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Evaluation of Marginal Gap and Internal Adaptation of All-Ceramic Coping Fabricated With CAD/CAM and Press-Laboratory Technique; an In Vitro Study

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Abstract: *This study aims to evaluate marginal gap and internal adaptation of zircon reinforced lithium disilicate copping fabricated by conventional press-laboratory and CAD/CAM systems. Methods: Tooth #14 was prepared per standard specification to receive the zircon reinforced lithium disilicate copping. For press-laboratory technique fifty type IV gypsum dies tooth #14 were duplicated and divided into two groups (n=25). CAD/CAM technique (Group A) copping was fabricated with the CEREC CAD/CAM system according to manufacturer's instructions. Within press-laboratory made copping, impressions were taken on the region area with one-step impression techniques with light and putty consistency Polyvinyl siloxane. Impressions were sent to two independent dental laboratories (Groups B and C) for fabricating the press copping. Tooth #14 was optically scanned and zircon reinforced lithium disilicate blocks were used to fabricate copping using CAD/CAM technique. The marginal and internal gap of the copping was assessed by the silicone replica technique which use optical microscope at 160× magnification to comparison between results of replica. Eight sections of each replica were obtained, four section were used to measured internal gap and each section was evaluate at four points: cervico-axial (CA), mid axial wall (AW), axio-occlusal edge (AO) and Centro-occlusal wall (CO), and other four section used to measured marginal gap and each section was evaluate at one points: middle buccal, middle palatal, middle mesial and middle distal using an image analyzing software. Statistical analysis was performed using t-test. Result: there was a significantly differences in marginal (t=11.17, P-value=0.000), and internal gap cervically (t=2.79, P-value=0.007), middle (t=3.42, P-value=0.001) and occlusally (t=3.42, P-value=0.001) of press-laboratory technique and the CAD/CAM technique.*

Keywords: Marginal Gap, Internal Adaptation, Ceramic Coping, CAD/CAM, Vitro Study

1. Introduction

The aim of prosthodontics is to replace missing teeth and restore those that are mutilated. The fixed prosthodontics have many steps start with examination, planning, preparation of the tooth, impression making, restoration try-in and end with cementation of restoration. Success of fixed restorations depends on functional, esthetic and biological requirements, with the focus on the last one which depends to a large extent on the fit between crown and prepared tooth structure.

The adaptation of a crown to the abutment tooth can be one of the most important factors that affects crown prognosis, so the marginal gap is defined as the vertical distance from the internal surface of the abutment crown to prepared tooth surface closed to the prepared finish line, and the internal adaptation is defined as the width of the cement space between the tooth and the restoration. The marginal gap was evaluated clinically by Mclean and von Fraunhaufer that concluded to 120 µm was the maximum tolerable maximum opening (1). And as reported by Fransson et. al said theoretically, the internal space necessary of cement is 20 to 40µm (2) and other study concluded to the practical range for clinical acceptability of internal fit seems to be approximately 50 to 100µm (3).

Other factors such as margin configuration, impression making, material of the restoration, type of cement used, cementation technique, die spacer thickness, wax pattern fabrication, investment and casting are also affecting the prognosis of an adapted crown. One of the most critical aspects of providing marginal gap and internal adaptation of a crown is fabrication technique. There are many techniques of fabrication ceramic crown that used in dentistry, in this study we will use CAD/CAM and Press-laboratory techniques. CAD/CAM is generally standing for computer aided design and computer aided manufacturing numerical control respectively, designing usually starts with CAD software where the actual drawing of part to be machined is made which is followed by generating tool paths on CAM software. In other hand press-laboratory techniques is a method in which it fabricates crown using the lost wax ingots of ceramic material which heat pressed into mold with ceramic furnace to obtain desired shape after burn out

This study guides dentists in selecting the most adaptation and less marginal of fixed restoration.

2. Research objective

To assess the difference in marginal and internal adaptation of all-ceramic crowns fabricated with CAD/CAM and Press-Laboratory Technique.

3. Literature Review

3.1 Background of full coverage restoration

Full-coverage dental restorations are integral part of fixed prosthodontics. The reasons that compel patients to seek any type of dental restorations including inlays, onlay, veneers and crowns, could be divided into the following: Dental disease including caries or periodontal causes, Trauma such as accidents and Esthetics to improve the appearance of their smile. Along with the diversity of the restoration type, comes the diversity of materials used to produce each one of those types.

3.2 All-ceramic

With the increased demand for more esthetic appearance, all-ceramic restorations have become very popular over the last decades. Such restorative all-ceramic systems must fulfill biomechanical requirements and should provide longevity similar to metal–ceramic restorations while providing enhanced esthetics [(4)]. All-ceramic fixed dental prostheses (FDPs) are considered an established treatment alternative to metal-ceramic FDPs in daily clinical practice. The main reason to use of the all ceramics instead of metal-ceramics is based on more favorable esthetics.

There are two concepts behind the science of ceramics used in dentistry (5). The first concept includes three main groups: predominantly glassy materials, particle-filled glasses and polycrystalline ceramics and the second concept includes any composition of two or more of those groups. The ceramics that best mimic the optical properties of enamel and dentin belong to the first group and the filler particles that improve the mechanical properties and control optical results belong to the second group. The third group has no glassy components and is much tougher and stronger than glassy materials.

The main shortcoming of the firstly introduced ceramics like, e.g. feldspathic glass ceramic, yet, was low mechanical stability, which limited the indications for all-ceramic reconstructions to anterior regions and to single-unit FDPs. In the past years, numerous new dental ceramic materials were developed with the aim to increase the overall stability of the all-ceramic reconstructions, while still maintaining the esthetic benefit. Among those materials, leucite or lithium disilicate leucite or lithium disilicate reinforced glass ceramics and oxide ceramics such as alumina and zirconia appeared to be very promising for different indications. Reconstructions made of these more recently developed ceramics were placed at posterior sites and even included multiple-unit FDPs.

