AL-AZHAR
Dental Journal
For Girls

The Official Publication
of The Faculty of Dental
Medicine For Girls,
Al-Azhar University
Cairo, Egypt.

Print ISSN 2537-0308 • Online ISSN 2537-0316

ADJ-for Girls, Vol. 8, No. 3, July (2021) — PP. 389:400

Effect of Material Selection and Different Fabrication Techniques on Marginal and Internal Fit of Metal Ceramic and All Ceramic Crowns (In vivo and In vitro study)

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Codex : 06/21.07

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http://adjg.journals.ekb.eg

DOI: 10.21608/adjg.2021.30186.1260

Restorative Dentistry
(Removable Prosthodontics, Fixed Prosthodontics, Endodontics, Dental Biomaterials, Operative Dentistry)

ABSTRACT

Purpose: Assess the effect of material selection as well as different fabrication techniques of metal ceramic (MC) and all ceramic crowns on their clinical outcomes, marginal and internal fit. **Materials and methods:** In vivo study(I); twenty-eight patients were provided with twenty-eight crowns restoring mandibular first molar tooth. Patients were distributed into 2 groups and 2 subgroups according to different materials and fabrication techniques: fourteen patients received MC crowns, group (I); seven patients received crowns with conventional casting of Co-Cr copings, subgroup (A) and seven patients received crowns with direct milling of Co-Cr copings, subgroup (B). Fourteen patients received IPS e.max press crowns, group (II); seven patients received crowns with conventional wax pattern, subgroup (A) and seven patients received crowns with 3D printing resin pattern, subgroup (B). The survival rate of these crowns was evaluated and statistically analyzed. In vitro study(II); one machined die was prepared to simulate crown preparation of mandibular first molar tooth. 60 crowns were constructed on die and divided into 2 groups (30 samples each) and 2 subgroups (15 samples each) according to different materials and fabrication techniques similar to in vivo study. Replica technique obtained to measure marginal and internal fit using Digital microscope. **Results:** The survival rate of MC and press crowns was 98% and 60% respectively. Press crowns and digital technique showed superior marginal and internal fit than MC crowns and conventional technique respectively. **Conclusions:** Material type and fabrication technique of MC and all ceramic crowns influence their clinical outcome, marginal and internal fit.

KEYWORDS

Metal ceramic,
IPS e.max press, Internal fit.

- Paper extracted from Doctor thesis titled » Effect of Material Selection and Different Fabrication Techniques on Marginal and Internal Fit of Metal Ceramic and All Ceramic Crowns (In vivo and In vitro study)”.

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INTRODUCTION

Patients with severe loss of tooth structure due to caries or trauma and after endodontic treatment usually use full coverage crowns. Metal ceramic are still the most widespread used material for constructing full coverage crowns and is considered as the typical treatment in dentistry[1].

Many metal alloys have been used as the metal framework of metal ceramic restorations. In the old ages gold-based restoration were used in casting technique; they were substituted by base-metal alloys as nickel-chromium (Ni-Cr) and cobalt-chromium (Co-Cr). Ni-Cr may cause allergic reactions, therefore, Co-Cr are used as alternative for patients who have sensitivity to nickel [2].

Traditional casting technique is more broadly used to create metal frameworks or copings but it has many problems as it is complex and needs great technical skill. The introduction of computer aided design and computer aided manufacturing (CAD/CAM) process have revolutionized to improve quality of full coverage restorations as well as to reduce costs and time [3].

Due to the continued interest in esthetic dentistry, studies of restorations with similar dental colors have continued along with those of dental materials with satisfactory strength. Ceramic restorations with high crystalline content were evaluated to substitute metal frameworks used for metal ceramic restorations [4].

Lithium disilicate glass ceramic material exists in two forms an ingot that can be press-fit (IPS e.max press) and block that can be milled (IPS e.max CAD). IPS e.max press is typically fabricated from conventional wax pattern. Recently CAD-CAM systems with recent fabricating wax and polymers have been evaluated [5]. In CAD-CAM, two dissimilar systems create physical products from 3-dimensional (3D) models: subtractive and additive. Additive manufacturing is an innovative method that rapidly creates parts and prototype models from 3D (CAD) model data which produced by 3D digitizing systems [6].

The clinical performance of dental restorations and their accuracy of fit are considered an essential feature for the long-term success of restorations. The latter can be evaluated in vivo and in vitro. Investigations in patients' mouth can directly reflect the clinical results, but due to the differences in the restorations geometry, ecological factors and occlusal forces, it is very hard to be standardized [7]. In vitro studies have to simulate clinical situation as far as possible and the outcome should be easily reproduced with the least differences, thus helping clinical research.

MATERIALS AND METHODS

Part (I): In vivo study:

Ethical considerations:

The present study was reviewed and confirmed by Research Ethical Committee (REC) of the Faculty of Dental Medicine for Girls, AL-Azhar University, Egypt. The purpose of the investigation was informed to patients. These patients signed an informed consent prior to start in this research.

