

# Using Artificial Intelligence-Based 3D Smile Design: REBEL in Prosthetic Rehabilitation with Patient's Personal Preferences. Case-1

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## Abstract

Each smile is unique, and smiles reflect the different shapes, textures, and colors of the teeth and their combinations. When creating a new smile design dentists need to consider the biology, structure, function, and esthetics to create the fifth dimension of the smile. This approach is completely different from the conventional one. A smile reflects the personality and emotional state of the patient, and the translation of this into a new smile design occurs either by analog methods or digitally. A smile is a person's ability to express a wide range of emotions with the movement and structure of the teeth, dentofacial, esthetic lips, social and psychological (Rambabu et al, 2018) it also determines how well a person functions in society. When a person has a harmonious smile (Paolucci et al, 2012) it is always assumed that it increases self-esteem and their ability to interact properly and more confidently in their surroundings.

**Keywords:** psychological; prosthetic rehabilitation; dental implant

## Introduction

Each smile is unique, and smiles reflect the different shapes, textures, and colors of the teeth and their combinations. When creating a new smile design dentists need to consider the biology, structure, function, and esthetics to create the fifth dimension of the smile. This approach is completely different from the conventional one. A smile reflects the personality and emotional state of the patient, and the translation of this into a new smile design occurs either by analog methods or digitally. A smile is a person's ability to express a wide range of emotions with the movement and structure of the teeth, dentofacial, esthetic lips, social and psychological (Rambabu et al, 2018) it also determines how well a person functions in society. When a person has a harmonious smile (Paolucci et al, 2012) it is always assumed that it increases self-esteem and their ability to interact properly and more confidently in their surroundings. In the last two decades, smile designing has progressively evolved from physical analog to digital designing which has advanced from 2D to 3D.

Smile esthetics concerns represent one of the most important issues of daily dental treatments. Regardless of the cases' difficulty, the patients usually look for better-looking smiles. Often the final esthetic results may fail to meet the patient's expectations due to disharmony between the smile design and the patient's identity.

To achieve an optimal esthetic result from dental treatment, we need to create a suitable smile design that satisfies patients' expectations largely influenced by psychological features of character, social status, and education (Gurel, 2020; Paolucci et al, 2012).

Various DSD software products are available but do not consider the personality factor in designing the smile (Omar and Duarte, 2018).

Before initiating any treatment, it is necessary to visualize the desired outcomes. It then becomes possible to formulate the steps required to achieve this result.

**The fifth dimension of the smile**

The smile design in dentistry so far till recent years has been based on four dimensions: biology, structure, function, and aesthetics. The esthetic parameters were dependent on age, gender, and sex. However, in reality, none of these dimensions took into consideration the personality of the patient, even though a 'perfect' smile design should reflect this. Patient identity, which includes personality, is therefore the fifth dimension of the smile.

The key to this translation of the patient's personality and feelings into the new smile design is visual language.

**Visual Language**

Each type of line or shape has a specific emotional meaning.

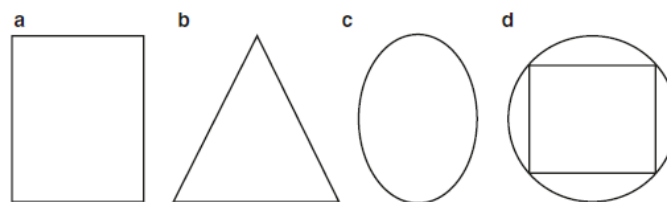
Lines represent the most basic elements of visual language. Horizontal lines, because they conform to gravity, express stability, passivity, and calmness. In contrast, vertical lines represent the movement of the point against gravity, expressing strength and power, just as inclined lines arouse the sensation of instability, tendency to movement, and dynamism. Curved lines are associated with delicacy, sensuality, and feminine gender (Figure. 1a-d) and (Figure. 2a-d).

The combination of lines generates the most basic forms, transferring to them their expressions.