Culp and McLaren presented three disadvantages of veneered all-ceramic restorations (6). The first disadvantage is the high value and increased opacity of the substructure material, which prevent it from being used for the whole thickness of the prosthesis especially in aesthetic areas. The second disadvantage is that although the high-strength material has excellent mechanical properties, the layering ceramic, to which is veneered, exhibits a much lower flexural strength and fracture toughness. The third disadvantage is the combination of two incompatible materials in a synergistic way, whether that combination is metal with metal-ceramic or zirconia with zirconia layering ceramic, where a strong bond is difficult to create.

3.3 IPS e.max all-ceramic

First developed IPS Empress which is a leucite-reinforced glass ceramic. It is used with the hot-pressing technique that involves the use of a pre-colored glass-leucite ingot that is heated and pressed into a phosphate-bonded investment. This technique produces a restoration with good marginal adaptation, the strength of the material itself has limited its use to single unit full-coverage restorations in the anterior segment (7,8,9). In the posterior segment it can only be used as onlays or partial veneer crowns with 97.1% survival rate in 3 years (10).

The same company introduced IPS Empress 2, in 1998. It was a lithium-silicate based glass ceramic (SiO_2-Li_2O) using the heat-pressing procedure with *in vitro* mean fitting accuracy of posterior crowns amounted to less than 50 µm (11). The survival rate of this new all-ceramic material was found to be 100% for posterior single crowns and 70% for 3-unit FDPs, in the anterior and premolar area, in a 5-year prospective clinical study (12). The properties that the material possesses include high flexural strength (360 MPa to 440 MPa), high fracture toughness (2-3 MPa) and high thermal shock resistance due to the low thermal expansion (13)

Lithium disilicate can be processed using either lost-wax hot-pressing techniques (IPS e.max Press) or CAD/CAM milling procedures (IPS e.max CAD). The pressable lithium disilicate (IPS e.max Press) consists of approximately 70% needle-like lithium disilicate crystals embedded in a glassy matrix. lithium disilicate provides the option of a monolithic/fully anatomical restoration fabricated exclusively from this material. This produces a final restoration with high strength and good esthetics.

3.4 Longevity of all ceramic restoration

Pjetursson et al. published a systematic review of all-ceramic and metal-ceramic crowns. After the exclusion criteria were applied, a final number of 34 (28 all-ceramics and 6 metal-ceramics) studies were evaluated [(14)]. The authors were surprised to find that there were only 6 studies evaluating long-term survival of metal-ceramic restorations available and moreover, that four of them had been published very recently. In meta-analysis, the 5-year survival of all-ceramic crowns was estimated to be 93.3% and 95.6% for metal–ceramic crowns. All-ceramic crowns were also analyzed according to the material utilized; Procera crowns showed the highest 5-year survival rate of 96.4%, followed by reinforced glass-ceramic (Empress) and In Ceram crowns with survival rates of 95.4% and 94.5%, respectively.

Etman and Woolford, in another study, compared Procera All-Ceram and IPS e.max Press to metal ceramic restorations, and the 3-year clinical evaluation indicated similar success rates for all 3 groups (15). The modified United States Public Health Services (USPHS) evaluation showed that the IPS e.max Press and metal-ceramic crowns experienced fewer clinical changes than Procera All-Ceram.

3.5 The marginal and internal fit of the dental restoration

The accuracy of fit is the characteristic that is most closely related to the longevity of a restoration (16,17). Ideally the cemented crown should precisely meet the finish line of the prepared tooth. The importance of a well-fitting full-coverage restoration can be illustrated most clearly when considering the implications that occur with an ill-fitting restoration. Luting agent dissolution (18), microleakage (19,20), caries (17,19,20), hypersensitivity and periodontal inflammation (20,22) are the most common of such implications. Caries have been shown to be the most common reason (36.8%) for crown failure according to a 3-year clinical survey study by Schwartz et al. Bader et al. found that plaque and calculus scores, gingival inflammation and bleeding were significantly higher on crowned teeth than uncrowned teeth.

The traditional methods of ceramic fabrication have been described to be time-consuming, technique sensitive and unpredictable due to the many variables and CAD/CAM may be a good alternative for both the dentists and laboratories. CAD/CAM may also reduce the fabrication time of high strength ceramics such as InCeramTM (Vita Zahnfabrik, Bad Sackingen, Germany) by up to 90%. The accuracy of marginal fit is valued as one of the most important criteria for the clinical quality and success of prosthetic restorations.

Christensen found, using a linear regression prediction formula, that an acceptable gingival margin range is 34-119µm (23). McLean and von Faunhofer, also, suggested that restorations with marginal gap less 120µm are more likely to be successful (24).

Several studies have investigated the internal fit with regard to crown adaptation (24-33). Eames et al. discovered that a 25µm thickness of a die spacer not only improved the casting seating but also increased retention by 25% (26). Grajower and Lewinstein said that the thickness of the spacer should allow for the cement film thickness, roughness of the tooth and casting surfaces, dimensional inaccuracies of the die and distortions of the wax pattern (27). Wilson showed that there was a significant correlation between increased spacing and decreased seating time and decreased seating discrepancy (28). He also concluded that spacing of less than 40µm prevented the crown from seating well before the set of the cement, which resulted in marginal discrepancy.

Another aspect of the importance of the internal fit of the crowns is its effect on fracture resistance of all-ceramic restorations. More specifically, Tuntiprawon and Wilson evaluated the effect of increasing cement thickness (using platinum foil and die spacer) on the fracture strength of all-ceramic crowns (30). They found that a decrease in strength was observed with increase of cement thickness and the strength decrease was possibly attributed to the greater deformation of the porcelain into the cement as well as the decreased thickness of the crown itself.