Patient selection:

Twenty- eight patients participated in the present study seeking restoration of single crowns for endodontically treated mandibular first molar teeth. **Inclusion criteria:** Patients received either metal-ceramic or IPS e.max press ceramic crowns on abutments with appropriate endodontic treatment for mandibular first molar teeth characterized by less than 50% of coronal tooth structure missed. Patient age (20-50) years old, in good overall general health with adequate oral hygiene and adequate crown/root ratio. Acceptable tooth reduction length was required to guarantee suitable retention and resistance form. **Exclusion criteria:** Patients with abnormal occlusion, bad oral hygiene or else with highly caries index were omitted from the present research [8].

Patients were distributed into two groups and two subgroups in relation to different materials and fabrication techniques as illustrated in table 1.

Table (1): *Samples' grouping*.

Groups according to material	Subgroups according to fabrication technique	Number of Patients
Group (I) Metal-ceramic crowns.	Subgroup (A): Metal-ceramic crowns with cobalt chromium copings fabricated by conventional casting.	7
	Subgroup (B): Metal-ceramic crowns with cobalt chromium copings fabricated by direct milling of alloy.	7
Group (II) IPS e.max press crowns.	Subgroup (A): IPS e.max press crowns fabricated by conventional wax patterns.	7
	Subgroup (B): IPS e.max press crowns fabricated by three – dimensional printing of resin patterns.	7
Total number of patients		**28**

Pre- operative phase:

A case history was taken from patients. A pre-operative clinical examination, periapical radiograph for abutment tooth and analytical casts for maxillary and mandibular arches were prepared from alginate (Tropicalgin, Zhermack SPA,Italy) impression material. The maxillary and mandibular casts were secured on the articulator[8] (A7 Fix; BioArt, Brazil).

Operative phase:

All non-vital teeth included in this study were either restored by a direct composite build-up material (Charmcore,Dentkist,Korea) or in case of destroyed tooth structure, restored by a manufactured titanium post (Screw Posts,Nordin Dental, Swiss) or glass fiber post (Glassix plus, Nordin Dental, Swiss) in combinations with a composite material. Shade selection was determined prior to tooth preparation in natural sunlight at 11 o'clock. The putty index was used to standardize the amount of tooth reduction [8]. Abutment tooth was prepared with 2.0 mm occlusal reduction and supragingival deep chamfer margin of 1.2 mm in width. All sharp edges and angles were rounded [9]. Final impression was taken with a polyvinylsiloxane material (Zetaplus ,Zhermack SPA, Italy) using a two-stage putty-wash impression procedure. The prepared tooth was covered by light-curable composite provisional crown (PerfecTemp II, DenMat,U.S.A.). The final impressions and occlusal bite were sent to laboratory for construction of copings by standardized techniques.

Metal and IPS e.max press ceramic copings were tried-in intraoral and evaluated initially for seating, marginal fit, inter-proximal and occlusal clearance. All the evaluated copings were sent to the laboratory for building up the veneering layer of both groups.

Prior to cementation procedure; the teeth were cleaned for any remaining cement with polishing brush and all crowns were evaluated once more. All crowns were cemented using Supercem (DentKist, Korea) self-adhesive resin cement. No surface conditioning was done for the intaglio surfaces of metal ceramic crowns. While surface conditioning of intaglio surfaces of crowns constructed from IPS e.max press restoration was performed according to the manufacturer's instructions using Ceramic Etching Gel (5% HF acid gel) (Ivoclar Vivadent, Liechtenstein, Germany) applied on the cementation surfaces for 20 seconds. Then, the crowns were washed and air dried. These were followed by application of Silane Coupling Agent (Bisco,Inc,U.S.A.) which was allowed to react for 30 seconds, according to manufacturer's recommendations and then thoroughly dispersed with air. After that, crowns constructed from IPS e.max press restoration were adhesively cemented to their particular abutments by supercem resin self-adhesive cement following manufacturer's instructions. Periapical radiographs were taken after cementation.

Post – operative phase:

Patients were instructed to follow prescribed oral hygiene measures including 45° angle brushing twice a day, flossing once a day and using warm mouth wash to avoid recurrent caries or gingival inflammation around new crowns [8].

Clinical evaluation:

Clinical assessment of all crowns was accomplished by Modified United States Public Health Service Ryge criteria, at base line (1 week), 3, 6 and 12 months later to cementation. Fractures, sensitivity and recurrent caries at the crown margin, marginal adaptation and discoloration were assessed [10]. In addition, Plaque presence was assessed by L¨oe plaque index and recorded as 0, 1, or 2. Clinical examinations were accomplished by mirror and sharp explorer, photographs as well as radiographic examinations.

Part (II): In vitro study:

Model construction:

One stainless steel master die was designed and milled using an engineering lathe (CNC 350; Arix,Taiwan) to mimic the preparation of complete coverage metal ceramic and all- ceramic crowns of mandibular first molar tooth with 1.2mm deep chamfer margin all around the total boundary. Preparation was standardized with an axial wall inclination of 6° and 7mm height while the occlusal diameter was 6mm [11].

