at different locations are geometrically related to each other and defined as internal gap, marginal gap, vertical marginal discrepancy, horizontal marginal discrepancy, overextended margin, under extended margin, absolute marginal discrepancy, and seating discrepancy, significance and difference in magnitude of different locations. The best alternative is perhaps the absolute marginal discrepancy, which would always be the largest measurement of error at the margin and would reflect the total misfit at that point.[8]

Andersson M et al (1993) described the method of manufacturing an all-ceramic crown composed of a coping of dense-sintered, high-purity alumina with dental porcelain. This method takes the sintering shrinkage of alumina into consideration and makes it possible to produce individual dental copings in dense-sintered, high-purity alumina, which is a biocompatible implant material. The alumina used has density, grain size, and flexural strength within the limits of the values required.[9]

Karlsson S. (1993) evaluated the fit or adaptation of Procera titanium crowns to the stone die and in vivo to the tooth before cementation. For any combination, the marginal adaptation was superior to and significantly better than the occlusal areas and axial surfaces, respectively. The crowns also had a significantly better fit to the stone die than to the tooth.[10]

Jürgen Willer et al (1998) presented a new CAD/CAM process that has been developed for the fabrication of dental restorations. Imaging is accomplished with 2-dimensional line grids projected onto an object, which allows for a mathematical reproduction of prepared and unprepared tooth surfaces, including those that are outside the direct line of light. They conclude that this system, which is undergoing clinical testing, allows the generation of various types of highly accurate dental restorations.[11]

BINDL et al (2005) evaluated the marginal and internal fit of all-ceramic molar crown-copings hypothesizing that Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) fabrication shows the same accuracy of fit as conventional techniques. The results showed that fit of conventional and CAD/CAM all-ceramic molar crown-copings covered the same range of gap width confirming the assumed hypothesis.[2]

Beuer et al (2008) overviewed the CAD/CAM-technologies and systems available for dentistry today, continual developments in computer hardware and software, new methods of production and new treatment concepts are to be expected, which will enable an additional reduction in costs.[12]

Katrin Quantea et al (2008) evaluated the marginal and internal fit of metal-ceramic crowns fabricated with a new laser melting procedure and investigated the influence of ceramic firing on the marginal and internal accuracy of these crowns. After tooth preparation, impression taking using polyvinylsiloxane and model casting, each preparation scanned by strip-light-projection. Using CAD/CAM software the metal copings were produced by BEGO Medical (Germany). A base metal alloy (Wirobond C) and a precious alloy (BioPontoStar, both: BEGO Medical) were used. The results of the in vivo study showed that crowns produced with laser melting technology exhibit a marginal and internal accuracy that is comparable to conventional production procedures.[13]

Kyu-Bok LEE et al (2008) evaluated the accuracy of marginal and internal fit between the all-ceramic crowns manufactured by a conventional double-layer computer-aided design/computer-aided manufacturing (CAD/CAM) system (Procera) and a single-layer system (Cerec 3D). Ten standardized crowns were fabricated from each of these two systems and marginal discrepancies, internal gaps were measured. From the study they concluded marginal discrepancies of Procera copings were significantly smaller than Procera crowns and Cerec 3D crowns. On internal gaps, Cerec 3D crowns showed significantly larger internal gaps than Procera copings and crowns. Within the limitations of this study, the single-layer system demonstrated acceptable marginal and internal fit.[3]

Andreas Syrek a et al (2010) aimed to compare the fit of all-ceramic crowns fabricated from intraoral digital impressions with the fit of all-ceramic crowns fabricated from silicone impressions. Their study showed that crowns from intraoral scans revealed significantly better marginal fit than crowns from silicone impressions, marginal discrepancies in both groups were within the limits of clinical acceptability, crowns from intraoral scans tended to show better interproximal contact area quality and crowns from both groups performed equally well with regard to occlusion.[14]

Charlotte Grenade et al (2011) compared the internal and marginal fit of single tooth zirconia copings manufactured with a CAD/CAM process (Procera; Nobel Biocare) and a mechanized manufacturing process (Ceramill; Amann Girrbach).They found that internal gap values between Procera and Ceramill groups were not significantly different . The mean marginal gap (SD) for Procera copings was significantly smaller than for Ceramill. Within the limitations of this in vitro study, the marginal fit of Procera copings was significantly better than that of Ceramill copings. Furthermore, Procera copings showed a smaller percentage of over-extended margins than did Ceramill copings.[15]

Yuji Kokubo et al (2011) evaluated marginal and internal gaps of NobelProcera crown zirconia silicone materials. Ninety-one crowns were examined before final cementation, and white and black silicone materials were used to record the marginal and internal fit. Mean marginal gaps among anterior, premolar, and molar tooth groups, in addition to mean gaps at the reference points within the groups, were compared. The marginal mean values were the smallest among all tooth groups, and the largest were at the rounded shoulders. The study results show the mean marginal gap of the NobelProcera crown zirconia was 44.2 mm, which is within clinically accepted standards.[16]

Jamasp Jhabvala et al (2012) proposed an innovative laser manufacturing method by combining pulsed and continuous modes of radiation. Continuous radiations were used for the object-to-build itself, in order to guarantee the requested mechanical properties. Pulsed radiations were used to build the support structures. Their study showed that resulting support structures had sufficient mechanical properties to withstand the deposition system and to evacuate heat, and are easy to remove from the denser parts.[17]

Anadioti Evanthia et al (2013) examined the three-dimensional and two-dimensional marginal and internal fit of pressed and CAD/CAM lithium disilicate crowns made from conventional and digital impressions. Based on the results the null hypotheses were rejected and there was a difference in accuracy between the two impression techniques, conventional and digital, difference in accuracy between the crown fabrication methods, press and CAD/CAM , interaction between the impression, the combination of the conventional impression and the pressed crown produced the most accurate marginal fit and there was no statistical difference among the conventional impression/CAD crown, digital impression/ press crown and digital impression/CAD/CAM crown with regard to the marginal fit. [18]

Paul Seelbach et al (2013) compared the accuracy of full ceramic crowns obtained from intraoral scans with Lava C.O.S. (3M ESPE), CEREC (Sirona), and iTero (Straumann) with conventional impression techniques. They concluded that within the limitations it can be stated that digital impression systems allow the fabrication of fixed prosthetic restorations with similar accuracy as conventional impression methods. Clinical relevance Digital impression techniques can be regarded as a clinical alternative to conventional impressions for fixed dental restorations.[19]

Vijay Venkatesh et al (2013) discussed the process of laser sintering for making metal crowns and fixed partial dentures with a understanding of their pros and cons. [1]

Demir N et al (2014) evaluated the marginal gap (MG) and absolute marginal discrepancy (MD) of full ceramic crowns with two finish line designs, shoulder and chamfer, using microcomputed tomography (micro-CT) before and after cementation. Sixty extracted human maxillary premolar teeth were divided into two groups based on the finish line design: Group I: 90° shoulder and Group II: 135° chamfer. Based on the results the full-ceramic crowns showed clinically acceptable marginal adaptation values.[20]

Mohammed M. Beyari et al (2014) evaluated the marginal and internal fit between the all-ceramic crowns manufactured by the conventional press-dental laboratory and CAD/CAM systems. Forty-five prep tooth were duplicated and randomly divided into three groups . All-ceramic CAD/CAM system (Group 1) was fabricated with the E4D CAD/CAM system, Groups 2 and 3 for fabricating the monolithic press lithium disilicate crown. Based on the statistical results he concluded that there was no statistical difference in marginal fit of all-ceramic crowns made by CAD/CAM system or dental laboratory press ceramic.[21]

Pradı´es G et al (2014) compared the fit of ceramic crowns fabricated from conventional silicone impressions with the fit of ceramic crowns fabricated from intraoral digital impressions. One crown was fabricated from an intraoral digital impression system (IDI group) and the other crown was fabricated from a conventional two-step silicone impression (CI group). Based on the results the all-ceramic crowns fabricated from intraoral digital impressions with wavefront sampling technology demonstrated better internal fit than crowns manufactured from silicone impressions.[22]

Sundar MK, et al. (2014) aimed to compare the marginal fit and micro leakage of metal laser sintered Co–Cr alloy copings and conventional cast Ni–Cr alloy copings using a stereomicroscope. Forty extracted maxillary premolars were randomly divided into two groups. One group was subjected to coping fabrication using conventional lost wax (LW) technique; other group was fabricated using metal laser sintering (MLS) technology. The study results showed that the copings fabricated using MLS technique had a better marginal fit and an observable decrease in microleakage when compared to the copings fabricated using the conventional lost wax (LW) technique.[23]