Bottino et al. studied the cervical adaptation of metal crowns with regard to the influence of cervical finish line, internal relief and cement type (28) The least marginal discrepancy was achieved with chamfer finish line, internal relief and use of glass-ionomer cement. Marginal fit was measured with a light microscope in a plane parallel to the tooth surface before and after cementation.

3.6 Methods to measure the marginal gap

Several techniques have been suggested for the measurement of the marginal fit alone or in combination with the internal fit of crowns. All of these present advantages and disadvantages, and a small description of the most commonly used ones will follow.

To begin, the dental explorer is the most common tool used to detect marginal adaptation, as it is often the only clinical instrument available. Hayashi et al. studied the influence of the explorer tip diameter and the visual condition in evaluating vertical steps and horizontal gaps (34, 35). This technique becomes even less accurate with subgingivally placed margins where, according to Christensen, in an ideal environment, the acceptable mean opening of subgingivally marginated cast restorations was shown to be almost 3.5 times the acceptable mean opening of supragingival margins (23).

The radiograph could also be considered a tool that would provide information with regard to the marginal fit of the crown; Assif et al. compared the tactile method the use of explorer) to the use of radiographs and to a technique using impression material in order to examine the marginal fit (36). The results supported that neither the explorer nor the radiographs were superior in detecting discrepancies, with the impression technique presenting the most accurate data of the three.

A technique used *in vitro* is the classic destructive method of sectioning the specimens and then studying them under an optical or scanning electron microscope [37,38]. The advantage of this technique is the accuracy and the precision in repeatability of the measurements; however the obvious limitations of this method are the destruction of the specimens which creates the need for duplicates, the limited area that is evaluated since the sections have a minimum thickness and the additional steps that are required (embedding in resin and sectioning).

Romeo et al. used a stereomicroscope under 50x magnification to measure the marginal adaptation of CAD/CAM restorations [39]. Photographs were taken under the microscope and the measurements were performed with PC software. It is very technique-sensitive; a slight deviation of the photographic angle will distort the measurement. Specifically, because the microscope is set perpendicular to the margin of the restoration, it makes it impossible to evaluate the marginal gap of an overhanging restoration.

Tan et al. used a similar setting (and therefore similar technique limitation) in order to compare the marginal adaptation of CAD/CAM, wax/CAM and wax/cast restorations [40]. They took a 1:1 photograph of each of four sides of the die using a digital camera mounted on a tripod. All photographs were taken sequentially with no change in the horizontal inclination of the camera. Calibrated digital measurement software was used to measure the marginal openings.

Mitchell et al. compared, *in vitro*, the marginal fit of 4 types of complete crowns on human premolar teeth with the use of a nondestructive technique called profilometry [41]. This method determined whether the fit was influenced by type of the crown or surface morphology of the tooth (grooved or ungrooved surfaces). It was found to be an accurate method, but considering that this technique does not identify cases of vertical overextension, the results once again are subjected to false interpretation.

A technique that has been suggested by Pelekanos et al. was the computerized x-ray microtomography, where multiple projections of an object were taken as the source rotated around it [42]. The projections were transferred to a computer and with special software; small slices of the object's internal structure could be added to the object's 3-D image. Advantages of this technique included the ability to produce images of the internal structure of the specimen, in section form, while allowing for 3-D reconstruction, and the possibility of obtaining very proximate sections. On the other hand, the disadvantages that this method presented included the low capacity of discrimination of CT microtomography in comparison with the optical or electron microscope, the possible artifacts from refraction of the images from radiation, the compulsory radiopacity of the material tested and the difficulty to define the materials that have different coefficients of absorption.

The most commonly found nondestructive technique in literature is the replica technique (RT) [43,49]. Replicas of the intermediate space between the inner surface of the crown and tooth surface are made by the method described by Molin and Karlsson [43]. The important characteristic of this technique is that it can be used *in vivo* as well as *in vitro* since it does not involve the destruction of the specimens. Boening et al., using an RT based on the previously mentioned study, measured *in vivo* the marginal fit of Procera All-Ceram crowns using a light body silicone to fill space between crown and tooth and a heavy body silicone to stabilize the light body film [44]. After removal from the artificial crowns, the replicas were segmented, and measurements of the film thickness were performed with a light microscope. The main limitation of this method is the distortion or even the damage of the material during manipulation.

More recently the measurement using the RT has changed. Luthardt et al. developed an indirect technique in order to achieve 3-D analysis of the internal space between the crown and the metal master die [50]. The method used gypsum duplicate dies along with silicon films (replicas) that represent the internal surface of the crowns, which were, then, digitized using the same measuring position.

3.7 Marginal adaptation of all-ceramics

Yeo et al. evaluated, *in vitro*, the marginal discrepancies of 3 different all-ceramic crown systems (Celay In-Ceram, conventional In-Ceram, and IPS Empress 2 layering technique) in comparison to a control group of metal ceramic restorations using an optical microscope [51]. The results indicated that the IPS Empress 2 system showed the smallest and most homogeneous gap dimension, whereas the conventional In-Ceram system presented the largest and more variable gap dimension compared with the metal ceramic (control) restoration.