Sixty crowns were constructed on die and divided into 2 groups (30 samples each) and 2 subgroups (15 samples each), according to different materials and fabrication techniques similar to groups and subgroups of in- vivo study.

Construction of the crowns:

A: Construction of metal – ceramic crowns, group (I):

Subgroup (A): Construction of metal-ceramic crowns with cobalt chromium copings fabricated by conventional casting.

To standardize the thickness of the wax copings 0.5mm; a specially designed split brass internal counter die with a highly polished fitting surface and an external ring (sleeve) was used. The inner ring was splitted longitudinal to aid in wax patterns removal. Five layers of die spacer material (YETI; Renfert GmbH, Germany) with approximately 50 microns thickness was applied to surfaces of die leaving 1mm short of finish line. Wax copings were made by pouring the molten casting wax (Bego, DentalMart, U.S.A.) into the mold space. After complete hardening the excess wax was trimmed and shaved with sharp carver [11].

Wax sprue formers (Wachsdraht, Bremen, Germany) were attached to the wax patterns at occlusoaxial line angle with 45° to the long axis, then the sprued wax patterns were assembled in the center of a rubber crucible former inside rubber casting ring. The sprued wax copings were vacuum invested. After setting of the investments, they were placed for one hour in a burn-out oven at 970°C, the metal copings after that were obtained by casting with Co-Cr alloy (Eisenbacher Dentalwaren ED GmbH, Germany) using centrifugal casting machine [11].

Subgroup (B): Construction of metal-ceramic crowns with cobalt chromium copings fabricated by direct milling of alloy.

The Ceramill Motion 2 machine (AmannGirrbach, Germany) was used for fabricating soft non-presintered Co-Cr blanks (Ceramill sintron, AmannGirrbach, Germany). To achieve scannable surfaces, metal die was sprayed with light reflecting powder. The coping thickness was adjusted at 0.5mm while the width of cementing gap was adjusted at 50mm. The Co-Cr blank was cut and milled in green state. Subsequently, all samples were sintered under an inert gas in a special argon furnace (Ceramill Argotherm, AmannGirrbach,Germany) [12].

Each coping within both groups was placed on the die and checked for complete seating using USB Digital microscope (Scope Digital Stereo

Microscope, China) (x = 10). The coping was discarded if any small nodule or defect was detected.

Veneering of both subgroups by VITA VMK Master (VITA Zahnfabrik, Germany). Building the porcelain layers (opaque, dentin and enamel) over the metal copings was carried out respectively, then they were properly placed on the die. External counter die was used to standardize the thickness of porcelain 0.7mm over the substructure copings. Firing of porcelain layers on metal copings was performed at 960°C in 7 minutes. The finished crown was seated on the die and checked for complete seating using USB Digital microscope (x = 10). The crown was discarded if any small nodule or defect was detected [11].

B. Construction of IPS – e.max press crowns, group (II):

Construction of IPS – e.max press copings of both Subgroups A & B, group (II):

The difference between subgroup A and subgroup B only during construction and spruing of patterns either conventional wax for subgroup A or 3D printing resin for subgroup B.

Subgroup (A): Construction of IPS – e.max press ceramic crowns fabricated by conventional wax pattern.

Same procedures used for the construction and spruing of wax patterns of conventional metal copings were followed during the construction of subgroup (A).

Subgroup (B): Construction of IPS – e.max press ceramic crowns fabricated by three dimensional printing of resin pattern.

Metal die was scanned and the crowns were designed with the same previous procedures described in construction of metal CAD/CAM copings (subgroup I-B), then stored as a standard tessellation language (STL) file. The STL files for the copings were transferred to a resin-based 3D printer machine (Dent2 3D printer ,Mogassam, Egypt). Resin patterns (NextDent,Vertex -Dental, Netherlands) were produced from a photo-curable liquid resin which cured after its exposure to light by photo polymerization process. The resin patterns building was done layer by layer by moving the platform upward and downward until completion of resin patterns. After final setting for ten minutes through built-in UV lamp, the resin supports were cut. Each 3D printing pattern was seated on the die and checked for complete seating using USB Digital microscope (x = 10). The 3D printing resin pattern was discarded if any small nodule or defect was detected [13].

Axial wax sprues (diameter 3mm, length 5mm) were attached to the occlusal surface of the resin patterns at 45° to ensure that all sprue attachments were flared and smooth, then they were connected to the silicon ring base. The ring was then placed over the ring base and checked for correct fit [13].

Investing of patterns in both subgroups was carried out with the IPS Press Vest investment material (IPS e.max Special material, Ivoclar, Liechtenstein). Investment ring was preheated within conventional preheating furnace (Vulcan 3-550, Degussa-Ney Dental, NDI Inc) according to manufacturer's instruction. The investment ring with the ingot and plunger were placed in center of press furnace (EP600, Ivoclare Vivadent Schaan, Liechtenstein Germany) [14].

After that, each coping was placed on the die and evaluated for complete seating using USB Digital microscope (x = 10). The coping was discarded if any small nodule or defect was detected.

