Clinical comparative study between the classical and the digital wax-up and indirect mock-up
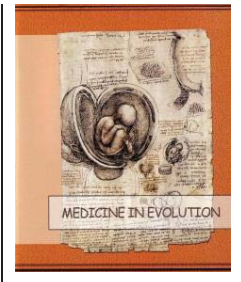
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Abstract

Obtaining functional and aesthetically pleasing dental restorations is the main goal of prosthetic treatments. A patient's smile should be in harmony with her/his facial features, reflect her/his personality and give her/him self-confidence. Nowadays, the vision that the doctor has in mind when designing a treatment plan can be materialised by means of a wax-up and subsequently by an indirect mock-up. Wax-ups can be made using the conventional method, i.e., by the addition of wax on a cast, or digitally, by creating 2D or 3D options of future dental restorations.

Keywords: dental aesthetics, conventional wax-up, Digital Smile Design, DSD, TRIOS, 3Shape, indirect mock-up.

INTRODUCTION

With rapid technological evolution and easy access to information, patients' demands have risen more and more, reaching as close to perfection as possible, hoping for an end-result that will presumably reflect their personality and their lifestyle [1].

The perception of beauty is a unique characteristic of every human being, describing an infinity of possibilities with various emotional nuances. In order to obtain predictable and stable results, both functionally and aesthetically, very good communication between the dentist, the dental technician and the patient is essential [2].

In modern prosthetic rehabilitations, the first stage of treatment begins with a thorough initial anamnesis in order to establish the patient's wishes and expectations, followed by a clinical analysis in order to establish her/his objective needs. Besides taking impressions for the study models, even beginning from this stage the practitioner can benefit from the help of digital technologies. These include digital photography, the use of digital software for the prefiguration of future dental shapes [3] and of the dental composition in a two-dimensional or a three-dimensional format, by means of a digital wax-up [4, 5, 6, 7].

Aim and objectives

The main objective of this study was to compare the preview of the future project in terms of dental shapes, size and arrangement, using two different methods (conventional and digital wax-up) and their assessment in terms of difficulty, working time, costs and aesthetic results. At the same time, the aesthetic performances of both methods were evaluated by the means of a questionnaire distributed to 100 subjects active in the dental field.

MATERIALS AND METHODS

A 25-year-old male patient came to our office with the desire to improve the aesthetics of his smile. Following the very thorough clinical examination, it was concluded that the patient had moderate caries risk, that he had undergone a series of dental and endodontic treatments and that he was not accusing any symptoms in temporal-mandibular joint and masticatory muscles.

For a better understanding the patient's perception of his physiognomic appearance and aesthetic desires, he was asked to complete an aesthetic questionnaire in order to establish the future treatment plan. The patient's complaints referred to the unpleasant appearance of his smile due to, in his opinion, the uneven gingival levels, the non-harmonious ratio between the length and the width of his teeth, their position on the arch and the spaces between the upper frontal teeth. The patient's desire was to have perfectly aligned teeth, with a more natural appearance and a lighter colour. At the same time, it was essential to preview the final aesthetic result from the beginning of the treatment.

The extra oral examination from a frontal view showed a correct symmetry and facial proportions (Fig. 1). From a lateral inspection, the patient had a straight profile (Fig. 2).
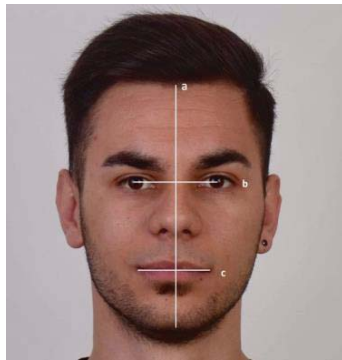
Figure 1. Frontal extra oral examination; a. The mid-sagittal line, b. The bipupillary line, c. The inter-commissural line
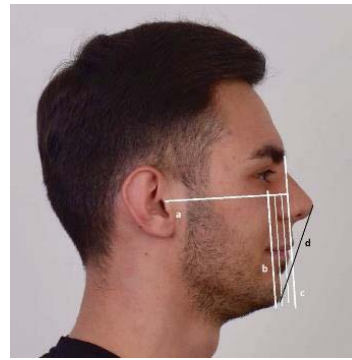