3.8 Dental impression

The dental impression is of great importance in dentistry in general, and in fixed prosthodontics in particular. At the beginning, rigid materials including zinc oxide eugenol paste, wax, modeling compound and impression plaster were used. Because of the obvious rigidity, distortion and breakage that occurred. In the 20th century, elastomeric materials were introduced. They are classified as aqueous and non-aqueous elastomers. The first category consists of the reversible hydrocolloid (agar) and the irreversible hydrocolloid (alginate). The second category, non-aqueous, consists of polysulfides (1950), condensation silicones (1955), polyethers (1965) and addition silicones (1975). Polysulfides they reproduced details with excellent results, were not rigid and captured subgingival margins but they were dimensionally unstable, did not have good elastic recovery and had long setting time. For the condensation silicones, the release of ethyl alcohol during polymerization that causes shrinkage was the main disadvantage. Polyethers are hydrophilic, thus they have superior detail reproduction in the presence of moisture. They are, also dimensionally stable and they provide an excellent reproduction of detail. However, strict disinfection guidelines should be respected in order to prevent expansion. Also, their rigidity makes them more difficult to remove than addition silicones and more likely to fracture delicate gypsum dies. Addition silicones, Polyvinyl siloxanes (PVS), have become the most widely used impression material in dentistry (52). They have the best detail reproduction and elastic recovery of all available materials, and their dimensional stability allows multiple pours; thus, PVS materials are the materials of choice in fixed prosthodontics (52, 53) They are moderately rigid, have good tear strength, relatively short setting time and can be used with most disinfection protocols. Their disadvantages include susceptibility to contamination as a result of sulfur and sulfur compound and hydrophobic behavior (contact angle 98 degrees) caused by hydrophobic aliphatic hydrocarbon groups around the siloxane bond. Today, in order to overcome this, nonionic surfactants (nonylphenoxypolyethannol homologues) have been incorporated and the new PVS materials, have improved wettability (contact angle 53 degrees); however, they are still clinically acceptable only in dry conditions (54).

Addition silicone impression materials had clearly better dimensional stability than polyether up to 720 hours which is in agreement with previous studies (55, 58). PVS materials have the best elastic recovery at over 99% with a specific test undercut (57).

The clinical success of the all-ceramic restorations depends not only on the mechanical and physical properties of the materials used but also on the precision of the particular computer-aided-designed/computer-aided-manufacturing systems used to 38 fabricate those restorations. The application of CAD/CAM systems in dentistry had initiated as early as 1970s by Duret and colleagues, but it was not until the 1980s when Mormann and colleagues developed the CEREC system, that they gained popularity (58, 59).

2.9 CAD/CAM system

The components of all CAD/CAM systems include: 1) The scanner, which is the tool that measures tooth, structures and transforms them into digital data sets. 2) Design software that can design the crown and fixed partial denture framework or the fully anatomical restorations. 3) The processing device where the restoration will be milled. Those devices are categorized based on the number of milling axes. (the increase of the number of axes does not increase the quality of the restoration which is much more dependent on the result of the digitalization, data processing and production process).

The CAD/CAM technology can be used either with fully sintered ceramic blocks (hard machining) or with partially sintered ceramics (soft machining) (60). Lithium disilicate (IPS e.max CAD) along with feldspar-based and leucite-based ceramics are the available materials used in hard machining, while partially-sintered zirconia blocks are used in soft machining. McLaren and Terry reported that the poor marginal and internal fit of the restorations produced by the early CAD/CAM systems was due to the low-resolution scanning and inadequate computing power of those systems and not to the ceramic material itself (61) .An important aspect/limitation of the CAD/CAM restorations that needs to be mentioned is the potential for machining-induced damaged and more specifically marginal chipping.

Achieving esthetically and functionally ideal restorations has been the goal of dental clinicians, prosthodontists, and manufacturers throughout the history of dentistry. Ceramic crowns have a natural appearance and excellent biocompatibility, and their clinical use has now been extended to the complete arch. The success of a dental restoration is determined by 3 main factors: esthetic value, resistance to fracture, and marginal adaptation. Inadequate fit leads to plaque accumulation, which increases the risk of carious lesions and can cause microleakage and endodontic inflammation. Plaque accumulation may also cause periodontal diseases especially with subgingival margins.

4. Material And Method

4.1 Materials

4.1.1 Material that use in this study:

- Extracted natural upper first premolar tooth
- Acrylic resin
- Zircon reinforced lithium disilicate ingots for Press-Laboratory Technique
- Zircon reinforced lithium disilicate blocks for CAD/CAM Technique
- Addition silicone impression, putty and light consistency
- Type IV gypsum
- Separating medium

Figure 4. 1: Extracted natural upper first premolar tooth

Figure 4. 2: Acrylic resin

Figure 4.3:Zircon reinforced lithium disilicate ingots for press-laboratory technique

Figure 4.4: Zircon reinforced lithium disilicate blocks for CAD/CAM technique

Figure 4.5: Addition silicone impression, Putty consistency

Figure 4.6: Addition silicone impression, light consistency

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ISSN: 2643-9824
Vol. 4 Issue 9, September -2020, Pages: 22-40

Figure 4.7: Type IV gypsum

Figure 4.8: Separating medium

Table 4.1 Materials composition and manufacturers used in this study:

Material	Composition	Manufacturer
Acrylic resin	Polymer: polymethylmethacrylate beads Monomer: Methyl methacrylate	Sela Dent
Zircon reinforced lithium disilicate blocks for CAD/CAM Technique	Zirconia-reinforced lithium silicate (ZLS), type II dental ceramic material, class 2a pursuant to DIN EN ISO 6872 (CTE 25 – 500C)	Dentsply Sirona, celtra for CEREC and inLab
Zircon reinforced lithium disilicate ingots for Press-Laboratory Technique	Multiphase ceramic consisting of a glass matrix and lithium disilicate crystals, In addition to LI2O and SIO2.	Dentsply Sirona, Celtra PRESS
Addition silicone impression	Base: siloxane prepolymer with silane group, filler according to consistency Catalyst paste: siloxane prepolymer with vinyl group, chloroplatinic acid.	Perfit: elastomeric impression material putty (type0, Light body (type 3)
Type IV gypsum	Calcium Sulphate hemihydrate	Sela Dent
Separating medium	Paraffinum Liquidum, Isopropyl Palmitate, Aloe Barbadensis Leaf Extract, Tocopheryl Acetate, Parfum	Proven