Su Ting-shu et al (2014) reviewed the categories and principles of intra oral digital impression devices currently available, operating characteristics of the devices and comparison of the manipulation, accuracy, and repeatability between intraoral digital impression and conventional impression.[24]

Ali AO et al (2015) aimed to compare the accuracy of digital impressions obtained from various digital impression systems. Using computer software, the differences in spatial measurements between the digital reference model and digital impressions were calculated. The results of the study showed within the limitations there were statistically significant differences between the accuracy of the digital impression systems. Furthermore, the results carried implications of whether digital impressions are accurate enough to be used as an alternative to conventional impression techniques.[25]

Evanthia Anadioti et al (2015) evaluated the internal fit of pressed and milled ceramic crowns made from digital and conventional impressions. Thirty polyvinyl siloxane (PVS) impressions and 30 Lava COS impressions made of a prepared dentoform tooth (master die) were fabricated. Thirty crowns were pressed in lithium disilicate (IPS e.max Press), and 30 crowns were milled from lithium disilicate blocks (IPSe.max CAD) with the E4D scanner and milling engine. The study concluded that combination of the digital impression and pressed crown produced the least accurate internal fit. [26]

Reich S, Wichmann M et al (2015) tested the marginal and internal fit of CAD/ CAM fabricated all-ceramic three-unit fixed partial dentures (FPDs) can be as good as in metal–ceramic FPDs. Twenty-four all-ceramic FPDs were fabricated and randomly subdivided into three equally sized groups. Eight frameworks were fabricated using the Digident CAD/CAM system (DIGI), another frameworks using the Cerec Inlab system (INLA). Vita Inceram Zirkonia blanks were used for both groups. In a third group frameworks were milled from yttrium-stabilized Zirconium blanks using the Lava system (LAVA). The results suggest that within the limits of the accuracy of CAD/CAM generated three-unit FPDs is satisfactory for clinical use.[27]

Adriana Postiglione Bührer Samraa et al (2016) related the state of art of the CAD/CAM systems in dentistry and some of the concerns and special cares that can interfere to optimize their results. They concluded that there are advantages to using CAD/CAM in Dentistry: the new materials were esthetically pleasing and durable; there was increased efficiency in laboratory processing; quick fabrication of the restoration; and quality control of restorations such as fit, mechanical durability and predictability. These advantages ultimately benefited the patients.[28]

Sergio Munoz (2016) evaluated and compared margin discrepancy of complete gold crowns (CGCs) fabricated from printed, milled, and conventional hand-waxed patterns. Thirty crown patterns were produced by each of 3 different methods: printed by ProJet DP 3000, milled by LAVA CNC 500, and hand waxed, then invested and cast into CGCs. Milled and hand-waxed patterns were not statistically different from each other while printed patterns produced significantly higher mean and maximum margin discrepancy than milled and hand-waxed patterns. He concluded that there is relative margin discrepancy to the LAVA CNC 500 milled and hand-waxed patterns which were not significantly different from each other.[29]

Francesco Mangano et al (2017) reviewed the advantages/ disadvantages of using optical impressions compared to conventional impressions; investigated if optical impressions are as accurate as conventional impressions; evaluated the differences between the IOS currently available commercially; determined the current clinical applications/limitations in the use of IOS. He concluded from the review that optical impressions reduce patient discomfort; IOS are time-efficient and simplify clinical procedures for the dentist, eliminating plaster models; however, with IOS, it can be difficult to detect deep margin lines in prepared teeth and/or in case of bleeding, there is a learning curve, and there are purchasing and managing costs.[30]

Iman Shafi ei et al (2017) aimed to determine dimensional accuracy of intraoral and laboratory scanners using the PubMed and Medline database English literature by the terms “Dimensional accuracy”, “Intraoral”, Laboratory scanners”.[31]

Kushal N Gandhi et al (2017) evaluated the marginal and internal fit of Laboratory fabricated monolithic zirconia crowns using direct and indirect methods of scanning. The direct method of scanning was carried out with a stainless steel die with the chair-side intraoral scanner and the impression of the stainless steel die was made and gypsum die was fabricated, which was then subjected to scanning with the laboratory indirect scanner. They found that the results show better marginal and internal fit in the crowns fabricated by the direct method. However, the crowns fabricated by the indirect method had more discrepancy, but were in the clinically acceptable limits.[32]

Lauren Oliveira Lima Bohner et al (2017)evaluated and compared the trueness of intraoral and extraoral scanners in scanning prepared teeth: an in vitro study. For intraoral scanners, each tooth was digitized individually. Extraoral scanning was obtained from dental casts of each prepared tooth. The discrepancy between each scan and its respective reference model.[33]

Raphael Richert et al (2017) summarized the technologies currently used (light projection, distance object determination, and reconstruction) in CAD/CAM technology, the clinical considerations of each strategy such as handling, learning curve, powdering, scanning paths, tracking, and mesh quality and the the accuracy of files and of the intermaxillary relationship registered with IOS. They concluded the overview that the current IOS is adapted for a common practice, although differences exist between the technologies employed and also highlighted the reduction in the volume of hardware which has led to an increase in the importance of software-based technologies was obtained by deviation analysis. Their study showed no significant differences in deviation values among scanner. Intraoral and extraoral scanners showed similar trueness in scanning prepared teeth. Higher discrepancies occured in the cervical region and on the occlusal surfaces.[34]

Sakura SHIMIZU et al (2017) aimed to evaluate the accuracy of an intraoral scanner with active triangulation (Cerec Omnicam), an intraoral scanner with a confocal laser (3Shape Trios), and an extraoral scanner with active triangulation (D810). They also compared the accuracy of the digital crowns designed with two different scanner/CAD combinations. The accuracy of the intraoral scanners and extraoral scanner was clinically acceptable. The study showed that marginal and internal fit of the digital crowns fabricated using the intraoral scanner and CAD programs were inferior to those fabricated using the extraoral scanner and CAD programs.[35]

Tsanka Dikova et (2017) aimed to investigate the fitting accuracy of Co-Cr dental bridges, manufactured by three technologies, with the newly developed method using CAD software. The four-part dental bridges of Co-Cr alloys were produced by conventional casting of wax models, casting with 3D printed patterns and selective laser melting. The marginal and internal fit of dental bridges was studied by – silicone replica test and CAD software. They concluded that fitting accuracy of the bridges, cast with 3D printed patterns, is the highest, followed by the SLM which is a good precondition for their successful implementation in the dental offices than conventionally cast bridges. The marginal fit of the three groups of bridges was in the clinically acceptable range.[3]

Zarina et al (2017) reviewed the history, evolution, components, and various materials used for fabrication of prosthesis. Also evaluated popular CAD/CAM systems, its limitations, future evolvement, and also the dental considerations while using them.[37]

Amelya et al (2018) analyzed and compared the marginal fit of all-ceramic crowns fabricated from impressions acquired by direct digital scans intraorally and by indirect digital scans extraorally from working models. They found that there was statistical difference in the marginal fit of the all-ceramic crowns between crowns fabricated from direct digitally scanned and indirect digitally scanned impressions. However, the all-ceramic crowns fabricated from the direct digitally scanned impressions were significantly more accurate than those from the indirect digitally scanned impressions.[38]

Gaikwad et al (2018) evaluated the marginal fit and axial wall adaptability of Co-Cr copings fabricated by metal laser sintering (MLS) and lost-wax (LW) techniques using a stereomicroscope. A stainless steel master die assembly was fabricated simulating a prepared crown. Group A coping was fabricated by LW technique and the Group B coping fabrication by MLS technique. The discrepancies between the dies and copings were measured along the axial wall on each halves. They found that the copings fabricated by MLS technique had better marginal fit and axial wall adaptability than the copings fabricated by the LW technique. However, the values of marginal fit of copings fabricated that the two techniques were within the clinically acceptable limit.[39]

Sason GK et al (2018) evaluated and compared accuracy of intraoral and extraoral digital impressions. Ten dentulous participants (male/female) aged 18–45 years with an asymptomatic endodontically treated mandibular first molars with adjacent teeth present were selected for the study. The tooth was then scanned using the intraoral scanner, and the extraoral scans were obtained using the casts made from the impressions. The results show higher “precision” and “trueness” values with intraoral scanner when compared with the extraoral scanner.[40]

Zhang et al. (2018) aimed for the development of laser fusion printing machine (LFP), also being called as selective laser melting (SLM), for ceramic teeth crown in dental restoration business. After post treatment with porcelain, it was found that the laser fusion printed porcelain teeth with titanium alloy had good metal-ceramic bonding strength, which is equivalent to the quality of traditional porcelain teeth, which showed that laser fusion printing can meet the requirements of dental restoration business and has a broad market outlook.[41]

MATERIALS AND METHODS

MATERIALS REQUIRED

1. Typhodont model
2. Tooth preparation burs
3. Agar duplicating material
4. Type 4 Gypsum (Die stone with high strength)
5. Intraoral Scanner
6. Extraoral Scanner

PROCEDURE

FIGURE 1: Typhodont Model

FIGURE 2: Prepared tooth (46) in a Typhodont Model

A typhodont model(Nissin), in which #46- mandibular first molar tooth was prepared with biomechanical principles of tooth preparation and given a shoulder finish line of 90 degrees, 6 degree taper, 4.5mm height.

