

# GRADUATION PROJECT

*Degree in Dentistry*

## MOCK-UP IN DENTISTRY

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## ABSTRACT

**Introduction:** The mock-up technique in restorative dentistry is defined as an intraoral transfer of a restorative project directly in the patient's mouth, used as a previsualization tool. Currently, digital technology provides a new workflow, aiming to facilitate and simplify the conventional workflow by offering a greater freedom of execution. Accuracy of the mock-up and patient satisfaction are key for a successful treatment. Without the accuracy of the mock-up, the final restoration may fail. If a patient is not satisfied with the outcome, then the process must be repeated. These two criteria go hand-in-hand in determining the success of the mock-up technique. It is important to evaluate the efficacy of both, the conventional and the digital mock-up technique, in term of accuracy and patient satisfaction; **Objectives:** The primary objective is to analyze the accuracy of reproducibility of both techniques. The second objective is to assess the patient's satisfaction; **Material and Method:** An adapted research question was established, with the research word "mockup" and "dental". A literature review was conducted through Pubmed, Dentistry and Oral Sciences and Medline Complete. These materials consisted of clinical systematic reviews or case studies, published between 1999 and 2023; **Results:** Applying the established inclusion and exclusion criteria, a total of 92 studies were collected. After scanning of these articles by their title, abstract and content, eight were included in the review: seven clinical studies and one case report; **Conclusions:** Based on the literature review, the accuracy of the mock-up technique is influenced by the material and design of the silicon key, as well as the experimentation of the operator. The digital technique is a more predictable and accurate technique than the conventional one. The mock-up technique increases patients' satisfaction and treatment acceptance, compared to other provisional or indirect methods.

**Keywords:** Dentistry; Mockup; Digital Mockup; Digital Smile Design; CAD-CAM

## RESUMEN

**Introducción:** La técnica del mock-up en odontología restauradora se define como la transferencia intraoral de un proyecto restaurador directamente en la boca del paciente, utilizado como herramienta de previsualización. Actualmente, la tecnología digital proporciona un nuevo flujo de trabajo, con el objetivo de facilitar y simplificar el flujo de trabajo convencional al ofrecer una mayor libertad de ejecución. La precisión del mock-up y la satisfacción del paciente son claves para un tratamiento exitoso. Sin la precisión del mock-up, la restauración final puede fallar. Si un paciente no está satisfecho con el resultado, se debe repetir el proceso. Estos dos criterios van de la mano para determinar el éxito de la técnica de mock-up. Es importante evaluar la eficacia de la técnica de maqueta tanto convencional como digital, en términos de precisión y satisfacción del paciente; **Objetivos:** El primer objetivo es analizar la precisión de la reproducibilidad de ambas técnicas. El segundo objetivo es evaluar la satisfacción del paciente; **Material y Método:** Se estableció una pregunta de investigación adaptada, con la palabra de investigación “mockup” y “dental”. Se realizó una revisión bibliográfica a través de Pubmed, Dentistry and Oral Sciences y Medline Complete. Estos materiales consistieron en revisiones sistemáticas clínicas o estudios de casos, publicados entre 1999 y 2023; **Resultados:** Aplicando los criterios de inclusión y exclusión establecidos, se recogieron un total de 92 estudios. Tras filtrar estos artículos por su título, resumen y contenido, ocho fueron incluidos en la revisión: siete estudios clínicos y un reporte de caso; **Conclusiones:** Basándonos en la revisión bibliográfica, la precisión de la técnica del mock-up está influenciada por el material y diseño de la llave de silicona, así como por la experiencia del operador. La técnica digital es una técnica más predecible y precisa que la convencional. La técnica del mock-up aumenta la satisfacción de los pacientes y la aceptación del tratamiento, frente a otros métodos provisionales o indirectos.

**Palabras clave:** Odontología; Mockup; Mockup Digital; Diseño de Sonrisa Digital; CAD-CAM

# INDEX

<b>1</b>	<b>INTRODUCTION .....</b>	<b>1</b>
<b>1.1</b>	<b>History.....</b>	<b>3</b>
1.1.1	Evolution of esthetic dentistry .....	3
1.1.2	Evolution of adhesive dentistry .....	3
<b>1.2</b>	<b>The mock-up technique .....</b>	<b>4</b>
1.2.1	The concept .....	4
1.2.2	Definition .....	4
1.2.3	Indications .....	4
<b>1.3</b>	<b>Clinical Assessment .....</b>	<b>5</b>
1.3.1	Anamnesis and Psychological analysis.....	5
1.3.2	Facial analysis .....	5
1.3.3	Smile Design .....	5
<b>1.4</b>	<b>Different mock-up techniques .....</b>	<b>6</b>
1.4.1	Direct Mock-up technique .....	6
1.4.2	Indirect mock-up technique .....	6
<b>1.5</b>	<b>Others mock-up applications .....</b>	<b>8</b>
1.5.1	Mock-up as an APT (Aesthetic Pre-evaluative Temporary) .....	8
1.5.2	Mock-up as a BFEP (Bonded Functional Esthetic Prototype) .....	10
1.5.3	Mock-up tool a guide for posterior teeth's preparation .....	11
<b>1.6</b>	<b>Digital Mock-up .....</b>	<b>11</b>
1.6.1	Intraoral scan.....	12
1.6.2	Digital Smile Design .....	12
1.6.3	CAD-CAM Mock-up.....	12
<b>2</b>	<b>OBJECTIVES .....</b>	<b>14</b>
<b>3</b>	<b>MATERIALS AND METHODS.....</b>	<b>15</b>
<b>3.1</b>	<b>Methodology.....</b>	<b>15</b>
3.1.1	Data Bases .....	15
3.1.2	Research question .....	15
3.1.3	Research strategies.....	15
3.1.4	Date range .....	16
<b>3.2</b>	<b>Criteria selection .....</b>	<b>16</b>
<b>3.3</b>	<b>Limitations .....</b>	<b>17</b>

<b>4</b>	<b>RESULTS .....</b>	<b>18</b>
4.1	Flowchart .....	18
4.2	Result tables.....	19
4.3	Analyses of the results.....	21
<b>5</b>	<b>DISCUSSION.....</b>	<b>24</b>
5.1	Accuracy of the mock-up between the conventional and the digital technique. ....	24
5.1.1	Comparison of different mock-up technique .....	24
5.1.2	Influence of the silicon key.....	26
5.2	Studies analyzing the patient’s satisfaction and perception regarding the mock-up technique.....	27
<b>6</b>	<b>CONCLUSION .....</b>	<b>29</b>
<b>7</b>	<b>BIBLIOGRAPHY .....</b>	<b>30</b>
<b>8</b>	<b>ANNEXES.....</b>	<b>33</b>

## **1 INTRODUCTION**

People have become increasingly interested in their health in the past twenty years, especially in regard to their oral health (1). Nowadays, the smile plays an important role in our social relationship. Patients place more value on their facial appearance than ever before. In clinic settings, it has been observed that the reason for consultations is more oriented towards aesthetic rehabilitation (2,3). Dental restoration adheres to the philosophy of conservative preparation, which is preserving as much healthy enamel tissue. Initially, dental restoration was limited to treating cavities and managing dental trauma and disease. Today, the practice has evolved into a more conservative and meticulous application (3). In this circumstance, dentist need to provide themselves solutions in order to respond at this double problematic: one about the esthetic demands and on the other hand preserving healthy dental tissue (2).

The mock-up technique is a clinical tool, responding well to this challenge. It is based on the intraorally transfer of a restorative project directly into the patient's mouth. It is conventionally done with a silicon key but can also be free-handed directly in the mouth of the patient, to replicate the restorative attempt. It allows the patient to visualize and anticipate the final result. This communicative tool facilitates exchange between patient and dentist opinions, and helps build a constructive and realistic idea on definitive restoration (4). Clinically it also worked as a guide for conservative tooth preparation. Practicians can better evaluate the minimal amount of preparation needed according to the final restoration (2).