4.1.2 Tools that use in this study:

- Acrylic model
- Medical gloves
- High speed handpiece
- Dental preparation burs
- Metal impression trays
- Vibrators for pouring impression
- Gypsum model trimming
- Ivoclar vivadent programat p 3010
- CEREC Omni-cam
- CEREC milling machine
- Pressure device
- Manual microtome
- Optical microscope with digital camera

Figure 4.9: Acrylic model

Figure 4.10: Medical gloves

Figure 4 11: High speed handpiece

Figure 4. 12: Dental preparation burs

Figure 4. 13: Metal impression trays

International Journal of Academic Health and Medical Research (IJAHMR)
ISSN: 2643-9824
Vol. 4 Issue 9, September -2020, Pages: 22-40

Figure 4.14: Vibrators for pouring impression

Figure 4. 15: Gypsum model trimming

Figure 4.16: Ivoclar vivadent programat p 3010

Figure 4.17: CEREC Omni-cam

Figure 4.18: CEREC milling machine

International Journal of Academic Health and Medical Research (IJAHMR)
ISSN: 2643-9824
Vol. 4 Issue 9, September -2020, Pages: 22-40

Figure 3.19: Pressure device

Figure 4.20: Manual microtome

Figure 4.21: Optical microscope with digital camera

Table 4.2: Tools and their manufacturers used in this study

Tools	system	Manufacturer
CEREC Omni-cam	Direct optical intraoral digital impression.	Sirona dental systems, Bensheim, Germany.
CEREC milling machine	CEREC MC XL	Sirona dental systems, Bensheim, Germany.
Ivoclar vivadent programat p 3010	Heat and press system	Ivoclar vivadent dental systems, United States of America (USA).

4.2 Methods

Table 4.3: Grouping of the samples, their technique of fabricated and their system

	Group B	Group C	Group A
Techniques	conventional impression and fabricated in the lab (B)	conventional impression and fabricated in the lab (C)	Direct model digitizing (intraoral camera)
system	Heat and press system	Heat and press system	CEREC Omni-cam
Number of samples	25 copings	25 copings	25 copings

4.2.1 Tooth preparation and adjusting in a model representing the dental arch:

Tooth selection

The specifications required for the tooth to be used are intact, cleaned, non-carious, and unrestored natural maxillary first premolar which was extracted to orthodontic reason. Immediately after extraction of the tooth, we will put it in sealed bag, then clean the tooth by soap and water to remove any blood and other residues then use cotton pad rubbed with alcohol to disinfected of extracted tooth, keep the extracted tooth hydrated in a sealable glass container which filled with normal saline until prepared the tooth within few days.

Tooth preparation

To have a standard preparation of the maxillary first premolar to receive full coverage single crown have to follow the ideal principle of the preparation, it is that: Occlusal reduction, 2 mm of clearance is needed on all cusps, then facial and lingual reduction 1 mm, proximal reduction, a taper of approximately 6 degrees, measured as the angle between opposing axial walls, is recommended, the continuity finish line around tooth will be shoulder margin in thickness 1mm.

Adjusting the prepared natural tooth in a model representing the dental arch

To stimulate the real position of a natural prepared tooth in the human arch during conventional and optical impression making the tooth adjust in model cast, the prepared extracted tooth should be fit in the model socket of maxillary first premolar by trimming the acrylic resin in the root portion layer by layer and check its position in the empty socket until the extracted tooth seated with some sort of friction with its finish line at equals gingival position of the margin of the model, if any gap found between extracted tooth and the model socket blocked it by pink wax.

4.2.2 Coping constriction

Conventional impression making

After the extracted tooth prepared we will get ready to take conventional impression by making special tray with 2 mm thickness of spacer and four standardized occlusal stop, it was constructed 24 hours before taking secondary impression, the stock tray constructed on a cast (model) that previously obtain by a primary impression (alginate), the fitting surface of the tray brush with thin layer of conventional impression adhesive and allow to completely dry according manufacturer instructions.

The secondary impression of the model contained prepared extracted natural tooth will take using monophasic polyether impression material medium body consistency that was automatically mixed, the impression left for complete setting according manufacturer instructions at room temperature. After setting, the impression separates from the model and the impression inspect under good lightening condition for any bubbles or discrepancies then poured by gypsum.

4.2.3 CAD/CAM system

Indirect scanning of poured conventional impression (gypsum model)

To scan the gypsum model focuses on the prepared abutment to provide data that are required for the CAD/CAM software in 3D image form.

Designing phase

After following the software prompts, the image will trim stimulating die trimming on the physical working cast, the next step is to outline and locate the finish line of the die. The designing phase the software precedes then the single unit coping was generated by the software guided with the default milling parameters.

Milling phase

After pressing the milling phase icon, the software choses the desired zircon block. The block secured in place in the milling machine. After closing the milling

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Vol. 4 Issue 9, September -2020, Pages: 22-40

machine door, it started to scan the barcode of each block to confirm the milling parameter. Finally, the milling process start by spraying a copious amount of coolant and lubricant. This process is repeated for 30 times.

