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Clinical Performance and Patient Satisfaction with Different Types of Mock ups for Aesthetic Cases

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ORIGINAL STUDY

Clinical Performance and Patient Satisfaction With Different Types of Mock Ups for Aesthetic Cases

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Abstract

Purpose: This clinical study was designed to evaluate clinical performance and patient satisfaction of different types of mock-ups for esthetic cases (Mock-up constructed conventionally, using computer-aided design/computer-aided manufacturing and three-dimensional printed mock-up). **Patients and methods:** A total of 30 patients with esthetic defects were enrolled in this study. Patients were divided into two equal groups according to the clinical situation as follows: group 1: Cases with defects in color or texture (size and shape of teeth will not be changed). Group 2: Cases with defects in size or spacing or alignment (size and/or shape of teeth will be changed). A digital smile design program was used to design the smile and accordingly the restorations. Mock-ups were then constructed. Every group were further divided into three subgroups, according to the method of mock up construction as follows: Subgroup A: Mock-ups were constructed conventionally. Subgroup B: Mock-ups were milled using computer-aided design/computer-aided manufacturing. Subgroup C: Mock-ups were three-dimensional printed. Clinical performance was evaluated according to the USPHS criteria and patient satisfaction was evaluated by filling in the questionnaire. **Results:** The results revealed that all groups have statistically insignificant differences in the two clinical situations. **Conclusion:** All the construction methods can be used for mock-up fabrication with accepted clinical performance and patient satisfaction.

Keywords: Conventional mockup, Digital smile design, Milled mockup, Printed mockup

1. Introduction

Recently, patients' expectations about how they look have increased [1]. Successful therapy is measured by the patient's satisfaction; it is critical to understand and meet his expectations. This can only be accomplished by communicating with him via a three-dimensional (3-D) facsimile of his sound teeth. Along with aesthetic communication, function control may be considered at this stage. The most crucial aspects for the clinician are the use of a noninvasive approach in prosthetic restoration fabrication as well as the protection of both sound tooth structure and surrounding soft tissues [2]. The diagnostic wax-up is built in accordance with the digital smile design (DSD) planning, as it has been proven to be the most essential instrument in increasing patient communication and assisting him to understand and accept the dental plan [3,4]. DSD planning software with both 2-D and 3-D characteristics may produce excellent outcomes in a straightforward, consistent, and documented manner that is less operator-dependent [5].

Silicone matrices are regarded as a traditional approach for the manufacturing of mock-ups, in which resin materials and silicone imprints are utilized to transfer the new diagnostic waxing design onto unprepared teeth [6]. However, this traditional method of mockup production appears to be exceedingly problematic because the matrix is unevenly balanced placement, different pressure is provided during stabilization and resin sets, and it is difficult to remove excess resin and finish to obtain a smooth and desirable outcome. Furthermore, the procedure is exceedingly operator-dependent, in addition to being manufactured directly in the patient's mouth, resulting in a lake of

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marginal adaption owing to polymerization shrinkage [7]. These multiple steps can lead to a lack of accuracies [8].

Computer-aided design and computer-assisted manufacture (CAD CAM) were initially used in dentistry in the 1970s. It is now the most widely used technology in dentistry practice, whether in laboratories or at the chairside with some challenged practitioners [9]. CAD CAM mockups have been used to simplify processes and provide patients with additional cosmetic alternatives in a single visit. These subtractive methods have been applied for a variety of purposes, including terminal restorations made by milling a resin block that has already been cured under precise circumstances [10]. This approach improved mechanical qualities, reduced porosity in the restorations, and reduced chair side time. The good marginal adaptation of the milled CAD CAM temporary prostheses reduces bacterial formation in the tooth and minimizes pulp irritation caused by temperature variations during the polymerization process [11].