Figure 2. Extra oral lateral examination a. Frankfurt plane, b. Dreyfuss plane, c. Simon plane, d. E-line

A standard set of photographs was taken, which included portrait and profile photos, the mandibular rest position, the dental arches in maximum intercuspation (MI) front view, as well as from the left and the right side, and an occlusal view of each dental arch (Fig. 3).

Figure 3. The standard set of photographs

Following the clinical examination, the patient was diagnosed with Angle Class II/2, with an increased overbite and no overjet (Fig. 4). The shape of the maxillary central incisors was square, and they were situated orally.

Figure 4. Dental analysis

After completing the detailed clinical analysis and the complementary examinations, the functional and aesthetic objectives of the treatment plan were established:
1. Alignment of the maxillary frontal teeth;

2. Closing of the diastema;
3. Compensation of the palatal position of the maxillary incisors by adding vestibular volume;
4. Volume addition in the upper premolar area, in order to compensate for the negative buccal corridors;
5. Correction of the gingival smile by performing crown lengthening and implicitly correcting dental proportions (length/width ratio).

To preview the patient's future smile, two types of wax-ups, conventional and digital, were obtained. For the conventional wax-up, the impression of the dental arches was taken using a polyvinyl siloxane silicone (Express VPS, 3M Espe, USA) and a face bow recording was also carried out. The models were mounted in the semi-adjustable articulator (Artex® cr, Amann Girrbach, Austria) (Fig. 5) in the MI position, and the condylar slopes and Bennett angles were programmed by computerised axiography.
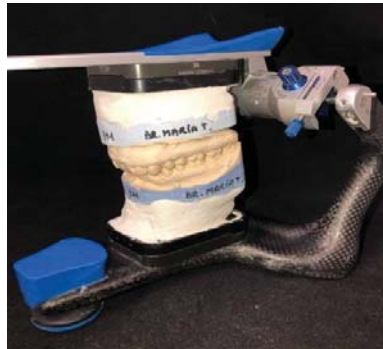

Figure 5. Casts mounted in the semi-adjustable articulator

In the dental laboratory, on the study models, the technician performed the wax-up according to the indications provided by the dentist. The wax-up was created with white wax by correctly repositioning the incisal edges of the central maxillary incisors (8), continuing with the buccal surface design and continuing with the entire dental arch up to the upper 2nd premolars (Fig. 6).

Figure 6. Classical maxillary wax-up

The dentist verified that the indications given to the dental technician were included in the wax-up design. Testing the project intra orally was performed using the indirect mock-up. An impression of the wax-up was taken with a putty addition silicone (Fegura Sil Putty, Feguramed GmbH, Germany), which was checked to fit perfectly into the oral cavity.

For the indirect mock-up, an A1 colour composite (LuxaCrown, DMG, USA) was used (Figs. 7, 8, 9).

Figure 7. Extraoral frontal view
of the mock-up

Figure 8. Extraoral lateral view
of the mock-up

Figure 9. Intraoral frontal view of the
mock-up

Subsequently, the mock-up was verified by the practitioner in the oral cavity. The distribution and intensity of the contact points in MI position, the anterior guidance and the lateral guidances were verified. The phonetic tests were also carried through.

As for the modern technique of previewing prosthetic restorations, a 2D digital simulation technique - Digital Smile Design (DSD), and 3D simulation - digital wax-up, were performed.