4.2.4 Press laboratory technique

Conventional impression making

Figure 4.22: Conventional impression

Pouring conventional impression

Figure 3.23: Pouring conventional impression

wax contouring

Figure 4.24: Wax contouring

sprueing

Figure 4.25: Sprueing

International Journal of Academic Health and Medical Research (IJAHMR)
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Vol. 4 Issue 9, September -2020, Pages: 22-40

Investing

Figure 4.26: Investing

preheating and pressing

Figure 4.27: Preheating and pressing

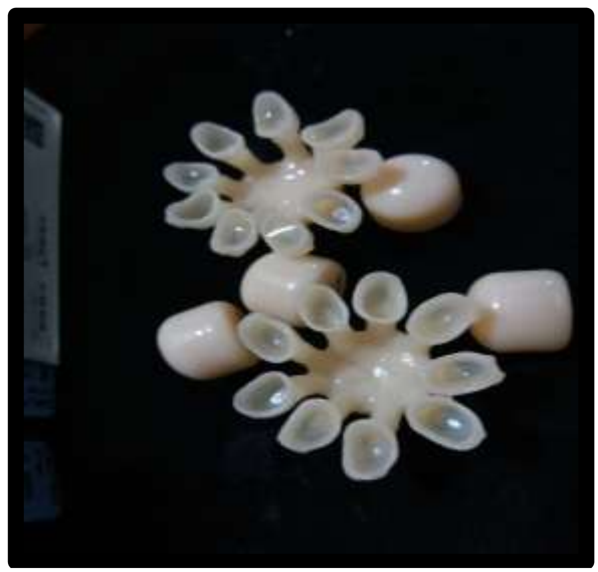

Figure 4.28: Preheating and pressing

Coping result in all groups

Figure 4.29: Group A

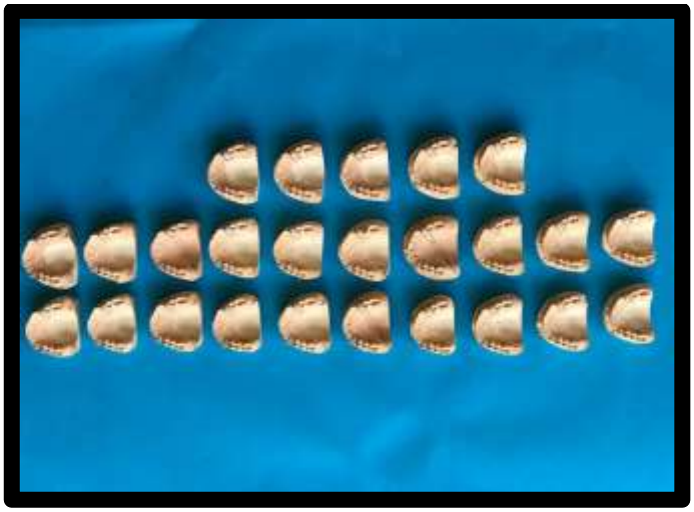

Figure 4.30: Group B

Figure 4.31: Group C

5. Result And Discussion

The purpose of this study was to evaluation of marginal gap and internal adaptations of All-ceramic coping fabricated with CAD/CAM and press-laboratory technique. The accurate manufacturing of dental prostheses is important for long-term clinical applications. Accuracy and precision between abutment teeth and dental prostheses are required in the manufacturing process of dental prosthesis, the silicone replica technique (SRT) has been frequently utilized owing to its ability to measure the fitness of a dental prosthesis without causing damage.

In the present study, the assessment was adopted to investigate the marginal gap and internal adaptation of Zircon reinforced lithium disilicate copings. The in-vitro study is supposed however to offer standardized conditions with respect to the preparation design leading to assessment that may be closer to reality. the in vitro study allows standardization in comparison to in vivo which is more complex[14]. Nevertheless, it is worthy to mention that in contrast to the vivo studies, the in vitro results should be viewed cautiously because of the testing limitations[50], which cannot reflect exactly the clinical situations. But it might be beneficial to provide valuable guidelines for the clinical applications. In the present study, human tooth was used for tooth preparation to simulate the clinical procedures as much as possible. This was adopted by Beschnidt and Strub**.**

The tooth sample in this study was mounted in acrylic resin block holding the tooth with its long axis parallel to the box to allow accurate centralization of the tooth during tooth preparation and during marginal adaptation testing phase[15]. Before starting this study, a pilot study was done to try digitizing the tooth in its acrylic resin block but the absent of the adjacent teeth confuse the scanning process and the milled copings were ill fitted on its corresponding tooth and with huge marginal gap. To overcome this problem the prepared tooth was adjusted in a model representing the dental arch (master model) to simulate the real position of a natural prepared tooth in the human arch during the scanning phase.

The tooth was designed with a 6-degree occlusal convergence[15]. The occlusal surface was prepared with 2 sloping surfaces, one of which was slightly beveled. The preparation was finished with 1mm wide round shoulder finish line. This design was chosen to prevent rotation of the copings on the die and also to ensure that their placement could be reproduced on the die according to Hamza et al [28]**.**

In group A (direct digital impression) using CEREC Omni-cam the digitizing is optimized for powder free scanning of the model as recommended by the manufacturer. For the indirect digitizing groups B, C a secondary impression of the model was taken using one step addition impression material putty and light consistency using stock tray.

In our study the use of non-anatomical crowns without cementation (27 42) since the marginal gap and internal adaptation might be affected by cementation which causes a significant increase discrepancies of the test samples[44]. Other authors as Quintas et al. and Subasi et al. conducted marginal gap and internal adaptation measurements after cementation as they believed that, the most important inadaptability is the one that occurs in vivo when the crowns are already cemented (93,94). The long-term success of ceramic restorations depends on the marginal fit. Inaccurate marginal fit is responsible for plaque retention, micro leakage and cement break down. The risk of carious lesions, periodontal disease and endodontic inflammation is thus increased, and adverse consequences affecting the health of underlying abutments and optical properties may result[41].

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Many authors detected that range of clinical acceptability of vertical marginal gap openings were between 50 and 150µm and range of clinical acceptability of internal adaptations were between 50 and 100µm(34,33,31). The results of the present study for all groups were in the range which was considered to be within the recorded clinically acceptable value. This gives an indication of a high accuracy milled copings was obtained from this study. This result may be because in this study we chose carefully all possible factors that lead to perfect and ideal marginal adaptation as finish line geometry, finish line thickness, occlusal convergence, pattern of occlusal reduction, die spacer and other factor according to several research that supported and confirmed this choice as it was discussed before in this study.