Aside from subtractive approaches, additive manufacturing (3D printing) is being used as a new technology to manufacture a variety of materials in a variety of fields. One of these materials is resin, which is used to make mock-ups. The American Society for Testing and Materials defines printing as a process for making 3D things out of materials, frequently layer by layer, as opposed to subtractive manufacturing techniques for creating mockups, models, and casting patterns [12]. Rapid prototyping (RP) is employed in several dental specialties, including oral and maxillofacial prosthodontics and dental implantology. It is used to create physical models, surgical guides, extraoral maxillofacial prostheses, and, more recently, fixed prosthodontics for short and long-term Provisional prostheses. This approach is the best since it produces no waste [13–16].

The purpose of this study was to accept or reject the null hypothesis that there is no significant difference in clinical performance and patient satisfaction with different types of mock-ups (traditional mock-up, CAD/CAM mock-up, and 3D printed mock-up) for aesthetic purposes.

2. Patients and methods

2.1. Sample size calculation

Sample size was calculated according to the following formula [17].

$n = (Z\alpha/2 + Z\beta)\ 2*2*(\sigma)\ 2/d2,$

Where $Z\alpha/2$ is the critical value of the Normal distribution at $\alpha/2$ (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96), $Z\beta$ is the critical value of the Normal distribution at β (e.g. for a power of 80%, β is 0.2 and the critical value is 0.84), $\sigma 2$ is the SD of ΔE after 2 weeks of Staining with black tea in conventional materials from a previous study which was 1.56, and d is the difference in ΔE between groups that we expect to detect, d=(2).

$n = (1.96 + 0.84)2*2*(1.56)2/22 = 9.54$. Therefore 10 patients (N = 10) will be included in each group with a total sample of 30 patients in the three groups.

2.2. Subjects

A total of 30 patients were enrolled in this study, selected from the outpatient clinic of the Crown and Bridge Department, Faculty of Dental Medicine for Girls, Al-Azhar University. The procedure was explained to the patient, and written informed consent was obtained. The possible discomforts, risks, and benefits were fully explained to the patients.

2.3. Eligibility criteria

2.3.1. Inclusion criteria

Both sexes' ages ranged from 25 to 40 years. Veneers and/or crowns were required to repair the patients' top anterior teeth. Patients with good oral hygiene and a whole set of anterior teeth were chosen [18,19].

2.3.2. Exclusion criteria

Patients with missing teeth or any periodontal problems in the maxillary anterior region, Patients with bruxism, clenching and/or any other habits, and Patients with a history of orthodontic treatment or with uncontrolled systemic diseases were also excluded [20].

2.3.3. Ethical approval

Approval of the Research Ethics Committee (REC) of Faculty of Dental Medicine for Girls, Al Azhar University was obtained, (approval code: REC-CR-23-08).

2.3.4. Grouping of patients

The 30 patients that were chosen were split into two equal groups based on their clinical circumstances. Group 1: Cases with defects in color or texture (size and shape of teeth will not be changed). Group 2: Cases with defects in size or spacing or alignment (size and/or shape of teeth will be changed).

Patients of both groups were subjected to the following procedure: Photographs of the patients

and impressions recording the dental arches were taken. Impressions were scanned by a digital scanner. DSD program was used to design the smile and accordingly the restorations. Mock-ups were constructed.

Each group was further subdivided into three subgroups according to the method of mock-up construction:

Subgroup A: Mock-up was constructed conventionally (Fig. 1).
Subgroup B: Mock-up was milled using CAD/CAM (Fig. 2).
Subgroup C: Mock-up was 3D printed (Fig. 3).