Keynote presentation software (Apple Inc., USA) was used to perform the digital simulation (DSD) and the wide-smile portrait photography and the intra oral photography of the maxillary arch with contrastor were selected for best results. Because the patient's facial symmetry was maintained, the reference line in the horizontal plane was the bipupillary line, while in the vertical plane the face midline was used [9]. Although the program generated a variety of dental shapes, the one that was presented to the patient was the one depicting square-shaped incisors and canines with rounded cusp tips (Figs. 10, 11).

Figure 10. Final dental shapes selected for the case

Figure 11. Aesthetic aspect of final DSD

An innovative 3D-preview method of future prosthetic restorations is using the digital wax-up. This involves obtaining a digital impression using the intra oral scanner. With the TRIOS intra oral scanner (3Shape, Denmark), the optical impression of the two dental arches was obtained, including the dental contacts in the MI position (fig. 12).

Figure 12. Digital impression of the occlusion (frontal and lateral views)

All this information was sent to the dental technician's laboratory who created a digital wax-up using special software (Argen, USA). Respecting the indications for the realisation of the 2D digital wax-up, the technicians chose the most suitable dental shapes from the dental library contained in the software (according to the 2D project). This wax-up was positioned in occlusal-gingival direction at the same level with the patient's natural incisal edges and exceeding the natural cervical contour by 2-3 mm on the maxillary frontal teeth. In a bucco-oral direction, a compensation for the retruded maxillary central incisors and for negative buccal lateral corridors was performed by accentuating the thickness of the buccal surfaces (Fig. 13).
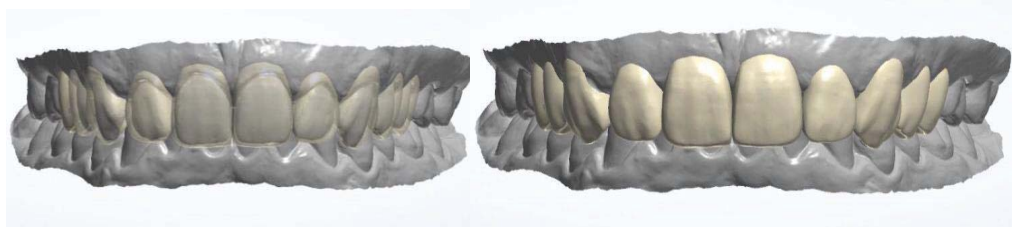

Figure 13. The digital wax-up viewed from the front

The 3D digital wax-up was superimposed over the patient's dental arch using a portrait photography (Fig. 14).

Figure 14. Final digital aspect provided by the digital wax-up

In order to check the 3D wax-up into the patient's mouth, a 3D printed model (Form 3 3D Printer, Formlabs, USA) was done. On the model a silicone guide (Fegura Sil Putty, Feguramed GmbH, Germany) (Fig. 15) was created for obtaining an indirect mock-up through the same procedure as for the conventional one (Fig. 16).

Figure 15. 3D-printed model and silicone key

Figure 16. Extraoral portrait and profile of the digital mock-up

With the patient's consent, separate photographies containing the conventional mock-up, the digital mock-up and the initial situation of the patient were assessed by a group of evaluators. This group was composed of 100 6th-year Dental Medicine students of the "Iuliu Hatieganu" University of Medicine and Pharmacy, Cluj-Napoca, who had already attended the lectures of Dental Aesthetics. They answered 5 questions in order to aesthetically compare the 2 mock-ups (the classic and the digital ones).

The questions included in the questionnaire were:
1. Which variant do you consider to be the best in terms of dental shapes?
2. Which variant do you consider the most aesthetic?
3. Which variant looks more natural to you?
4. Which variant do you think fits the face better?
5. Which variant would you choose?

All responses received were anonymous. The information obtained from the questionnaires was entered in an Excel spreadsheet and analysed through a pie chart. The questions referred to the intraoral and extraoral characteristics of dental proportions, shapes, inclinations, but also to the facial aesthetic aspect of the patient.