Veneering of IPS e.max press copings of both subgroups with IPS e.max ceram (Ivoclar Vivadent, Liechtenstein ,Germany) nano- fluorapatite glass ceramic. Building the glass ceramic layers (wash, first /second dentin and glaze /stain) over the ceramic copings was carried out respectively while the substructure copings were properly seated on the master die. Firing of ceramic layers on press copings was performed at 730°C in 7 minutes. The finished crown was seated on the die and checked for complete seating using USB Digital microscope (x = 10). The crown was discarded if any small nodule or defect was detected [13].

Thermocycling procedure:

Samples were placed for 24 hours in distilled water at 37°C, after that exposed to routine thermocycling in automatic thermal-cycling device (Thermo-cycler, SD Mechatronik GMBH,Germany) for 5000 cycles in two water bath at 5 and 55°C. The settle time at each temperature was 30 seconds and the move time from one bath to the other was 2 seconds [14].

Testing procedure:

Marginal and internal gap measurements:

The current study used an impression replica technique to evaluate the marginal and internal gaps in all crown. This technique reproduces the distance between inner surface of the crowns and master model surface with light silicone and the gap is then checked based on silicone thickness [12].

A light blue - colored addition silicone material (ExpressTM, 3M ESPE, Germany) was injected into the fitting surface of each crown then placed on the metal die with constant load about (50 N) for 2 minutes applied along the major axis of the crown using holding device until it set. Then each crown was gently disconnected from die leaving a thin layer of light body attached to the fitting surface of it. After that, the fitting surface of each crown was filled by a medium violet - colored addition silicone material (Hydroise , Zermack, Italy).Once it set, the replicated die was disconnected from the crown [12].

A plastic cylinder was selected for construction of the silicone replica block. A heavy orange – colored body addition silicone material (ExpressTM , 3M ESPE, Germany) was mixed with the appropriate amount of catalyst according to manufacturer instructions. Then was packed immediately inside the plastic cylinder. The replicated die was embedded into un-polymerized heavy body addition silicone material till it completely polymerized. After that, the silicone replica block was separated into four equal cross sections by cutting out through the half of buccolingual and mesiodistal directions [12].

Gap measurement:

The gap between the master model and the inner surface of the crown represented by blue colored silicone layer was photographed at 32X magnification using a digital microscope with a corresponding digital camera and software. Thickness of the blue colored silicone layer was determined in microns. In order to measure the gap spaces, 48 points for each crown were considered; 12 points at each wall (buccal, lingual, mesial and distal) (6 points at right and 6 points at left) for each section. These points labelled into marginal gap, chamfer area, axial wall gap, axial- occlusal angle and occlusal wall gap [12,15]. To standardize the points of gap measurements; ruler was used to measure distance between them as shown in (Fig.1).

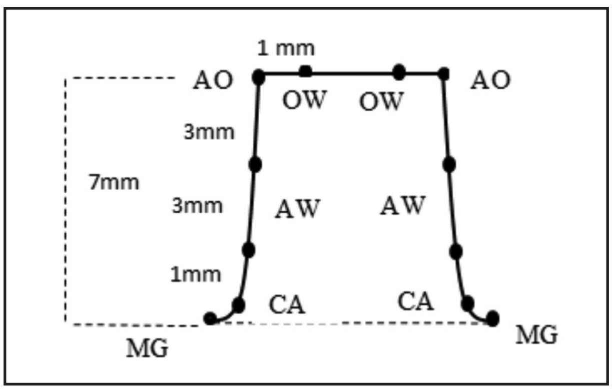

Figure (1): Points of gap measurement; (MG: marginal gap, CA: chamfer area, AW: axial wall, AO: axial – occlusal angle, OW: occlusal wall).

Statistical analysis

Data were analyzed by SPSS 18 (Statistical Package for Scientific Studies) for Windows. Kaplan-Meier statistics were used to resolve the survival rates obtained for all crowns. For parametric data, independent t test was used to compare between both groups. *P*-value less than 0.05 were reflected significant.

RESULTS

Part (I): Statistical analysis of in vivo study:

Twenty – six patients with twenty –six crowns were examined clinically at the specific recall periods. Two patients with two crowns at group (I) (one of each subgroup) didn't show up at the recall time. Their data were excluded from statistical evaluation.

Clinical evaluation:

During the observational period of base line, 3 months, 6 months and one- year: (table 2)

- No crown fractured at group (I), but five crowns fractured at group (II) [three in s-g (A) and two in s-g (B)]. Although it did not need repair; the crowns were assessed as a failure.
- No patient reported post-operative sensitivity after cementation of crown in group (I), but one patient reported post-operative sensitivity after cementation of crown in [group (II), subgroup(A)].
- None of 26 crowns exhibited secondary caries or marginal discrepancies or discoloration during the complete observation period.
- Three crowns scored (1) for plaque index at group (I) [one in s-g (A) and two in s-g (B)]. But, all crowns scored (0) at group (II).

Survival and success analysis:

The survival and success rate of metal ceramic restorations (group I) was 98% and 75% respectively which consistent with the Kaplan-Meier analysis. While the survival and success rate for IPS e.max press restorations (group II) was 60% and 57.1% respectively.