Before the preparation is done, silicone putty index was adapted to the facial, lingual and occlusal surfaces of the tooth. After polymerization, amid sagital index can be formed by cutting the silicone in half along the faciolingual midline of the tooth to be prepared. The putty is then placed back and checked for adaptation. The preparation is started by making depth orientation grooves with a flat end tapered diamond. A clearance of 1.5 mm to 2.00 mm is required which is then followed by reduction of the remaining intact enamel between the depth orientation grooves with the same diamond. The reduction should take the form of definite planes reproducing the gingival occlusal morphology.

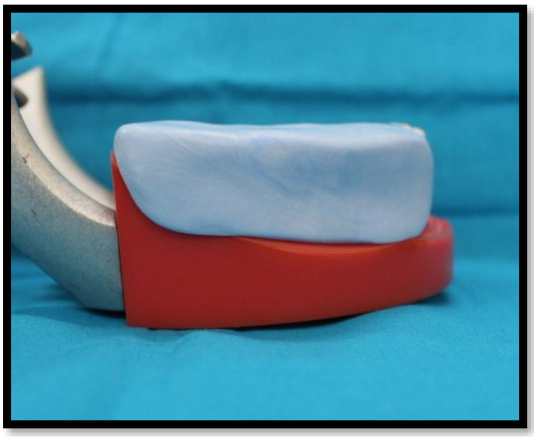


FIGURE 3: Silicone putty Index on the prepared tooth

FIGURE 4: Silicone putty Index Occlusal view

A functional cusp bevel is given on the facial inclines of the mandibular facial cusps, it is completed by removing the tooth structure between the depth orientation grooves. The angulation of the bevel approximates the inclination of the opposing cusps.

This is followed by facial reduction of 1.2 mm with a flat end tapered diamond. Then the proximal axial reduction is begun with short needle diamond. Its narrow diameter allows inter proximal reduction without nicking adjacent teeth. Once separation between the teeth is achieved, proximal axial surfaces are then planed with the needle diamond. The lingual axial wall is reduced with a TF-12 diamond. Enough structure is removed on both lingual and proximal axial walls to create a distinct shoulder finish line. The putty index section is used to check for adequate tooth reduction/ preparation.

FIGURE 5: Sectioned putty Index

FIGURE 6: Sectioned putty Index – Occlusal view

FIGURE 7: Prepared tooth with finish line- Occlusal view

FIGURE 8: Prepared tooth with finish line

MLS copings were fabricated by Computer aided Milling (CAM) using Direct and Indirect methods of scanning. The spacer thickness was uniformly 30 µm and it was designed with Computer aided Designing (CAM).

This study was broadly divided into two groups, each group consisting of 12 models each. These 24 models were achieved by duplicating the master model with Agar (Reprogel) in the conditioning unit.

FIGURE 9: Agar -Duplicating material

FIGURE 10: Agar Conditioning unit

FIGURE 11: Master model is prepared for Duplication

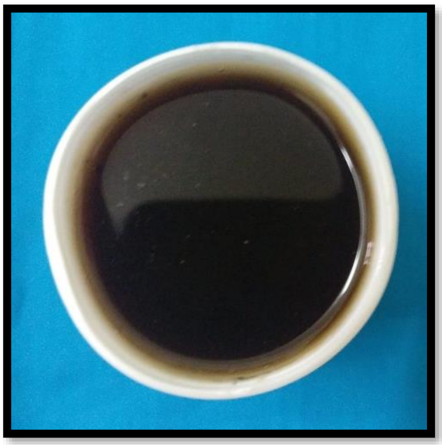


FIGURE 12: Agar conditioned and poured for duplicating the Master model

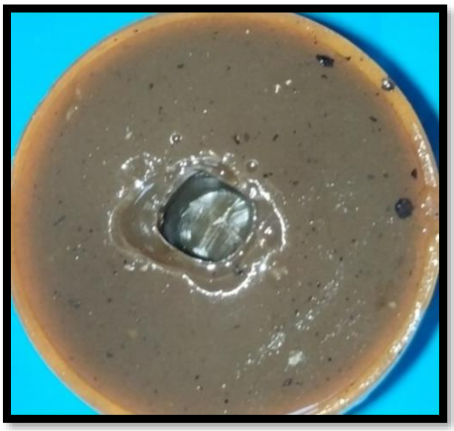


FIGURE 13: Mould of the Master model

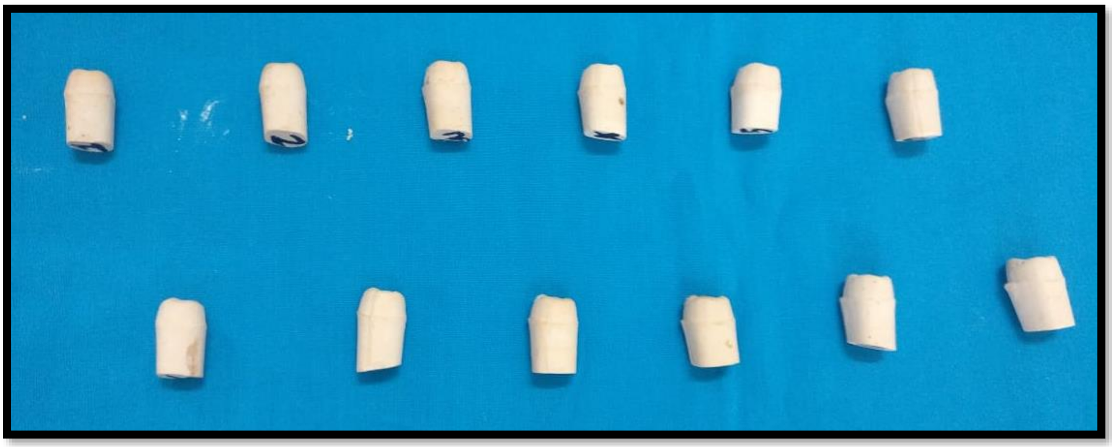


FIGURE 14: Duplicated Samples of the Master model

FIGURE 15: Duplicated Samples of the Master model- After numbering

In Group 1, direct method of scanning was done using Chair-side direct scanner (3-Shape 5axis Scanner). Here the die models were scanned to obtain 3D images of the master die on the Computer attached to the scanner. The finish lines were obtained and 30 µm spacer was used to fabricate the crowns. These scanned files were saved in STL format and sent for milling. Then the metal copings were milled using Metal Laser Sintering using CAM. Following the same procedure, the other 11 die models were scanned and another 11 MLS copings were virtually designed for fabrication of MLS copings and then the blocks were subjected to manufacture.