RESULTS

The two projects were carried out by two different technicians, each one being experienced with one of the two techniques. From the point of view of technical difficulty, they declared that the work seemed to be of reduced difficulty. Regarding the working time of the digital project (including the importing of the.stl file, the introduction in the virtual

articulator and the creation of the digital wax-up), 1 hour and 10 minutes were estimated. Regarding the working time of the conventional project (casting of the models and mounting in the semi adjustable articulator and applying the wax-up wax), 3 hours and 45 minutes were estimated. The costs were higher in the case of the digital system by purchasing the necessary equipment and amortisation, but also by printing of the model. The aesthetic analysis was carried out through questionnaires distributed to 100 students.

Regarding the dental shape, out of the total 100 participants in the study, 7% chose the variant in which the mock-up was obtained from the digital wax-up (2D and 3D), and the rest of 93% opted for the variant in which the mock-up was made starting from the conventional wax-up, modelled by the dental technician (Fig. 17).
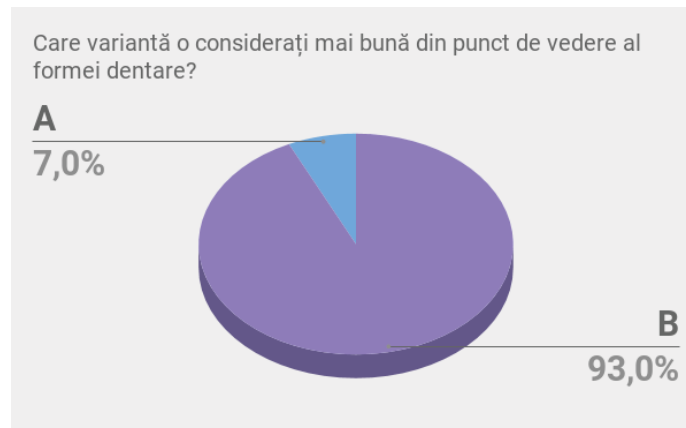

Figure 17. Dental shape evaluation

Similarly to the previous question, 93% of the participants in the study considered that the dental shape, and implicitly the shape of the dental arch, obtained from the conventional wax-up, had a more pleasant aesthetic aspect when compared to the digital variants (Fig. 18).
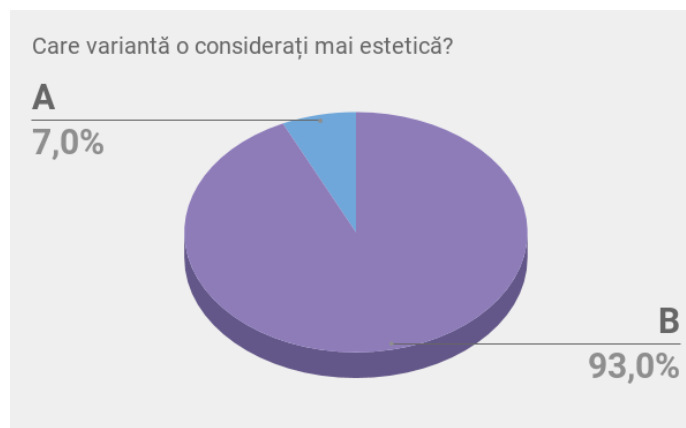