Table (2): *Clinical scores for all crowns in both groups.*

		Baseline				3-month recall				6-month recall				1-year recall			
		Group (I)		Group (II)		Group (I)		Group (II)		Group (I)		Group (II)		Group (I)		Group (II)	
		S-g (A)	S-g (B)	S-g (A)	S-g (B)	S-g (A)	S-g (B)	S-g (A)	S-g (B)	S-g (A)	S-g (B)	S-g (A)	S-g (B)	S-g (A)	S-g (B)	S-g (A)	S-g (B)
No. of patients		7	7	7	7	7	7	7	7	6	6	7	7	6	6	7	**7**
Category	**Score**																
	Alpha (A)	7	7	7	7	7	7	5	5	6	6	5	5	6	6	4	**5**
	Bravo (B)	-	-	-	-	-	-	2	2	-	-	2	2	-	-	3	**2**
Post-operative sensitivity	Alpha (A)	7	7	6	7	7	7	7	7	6	6	7	7	6	6	7	**7**
	Bravo (B)	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	Charlie (C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Secondary caries	Alpha (A)	7	7	7	7	7	7	7	7	6	6	7	7	6	6	7	**7**
	Bravo (B)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marginal adaptation	Alpha (A)	7	7	7	7	7	7	7	7	6	6	7	7	6	6	7	**7**
	Bravo (B)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Charlie (C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marginal discoloration	Alpha (A)	7	7	7	7	7	7	7	7	6	6	7	7	6	6	7	**7**
	Bravo (B)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Charlie (C)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Part (II): Statistical analysis of in vitro study:

IPS e.max press ceramic crowns (group II) registered better marginal and internal fit than metal ceramic crowns (group I). However both restorations are within clinical accepted range.

Digital technique namely; direct milling of alloy of metal ceramic (subgroup I-B) and 3D printing of resin pattern of IPS e.max press (subgroup II-B) registered better marginal and internal fit than conventional technique namely; conventional metal ceramic (subgroup I-A) and conventional IPS e.max press (subgroup II-A) respectively. (Table 3).

3D printing resin pattern of IPS e.max press (subgroup II-B) registered the best marginal and internal fit. Despite all different subgroups are within clinical accepted range. (Table 3).

Table (3): *Mean marginal and internal gaps (± SD) and comparison of fabrication techniques (ANOVA test).*

	Subgroups	Mean ±SD (µm)
Marginal gap	Metal ceramic (I-A)	60.20±2.85
	Metal ceramic (I-B)	53.32±3.54
	t value	3.199
	P value	0.0034*
Internal gap	Metal ceramic (I-A)	60.6±20.2
	Metal ceramic (I-B)	56.9±18.7
	t value	1.21
	P value	0.236 ns
Marginal gap	IPS e.max press (II-A)	51.09±4.02
	IPS e.max press (II-B)	41.68±2.95
	t value	7.31
	P value	<0.0001*
Internal gap	IPS e.max press (II-A)	50.9±11.6
	IPS e.max press (II-B)	43±11
	t value	1.211
	P value	0.235 ns

Significance level p≤0.05,
**significant, ns= non-significant*

DISCUSSION

Complete coverage dental restorations are considered the most important part of fixed prosthodontics as it is the most studied restoration over the years with regard to longevity, causes of failures as well as materials and techniques [16].

The most used material over the years is metal ceramic because it combines physical properties of metal i.e. rigidity and impact strength, with esthetic qualities, excellent biocompatibility of dental porcelain [17].

As the highly cost of noble metals, base metal alloys as nickel-chromium and cobalt-chromium are used as the framework material. But due to presence of nickel ,it can cause allergic reactions. The frequent use of it has been questioned [18]. So that, a substructure material without nickel and with better biocompatibility is desirable as alternative. Cobalt-chromium ceramic restorations are such alternative [19].

Co-Cr alloys are progressively used because of their low cost compared to noble alloys. It has high strength, heat resistance, excellent biocompatibility as well as demonstrated favorable resistance to tarnish and corrosion in vivo due to the formation of passive surface film [19].

Fabrication processes as the computer-aided design/computer-aided manufacturing and the traditionally fabricated by lost wax casting technique can be used to produce high-strength structural materials including Co-Cr containing alloys for restoration frameworks.

In the last years, the patients need for highly esthetic restorations that led to evolution of new metal free ceramic materials with better mechanical properties to confirm adequate longevity and reducing procedural drawback that replace metal-ceramic restorations. Lithium disilicate glass ceramic restoration is considered as the one of all-ceramic materials that provides favorable mechanical and esthetic properties to be suitable for mainly restorative situations [20].

The purpose of the present investigation was to evaluate the effect of material selection as well as different fabrication techniques of metal ceramic and IPS e.max press ceramic crowns on: plaque, fracture, postoperative sensitivity, secondary caries, marginal adaptation and discoloration at different time periods for in vivo study and marginal, internal fit of crowns for in vitro study.