### **Justification**

Nowadays thanks to the development of new technologies, the mock-up can be also proceeded by using a digital software such as Digital Smile Design (DSD) and Computer-Aid-Design-Computer-Aid-Manufacturing (CAD-CAM), offering a greater freedom of choice to execute the diagnostic. Several studies have demonstrated the convenience and practicality of digital workflow compared to the traditional one. However, the success of the mock-up depends on the accuracy of the mock-up reproducibility from wax-ups, as well as patient

treatment satisfaction. The degree to which a measurement or calculation, complies with an appropriate value, or a standard is known as accuracy. Satisfaction is a subjective evaluation of whether a patient's intentions for a medical visit is fulfilled. Without the accuracy of the mock-up, the final restoration may fail. If a patient is not satisfied with the outcome, then the process must be repeated. These two criteria go hand-in-hand in determining the success of the mock-up technique. The study aims to evaluate the accuracy of the mock-up between the conventional and the digital mock-up and to assess patient satisfaction.



## THEORETICAL FRAMEWORK

### 1.1 History

#### 1.1.1 Evolution of esthetic dentistry

The search of improve facial and dental appearance started in the 18<sup>th</sup> of century. Esthetic restoration became one of the subspeciality of dentistry, and its development greatly accelerated in the 20<sup>th</sup> of century (5). As defined in 1946 by the World Health Organization "Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." People have become increasingly interested in their health, especially in regard to their oral health, where smile appearance constituted a part on the social well-being (1).

Patients place a considerable amount of value on their facial appearance, and smiles play an important role in our social relationship than before. In clinical settings, the reason for consultation has become more oriented towards esthetic rehabilitation (2,3). Although the field of dentistry is constantly developing and evolving, the main goal of any dental treatment (prosthetic, restorative, periodontic...) is to mimic the most natural teeth following functional and biological considerations (5).

#### 1.1.2 Evolution of adhesive dentistry

For the past 30 years, adhesive dentistry has transformed restorative dentistry. The introduction of resilient and durable resin-based composite restorations, succeeding the traditional black amalgam filling, has had a profound impact on restorative dentistry by, fundamentally changing the way that dental restorations are approached (6).

Initially, dental restorations were limited to treat cavities and managing dental trauma and disease. Today, dental restoration adheres to the philosophy of following conservative preparation, conserving as much healthy enamel tissue as possible (3). In this circumstance, dentists need to provide themselves solutions to respond at this doble problematic: one about the esthetic demands and on the other hand preserving healthy dental tissue (2).

## 1.2 The mock-up technique

### 1.2.1 The concept

Currently, dentists have been able to develop the concept of aesthetics, from rules and fundamental pillars of smile design. However, there are situations where the final esthetic result does not meet the patient's expectations, despite following the esthetics' principles. This clash is created by ignoring the patient's self-identity, involving a feeling of misunderstanding and disappointment (4).

### 1.2.2 Definition

The mock-up can be defined as an intraoral transfer of a restorative project directly in the patient's mouth. It can be made of composite, acrylic resin, or bis-acryl (2,7). It offers a tactile evaluation of restoration project and allows direct adjustments (3).

The mock-up has three major functions in esthetic dentistry:

- Trilateral communication between the patient, the dentist, and the technician.
- Preliminary evaluation of the esthetic restorative project
- A guide for conservative tooth preparation (8).

Mock-ups are also used in prosthetic dentistry because they work as diagnostic tool, which warrants specific preparation to safe healthy enamel tissue. Because it is a simple approach, it does not require tooth preparation compared to traditional provisional technique (2).

Depending on the restorative protocol, the mock-up has different names: Mock-up, Bonded Functional Esthetic Prototype (BFEP), and Aesthetic Pre-evaluative Temporary (APT) (8).

### 1.2.3 Indications

Mock-ups have been used in multiples clinical situations for treatments such as diastema closure and correction of discolored, misaligned or misshapen teeth. They are also used in surgeries or even prosthetics in posterior teeth to increase the vertical dimension (7).

## 1.3 Clinical Assessment

### 1.3.1 Anamnesis and Psychological analysis

The initial appointment involves reviewing patient dental history, which is essential to perform a precise diagnosis and planning the corresponding treatment. Psychological questionnaires could be presented to help the practitioner envision characteristics of the patient's personality (shy, choleric, extrovert...) that may guide specific dental anatomical features (8). Past dental experience is also reviewed in order to complete the patient's psychological regarding dental procedures. State of mind is taken into account as well as it can affect the satisfaction of the treatment even if it complies with the patient's need (9).

### 1.3.2 Facial analysis

Patients should be carefully observed and photographed from the front, side and while smiling. Seeing the patient's face and smile at different scales is critical to visualizing the end result (10). The diagnosis starts sequentially with an extra-oral assessment, evaluating the facial proportions, reference lines and the shape of the face (11).

### 1.3.3 Smile Design

The smile analysis includes several parameters such as: the smile line, lip position at rest and when smiling, lip size, labial commissure, the gingiva phenotype and more (3). Following the diagnosis, an intra-oral examination is performed in regard to the position, shade, width, length, gingival tissue and occlusal scheme of the teeth, as well as a radiographic examination of the patient (2). The portfolio is supplemented with a cast and a video in some cases (10).

This collection of personalized patient information provides the practitioner with an objective and reproducible analysis of the patient minimizing the use of improvisation. This anticipation of early treatment is essential for the patient. It allows the practitioner to simulate the result and then decide, by mutual agreement with the patient, on a project based on different solutions available to the practitioner (3). Once the preliminary design is confirmed, the case is sent to the laboratory for the wax-up model (4).

## 1.4 Different mock-up techniques

There are several techniques and multiple material according to the indications, but generally follows the workflow, illustrated in figure 1: It begins with : 1<sup>st</sup> Complete examination, 2<sup>nd</sup> Wax-up of the ideal restoration, 3<sup>rd</sup> Silicon key creation, 4<sup>th</sup> Duplication of the model in the patient's mouth using the matrix and fluid resin, 5<sup>th</sup> Evaluation and approval of the template by the patient, 6<sup>th</sup> Send the model to the laboratory for the manufacturing of the final restoration (7).

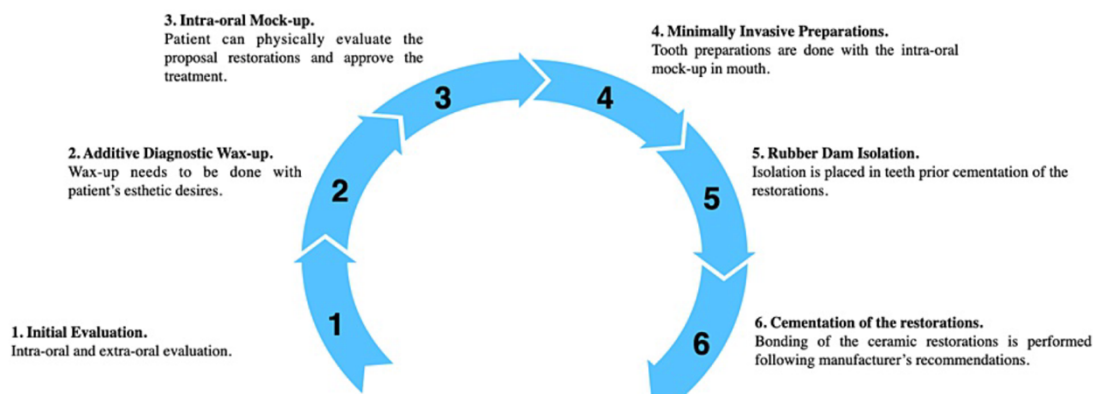


Figure 1: Clinical workflow for minimally invasive veneer restoration (3).