Since CEREC Omni-cam was newly introduced in the market, there is no study investigate its accuracy yet, but the value recorded by Omni-cam were in according with value recorded with another direct intraoral digitizing system not utilize powder call iTero system, which show a highest trueness than conventional approach in a study done by Christine K et al, they explained this high trueness was related to elimination of the long process chain of the conventional approach on the other hand in the direct digitization the restoration take place directly on the virtual three dimensional master cast. Consequently, it may be assumed, that decline of single steps in the work flow results in higher accuracy (55).

The surprising finding, in the present study, was that the pressed coping made from the conventional impressions (Group B, C) had a statistically significant smaller marginal and internal gap than the CAD/CAM coping made from the digital impressions (Group A). This means that the press-laboratory technique was accurate than CAD/CAM technique. However, no difference was found between the two group of press-laboratory (Group B, C). Direct comparison between the pressed and the CAD/CAM fabrication techniques should be done with caution, since the production methods are so different; in other words, since for the CAD/CAM coping the dies were scanned, there was the possibility that any irregularities on the dies were "smoothed out" by the software in order to facilitate the crown fabrication. The reason why the marginal gap of the (Group B, C) was statistically smaller than that of (Group A), might be attributed to the overall fit of the coping, another reason can affect the accuracy of CAD/CAM is experience of lab technician.

5.1 Comparison between Group B and Group C

In this study, about marginal and internal (cervical, middle and occlusal) gap of two groups B, C press-laboratory technique revealed that there was no statically significant difference in the average of marginal and internal gap according the press-laboratory method (group B, C). With regard to the marginal gap, it had (t = 0.730, p = 0.4563), where the two groups average was nearly equals group B (0.0524$\pm$ 0.0056) and group C (0.0546 $\pm$ 0.02701), that mean the two individuals take the press-laboratory normally have same accuracy.

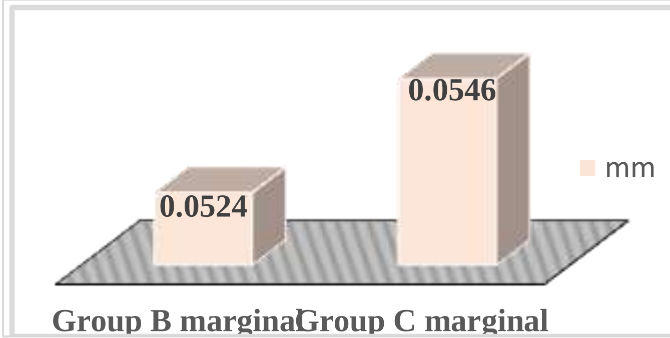

Figure 5. 1: Difference in average of the marginal between group B, C.

About internal gap (at cervical points), The results were (t = -0.740, p = 0.4643), where the two groups average was nearly equals group B (0.0516 $\pm$ 0.0067) and group C (0.0556 $\pm$ 0.02601), that mean the two individuals take the heat press normally have same accuracy.

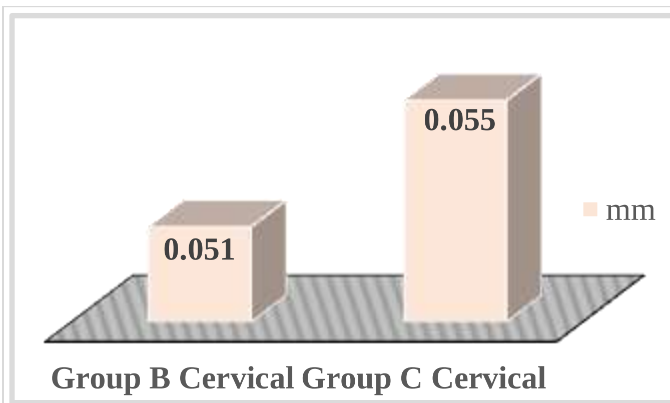

Figure 5. 2. Difference in average of the cervical points between group B, C.

About internal gap (at middle points), The results was (t = -0.8860, p = 0.3800), where the two groups average was nearly equals group B (0.0495$\pm$ 0.0062 mm) and group C (0.0546$\pm$ 0.0282 mm), that mean the two individuals take the heat press normally have same accuracy

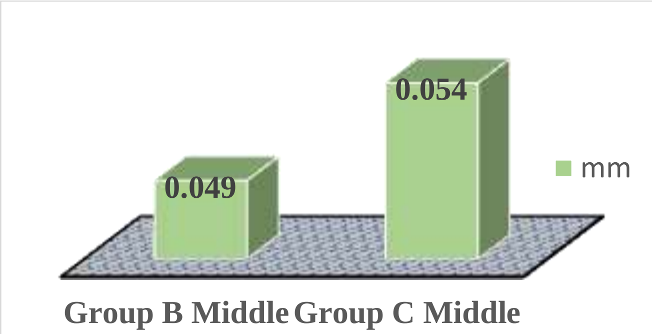

Figure 5. 3. Difference in average of the middle points between group B, C.

About internal gap (at occlusal points), The results was (t = -0.666, p = 0.508), where the two groups average was nearly equals group B (0.0658± 0.0057 mm) and group C (0.0711 ±0.0390 mm), that mean the two individuals take the heat press normally have same accuracy.

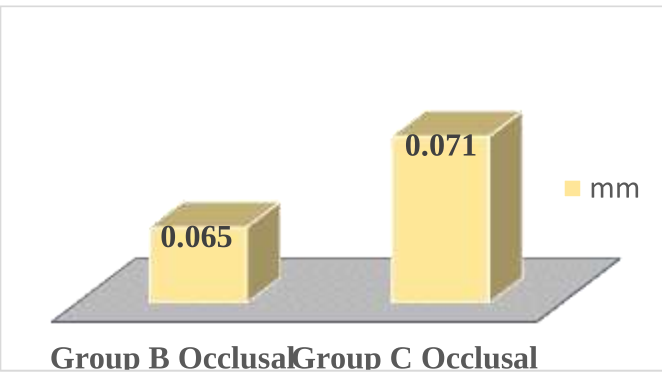

Figure 5. 4. Difference in average of the occlusal points between group B, C.