Figure 18. Evaluation of the aesthetics of the mock-ups

The next aspect of this study referred to the natural appearance of the mock-ups. The participants were asked to choose the mock-up that they considered to best mimic the natural appearance of teeth. The majority of 90% opted for the mock-up achieved by the conventional method to the detriment of the digital variant, which was only chosen by 10% of the subjects (Fig. 19).
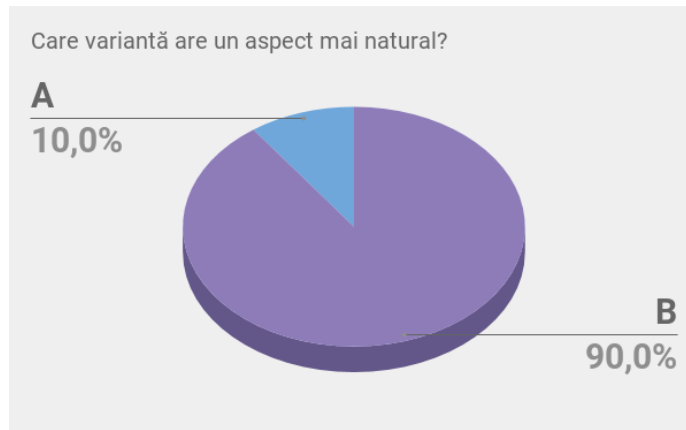
Figure 19. Evaluation of the natural appearance of the mock-ups

The next aspect that was analysed referred to the integration and harmonization of the new dental shapes with the patient's physiognomy. 85% of participants considered that the dental shape transposed from the conventional wax-up fitted best with the facial aesthetics, 14% of participants chose the digital version and only 1% of participants considered that both variants corresponded to the facial appearance (Fig. 20).
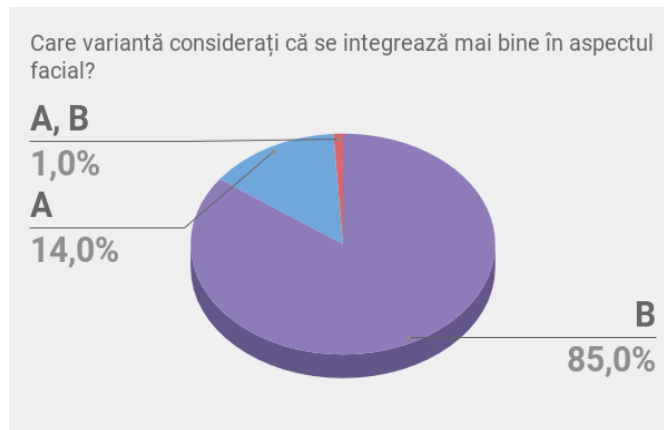

Figure 20. Integration of restorations in the facial aspect

When participants in the study were asked to opt for the mock-up variant that they considered optimal for the patient, 92% of them preferred the facial aesthetics offered by the conventional mock-up and only 8 % of participants opted for the mock-up made after the digital version (2D and 3D) (Fig. 21).
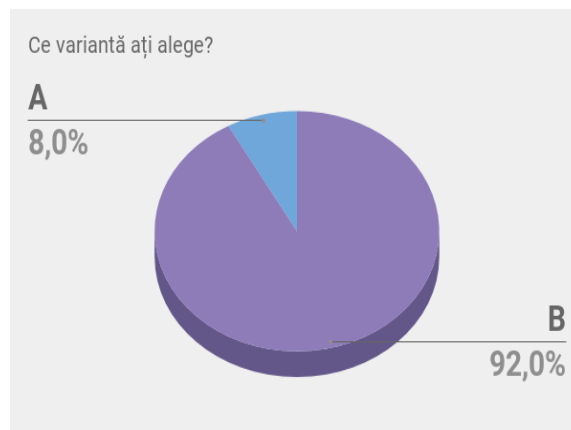

Figure 21. Graph with the choice of the preferred mock-up

DISCUSSIONS

The main purpose of this study was to compare two methods of wax-up, conventional and digital, and to evaluate the difference between them in terms of aesthetics, the costs involved and the time needed to their realisation. In order to obtain predictable results of the treatment plan, a prefiguration of the final result must be made right from the beginning.

The wax-up is an extremely important conceptual tool that offers the physician's vision of the treatment plan, facilitating communication between the medical team and the patient [11, 12].

Although we are living in a digital age, where technological progress is absolutely spectacular, in a relatively short period of time new and improved technologies appear to be replacing their conventional counterparts, human touch remains a necessity so far, being irreplaceable.