### 1.4.1 Direct Mock-up technique

The "freehand" method is the application of composite resin directly on the patient's dried teeth without preparation, while the patient is in the chair (2). This procedure is tested, functionalized, and modified with the possibility of reversibility until the ideal restoration is achieved. It follows these steps: sandblasting, bonding, and light cure resin application, without the need of anesthetization (12). Once the mock-up is validated, a silicone impression paired with photographs, is sent to the prosthetist. Two scenarios are possible: either the mock-up is directly copied, or the prosthetist created a more precise wax-up also known as: the indirect mock-up (7).

### 1.4.2 Indirect mock-up technique

The technician may additionally finish or fully elaborate the mock-up based on the data required for the smile design. The diagnostic wax-up is made on study casts, as illustrated in

the image a et b of the Figure 2. It is duplicated in the patient's mouth using either a silicone key filled with bis-acrylic resin, or a transparent matrix injected with fluid composite resin (3,7). An inaccurate wax-up transfer may lead to debonding complications and have an adverse effect on the aesthetic outcome (2).

#### 1.4.2.1 Silicon key with bis-acrylic resin

Hard silicone material provides a good seating of the cured material and is essential for an accurate reproducibility of the wax-up in the mouth of the patient (7). Additive techniques are used to avoid any deformation in the patient's mouth during the wax-up reproduction, such as gingival retraction cords and cutting along the collars of the anterior teeth, as illustrated in the image c of the Figure 2 (13).

When using a silicone key, the material can be acrylic resin or bis-acryl, where both are auto-polymerizable. This technique is applied when a partial coverage of the teeth is needed either in buccal or palatal (7).



Figure 2: Study model (a), Diagnostic wax-up (b), Waxing impression (c) and Analysis and adjustment of mockup (d) (14)

#### 1.4.2.2 Transparent matrix injected with fluid composite resin

Another method of creating a wax-up is by taking an impression using a clear polyvinyl siloxane (PVS) with a non-perforated metal tray. Once this is applied, small incisions are created at the incisal area allowing the injection of flowable composite resin and photopolymerized across the index, as illustrated in the Figure 3 (14). This technique is preferred to the silicon key with bis-acrylic resin because they fit and set into the transparent

mold without the need of external index pressure, avoiding distortion (13). In the case of full coverage restoration, the transparent index is more obvious and allows the use of light cure composite resin. It is highly recommended to ensure that the mixture is deep inside to avoid creating bubbles. However, if bubbles appear, flowable composite will be able cover them (7).

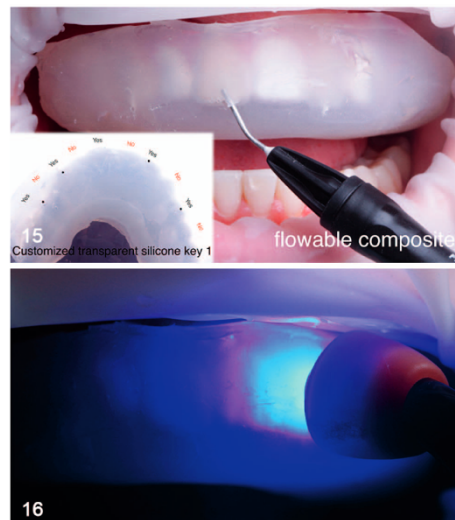


Figure 3: Injection of flowable composite resin in the silicone key (15) and photopolymerization of the composite resin through the silicone key (16) - (14)

## 1.5 Others mock-up applications

### 1.5.1 Mock-up as an APT (Aesthetic Pre-evaluative Temporary)

#### 1.5.1.1 Principe of adhesion and conservation

Enamel has a higher modulus of elasticity than dentin, so it has a stronger effect on the stability of the repair and the preservation of the tissue. Enamel should be retained whenever feasible as it enhances the bonding and fracture strength of the repair, achieving a thinner ceramic covering in its stead (2). The accuracy of the mock-up heavily influences the result of the restoration. An excessive extension of the tooth preparation can also compromise esthetic outcome (15). Enamel tissue is a key point in the realization of dental preparations (2).

### 1.5.1.2 APT (Aesthetic Pre-evaluative temporary)

Traditionally, tooth preparation depth is estimated through visual acuity of the practitioners which can be distorted by different factors such as dental anatomy, malocclusion (15). Doctor Galip Gürel developed the concept of tooth preparation through mock-ups, called the esthetic pre-evaluative temporary (APT) (2). The APT technique is based on “additive mock-up”, where tooth preparation is carried out when the final restoration’s volume has been determined by the mock-up (16). This technique is more efficient when the teeth are aligned (17).

Dental preparation starts by first reducing the provisional material before the natural tooth and conserving the enamel structures with depth vertical reduction grooves on the incisal edge and horizontal reduction grooves on the facial surface. These grooves are made with calibrated diamond burs that match the exact thickness of the selected restorative material (3,10). The practitioner will know exactly how much provisional material reduction is needed due to the bur marks left on the resin, as illustrated in the figure 4 (3).

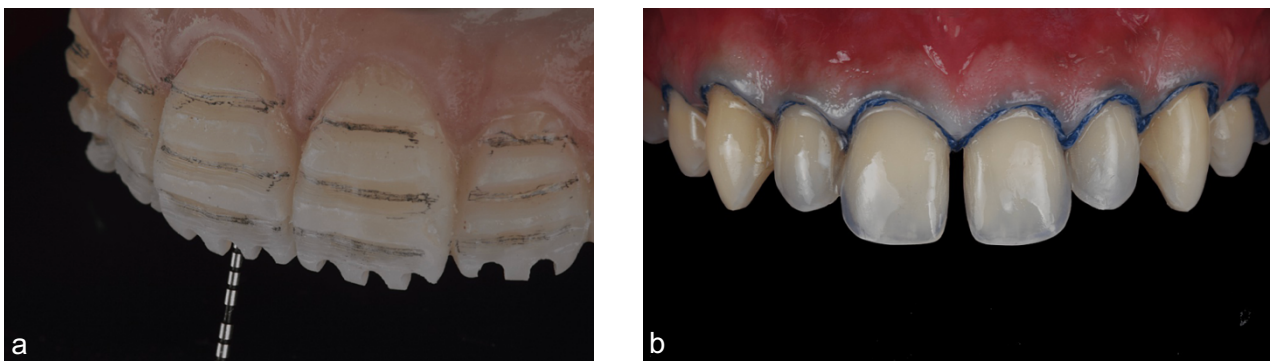


Figure 4: Conservative preparation using the APT's technique (a), Final preparation with placement of gingival retraction cords before the final impression (b) (3)

An over or under-contour of the preparation can lead to potential clinical issues (2). Using the APT technique, will limit unnecessary reduction of healthy tooth tissue. Once the preparation is complete, the residual material is removed, and the tooth is polished. Retraction cords are collocated, and a final silicon impression is taken afterwards as seen in Figure 5 (3).

## 1.5.2 Mock-up as a BFEP (Bonded Functional Esthetic Prototype)

### 1.5.2.1 *Concept of the BFEP*

The anterior regions are commonly treated with the mock-up approach. However, in cases of extensive rehabilitations, the BFEP is particularly helpful. Presented by Doctor McLaren, this technique follows the same conventional mock-up workflow. It provides a previsualization restoration and a long-term provisional solution between the initial tooth preparation until the final treatment. BFEP's objective is to ensure that patients receive durable dental restorations that satisfy both their functional and esthetic requirements (18).