FIGURE 16: 3Shape Trios Intraoral Scanner

FIGURE 17: Different Scanner tips of the Intraoral Scanner

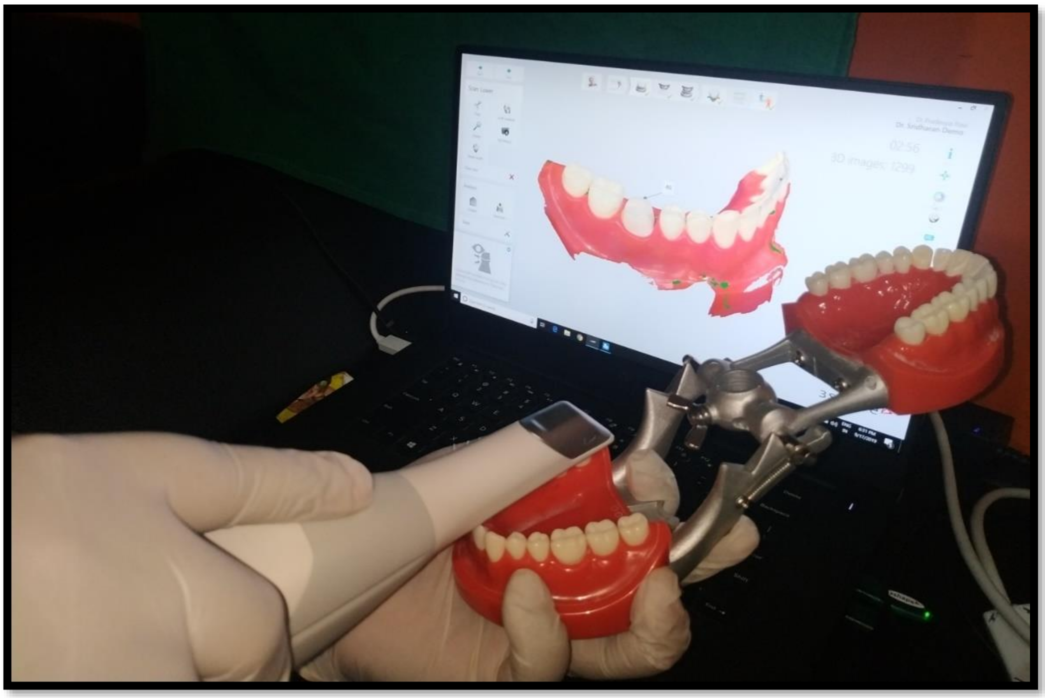


FIGURE 18: Scanning done with Intraoral Scanner

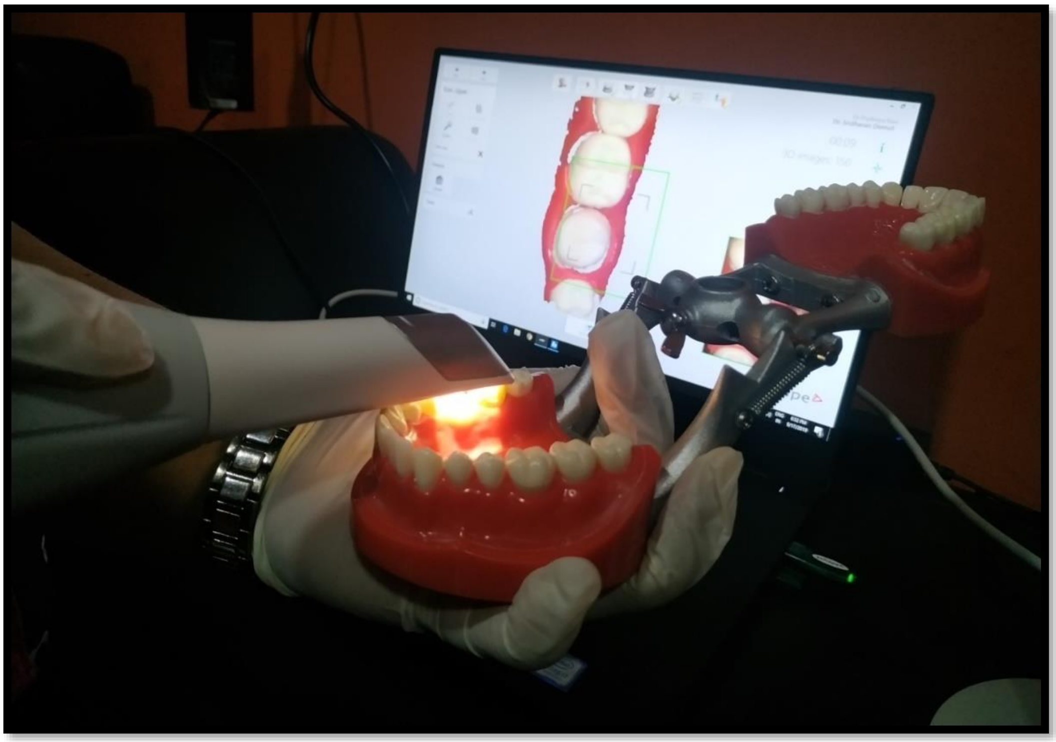


FIGURE 19: Scanned image obtained on the CAD Software

In Group 2, indirect method of scanning was carried out with indirect scanner (Ceramill map 400). Again 12 models were achieved by duplicating the master model with Agar (Reprogel) in the conditioning unit. Then the die models were fabricated using Type 4 Gypsum with the standardized water powder ratio to obtain 12 models of duplicated Gypsum dies and they were subjected to extra oral scanning. Then 3D image was obtained virtually and 30 µm spacer was designed to fabricate the copings using CAD. Then the STL files were sent for manufacturing using CAM.