To conduct the present study, mandibular first molar teeth were used as abutments for in vivo part of the study as it is considered the most common tooth to involve in the endodontic procedure and almost need crown [(21)]. On the other hand, as the result of difficulties in obtaining standardized abutments in clinical practice owing to the natural teeth obtain more variation due to their different in age, their individual structure, the standardized stainless steel die of a prepared mandibular first molar tooth was used as an abutment for in vitro part of the study to calculate the marginal and internal fit [(22)].

In the present clinical investigation 3, 6 and 12 months observational period of both groups, (table 2); no fractures were observed at metal ceramic crown, group (I). This is in agreement with short- term previous studies in which no fractures were reported [(8,23)]. On the contrary, IPS e.max press ceramic crown, group (II), exhibited higher fracture rates than metal ceramic crown when applied as single crown on first mandibular molar tooth, where fracture of five ceramic crowns was observed which are in disagreement with previous study [(24)]. This may be attributed to many factors including inadequate thickness of ceramic material, the difference in fabrication techniques and the presence of stress concentration area as well as improper manipulation of cement.

In the present investigation, slight soft tissues inflammation (i.e. PI score 1) was obtained in three metal ceramic crown with no soft tissues inflammation was obtained in IPS e.max press ceramic crown. Gingival inflammation is more in metal ceramic restoration than ceramic restoration because deformation of the metal framework which happen owing to leakage of metal ions which make contact with marginal gingival [(25)]. While all ceramic restorations are considered the most biocompatible material [(26)].

In the current investigation, survival rate of metal ceramic crowns, group (I) was 98% which is consistent with previous data published in scientific literature [(8,23)]. While the overall success rate was 75% which is in disagreement with previous studies that reported higher success rate than present study [(8,26)]. This may be attributed to the increased number of patients, the difference in tooth position, material composition and fabrication techniques.

On the contrary, the overall survival and success rates of IPS e.max press crowns, group (II) was 60% and 54.5% respectively which is in disagreement with previous studies that reported higher survival and success rates than the present study [(24,27)].

Accuracy of the fit of restorations is considered an essential feature that determining the long-standing safety of dental restorations. Good fitting restoration required to be perfect along its margins as well as with regard to its internal surface [(28)]. Perfect marginal and internal fit of restoration is an essential feature to perform biological, mechanical as well as esthetic requirements of the restorations.

An impression replica technique was selected in the present investigation because it has advantage of being non – invasive and non-destructive technique without touching the restoration that can be measure at different time intervals [(15)].

Regarding the material type, table (1), IPS e.max press crowns (group II) registered lower mean marginal and internal gap values in comparison to metal ceramic crowns (group I) which are in agreement with previous studies [(29, 30)]. This is attributed to the higher dimensional stability of e.max press as the presence of crystalline phase (leucite reinforcement) imparts more strength to the ceramic core and thus increasing the marginal accuracy of the restorations than metal ceramic restoration [29].

Regarding the effect of different fabrication techniques of metal ceramic crowns used on the recorded marginal and internal gap mean values, (table 2), the direct milling of Co-Cr alloy using CAD/CAM system (subgroup I-B) registered significant lower marginal and internal gap mean values than the conventional casting of Co-Cr alloy (subgroup I-A). These results are similar to previous studies [31,32]. The low marginal and internal gap values for CAD/CAM system might be attributed to many factors including fewer production steps in CAD/CAM technique than the conventional casting technique and due to the precision of the scanner and CAM milling machine[32].

However, the outcomes of the current investigation are in disagreements with preceding investigations that reported that Co-Cr CAD/CAM milling is less accurate in margin and internal terms compared to casting method [22,33]. The authors explained their outcome to be due to the CAD/CAM process has some restrictions as the accurate fit inside contour of the restoration depends on size of the minimum tool used for each material, if the cutting tool was bigger in diameter than parts of the model preparation, the CAM system countenance a problem of cutting or no cutting parts which led to decrease of internal fit accuracy or marginal properties, correspondingly [34].

Regarding the effect of different fabrication techniques of IPS e.max press ceramic crowns used on recorded marginal and internal gap mean values, (table 2), patterns fabricated by 3D printing technique (subgroup II-B) showed less marginal and internal gap mean values than those fabricated by conventional one (subgroup II-A) which are in accordance with previous researches[13,35]. Lower marginal and internal discrepancy values for crowns fabricated by 3D printing resin pattern in the present study could be due to the accuracy of the scanner that digitize the working model, accuracy of the design via computer software as well as accuracy of the machine that produce the 3D design[35].

However, the results of the current research are in disagreements with preceding researches reported that restorations fabricated by 3D printing resin pattern technique had higher marginal and internal gap mean values than those fabricated by conventional wax pattern technique [22,36,37]. The explanation of this result was based on that the restoration manufactured by digital system (i.e. 3D printing) usually require another adjustment by technician which affect the accuracy of restoration[22].

Regarding the effect of both variables comparing all subgroups together, 3D printing resin pattern of IPS e.max press (subgroup II-B) registered the significant least mean marginal gap and non-significant least mean internal gap. These outcome are in harmony with prior studies said that the accuracy of dental restorations fabricated using the additive manufacturing methods and conventional e.max press is elevated than subtractive methods and conventional metal ceramic respectively [31,38].