### 1.5.2.2 *Mock-up in full mouth rehabilitation*

In cases of extensive rehabilitations, practitioners may need to raise the interocclusal space to create the desire esthetic outcome, as seen in bruxism patient (10). The functional wax-up is mounted onto the articulator, allowing the prosthesis to verify that the design obtained is truly functional in the mouth of the patient and not only esthetically pleasing, following the BFEP principle (7). This wax-up, which will affect both the front and posterior teeth, will offer a "Full mock-up" (12).

The position of the incisal edge is the first consideration in the creation of the mock-up, whether it is for an anterior or a whole mouth rehabilitation, for the new grin creation (4). Afterwards, the practitioner will proceed to register the patient's posterior sector bite, guiding him into the centric relation for his new vertical dimension. This increase of the interocclusal space correspond to the thickness of the palatal mock-up of the maxillary incisors (10).

### 1.5.2.3 *Mock-up as a provisional*

When considering only esthetic treatments in the anterior regions, the mock-up needs to be removed after esthetic try-in. In case of extensive restorations, the mock-up must be tested for a few months so that the patient can get used to the new occlusal scheme, and benefit from their new smile, as explained Doctor McLaren (18). The trial period allows the patient and practitioner to learn about the esthetic and functional result (speaking and chewing) of



the therapeutic project (2). Because the provisional is carried out for a longer period of time, selective etching is applied. The mock-up is made with self-curing bis-acrylates or composite resin materials (18). If modifications to the teeth are needed, additional wax-up is possible or the temporary material is easy to remove, allowing change about the size, shape, position, and color of the teeth. Once everything has been validated, the patient can undergo the requested treatment (3).

### 1.5.3 Mock-up tool a guide for posterior teeth's preparation

Maxillary and mandibular mock-ups are placed in patient's mouth, and conservative tooth preparation proceeds as shown in the figure 5 (10). Tooth preparation follows the same idea as the APT technique, with specific bur for the preparation of the axial walls, preservation of the marginal ridge, and occlusal tooth reduction (19). Once the minimally invasive tooth preparation and impression are completed, the provisional restorations made with acrylic resin or bis-acrylic can be prepared using the same technique to do the mock-up (8).



Figure 5: Functional full mock-up (a), Posterior preparation of the mock-up with 0,5mm depth cutter (b), Final tooth preparation preserving the marginal ridge (c) (10)

## 1.6 Digital Mock-up

Because the mock-up is usually an operator-dependent procedure, patient satisfaction is a challenge because of time costs, and flaws that are naturally part of handcrafting. The role of digital technology continues to grow over time due to greater accuracy and simplification of the conventional workflow (20).

### 1.6.1 Intraoral scan

Extraoral and intraoral scanners have replaced conventional alginate impression for more accurate and complete information, by allowing the evaluation of the dental and facial anatomical structures (5). The scan permits the transformation of 2D image into a virtual image of a wax-up (21). Both arches are intraorally scanned. Then after the smile design, the impressions will be sent to the CAD-CAM software (Computer Aided Design – Computer Aided Manufacturing) labs for the manufacturing of the prosthetic restorations (22).

Digital smile design (DSD) and CAD-CAM software (Computer Aided Design – Computer Aided Manufacturing) make it possible directly present different virtual projects to the patient. They have shown predictable results of esthetic restorations (20,23).

### 1.6.2 Digital Smile Design

The DSD is a modern innovative tool in the patient dental planning protocol. It was invented by the doctor Coachman in 2007. It allows professionals to design the patient 'smile from full face and profile photographs at rest and accurate dynamic video. These elements are fundamental for the digital procedure (22). Thanks to the digital library, tooth design is created following patient's reference, offering several smile template compared to the traditional mock-up design workflow (5). He presents pre-visualizations of treatments to the patient, which in turn strengthens patient-doctor relationship (24). There are several programs that can be used for the digital smile design such as Photoshop, Keynote, Digital Smile Design App (DSDapp) (22). DSDapp is an online application format, making the smile design protocol and execution easier for the dentists compared to the conventional DSD. It also improves patient participation and acceptance on the dental treatment (21).

### 1.6.3 CAD-CAM Mock-up

Demonstrated in 1985, CAD-CAM includes an optical scanner with a numeric milling machine, providing predictable dental restorations. They are easy to modify and realize. From metals, polymers, composite resin to ceramics they have high physical and esthetical

properties. The milling technique is the method the most used for the manufacturing (CAM). Developed by Doctor Andersson, it consists of subtracting dental material to create the prosthesis. However additive technique exists also but are less used (5).

## 2 OBJECTIVES

General objective:

- To evaluate the efficacy of the mock-up technique between the conventional and digital methods.

Secondary objectives:

- To analyze between the conventional and the digital workflow which one provide the most accurate mock-up.
- To assess the patient's satisfaction and perception regarding the mock-up technique

### 3 MATERIALS AND METHODS

#### 3.1 Methodology

For the preparation of the bibliographic review, the following has been used:

##### 3.1.1 Data Bases

The research has been made through the online library of the European University of Madrid. Three data based were consulted to identify available publications about the Mock-up in dentistry: Pubmed, Medline complete and Dentistry and Oral science source.

##### 3.1.2 Research question

**Table 1.** PICO Model of the bibliographic research

PICO ELEMENTS	KEYWORDS
<b>P</b> (Patient or Population)	Patients with esthetic complaints
<b>I</b> (Intervention)	Mock-Up technique
<b>C</b> (Comparison)	Conventional and Digital Technique
<b>O</b> (Outcome)	Accuracy and Satisfaction
<b>S</b> (Study type)	Clinical study

Research question based on the PICO Model. **Table 1**

→ In patients with esthetic needs, is there a difference regarding conventional and digital mock-up technique in term of success?

##### 3.1.3 Research strategies

- The search first was based on the research word «mockup» to have an overview of the subject. 3280 papers were obtained using any filters. (Pubmed= 821, Medline complete= 2267 and Dentistry and Oral Science n= 200).
- To refine the results regarding the mock-up technique used in dentistry, the research word “dental” was added combined by Boolean operators “AND” and “OR” to give

the following equation: (Mockup) AND (dental). A total of 145 articles are obtained. (Pubmed= 117, Medline complete= 14, Dentistry and Oral Science n= 14).

- From those 145 articles, the sort is done including the inclusion and exclusion criteria. This research was carried out in three different languages including English, Spanish and French with the aim of obtaining more in-depth results.
- The selection continues with the elimination of duplicates.
- It is pursued according to the relevance of the information contained in the titles, abstract.
- Subsequently, the entire articles were studied to assess their eligibility and relevance.

All the results of the different databases were recorded on the Mendeley Desktop bibliographic management software.

### 3.1.4 Date range

During the bibliographic search, in any database, the selection of articles has been chosen from 1999 to 2023. As this study aim to assess the accuracy between the conventional and digital mock-up technique, it was relevant to included articles from 1999 in order to obtain an accurate study. Therefore, the range was [1999; 2023]. **Table 2**