FIGURE 20: Ceramill map 400 Extraoral Scanner

FIGURE 21: Die Model attached to Extraoral Scanner

FIGURE 22: Scanning done with Extraoral Scanner

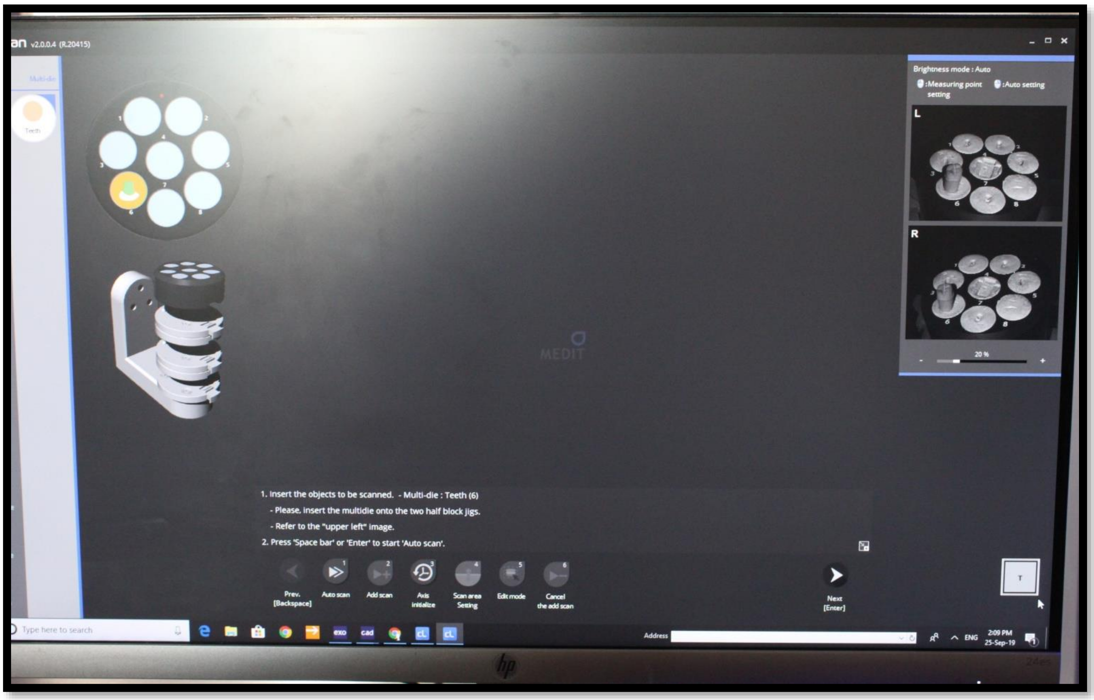


FIGURE 23: CAD Software linked with Extraoral Scanner

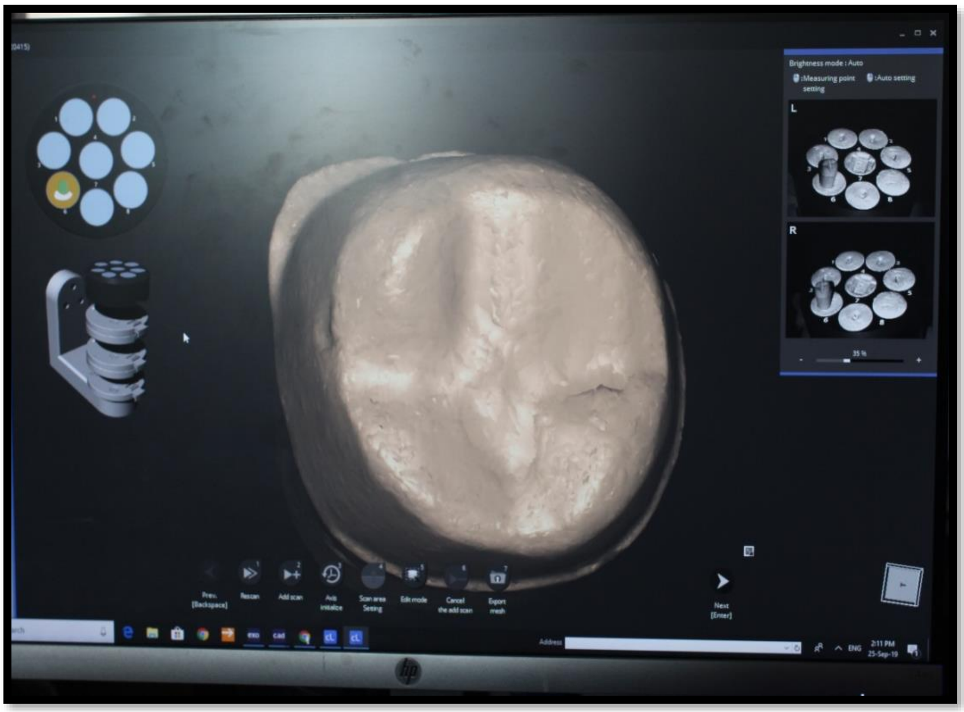


FIGURE 24: Scanned 3D image on the CAD Software

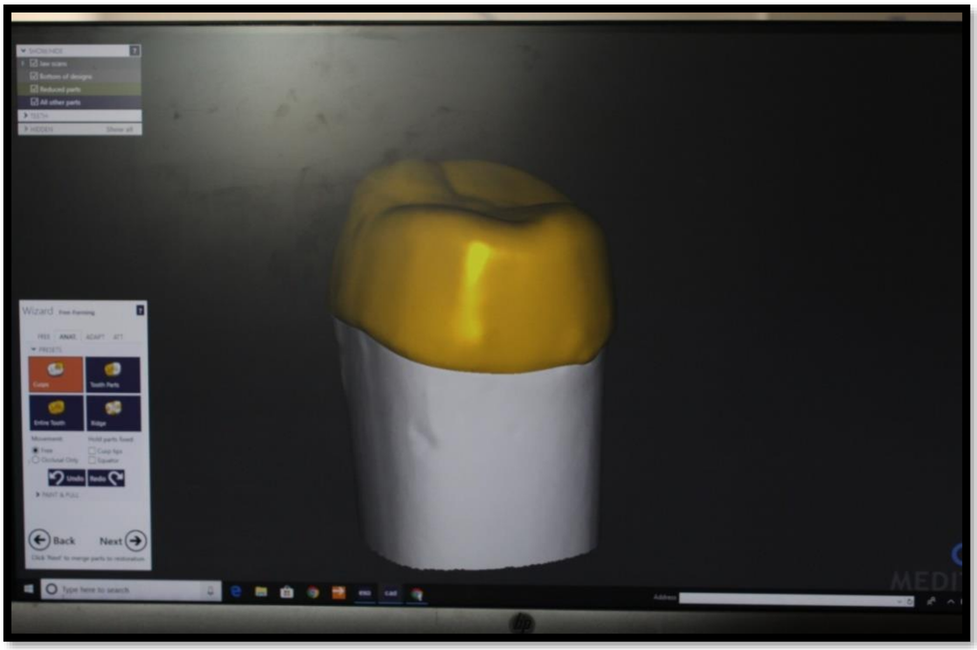


FIGURE 25: Virtually designed MLS crown on CAD

Thus 24 MLS copings were obtained for each Group and numbered from 1 to 12 for Group 1 and 13 to 24 for Group 2 for identification.

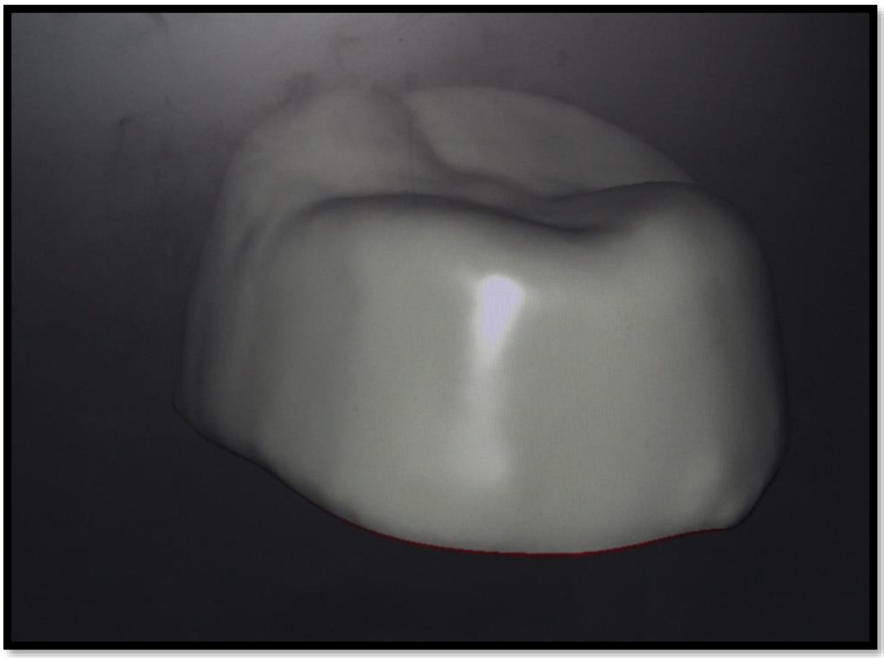


FIGURE 26: 3D image of designed crown

FIGURE 27: MLS crowns of the respective Die Samples fabricated by CAM

This was followed by evaluation of the Marginal and Internal fit of each crown in both the Groups. The Marginal and Internal adaptation of all the copings were evaluated using the Exocad Software at five points in the CAD model which was designed earlier. The measurement tool within the software measures the distance between the abutment tooth and the coping with standard evaluation parameters. The cement analog thickness was measured was also measured in these 5 predetermined regions which are:

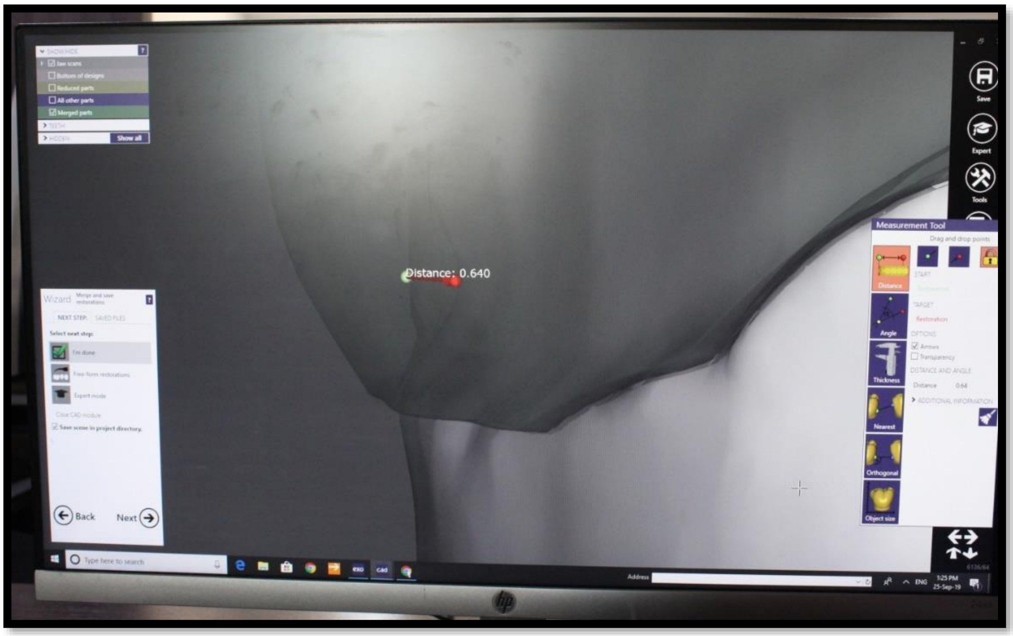


FIGURE 28: Marginal and Internal gap measured through CAD

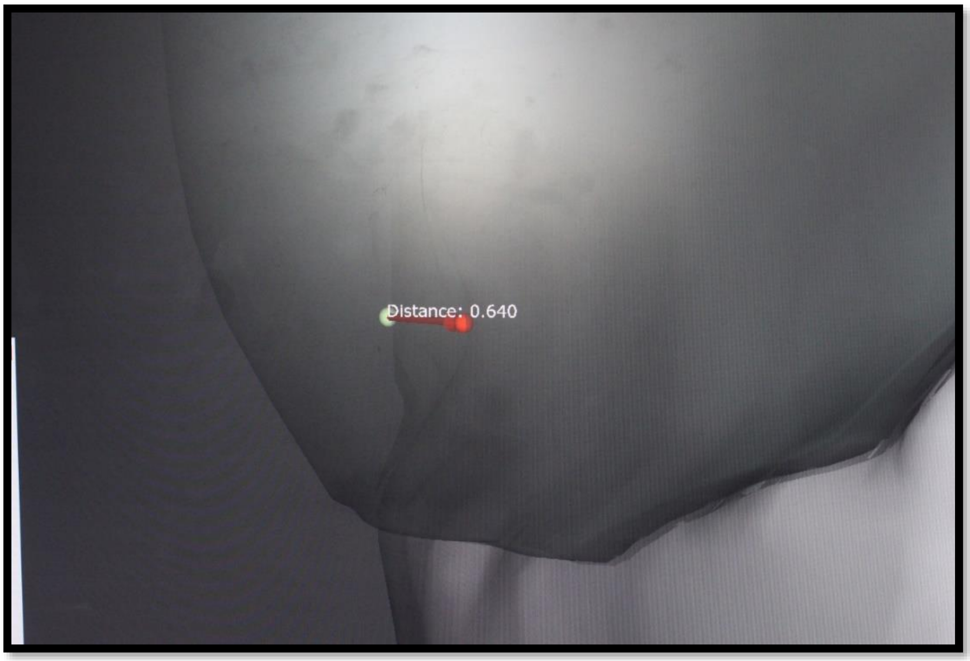


FIGURE 29: Evaluation done with the Ruler on the CAD Software

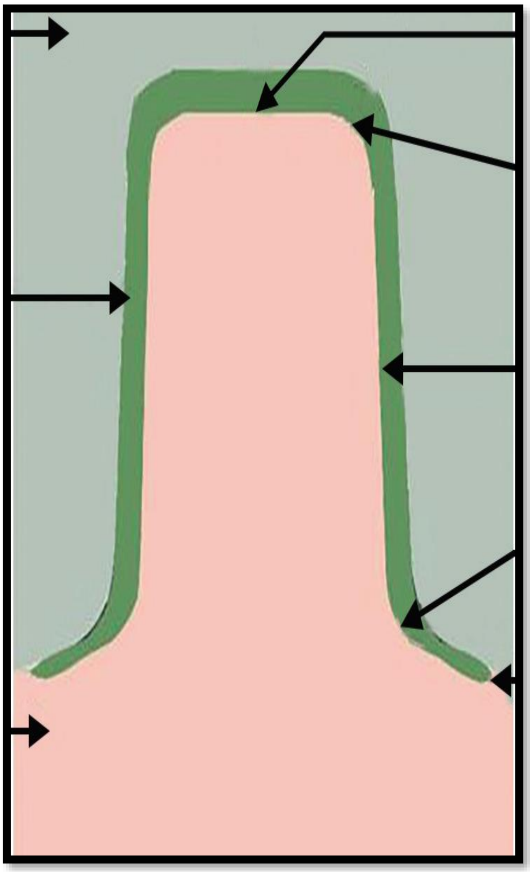


FIGURE 30: Schematic diagram of the Evaluation done on 5 Predetermined regions

1. Marginal fit: perpendicular measurement from the internal surface of the crown to the margin of the die.
2. Shoulder area: 800µm occlusal to the margin of the die.
3. Axial wall: Internal adaptation at the midpoint of the axial wall.
4. Axio – Occlusal transition area: Transition from the Occlusal plateau to the axial wall.
5. Occlusal area:500 µm from the axio occlusal angle in the direction of the center of the occlusal plateau.[32]

Location 1 represents Marginal fit and 2,3,4 and 5 represents Internal fit of the Crowns.

All the Measurements were taken the measuring locations were standardized to minimize errors.

RESULTS

In view of the current study, the results were obtained from evaluating the Samples (Die Stone models) and the fabricated MLS copings through the CAD software. The distance between the models and the fabricated crowns were directly measured with the CAD software which had ruler icon. The measurements were accurately made in the software with two points in which one point was placed on the inner border of the virtually designed MLS crown and the other point was placed on the inner border of the virtual image of the model. The evaluation parameters included five predetermined regions from which measurements were made. The measuring locations were standardized to minimize errors. Group A and Group B were evaluated and the readings were recorded separately. The obtained evaluations are as follows

Table 1: INTRORAL SCANNING (Group 1)

SAMPLES	MARGINAL FIT	SHOULDER AREA	AXIAL WALL	AXIO-GINGIVAL ANGLE	OCCLUSAL AREA
1	0.147mm	0.332mm	0.647mm	0.424mm	0.505mm
2	0.086mm	0.119mm	0.149mm	0.114mm	0.121mm
3	0.091mm	0.153mm	0.173mm	0.150mm	0.150mm
4	0.155mm	0.144mm	0.124mm	0.101mm	0.090mm
5	0.086mm	0.251mm	0.127mm	0.101mm	0.107mm
6	0.093mm	0.150mm	0.175mm	0.145mm	0.150mm
7	0.093mm	0.155mm	0.170mm	0.150mm	0.149mm
8	0.155mm	0.144mm	0.124mm	0.101mm	0.090mm
9	0.086mm	0.119mm	0.149mm	0.114mm	0.121mm
10	0.147mm	0.332mm	0.647mm	0.424mm	0.505mm
11	0.147mm	0.332mm	0.647mm	0.424mm	0.505mm
12	0.086mm	0.251mm	0.127mm	0.101mm	0.107mm

Table 2: EXTRAORAL SCANNING (Group 2)

SAMPLES	MARGINAL FIT	SHOULDER AREA	AXIAL WALL	AXIO-GINGIVAL ANGLE	OCCLUSAL AREA
1	0.063mm	0.183mm	0.188mm	0.137mm	0.227mm
2	0.136mm	0.160mm	0.156mm	0.142mm	0.156mm
3	0.160mm	0.366mm	0.236mm	0.182mm	0.183mm
4	0.226mm	0.515mm	0.688mm	0.748mm	0.640mm
5	0.797mm	0.72mm	0.484mm	0.723mm	0.784mm
6	0.164mm	0.377mm	0.234mm	0.187mm	0.183mm
7	0.136mm	0.160mm	0.156mm	0.142mm	0.156mm
8	0.790mm	0.750mm	0.486mm	0.725mm	0.784mm
9	0.063mm	0.183mm	0.188mm	0.137mm	0.227mm
10	0.797mm	0.72mm	0.484mm	0.723mm	0.784mm
11	0.797mm	0.72mm	0.484mm	0.723mm	0.784mm
12	0.226mm	0.515mm	0.688mm	0.748mm	0.640mm

In this Study, All statistical analysis were performed using Statistical Package for Social Science (SPSS, version 17) for Microsoft windows. The data were not normally distributed. And therefore Non Parametric tests were performed. The data were expressed as Mean and Standard Deviation. Mann Whitney test were used to compare continuous variables between two groups. A two sided p value < 0.05 was considered statistically significant.

The results were found to be

TABLE 3: GROUP STATISTICS

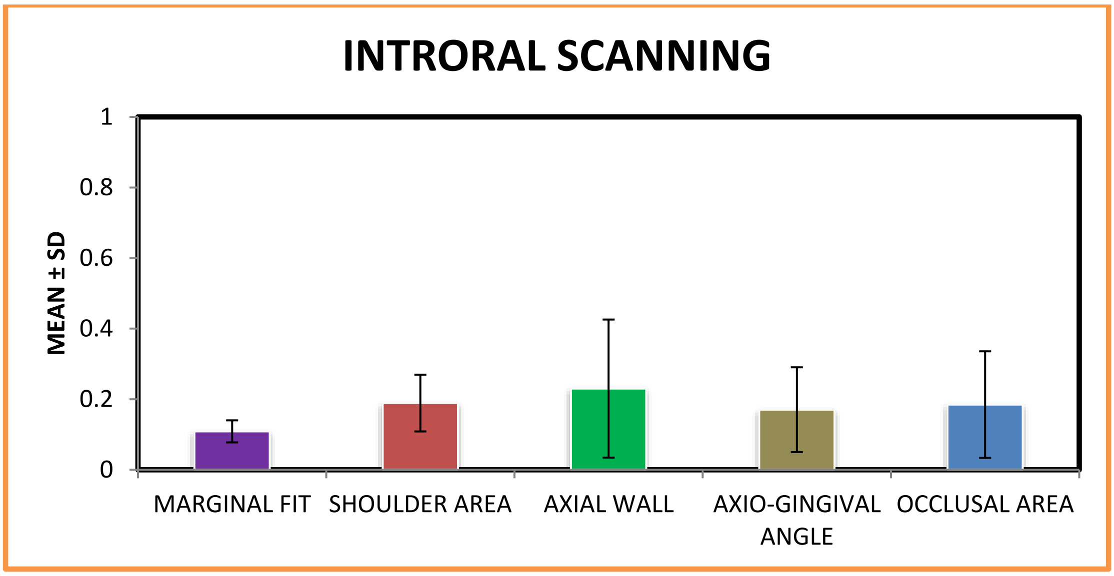
	SAMPLES	N	Mean	Std. Deviation	Std. Error Mean
MARGINAL FIT	INTRORAL SCANNING	12	.25500	.258051	.074493
	EXTRAORAL SCANNING	12	.10892	.031242	.009019
SHOULDER AREA	INTRORAL SCANNING	12	.36783	.210903	.060882
	EXTRAORAL SCANNING	12	.18917	.080467	.023229
AXIAL WALL	INTRORAL SCANNING	12	.32467	.204735	.059102
	EXTRAORAL SCANNING	12	.23017	.195610	.056468
AXIO-GINGIVAL ANGLE	INTRORAL SCANNING	12	.34900	.286079	.082584
	EXTRAORAL SCANNING	12	.17033	.120107	.034672
OCCLUSAL AREA	INTRORAL SCANNING	12	.35992	.264672	.076404
	EXTRAORAL SCANNING	12	.18475	.151051	.043605