The current study was not free of limitations; in vivo part; short follow-up time and small number of patients. In vitro part; no mechanical loading was added as fraction of artificial aging procedure, which may cause harmful effects on studied properties. Therefore, further studies that better simulate the oral environment, including mechanical loading are recommended.

CONCLUSIONS

1. Type of material as well as fabrication process of metal ceramic and all ceramic restorations are considered important factors which influences their clinical performance, marginal and internal fit.
2. Metal-ceramic has higher survival and success rate than glass ceramic mandibular first molar restorations.

3. Ceramic restorations have superior marginal and internal fit than metal ceramic restorations.
4. Digital technique provides restorations with superior marginal and internal fit.
5. 3D printing resin pattern of restoration has advantages for dental applications because of higher marginal and internal adaptation.

REFERENCES

1. Fathi H, Al-Masoody A, El-Ghezawi N, Johnson A. The accuracy of fit of crowns made from wax patterns produced conventionally (Hand formed) and via CAD/CAM technology. Eur J Prosthodont Restor Dent. 2016; 24:10-7.
2. HoHong M, Hanawa T, HoonSong S, KiMin B, YubKwon T. Enhanced biocompatibility of a Ni–Cr alloy prepared by selective laser melting: a preliminary in vitro study. J Mater Res Technol. 2019; 8: 1587-92.
3. Bilgin M, Baytaroğlu E, Erdem A, Dilber E. A review of computer-aided design/computer-aided manufactures techniques for removable denture fabrication. Eur J Dent. 2016; 10:286-91.
4. Silva L, Lima E, Paula Miranda R, Favero S, Lohbauer U, Cesar F. Dental ceramics: a review of new materials and processing methods. Braz oral res. 2017; 31:133-46.
5. Willard A, Min-Gabriel T. The science and application of IPS e.Max dental ceramic. Kaohsiung J Med Sci. 2018; 34: 238-42.
6. Shah S, Ashok V, Ganapathy D. Comparative evaluation of rapid prototyping and computer-aided milling in prosthodontics – A review. Drug Inven Today J. 2019; 12: 1040- 3.
7. Kaleli N, Sarac D. Influence of porcelain firing and cementation on the marginal adaptation of metal-ceramic restorations prepared by different methods. J Prosthet Dent. 2017; 117: 656-61.
8. Sorrentino R, Leone R, Leuci S, Ausiell P, Zarone F. CAD/CAM cobalt-chromium alloy single crowns in posterior regions: 4-year prospective clinical study. Osseo J. 2017; 9:282-8.
9. Elhoteiby M, Katamish H, El-Agroudi M ,Mahaa A , Ramzy I. Effect of three veneering techniques on marginal accuracy and fracture resistance of zirconia base fixed restoration: An in vitro study. Int J Adv Res. 2017; 5: 1475-82.
10. Aslı Akın A, Toksavul S, Muhittin T. Clinical Marginal and Internal Adaptation of Maxillary Anterior Single All-Ceramic Crowns and 2-year Randomized Controlled Clinical Trial. J Prosthodont Res. 2015; 4: 345-50.
11. Kocaagaoglu H, Halil I, Albayrak H, Kara M. In vitro evaluation of marginal, axial and occlusal discrepancies in metal ceramic restorations produced with new technologies. J Prosthet Dent. 2016; 116: 368-74.
12. Vojdani M, Torabi K, Atashkar B, Heidari H, Ardakani M. A Comparison of the Marginal and Internal Fit of Cobalt-Chromium Copings Fabricated by Two Different CAD/CAMSystems (CAD/ Milling, CAD/ Ceramill Sintron). J Dent Shiraz Univ Med Sci. 2016; 17: 301-8.
13. Elfar M, Korsel A, Kamel M. Marginal fit of heat pressed lithium disilicate crowns fabricated by three-dimensional printed and subtractive CAD/CAM wax patterns. Tanta Dent J 2018, 15: 199-208.
14. Al Assar R, Al yasky M, Mandour M, Amin R. Fracture Resistance and Retention of Metal-Free Inlay Retained Fixed Partial Dentures. Al-Azhar Dent J. 2017; 4: 395-407.
15. Yeon D, Hwan J, Young H, Chul W. Comparison and evaluation of marginal and internal gaps in cobalt–chromium alloy copings fabricated using subtractive and additive manufacturing. Prosthodont Res J. 2018; 62: 56-64.
16. Anadioti E, Aquilino SA, Gratton DG, Holloway JA, Denry IL, Thomas GW. Internal and marginal fit of pressed and cad lithium disilicate crowns made from digital and conventional impressions. J Prosthet Dent. 2015; 113:304-9.
17. Haider Y, Dimashkieh M, Rayyan M. Survey of dental materials used by dentists for indirect restorations in Saudi Arabia. Int J Prosthodont. 2017; 30: 83-5.
18. Karaman T , Ulku S , Zengingul A, Guven S, Eratilla V, Sumer E. Evaluation and comparison of the marginal adaptation of two different substructure materials. J Adv Prosthodont. 2015; 7:257-63.
19. Singh A, Ramachandra K, Devarhubli R. Evaluation and comparison of shear bond strength of porcelain to a beryllium-free alloy of nickel-chromium, nickel and beryllium free alloy of cobalt-chromium, and titanium: An *in vitro* study. J Indian Prosthodont Soc. 2017; 17:261-6.
20. Zarone F, Ferrari M, Mangano FG, Leone R, Sorrentino R. Digitally oriented materials: Focus on lithium dislicate ceramics. Int J Dent. 2016; 9:1-10.
21. Sabeti M, Dianat O, Kazem M. Impact of Access Cavity Design and Root Canal Taper on Fracture Resistance of