## 3.2 Criteria selection

**Table 2.** Inclusion and exclusion criteria for this research.

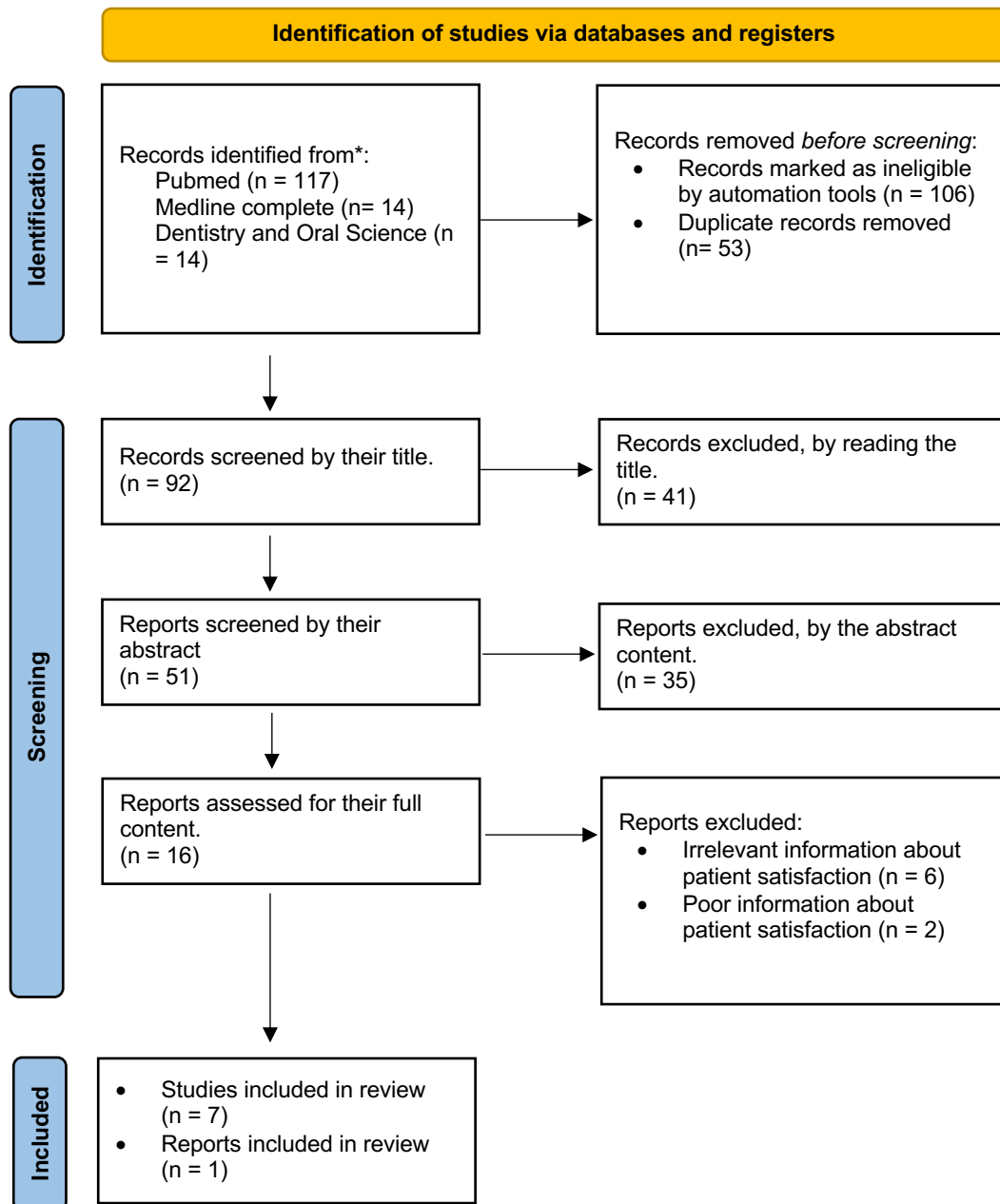
Inclusion criteria	Exclusion criteria
- Articles published after 1999	- Articles published before 1999
- English, Spanish and French Articles	- Articles written with another language than English, Spanish and French
- Full article available	- Full article not available
- Title and abstract with relevant content regarding our subject	- Title and abstract with irrelevant content regarding our subject
- Clinicals trials	- Review and meta-analysis
- Clinicals studies	- In dentate patients' (implant's mock-up)
- Dentate patient's	

### **3.3 Limitations**

This bibliographic research was limited to the two-research key word “mockup” and “dental”. It was justified by the technical and precise technique widely used in dentistry. There were issues with the lack of clinical trials and studies. Utilizing additional research keyword considerably restricted the number of articles available. The results are very poor in regard to the objective, showing few systemic studies for the research.

## 4 RESULTS

### 4.1 Flowchart



**Figure 6:** Flowchart of the bibliographic research (25)



## 4.2 Result tables

- Studies evaluating the accuracy of the mock-up between the conventional and the digital technique.

**Table 3.** Studies collection about accuracy of mock-up between both techniques

Authors, Year and Type of study	Samples and Groups	Objectives and Intervention	Significant Findings
Etienne O, et al 2021 (2)  Clinical studies	One patient	To evaluate indirect mock-up reproducibility	<ul style="list-style-type: none"> <li>• Accuracy by STL image superposition</li> </ul>
	20 mock-ups of the anterior sector made on the same patient: 10 LAB index and 10 CHAIR index, made by one practitioner.	To know if the material and design impact the mock-up accuracy  Intervention through: Geomagic Control X metrology software	<p>The positive and negative deviation values were +91.38 <math>\mu\text{m}</math>, and -79.41 <math>\mu\text{m}</math> for the CHAIR index and +72.22 <math>\mu\text{m}</math> m and -155.72 <math>\mu\text{m}</math> for the LAB index.</p> <ul style="list-style-type: none"> <li>• Accuracy related to the silicone key</li> </ul> <p>-The resin of the LAB index presents insufficient thickness compares to the wax-up. -The CHAIR index has a more homogenous resin thickness.</p>
Cattoni F, et al (2019) (26)  In vitro study	One patient	To understand the advantages and disadvantages of the analogue and digital mockup technique.	<ul style="list-style-type: none"> <li>• Accuracy by STL image superposition</li> </ul>
	25 molded (CG group) and milled mock-up (TG group) obtained from one patient.  Clinical protocol performed by an unexperimented practitioner.	Intervention through CloudCompare and DSS 3D software	<p>-Variance of the molded type: 0.0004 and variance of the milled type: 0,00002</p> <ul style="list-style-type: none"> <li>• Accuracy with silicone key</li> </ul> <p>-Anatomical deviations at the cervical and incisal part for the conventional mock-up</p>
Lo Giudice A, et al (2020) (20)  Clinical study	10 adults (8 females and 2 males, mean age)	To investigate the accuracy of the milled mock-up and the prototyped mock-up	<ul style="list-style-type: none"> <li>• Accuracy by STL image superposition</li> </ul>
	10 milled and 10 prototyped mockups obtained from the original stl files made it from 10 adults	Intervention through Exocad software and digital caliper	<p>-According to the post-hoc tests: prototyped mock-up shows only an increase of transversal linear measurement, compared to the milled mockup that show vertical and transversal increase of linear measurements.</p> <p>-According to the deviation analysis test: -80,31% between the 3D project and the milled mockups -69,17% of matching between the 3D project and the prototyped mockups. (<math>p &lt; 0,001</math>)</p>

Li Z, et al (2022) (15) In Vitro Study	A maxillary typodont model	To assess the influence of the thickness of different silicones matrices on the accuracy of the mock-up.	<ul style="list-style-type: none"> <li>• Accuracy with silicone key</li> </ul>
	72 silicones matrices divided in 4 groups according to two variables: labial margin position and the palatal notch.	Intervention through: Geomagic-studio software	<ul style="list-style-type: none"> <li>- Labial margin position highly improves the mockup precision in the labial area: (F=10,374, P&lt;0,01)</li> <li>- Palatal notch improves the trueness of the mockup in the incisal area (F=103,528, P&lt;0,01)</li> <li>- An heterogenous thickness ratio of the anterior teeth's mock-up is evaluated following the silicone key's design.</li> <li>- The average thicknesses of wax-up is 0.65 (0.61–0.69) mm in the labial area and 0.62 (0.56–0.67) mm in the incisal area, less than that in the mock-ups.</li> </ul>

- Studies collection of analyze of the patient satisfaction regarding the mock-up technique.