At the present time, in addition to the conventional way of achieving future dental arch shapes, it is also possible to create 2D and 3D previews of future dental restorations. Regarding the technological process of obtaining the two types of arch configurations, it is a well-known fact that the digital version performs faster, being achieved in a relatively short period of time, especially if the software design is done by an experimented technician. Digital technology is very advanced: the software programmes contain libraries of personalised teeth, offering a variety of shapes, dimensions, inclinations and alignments of virtual teeth. However, when they are transposed into the oral cavity, these digitally obtained shapes do not always manage to mimic the naturalness of real teeth, they do not always fit into the facial aesthetics and they may fail to harmonise the smile that patients desire. The precision and talent of the dental technician to create dental shapes that are in accordance with the patient's physiognomy and personality have not been completely replaced by any technological process so far. The creation of dental shapes by adding successive layers of wax on the cast is a time-consuming method, which implies solid knowledge of occlusion and dental morphology, craftsmanship, precision and artistic sense from the part of the dental technician.

However, after the try-out in the oral cavity, there are cases where the dentist may ask for changes in the wax-ups. The ones made in digital format are easy to correct directly in the software, in a short time, but for the conventional ones the technician needs to devote more time and attention, to remodel the dental surfaces and to create new fully functional contacts. However, for an experienced technician, this task should not be very time consuming.

To achieve the 3D digital wax-up, the teeth and arch designs are created with the help of special software and they are materialised by printing a 3D model using a special resin and a 3D printer [13,14]. At the same time, if changes to the initial shape of the wax-up are required, after the corrections are made in the software, a new 3D model is quite rapidly printed with the new configuration of the arch.

Digital workflows require a significant investment from the part of the dental laboratory in order to have all the technology required to perform all necessary operations.

Coachman et al. concluded in their article that the realisation of the treatment plan in a digital format facilitates interdisciplinary communication between doctors of different specialties involved in treating a clinical case, since they can have access to the patient's documentation even if they are not present at the time of initial consultation. When performing a digital wax-up from the 2D and 3D configuration of the dental arches, one obtains useful information that is available to all specialists in the case team, including the prosthodontist, the orthodontist and the surgeon, in order to establish correct staging of the treatment plan, even if the doctors collaborate remotely. At the same time, by performing the mock-up in the oral cavity, the patient is involved in the final decision to establish the final dental shapes and the aesthetic configuration of the arches [15].

Tarantili et al. conducted a study in which they concluded that the average exposure time of a smile is 500 ms. In order to obtain the conventional wax-up, the dental technician uses the standard photography set. However, capturing the complete dynamics of a smile in single snapshots is very difficult, therefore, a video recording of the patient's speech and smile would be necessary. In their opinion, the ideal method of achieving the shape of the dental arch is to create a 2D digital wax-up, which will fit in the facial dynamics and aesthetics [16].

Stanley et al. concluded in their article that performing a digital diagnostic mock-up helps both the medical team to properly plan the therapeutic steps, but it also allows the patient to visualise the future aspect of her/his smile, making her/him aware of the future design of the dental restorations and being able to express her/his opinion regarding the aesthetic aspect [17].

However, in order to create a highly accurate design of 3D digital wax-ups, in addition to the standard set of photographs, the patient's facial scan is also needed to accurately create the image of a perfect smile [18,19].

CONCLUSIONS

In order to achieve predictable aesthetic results, communication between the dentist, the dental technician and the patient is essential. The use of questionnaires, photography sets, diagnostic models, wax-ups and mock-ups is mandatory in cases of complex oral rehabilitation. Although the 2D and 3D representations of the shapes of the future dental arches is an important element that allows visualisation of the expected results, the craftsmanship and the delicacy with which the technician creates the dental shapes cannot be completely replaced by a digital system. However, the ease of making changes and the possibility to evaluate them in real time (on the patient's photograph), represent a huge benefit that will firmly place the digital preview technology in the current practice.

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