5.2 Comparison between Group (A) and Group (B, C)

About marginal and internal (cervical, middle and occlusal) gap of groups (A) and (B, C) revealed that there was statically significant difference in the average of marginal and internal gap according CAD/CAM technique (group A) and press-laboratory method (group B, C). With regard to the marginal gap, it had (t=11.17, P-value=0.000), Where the mean of gap by CAD/CAM measurement (0.0700+0.0048 mm) was higher than the mean of gap by press-laboratory technique (0.0573+0.0030 mm).

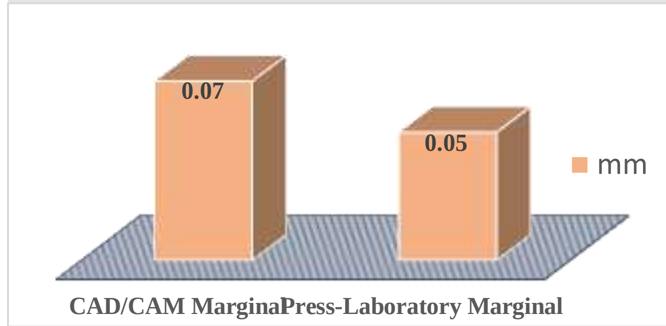

Figure 5. 5. Difference in average of the marginal gab.

About internal gap (at cervical points), (t= 2.797, p=0.007). Where the mean of gap by CAD/CAM measurement (0.0802±0.45 mm) was higher than the mean of gap by press-laboratory technique (0.0536±0,01 mm).

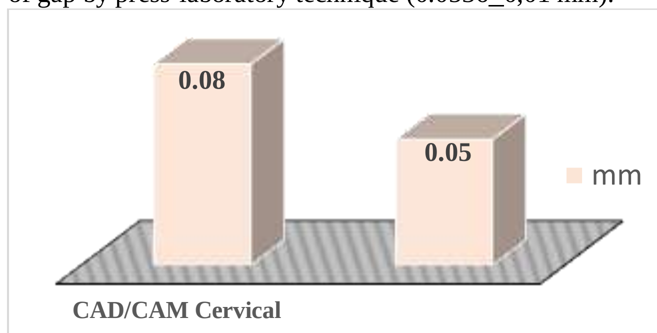

Figure 5. 6. Difference in average of the internal gab cervically.

About internal gap (at middle points), (t=6.58, P-value=0.000) Where the mean of gap by CAD/CAM measurement (0.0753+0.0097 mm) was higher than the mean of gap by press-laboratory technique (0.0520+0.0147mm).

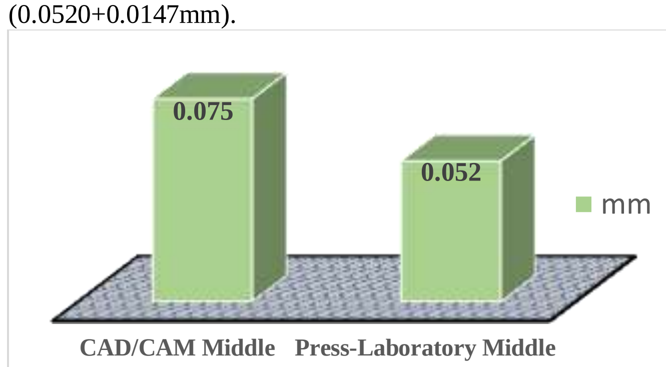

Figure 5. 7. Difference in average of the internal gab at middle

About internal gap (at middle points), (t=3.42, P-value=0.001) Where the mean of gap by CAD/CAM measurement (0.0959 0.0347 mm) was higher than the mean of gap by press-laboratory technique (0.0685± 0.0198 mm).

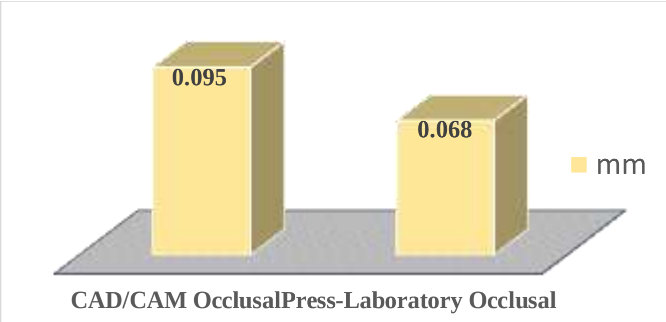

Figure 5. 8. Difference in average of the internal gab occlusally.

6. Conclusion and Recommendation

Based on this study, which assessed the marginal and internal gaps of zircon reinforced lithium disilicate copping fabricated using a press method or a CAD/CAM method, the following observations were made:
1. The press technique demonstrated a significantly smaller marginal and internal gap than the CAD/CAM technique.
2. Both techniques allowed the fabrication of copping that are within the accepted clinical recommendations for marginal and internal gaps.

From the present work and conclusions, the following recommendations are offered:
1. further investigations to assess the influence of different CAD CAM systems that used in all ceramic crowns fabrication techniques on the marginal and internal adaptation.
2. Further investigations are recommended to determine the effect of different cements that used for crowns cementation on the marginal and internal adaptation of all ceramic copings.
3. Future studies are needed to evaluate the accuracy of the technology in capture.
4. This research study suggests testing the marginal and internal adaptation for one group using different methods to evaluate the accuracy of each.

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