**Table 4.** Studies collection on patient satisfaction regarding the mock-up technique.

Authors, Year and Type of study	Samples and Groups	Objectives and Intervention	Significant Findings
De Cristina Mocelin R, et al (2021) (27) Clinical study (randomized restorative trial)	20 patients with restorative need receiving randomly a conventional or digital molding. The restoration trial is assessed by one dentist.	To compare between the conventional and the digital technique the diagnostic wax-up and to evaluate patient (questionnaire 2) and dentist (questionnaire 3) perspective regarding both techniques.	<p>Patients:</p> <ul style="list-style-type: none"> <li>-85% already experienced a digital workflow in a dental clinic and show more comfort and more convenient in execution time during dental care than with the conventional technique. They also preferred the digital method for his reliability. (Questionnaire 1)</li> <li>-After the mockup test performed, 65% preferred the conventional waxing for the previsualization of the esthetic restoration. (Questionnaire 2)</li> </ul>
Pantea M, et al (2020) (28) Clinical study	11 geriatrics patients. (>65 years old) (Questionnaire answered by the sample at the begin and end of the study)  Answered recorded by 3 dentists	To understand patient's perception on the existing tool for the previewing of dental restoration.  To evaluate his influence on the treatment acceptance.	<ul style="list-style-type: none"> <li>Indirect mock-up has a positive impact on acceptance of prosthetic treatment (72,7%)</li> <li>After the clinical test, we obtained: 6 previews with DSD, 6 with wax-up, 6 with mock-up, 4 with temporary restorations and 5 with CAD.</li> <li>The mockup is the technique that shows the greatest increase of positive evaluation. It has the most important impact on treatment previsualization.</li> </ul>

Cattoni F, et al (2016) (29)	28 patients (9 male and 19 female) (mean age of 36 years)	To evaluate the role and influence of the 3D digital smile planning technique on the previsualization stage.	Regarding the appreciation of the previsualization stage (visual scale):  -18/28 patients found the test with the smile design software very effective: 64,3%
Clinical study	Each patient received a fully digital workflow for anterior esthetic rehabilitations		-24/28 patients found the test with the mock-up tool very effective: 85,7%
Reshad M, et al (2008) (9)	A woman	To understand the role of diagnostics mock-ups on patient's esthetic demands	Evaluation of patient attitude regarding dental treatment is fundamental prior any planning.  The success of a treatment also depends on patient's psychology that the dentist needs to assess. It can affect the satisfaction of the treatment even if it complies with the patient need.
Case report		Treatment of the maxillary anterior teeth with porcelain laminate veneers.	

### 4.3 Analyses of the results

- Analyses of the results concerning the assessment of the accuracy of the mock-up between the conventional and the digital technique

In the study of **Etienne O**, 2 types of silicone key indexes are evaluated. The LAB index was made with a wash technique of polycondensation silicone (95 Shore) design with removal of some material at the interdental papillae. The CHAIR index was created with the wash technique silicone (60 shore) placed in a metallic tray. Every STL file was scanned and registered in the Geomagic Control X software, and the statistical analysis was carried out. The reproducibility of the STL file and the reference one was assessed by 3D comparison calculating the distance between two points of the superimposed meshes. Positive value meant an excessive thickness of the mock-up and a negative value, an insufficient thickness of it. Negative deviations compared to the positive one, showed significant differences ( $P < 0.05$ ) in favor of the CHAIR compared with the LAB index.

52 resin model were produced in the study of **Cattoni F, et al (2019)**, in a patient with esthetic restorative needs. From a CAD smile design, conventional and digital wax-up were created. 25 mockups were reproduced from the wax-up. The molding (Control-Group CG) and the milled mockup (Test-Group TG) laid on the 50 resin models, and all the STL file are compared with CloudCompare software (molded mockup) and the DSS 3D software (milled mock-up). A small variance suggests that the data points tended to be quite close to the mean, and to each other. Molded mock-up had a greater variance than the milled one, indicating more dispersion of the results. The clinical protocol was performed by an inexperienced operator.

**Lo Giudice A** studied the trueness of milling and prototyped mockup. 10 adults, with maxillary anterior esthetic needs, participated at the study. 2D virtual smile design was realized and the derived STL file was sent to a 3D printed and a milling machine. Each mockup underwent a specific surface to surface analysis, which were exported into the exocad software and evaluated by using a digital caliper. The exocad software evaluated the percentage of superposition with a  $p < 0,001$ . The clinical data accomplish with the caliper followed different statistical test, demonstrating significant results with a  $p < 0,001$ .

**Li Z, et al** evaluated the accuracy of the mockup by assessing the thickness of the silicone key. 72 matrices were manufactured by the same 3D mold, so that he ensured identical shape and thickness of the silicone keys. 4 group ( $n=18$ ) were created according to two variables: labial margin position (equigingival or with 1-2 mm coverage of labial gingiva) and the presence or not of the palatal notch. 3D scanning and 3D deviation analysis tools compared the diagnostic waxing with the thickness accuracy of the mockups, through the Geomagic Studio Software. A statistical analysis is performed, and the significant level is calibrated at 0,05. Labial margin positions of silicone matrices showed significant results on the trueness of mock-ups in the labial area ( $F=10.374, P<0.01$ ), and the palatal notches significantly increase the accuracy of the mock-ups in the incisal area ( $F=103.528, P<0.01$ ).

- Analyses of the results concerning the patient's satisfaction regarding the mock-up technique.

**De Cristina Mocelin. R:** The assessment of the patient's preference and satisfaction was evaluated by gathering the answers of two questionnaires, informing the dentist about their clinical experience and satisfaction regarding the mock-up technique. The results were described in percentage.

**Pantea M:** The evaluation of patient previewing in regard to different prosthetic tool was assessed through the same questionnaire at the beginning and the end of the clinical study.

**Cattoni F (2016):** A questionnaire was answered by the sample to understand patient preference between the digital smile planning and the mockup tool. The results were based on visual scales of each patient and expressed in percentage. In regard to the digital smile design, 64% of patients found it very effective and 36% effective. 86% found the milling mock-up very effective and 14% effective.

**Reshad M,** demonstrated on an unsatisfied patient that had undergone several failed prosthetic treatments, the influence and the efficacy of the mockup on patient satisfaction.

## 5 DISCUSSION

### 5.1 Accuracy of the mock-up between the conventional and the digital technique.

#### 5.1.1 Comparison of different mock-up technique

Through the four clinical studies mentioned above, the assessment of the mock-up accuracy has been surpassed by the superposition of the STL file of the different mock-up, and by the influence of the silicone key technique.

In studies performed by **Etienne O, Cattoni F (2019)** and **Lo Giudice A**, the degree of reproducibility between the different methods was calculated by assessing the distance between the location of the overlapping of the STL files. In this review, different mock-up techniques were tested to evaluate the most accurate one, from direct conventional to the full digital mock-up technique.

**Etienne O** showed contrasting results in his study. Whereas the positive deviations did not indicate substantial variation ( $P > 0.05$ ) between the CHAIR (+91.38  $\mu\text{m}$ ) and the LAB (+72.22  $\mu\text{m}$ ) index, the data on the negative deviations demonstrated significant variations ( $P < 0.05$ ) in favor of the CHAIR (-79.41  $\mu\text{m}$ ) contrasting with the LAB (-155.72  $\mu\text{m}$ ) index. It was established that in the CHAIR index, the pressure was better distributed, and the insufficient thickness of the mock-up created by the LAB index, may be explained by the toughness of the lab' silicone. However, several factors can increase these aforementioned results such as the margin of error of the scanner, the amount of resin in each mock-up, the precise tooth preparation... Hence considering these results, by compensation a deviation, 0,1mm is accepted and the indirect lab technique showed good reproducibility and could be enhanced with the combination of a metallic tray, taking advantages of both techniques.