TABLE 4: MANN-WHITNEY TEST

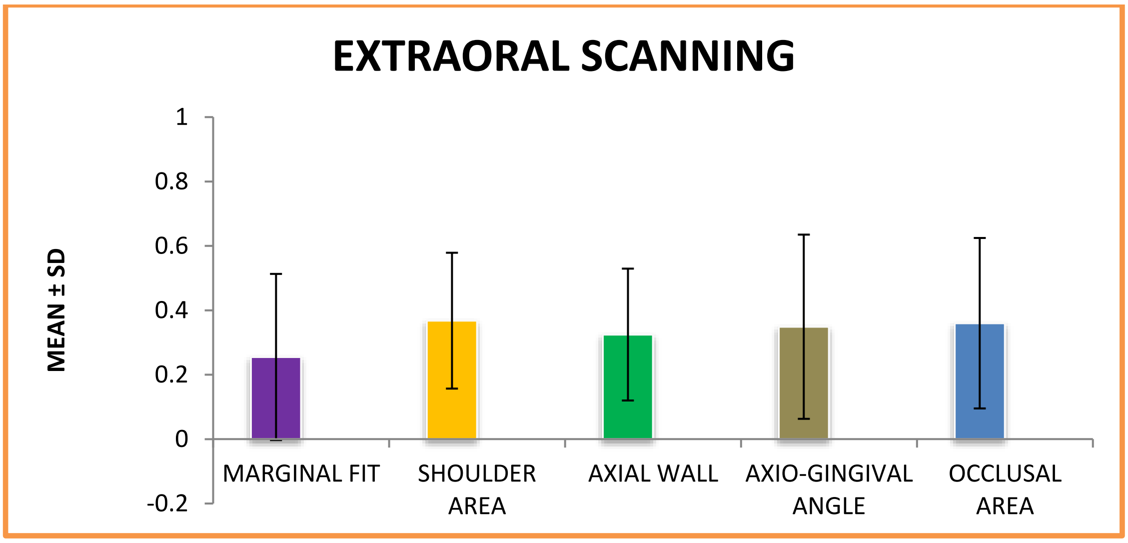
Variables	**SAMPLES**	**Mean Rank**	**Sum of Ranks**	**Mann Whitney U**	**Z**	**P value**
MARGINAL FIT	INTRORAL SCANNING	15.50	186.00	36.0	-2.095	**0.036**
	EXTRAORAL SCANNING	9.50	114.00			
SHOULDER AREA	INTRORAL SCANNING	16.83	202.00	20.0	-3.017	**0.003**
	EXTRAORAL SCANNING	8.17	98.00			
AXIAL WALL	INTRORAL SCANNING	16.08	193.00	29.0	-2.495	**0.013**
	EXTRAORAL SCANNING	8.92	107.00			
AXIO-GINGIVAL ANGLE	INTRORAL SCANNING	15.92	191.00	31.0	-2.383	**0.017**
	EXTRAORAL SCANNING	9.08	109.00			
OCCLUSAL AREA	INTRORAL SCANNING	17.17	206.00	16.0	-3.24	**0.001**
	EXTRAORAL SCANNING	7.83	94.00			

The graphs of the obtained results are as follows

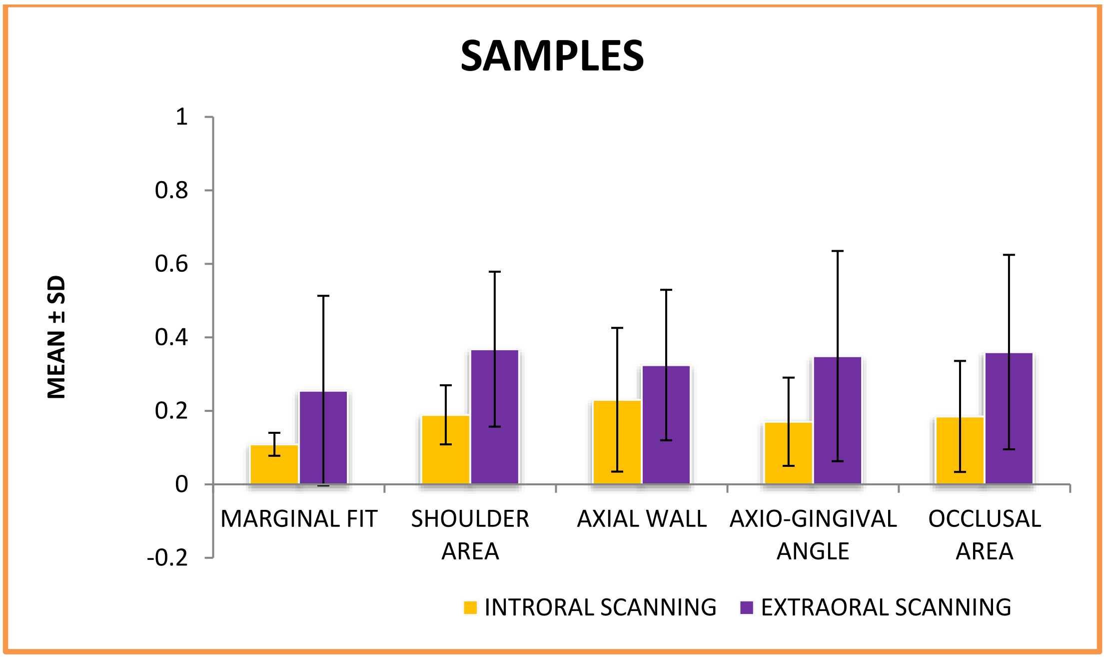
Graph1



Graph 2



Graph 3



Graphs reveal the mean marginal fit and internal fit for extra oral scanning is on the upper side of the scale, whereas the mean for the intraoral scanning is on the lower side of the scale for each predetermined region. Thus, the difference in the means of two methods is quite large and is likely to be significant. In summary, the present data supported the fact that the marginal and internal fit by intraoral scanning is statistically different than extra oral scanning method at each predetermined region.

DISCUSSION

Marginal and Internal fit are the important criteria for the success of crowns and Fixed Partial Dentures. When there is lack of adequate fit it leads to increased dissolution of the luting cement and will eventually lead to caries and periodontal disease. This will reduce the longevity of the restorations.