Endodontically Treated Teeth: An Ex Vivo Investigation. J endod. 2018; 44:1-5.

22. Chang H, Peng Y, Hung W, Ming L. Evaluation of marginal adaptation of Co-Cr-Mo metal crowns fabricated by traditional method and computer-aided technologies. Dent Sci J. 2019; 14: 288- 94.
23. Jamal S, Ghafoor R, Khan F, Zafar K. Five year evaluation of the complications observed in porcelain fused to metal (PFM) crowns placed at a university hospital. J Pak Med Assoc.2020; 70:845-50.
24. Ferrari M, Cagidiaco E, Goracci C, Sorrentino R, Zarone F, Grandini S. Posterior crowns out of lithium disilicate (LS2) with or without posts: a randomized controlled prospective clinical trial with a 3-year follow up. J Dent. 2019; 83:12–7.
25. Vincent M, Hartemann P, Duval R. Contact killing and antimicrobial properties of copper. App Microbiol J. 2018; 124: 1032-46.
26. Kalghoum A , Harzallah B, Cherif M, Hadyaoui D. All-Ceramic versus Metal-Ceramic Tooth Supported Single Crowns with a Minimum Follow-up Time of 3 Years; Survival and Complications: A Systematic Literature Review. J Dent Oral Disord Ther. 2018; 6: 1-14.
27. Sulaiman T, Delgado A. Survival rate of lithium disilicate restorations at 4 years: A retrospective study. J Prosthet Dent. 2015; 11:1-4.
28. Farjood E, Vojdani M, Torabi K, Khaledi A. Marginal and internal fit of metal copings fabricated with rapid prototyping and conventional waxing. J Prosthet Dent 2017; 117: 164-70.
29. Parimala V, Meenakshi A,Vinayagavel K, Sabarigirinathan C, Kanmani M. Evaluation Of Marginal Fit Of Metal Ceramic And Metal Free Ceramic Crowns: An In Vitro Study. Int J Dent Health Sci. 2015; 2:530-5.
30. Amarnath G, Jakhanwal I, Prasad H, Anupama T, Ayush M. Comparison of Marginal Fit of “All Metal”, “Porcelain Fused to Metal” and “All Ceramic” Crowns. Int J Bio Sci. 2017; 13:147-53.
31. Ghahremanloo A, Movahedzadeh M, Rashid A. The evaluation and comparison of marginal adaptation in metal ceramic and all ceramic restorations fabricated by two methods: CAD/CAM and conventional. J Dent Mater Tech. 2018; 7:53-62.
32. Gamze A, Subaşi M, Muhtaro M. Comparison of Marginal Fit of Cobalt-Chromium and Zirconia Cores Fabricated by Different Techniques Before and After Cementation. Turk Klinik J Dent Sci 2015; 21:77-82.
33. Joo Kim M, Jung Choi Y, Kyun Kim S, Joo Heo S , Young Koak J. Marginal Accuracy and Internal Fit of 3-D Printing Laser-Sintered Co-Cr Alloy Copings. Mater J. 2017; 10: 2-13.
34. Goujat A, Colon P, Abouelleil H, Jeanin C. Marginal and internal fit of CAD-CAM inlay/onlay restorations: A systematic review of in vitro studies. J Prosthet Dent. 2018; 121:245-52.
35. Arora A, Yadav A, Upadhyaya V, Jain P, Verma M. Comparison of marginal and internal adaptation of copings fabricated from three different fabrication techniques: An in vitro study. J Ind Prosthodont Soc. 2018; 18:102-7.
36. León M, Vielba M , Saiz E, Klemm I , Özcan M. Marginal and Internal Gap of Handmade, Milled and 3D Printed Additive Manufactured Patterns for Pressed Lithium Disilicate Onlay Restorations. Eur J Prosthodont Restor Dent. 2018; 26:31-8.
37. Taha D , Nour M, Zohdy M, El-Etreby A, Hamdy A, Salah T. The Effect of Different Wax Pattern Fabrication Techniques on the Marginal Fit of Customized Lithium Disilicate Implant Abutments. J Prosthodont.2019; 28:1018-23.
38. Bae EJ, Jeong ID, Kim WC, Kim JH. A comparative study of additive and subtractive manufacturing for dental restorations. J Prosthet Dent. 2017; 118:187-93.