**Etienne O's** appraisal had limitations. He compared several factors influencing the accuracy of the mockup such as the material, design and way of manufacturing the silicone index. Moreover, the study was performed by only one operator. To have more relevant results, specific studies should be performed to analyze each element individually, as **Li Z** who

evaluated four different designs of the silicone key on the accuracy of the mock-up technique. Comparatively, **Etienne O** hasn't expressed relevant conclusions on the design of LAB index.

However, **Cattoni F (2019)** expressed in his article the inaccuracy of the molded mock-up. In fact, he indicated significant difference in accuracy between the molded and milled mock-up. The measure of the variance of the molded shows more dispersed data compared to the variance of the milled. The variance and dispersion values are higher, therefore suggesting less degree of precision. Moreover, the degree of overlapping of between the molded mock-up and the wax-up was significantly lower than the one of the milled one. The milled technique showed higher accuracy and precision of the reproducibility between the CAD design and the milled mockup. The limitation of this study was related to the comparison of both technique that were using two different software, respectively, where interpretation of the findings can be controversial due to their different marge of error.

**Lo Giudice A**, evaluated in his study the accuracy of both milled and prototyped mock-up in a full digital mock-up technique, including a digital impression. Comparison of both deviation analysis and the statistical appraisal exhibited contrast result. The milling mock-up shows a higher matching percentage than the prototyped one. However, in further clinical investigations prototyped mock-up expressed more fitting and higher clinical adaptations compared to the milling one. Results must be taken with caution, when evaluating the accuracy of scans, algorithmic computation error could grossly underestimate the size of the real object. Controversially, **Cattoni F (2019)** revealed that the milled mockup was more accurate than the prototyped mock-ups, but **Lo Giudice A** suggested in case where a significant additive material were needed like in functional and aesthetic rehabilitations, the molded mock-up must be considered as the gold standard. Further investigation is needed as this article was the only one comparing two full digital mock-ups. Findings need to be also taken with some caution as the sample for this study was small and only one single milling and 3D printer machine were used.

### 5.1.2 Influence of the silicon key

Several authors mentioned in their studies silicon key consideration impacted the mock-up accuracy due to the amount of shore, design of the silicone key, and clinical experience of the operator.

**Etienne O.** was the only author in the review evaluating the accuracy of the mock-up between different silicone consistencies and expressed that with a stiffer material, the mock-up reproducibility was more precise. However, further investigation is needed to confirm this idea. Both **Li Z.** with **Etienne O** suggested that the influence of the design of the silicone key affects the quality of the mock-up technique.

**Li Z.** pursued a study on 4 different design of the silicon key and stated the significant effect of the palatal notch on the mockup accuracy of the incisal area, and considerable results with 1-2 mm coverage of labial gingiva on the labial area compared to an equigingival labial margin. The study showed no correlation between the labial margin and the palatal notch, but did with each design on their specific area, meaning that silicone key can be trimmed regarding specific requirements. He also analyzed a heterogeneous thickness ratio of the anterior teeth's mock-up is following the silicone key's design. Canine had a larger thickness change ratio than the lateral and the central incisors. The author explains that due to different operators' skills but also the material used, the results can be variables. He and **Etienne O** agree on the importance of having a homogeneous external pressure on the matrice, avoiding discrepancy between the area and the teeth.

However, despite the most precise silicone design, **Li Z.** founded an increase of around 15,7% to 22,7% thickness in mock-up compared to the wax-up. This discrepancy led to an insufficient tooth preparation based on the mock-up, and chair time adjustment was therefore needed.

**Cattoni F. (2019)** found in his study that milled mock-up is more accurate than the 3D printed one. However, according to **Li Z.** error exist, even with the CAD-CAM machine. He finally concluded that the mock-up tool is only a tool for doctor patient communication but can't be use as a guide for tooth preparation.



However, **Cattoni F. (2019)** suggested that milled mock-ups were more accurate than those made using silicone matrices. He argued that in conventional mock-up technique, discrepancies were mainly at the cervical and incisal area. Discrepancies in the cervical area were due to the removal movement of excess of resin material when set in the silicone key. At the incisal area, irregularities were explained by variation of pressure applied by the operator on the silicon key during the resin setting time. He affirmed that the milled mock-up was more reliable, in fact errors were made only due to the milling machine during the production. He added that the conventional additional step compared to the milling mockup, increased the chance of occurring error such as the positioning of the matrix or uneven pressure distribution during the hardening of the resin. Conversely, milled mockup met errors only during the mockup milling process. However, this study was performed by an inexperienced operator, who could have multiplied the number of errors. As confirmed **Lo Giudice A** and **Etienne O**, stated the importance of the operator on experiment in this conventional protocol.

## **5.2 Studies analyzing the patient's satisfaction and perception regarding the mock-up technique.**

**De Cristina Mocelin R** expressed that a patient's attitude was important before starting dental planning. It oriented the practitioner on patient's exigence and perception, and reassure them and increased their confidence, a key point on patient's satisfaction. Results of the first questionnaire were relevant. Patients with no prior experience with scanning, computer processes believed in a more trustworthy technique compared to the conventional technique. **Pantea M** shared the same idea. In his questionnaire, initially, patient preference on prosthetic previsualization turned towards digital workflow, such as DSD, CAD.... Although compared to the other technique, the mock-up showed the greatest increase of positive evaluation, between the first and the second session. In the **De Cristina Mocelin R'** study, despite this new technology, 65% choose the conventional digital waxing to be more relevant in the previsualization of their esthetic rehabilitations. The author explained that conventional individualization and personalization of the dental design was easier for the patient to own, compared to a dental restorative library that can be more impersonal for the patient. In a

study performed by **Pantea M**, all the patient at the end of the second session were convinced on the reliability of this clinical procedure. Because the sample comprised geriatric patient, dentists must adapt and show patience and pragmatism regarding third age patients. In this study, mock-up is the prosthetic tool of choice regarding the realism and easiness of understanding, compared to 2D digital tool, where visual projection is harder for third age patient. It increased patient assurance and treatment acceptance.

According to **Cattoni F (2016)**, the best previsualization method is the mock-up, enhancing the communication between the dentist and the patient. Following the results found by **De Cristina Mocelin R** and **Pantea M**, patient preferred a 3D to a 2D visual tool. However, in traditional planning methods, the transfer from virtual design to laboratory challenging and potentially error prone. This new digital tool should work in conjunction with the mock-up permitting easier diagnosis, reducing process time and increasing the predictability of the results.

Finally, **Reshad M**, demonstrated the efficacy of the mock-up tool on an unsatisfied and disappointed patient, regarding her past clinical experience. As **De Cristina Mocelin R** and **Pantea M**, the psychological assessment was effectuated in first appointment. The author devoted two appointments for the patient's data collection, with the intention for evaluating if the patient would allow a possible positive treatment satisfaction. In fact, numerous disappointing esthetic treatments were part of a negative conditioning of the patient even if the result followed the golden esthetics rules. In this case, the patient was very satisfied with her mock-up, felt understood, but needed to wear it for a longer period to have a step back on the esthetic. The following appointment allowed some modifications with patient cooperation. This report was a succeed, showing the significative positive impact of the mock-up on the patient, firstly unsatisfied and disappointed of dental treatment, to a patient with confidence and satisfaction.

Through the four clinical studies, patient psychology and knowledge regarding dental treatment were evaluated to better understand the patient's profile. First, their preference was oriented to new dental technology and digital tools, but after clinical tests, the conventional mock-up is the technique chosen by the majority. It showed how humans are more oriented towards something new that something that fits better for them.

## 6 CONCLUSION

The efficacy of the mock-up technique depends on the accuracy of the conventional or digital technique, and additionally by the satisfaction of the patient at the end of the treatment.