2.4. Construction of mock ups

2.4.1. Conventional mock up

After scanning the impression (Fig. 1a) and designing of DSD smile design by using Exocad DSD program (Fig. 1b), the impression was poured with hard stone to do study cast. The conventional wax-up was constructed on the study cast by using ivory wax (Renfert GmbH Durodent) following the DSD design (Fig. 1c). After finishing the wax up the rubber silicon index was made and cutting the indentation by blade number 15 following the gingival margin (Fig. 1d). The silicon matrix is filled with auto polymerizing resin (structure 2 SC, voco),

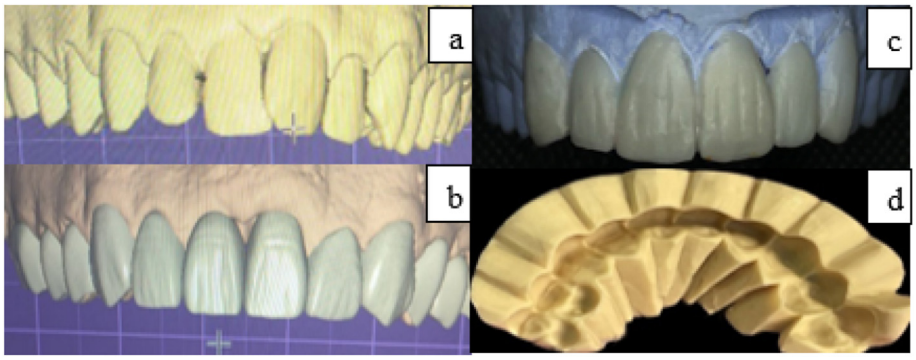

Fig. 1. Procedure for construction of conventional mock-up (a) scanning of impression, (b) digital smile design on the cast, (c) conventional mock-up on study cast (d)-rubber silicon index.

Fig. 2. Procedure for construction of computer-aided design/computer-aided manufacturing mock-ups: a-scanning of impression, b-digital smile design on the cast, c-milled mock-up.

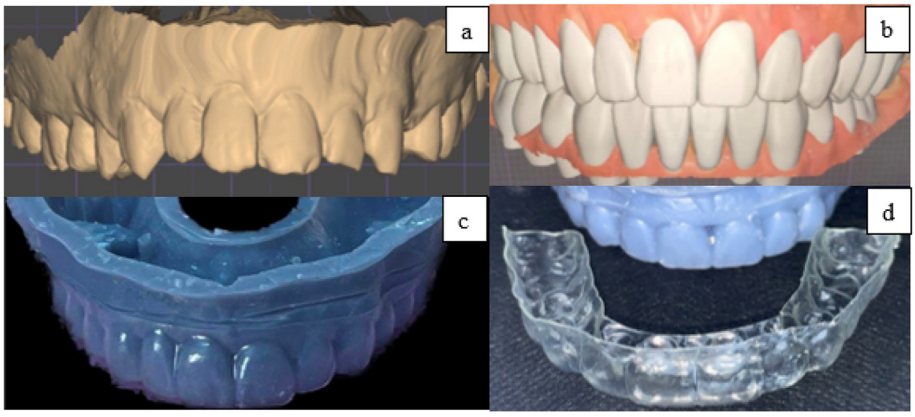

Fig. 3. (a) Scanning of impression, (b) digital smile design on the cast, (c) printed mock-up, (d) transparent silicon index and printed mock-up.

placed over the unaltered natural teeth and removed upon final polymerization and the excess on the margin was removed. The resin mock-up typically remains on the teeth as it is mechanically retained in undercuts. Finishing and smoothening the mock up then checking the patient occlusion.

2.4.2. Milled mock-up

After scanning the impression (Fig. 2a) and designing of DSD smile design by using Exocad DSD program (Fig. 2b). Milling the mock-up using CAD/CAM milling machine (Sirona COR TEC 250i) and milled pmma block (ACPW9814CA2 30837600) A_2 shade. The milled mock-up was finished and polished (Fig. 2c). The mock-up was inserted on patient mouth and cemented with temporary cement (cavex temporary cement eugenol free) and remove the excess cement with a dental prop.