Conventional casting technique involves manual procedures which is more susceptible for bias.[39] The three main factors that lead to crown misfit are[1]

1. Precision of scanner
2. The software of the scanning data into 3D model
3. Precision of milling machine

A precise casting procedure depends wholely on the accuracy of the wax pattern from which it is done. Thus, the fabrication of a flawless wax pattern is required. These wax patterns can be developed either by additive technique, subtractive technique, or combination of both. When the casting is done, the major drawback occurs with the fit of the crowns fabricated or it can be either too large or small, or it can occur when instructions of investment manufacturer is not properly followed. Thus, It is not possible to blame a single procedure since many variables and environmental conditions are involved during the conventional lost wax technique. Thus, the casting procedure is only a part of the complete procedure (that is the fabrication of Fixed Partial Dentures) and it should be rigidly followed to achieve precise castings and consistent results. The "misfit" of a casting can be measured between the casting surface and tooth perpendicularly from the internal surface of the casting to the axial wall of the preparation –'internal gap' and the measurement of it at the margin - 'marginal gap'. [39]The vertical marginal misfit parallel to the path of withdrawal is called the vertical marginal discrepancy. Clinically acceptable marginal discrepancy for cast restoration was found to be 10 to 160 µm. The marginal openings of 50 µm or less and probably of 100 µm clinically acceptable. The restorations need a luting cement of film thickness 20–40 µm. The luting agent will impart hydraulic pressure between the tooth and the restoration rendering incomplete seating with marginal discrepancy greater than before cementation, hence the cement space becomes critical for adaptation. If the axial walls are not well relieved, there will be premature contact, further preventing the seating of coping. Therefore, MLS technique were found to fabricate copings that had less marginal discrepancy and consistent axial wall adaptability when compared to Lost wax technique.[42]

The literature is scarce in studies that have compared the gap measurements of laboratory processed crowns and chair side processed crowns. Good adaptation is critical for longevity of a crown. Poor marginal fit leads to secondary caries, micro leakage, marginal discoloration and dissolution of the cement. Marginal fit plays an important role in clinical outcome of a crown. Some studies have found that durability of crown may be affected if the internal fit and marginal fit are not clinically relevant. This parameter in determining whether or not CAD/CAM chair side crowns are an acceptable alternative to laboratory processed crowns is important. Seating of the crown allowing both resistance and retention is facilitated by proper internal adaptation. Studies have found that utilization of CAD/CAM technology correctly can give adequate marginal fit which is clinically accurate. Some studies have been done on composite crowns manufactured by CAD/CAM technology that have found that the marginal accuracy was clinically acceptable.[6]

The CAD/CAM technique provides accurate fit of the restorations. It is a newer technology which requires acquisition of data and it is done by digitalized mechanical scanning. CAD/CAM was introduced in dentistry two decades ago for ceramic inlays and onlays. High speed acquisition of data with CAD/CAM technology helps in solving above mentioned problems. The use of this software results in full control over the framework designs. This technique involves fewer production steps compared to conventional techniques. Recently, various techniques are available for rapid production of FPD. They involve the CAD/CAM based systems. Such technology includes metal laser sintering (MLS). It is computer controlled, precise process that ensures consistent work quality. The defects or possible inclusions that are seen in conventional casting methods are dispensed with this method. Cement thickness and coping thickness can be standardized by using this method.[15] MLS has improved marginal fit as conventional technique usually has distortion while making of multiple unit framework. The metal laser sintering is an additive technique, based on the 3-dimensional information received from the CAD, prosthesis fabricated in CAM machine has an advantage that it eliminates the drawbacks of the lost wax technique like distortion, cleaning of moulds, elaborate steps are reduced, messy tasks of deflasking. MLS is an automated and shorter working time technique and it eliminates the procedures involved in LW technique. This procedure reduces the chair side time and the time required in dental laboratory. Scanners used with CAD/CAM technique could be optical, laser or contact scanners.[23] The MLS is a type of CAD/CAM based technology which helps in designing of the prostheses using software. Then the information is transferred to MLS unit and then fabrication of prostheses is done which is fabricated by incremental layering of the alloy powder of approximately 20 µm thickness. The alloy particles are sintered by high powered laser and the process is repeated.[39]

The literature is somewhat sparse in comparing laboratory processed pressed ceramics to CAD/CAM crowns, there is literature supporting the finding of clinically acceptable marginal fit of

CAD/CAM restorations of various types. In one study which compared laboratory made CAD/CAM crowns the marginal gap for each experimental crown met the clinically acceptable level. Some studies have been done on composite crowns manufactured with a CAD/CAM system that have found that the marginal accuracy was clinically acceptable. Studies have also compared in-office CAD/CAM generated copings and those generated in a private laboratory and found that the accuracy of fit of the CAD/CAM copings was acceptable. One study that compared laboratory processed pressed ceramic onlays to chair side CAD/CAM onlays found that both systems exhibited a clinically acceptable gap width. Kushal N Gandhi et al (2017) in their study, evaluated that the internal and marginal fit of the Laboratory fabricated monolithic zirconia crowns using both direct and indirect methods of used for scanning and found that better marginal and internal fit was seen in the crowns fabricated by the direct method. However, the crowns fabricated by the indirect method had more discrepancy but were in the clinically acceptable limits. [13]

The 3Shape Trios, which operates on the basis of the ICL method, is used in clinical environments.

The D810, which is an EAT scanner from the 3Shape is used for the fabrication of prostheses in dental clinics. Earlier, the studies performed, showed that the accuracy of them are acceptable for long-term clinical success in the industry.

In a study done by Francesco Mangano et al (2017) he compared among optical impressions and conventional impressions and evaluated the most differences between the IOS can be currently availed commercially. He also determined the current usable clinical applications/limitations in the use of IOS respectively.[36]

He concluded from the review that

The optical impressions can reduce patient discomfort a great extent; IOS are mainly time-efficient and can simplify most clinical procedures for the operator, thereby eliminating plaster models;

However, with IOS, demerits persist, such as it can be difficult to detect the deep margin lines in a prepared teeth and also in case of bleeding, however there is a learning curve, and also purchasing and managing costs comes into consideration.

Though intra oral scanners have its perks, the accuracy of a scanner varies from each manufacturer and must be selected accordingly. Care should be taken prior scanning because of the materials scanned will have variable translucencies which affects the results of the scan; hence they are coated with powder for standardizing the translucency. Using the powder, ensures the optical properties processed by the experimental model that are close as possible to the materials scanned in the dental office.[29]

The discrepancy of the digital crown is directly proportional to the discrepancy of the scanned data of the master die which the data adaptation value. The recommended marginal gap in the crown restorations should be less than 120 µm for longevity. Marginal gaps much smaller than 120 µm: also 6 µm for the extra oral scanner mode and 9 µm for the intraoral scanner mode were evaluated. A comparison made on the accuracies of the crowns generated from the scan needs the use of both the scanner and the CAD software simultaneously. However, the EAT and IAT systems are widely used with the ICL scanner. Thus, in clinical practice, ICL is recommended to be used with many different software, which itself makes a general comparison of the clinical advantages of the ICL system to other scanners. The Crowns fabricated using CAD/CAM system showed the marginal gaps which is of less than 120 µm in. These gaps are comparatively much smaller than those observed in previous studies. This difference can also arise in the transition of a digital model to a physical model. The knowledge of how perfect the marginal fit and the thickness of the cement being used is of equal importance. Nevertheless, the internal fit is largely neglected in earlier made researches, despite of the extensive studies of marginal fit performed.[11]

The accuracy of a digital crown depends on the scanning data. All the scanned data at the axial wall were smaller than the master die, except at the margin. Clinically, the discrepancy between abutment teeth and the data scanned in each scanner should be known as a design value before designing a digital crown. While designing, the value must fulfill target cement thickness. This will contribute to the accuracy of the digital crown.

Thus, from the above literature, this in vitro study was carried out with an objective to compare the Marginal and Internal fit of Metal Laser Sintered crowns scanned by Direct and Indirect scanning methods for long term clinical success of fixed partial dentures/ crowns.

CONCLUSION

This in vitro study aims at observing the three - dimensional fit of a MLS crown fabricated via both direct and indirect scanning methods. Based on the findings of this study, it is concluded that, No1.BothIntraoral and extra oral scanners shows the same in scanning the prepared teeth. No2. Much Higher discrepancies are merely expected in the cervical and occlusal surfaces of the teeth.

The results did show better marginal and internal fit in crowns fabricated by the direct method; however, the crown fabricated by the indirect method has more discrepancy but was in the clinically acceptable limit. Both methods can be employed for fabrication of MLS crowns depending on the operator's preference of carrying out chair side scanning or laboratory scanning. The current study may serve as a useful guide in deciding which method of scanning would give a better marginal and internal fit of MLS crowns, so that the longevity of the crowns in clinical situation can be predicted.[32]

With the limitations of this study performed, it is concluded that direct method of scanning is superior and more convenient to both operator and patient. There were statistical differences between both the groups except in the axial wall region with regard to marginal fit. Although not evaluated in this study, excessive internal gaps may adversely affect the fracture strength and longevity of crowns. Further in vivo studies should evaluate the clinical performance of MLS crowns made from these both methods.

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ANNEXURES

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This is to certify that **Dr. D. JENEFER SHEKINA** has done her work in **VITALIUM DENTAL LAB PRIVATE LIMITED, CHROMPET, CHENNAI** for the dissertation titled **"COMPARATIVE EVALUATION OF THE MARGINAL FIT AND INTERNAL FIT OF METAL LASER SINTERED CROWNS WITH DIRECT AND INDIRECT SCANNING TECHNIQUES: AN INVITRO STUDY"** for the fabrication of MLS Crowns. Samples using CAD/CAM with Extraoral Scanners.

For Vitalium Dental Lab Pvt Ltd

Director

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