In conclusion:

- Accuracy of the wax-up transfer made by the silicone key into the mouth of the patient is affected by a consistent silicone material combined with an appropriated design. Higher reproducibility is achieved with an experiment operator. Furthermore, the digital mock-up technique is a more predictable and accurate mockup than the conventional technique.
- The mock-up technique is a valuable tool for both dentists and patients. It gives patients an opportunity to see and approve anticipated results. Through several clinical studies, the mock-up technique compares to other provisional indirect method shows more efficiency on patient treatment acceptation and gives the best pre-visualization approach of the restorative project.

The eight articles analyzed in this research show convincing results on the success factor of the mock-up technique. While they demonstrated positive outcome regarding clinical and practical field, few studies are available and further investigation is needed.

## 7 BIBLIOGRAPHY

1. Grad FP. The Preamble of the Constitution of the World Health Organization. *Bull World Health Organ.* 2002;80(12):981–4.
2. Etienne O, Assistant Professor H. Esthetic mock-ups: a clinical study of reproducibility. Vol. 16, 310 | *The International Journal of Esthetic Dentistry* |. 2021.
3. Villalobos-Tinoco J, Jurado CA, Rojas-Rueda S, Fischer NG. Additive Wax-Up and Diagnostic Mockup As Driving Tools for Minimally Invasive Veneer Preparations. *Cureus.* 2022 Jul 28;
4. Gürel G, Paolucci B, Iliev G, Filtchev D, Schayder A. The fifth dimension in esthetic dentistry. Number 1 | Spring. Vol. 10, *The International Journal of Esthetic Dentistry* |. 2021.
5. Blatz MB, Chiche G, Bahat O, Roblee R, Coachman C, Heymann HO. Evolution of Aesthetic Dentistry. *J Dent Res.* 2019 Nov 1;98(12):1294–304.
6. Rasines Alcaraz MG, Veitz-Keenan A, Sahrman P, Schmidlin PR, Davis D, Iheozor-Ejiofor Z. Direct composite resin fillings versus amalgam fillings for permanent or adult posterior teeth. Vol. 2014, *Cochrane Database of Systematic Reviews.* John Wiley and Sons Ltd; 2014.
7. Heinsohn JPS, Arteaga EM, Rivera GJ, Stange VB. Mock-Up An Old Tool Renewed. 2018;
8. Dragusha R, Ibraimi D. Mock-up: An Aid in the Different Steps in Aesthetic Dental Treatment. *European Scientific Journal, ESJ.* 2016 Feb 29;12(6):290.
9. Reshad M, Cascione D, Magne P. Diagnostic mock-ups as an objective tool for predictable outcomes with porcelain laminate veneers in esthetically demanding patients: A clinical report. *J Prosthet Dent.* 2008;99(5):333–9.
10. Koubi S, Gurel G, Margossian P, Massihi R, Tassery H. A Simplified Approach for Restoration of Worn Dentition Using the Full Mock-up Concept: Clinical Case Reports. *Int J Periodontics Restorative Dent.* 2018 Mar;38(2):189–97.
11. Sabbah A. Smile Analysis: Diagnosis and Treatment Planning. Vol. 66, *Dental Clinics of North America.* W.B. Saunders; 2022. p. 307–41.
12. Foschi D, Abate A, Maspero C, Solimei L, Lanteri C, Lanteri V. Method Presentation of a New Integrated Orthodontic-Conservative Approach for Minimally Invasive Full Mouth Rehabilitation: Speed Up Therapy. *Biomedicines.* 2022 Oct 1;10(10).
13. Alberton SB, Alberton V, de Carvalho RV. Providing a harmonious smile with laminate veneers for a patient with peg-shaped lateral incisors. *Journal of Conservative Dentistry.* 2017 May 1;20(3):210–3.
14. Coachman C, de Arbeloa L, Mahn G, Sulaiman TA, Mahn E. An improved direct injection technique with flowable composites. A digital workflow case report. *Oper Dent.* 2020 May 1;45(3):235–42.

15. Li Z, Ye H, Bai H, Zhao Y, Wang Y, Sun Y, et al. Three-dimensional digital evaluation of thickness accuracy of mock-ups fabricated by silicone matrices: An in vitro study. *J Prosthodont Res.* 2022;66(3):445–51.
16. Gurel G, Morimoto S, Calamita MA, Coachman C, Sesma N, Practice P, et al. Clinical Performance of Porcelain Laminate Veneers: Outcomes of the Aesthetic Pre-evaluative Temporary (APT) Technique. Vol. 32. 2012.
17. Gürel G. PREDICTABLE AND PRECISE TOOTH PREPARATION TECHNIQUES FOR PORCELAIN LAMINATE VENEERS IN COMPLEX CASES. *International Dentistry SA.* 2007;9(1):30–40.
18. Fabbri G, Cannistraro G, Pulcini C, Sorrentino R. The full-mouth mock-up: a dynamic diagnostic approach (DDA) to test function and esthetics in complex rehabilitations with increased vertical dimension of occlusion. *Int J Esthet Dent.* 2018;13(4):460–74.
19. Moreira A, Freitas F, Marques D, Caramês J. Aesthetic Rehabilitation of a Patient with Bruxism Using Ceramic Veneers and Overlays Combined with Four-Point Monolithic Zirconia Crowns for Occlusal Stabilization: A 4-Year Follow-Up. *Case Rep Dent.* 2019;2019.
20. Giudice A Lo, Ortensi L, Farronato M, Lucchese A, Castro E Lo, Isola G. The step further smile virtual planning: Milled versus prototyped mock-ups for the evaluation of the designed smile characteristics. *BMC Oral Health.* 2020;20(1).
21. do Vale Voigt M, Espíndola-Castro LF, de Melo Monteiro GQ, Ortigoza LS, dos Santos Torreão A, Georg R. DSDapp use for multidisciplinary esthetic planning. *Journal of Esthetic and Restorative Dentistry.* 2020 Dec 1;32(8):738–46.
22. Thomas P, Krishnamoorthi D, Mohan J, Raju R, Rajajayam S, Venkatesan S. Digital smile design. *J Pharm Bioallied Sci.* 2022;14(5):43.
23. Carla Pires L, Piragine Leandrin T, Andres Tinajero Aroni M, José Pimentel Lopes de Oliveira G, Henrique Barbeiro R, Henrique Verzola M, et al. Digital Smile Design and mock-up technique in esthetic crown lengthening: 2-year follow-up of six cases. Vol. 58, *The International Journal of Esthetic Dentistry.* 2022.
24. Cervino G, Fiorillo L, Arzukanyan AV, Spagnuolo G, Cicciù M. Dental restorative digital workflow: Digital smile design from aesthetic to function. Vol. 7, *Dentistry Journal.* MDPI Multidisciplinary Digital Publishing Institute; 2019.
25. Cattoni F, Teté G, Calloni AM, Manazza F, Gastaldi G, Capparè P. Milled versus moulded mock-ups based on the superimposition of 3D meshes from digital oral impressions: a comparative in vitro study in the aesthetic area. *BMC Oral Health.* 2019 Feb;19(1):230.
26. de Cristina Mocelin R, Penteado MM, Pierre FZ, Saraiva ACV, Uemura ES, da Silva JMF. Assessment of patient and dentist preference between conventional and digital diagnostic waxing. *International Journal of Esthetic Dentistry [Internet].* 2021 Feb;16(3):300–9. Available from: <https://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=ddh&AN=153139402&lang=es&site=ehost-live&scope=site&custid=s1136447>

27. Pantea M, Tancu AMC, Petre A, Imre M, Ionescu E. Elderly Patients' Perception of Previewing the Prosthetic Treatment Outcome. *J Med Life*. 2020;13(1):82–6.
28. Cattoni F, Mastrangelo F, Gherlone EF, Gastaldi G. A New Total Digital Smile Planning Technique (3D-DSP) to Fabricate CAD-CAM Mockups for Esthetic Crowns and Veneers. *Int J Dent*. 2016;2016.
29. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021 Mar 29;n71.