2.4.3. Printed mock up

After scanning the impression (Fig. 3a) and designing of DSD smile design by using Exocad DSD program (Fig. 3b). A new cast was printed by using printer (formlabs DAZZLE impresora 3D resina) printer and photopolemer resin (white photopolemer resin formlab SLA 3D). Silicon transparent silicon index sheet (hard sheet −2 mm thickness) (bio art soluoes inteligentes) pressed on the resin printed cast with (PlastVac P7, blo-art) pressing machine. The transparent silicon index was separated from the excess using disc and all margin was smoothened. The transparent silicon index was removed from the resin cast and auto polymerizing resin (structure 2 SC, voco), was injected into the index and placed over the unaltered natural teeth and removed upon final polymerization and the excess on the margin was removed. The resin mock-up typically remains on the teeth as it is mechanically retained in undercuts. Finishing and smoothening the mock-up then checking the patient occlusion.

2.4.4. Clinical evaluations

The constructed mock ups were inserted in the patient's mouth and the following criteria were evaluated at the base line and after two weeks according to USPHS and FDI. Aesthetics was evaluated through difference in color matching by digital shade guide. Debonding by checking if there was any loss of one or more of mock up. Marginal discoloration by inspection of all margin if there was any discolored or stained area in the margin. Marginal adaption if the margin was smooth, or there was slight discontinuity or catch detected by explorer. Fracture of restorations by checking the mock up is intact or there was any craze, crack or chipping. Gingival inflammation, rescission and plaque accumulation were evaluated by visual if there were any signs of inflammation (change in color, texture, redness, edema, hypertrophy or bleeding on propping with periodontal prop and if there was any gingival recession that checked on mesial, distal and middle of buccal surface. Patients filled in a questionnaire to determine their satisfaction about (color, shape, chewing, food impaction, gingival bleeding, cleaning and brushing.

2.5. Statistical analysis

Qualitative data were presented as frequencies and percentages. Fisher's Exact test was used to compare between groups and subgroups. Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov–Smirnov and Shapiro-Wilk tests). Gingival Index (GI) and satisfaction scores data showed non-normal (nonparametric) distribution. Data were presented as median, range, mean, and standard deviation (SD) values. Mann–Whitney *U* test was used to compare the two clinical situations. Kruskal–Wallis test was used to compare between the three construction methods. The significance level was set at *P* less than or equal to 0.05. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

3. Results

3.1. Clinical evaluation

(i) Color match

(a) Comparison between clinical situations

With conventional as well as 3D printing construction methods; there was no statistically significant difference between the two clinical situations. Regarding to CAD/CAM method; all restorations in the two groups showed (Alpha) score, so no statistical comparison was performed (Tables 1 and 2).

(b) Comparison between construction methods

In both clinical situations, there was no statistically significant difference between different construction methods (Table 1).

(ii) Debonding

(a) Comparison between clinical situations

With conventional, CAD/CAM as well as 3D printing construction methods; there was no

Table 1. Descriptive statistics and results of Fisher's Exact test for comparison between clinical evaluation scores of clinical situations for different construction methods.

Clinical situation	Domain	Conventional ($n = 5$)			CAD/CAM ($n = 5$)			3D printing ($n = 5$)			P value
		Alpha	Bravo	Charlie	Alpha	Bravo	Charlie	Alpha	Bravo	Charlie	
Defect in color/texture	Color match	4	1	0	5	0	0	3	2	0	0.725
	Debonding	4	1	0	5	0	0	4	1	0	1
	Marginal Adaptation	3	2	0	3	2	0	3	2	0	1
	Fracture	3	2	0	4	1	0	3	1	1	1
	Plaque Formation	2	3	0	3	2	0	3	2	0	1
Defect in size/spacing	Color match	3	2	0	5	0	0	4	1	0	0.725
	Debonding	3	2	0	4	1	0	3	2	0	1
	Marginal Adaptation	4	1	0	5	0	0	4	1	0	1
	Fracture	2	2	1	5	0	0	2	2	1	0.241
	Plaque Formation	4	1	0	5	0	0	4	1	0	1

*Significant at P less than or equal to 0.05.

Table 2. Descriptive statistics and results of Kruskal–Wallis test for comparison between satisfaction scores of different construction methods.

Clinical situation	Domain	Conventional ($n = 5$)				CAD/CAM ($n = 5$)				3D printing ($n = 5$)				P value
		Median	Range	Mean	SD	Median	Range	Mean	SD	Median	Range	Mean	SD	
Defect in color/texture	Color	5	3–5	4.4	0.89	5	4–5	4.8	0.45	4	3–5	4.2	0.84	0.429
	Shape	5	4–5	4.6	0.55	5	4–5	4.6	0.55	5	4–5	4.2	1.3	1
	Chewing	4	3–5	4	1	4	3–5	4.2	0.84	4	3–5	4.2	0.84	0.926
	Food impaction	4	3–5	4.2	0.84	3	3–5	3.4	1.14	4	3–5	3.4	1.14	0.431
	Gum bleeding	4	3–5	4.2	0.84	5	3–5	4.4	0.89	5	3–5	3.4	1.14	0.865
	Easy cleansing	4	3–5	4.2	0.84	5	3–5	4.4	0.89	5	3–5	4	1	0.865
	Total score	25	21–30	25.6	3.51	26	23–29	25.8	2.39	26	22–29	23.4	5.03	0.968
Defect in size/spacing	Color	4	3–5	4.2	0.84	5	4–5	4.8	0.45	5	3–5	4.4	0.89	0.429
	Shape	5	2–5	4.2	1.3	5	3–5	4.4	0.89	4	2–5	3.4	1.34	0.350
	Chewing	4	3–5	4.2	0.84	5	4–5	4.6	0.55	5	3–5	4.4	0.89	0.728
	Food impaction	3	3–5	3.4	1.14	5	3–5	4.4	0.89	4	3–5	3.8	1.3	0.368
	Gum bleeding	3	2–5	3.4	1.14	5	4–5	4.6	0.55	3	2–5	3.2	1.48	0.126
	Easy cleansing	4	3–5	4	1	5	4–5	4.6	0.55	4	3–5	4	1	0.495
	Total score	22	17–29	23.4	5.03	29	23–30	27.4	3.21	23	18–28	23.2	4.76	0.143

*Significant at P less than or equal to 0.05.

statistically significant difference between the two clinical situations (Table 1).

(b) Comparison between construction methods

In both clinical situations, there was no statistically significant difference between different construction methods (Table 1).

(iii) Marginal adaptation

(a) Comparison between clinical situations

With conventional, CAD/CAM as well as 3D printing construction methods; there was no statistically significant difference between the two clinical situations (Table 1).

(b) Comparison between construction methods

In both clinical situations, there was no statistically significant difference between different construction methods (Table 1).

(iv) Fracture

(a) Comparison between clinical situations

With conventional, CAD/CAM as well as 3D printing construction methods; there was no statistically significant difference between the two clinical situations (Table 1).

(b) Comparison between construction methods

In both clinical situations; there was no statistically significant difference between different construction methods (Table 1).

(v) Plaque formation

(a) Comparison between clinical situations

With conventional, CAD/CAM as well as 3D printing construction methods; there was no statistically significant difference between the two clinical situations (Table 1).

(b) Comparison between construction methods

In both clinical situations; there was no statistically significant difference between different construction methods (Table 1).

(vi) Gingival Index (GI) scores
(a) Comparison between clinical situations

With conventional, CAD/CAM as well as 3D printing construction methods; there was no statistically significant difference between the two clinical situations.

(b) Comparison between construction methods

In both clinical situations; there was no statistically significant difference between different construction methods.

3.2. Patient satisfaction

3.2.1. Comparison between clinical situations

With conventional, CAD/CAM as well as 3D printing construction methods; there was no statistically significant difference between satisfaction scores of the two clinical situations regarding all domains of patient satisfaction questionnaire as well as the total score (Table 2).

3.2.2. Comparison between construction methods

In both clinical situations; there was no statistically significant difference between satisfaction scores of different construction methods regarding all domains of the patient satisfaction questionnaire as well as the total score (Table 2).

4. Discussion

People nowadays are more concerned with and consider facial and dental aesthetics as a way to express their individuality and boost self-confidence [19]. As a result, it is critical to comprehend the patient's desires and expectations. This can only be accomplished by communicating with the patient via the diagnostic wax-up and mockup [20]. The mock-up mainly acts as a guide during the preparation step. Based on the definite depth preparation concept, the mock-up defines the exact restoration thickness sufficient for the ceramic restorations. In accurate fabrication of the mock-up may cause complications and negative result of the esthetic [21].

The fabrication of the mock-up can now be done in a variety of ways, including directly in the patient's mouth, indirectly using a silicone index, or using a CAD/CAM process. The Conventional mockup is a complexed method and operator-dependent procedure. As the resin mock-ups have several drawbacks, today, the clinician can rely on smile planning and designing tools and CAD/CAM technologies to reduce mistakes and shorten work times. The successful application of adhesive restorations in aesthetic areas has demonstrated the validity of these methods [22,23].

Based on the results of this study we can accept the null hypothesis, which implies that there is no statistically significant difference among the three-construction method concerning the clinical success and the patient satisfaction. All types (conventionally constructed mock-ups using CAD/CAM and 3D printed mock-ups) showed satisfactory results and this may be explained as all the types even the conventional one follows the digitalized procedure in designing, The very good care from the patient following all oral hygiene instructions.

The milled mock-up showed more marginal adaptation, esthetic satisfaction, and color stability. This may be attributed to that it has a highly smooth, finished, and polished surface. The milled mock-up showed more fracture and debonding and this may be due to it is one unit and cemented in place with temporary cement. The printed mock-up showed good marginal accuracy as it was constructed on digitally printed cast and digitally designed index. Also, the equal uniform pressure on the transparent index makes a uniform thin thickness for the mock up material that make it more accurate and more accepted to patient. This result is in accordance with a previous study which found that the 3D printing of a dental material for provisional crown and bridge was comparable to conventionally cured provisional dental materials in mechanical properties. Furthermore, the 3D printed specimens had also comparable elastic modulus to conventional provisional crown and bridge [24].

The traditional mock-up, on the other hand, demonstrated less accuracy since it is dependent on technicians' wax-up design skills and practitioners' competence and experience in index manufacture and mock-up application. In tough esthetic stops (maligned and numerous gaps), both printed and traditional mock-ups showed reduced breakage and

debonding. This might be related to the interlocking of the mock-up materials in the under cuts and spacing, which increases mock up retention.

In contrast, recent research discovered a little dimensional change when both prototype and milled mockups were compared with the original 3D concept. The milled prototypes fit poorly in patients' mouths. Because using a milling machine to manufacture thin things, such as mockups or veneers, can be difficult and imprecise because the bur (cutting tool) may not sufficiently penetrate the resin block, increasing the object's ultimate dimension [18].

A different investigation discovered a difference in accuracy between standard molded and milled mockups and their original wax-up. When it comes to developing an esthetic mockup that is not operator reliant and reduces the possibility of error, the digital technique provides for more accuracy and the totally digital workflow is to be deemed more dependable. The traditional mock-up is a tough and unreliable procedure because of the matrix alignment, silicon index pressing during resin hardening, and resin removal [1].

4.1. Conclusion

All construction methods used in this study namely (conventional, 3D printing and CAD/CAM) can be recommended for construction of mock-up with nearly equal degree of clinical performance and patient satisfaction.

4.2. Recommendation

Further clinical trials of longer follow-up periods are required to evaluate clinical performance and patient satisfaction of different types of mock ups for aesthetic cases (Mock-up constructed conventionally, using CAD/CAM and 3D printed mock-up).

Ethics information

Ethical approval Approval of the Research Ethics Committee (REC) of Faculty of Dental Medicine for Girls, Al Azhar University was obtained, (approval code: REC-CR23-08).

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Biographical information

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Conflicts of interest

There are no conflicts of interest.

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