Thus, the vertical rectangle expresses strength by the predominance of the vertical element on the horizontal, the triangle dynamism, the oval delicacy, the square stability, and immobility by the balance between its vertical element and the horizontal one. These basic shapes can be observed in the facial contour as well as in the shapes of the incisors and the three-dimensional configuration of the dental arrangement.



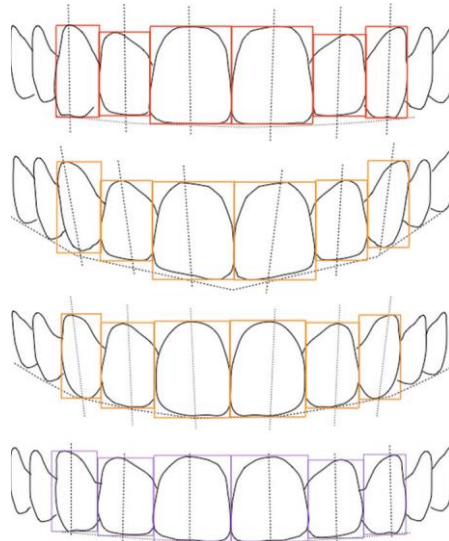
**Figure 1a-d.** vertical lines and rectangular shapes express strength due to the predominance of the vertical element on the horizontal (a) the horizontal line expresses stability and immobility due to the balance between the vertical and horizontal elements (b) the inclined lines and triangular shapes express dynamism (c), and the oval and round shape express delicacy (d).



**Figure 2a-d.** (a) vertical lines and rectangular shapes express strength due to the predominance of the vertical element on the horizontal the inclined lines and triangular shapes express dynamism (b). the oval and round shape express delicacy (c), and the horizontal line expresses stability and immobility due to the balance between the vertical and horizontal elements (d).

The knowledge of the visual language is therefore applied to the main expressive elements of a smile design (dental shapes, incisal edge,

interdental ratio dominance, and 3D positioning of the teeth in the arch). It determines the following four smile design types (Figure. 3).



**Figure 3.** The visual language knowledge applied to the main expressive elements of smile design such as dental shapes, incisal edge, interdental ratio or dominance, and 3D positioning of the teeth in the arch determined four smile design types with primary expression, from top to bottom: strong, dynamic, delicate, and calm.

**Strong:** The design is composed mainly of rectangular dental shapes, strong dominance of the central incisors and canines on the lateral incisors (radial symmetry) as well as plane incisal edge and rectilinear 3D dental positioning on the arch in the occlusal view.

**Dynamic:** Triangular or trapezoidal dental shapes, standard dominance, inclined incisal edge, and angled 3D dental positioning on the arch.

**Delicate:** Oval dental shapes, medium dominance, curved incisal edge, and standard 3D dental positioning.

**Calm or stable:** Smoothly rounded square dental shapes, weak dominance (current symmetry), horizontal incisal edge, and 3D rectilinear or standard dental positioning on the arch.

#### The Rebel software

Rebel software is an artificial intelligence-based program that enables the simultaneous generation of stereolithography (STL) files of digital wax models.

Software for creating a customized smile that takes into account the patient's personality, and biological, structural, functional, and aesthetic parameters to create a three-dimensional smile.

The Dellinger and Eysenck personality tests give insights about the patient's personality and enable the dentist to directly feed the data into the software and patient preferences, and personality, and the facial analysis is formulated into a mathematical formula wherein the 2D image is designed and transformed into a 3D smile design.

Including the patient's personality in the design of the smile will enable clinicians to offer patients new smiles that reflect them holistically.

It is considered to be an online facility that produces three-dimensional, custom smile designs (Sanketh, et al. 2023).

#### Esthetic Analysis and Rebel Simplicity

Esthetic design can be challenging for clinicians and dental technicians. Rebel Simplicity is a recent digital previsualization technique that allows the dentist to:

- Perfectly design the new smile;
- Improve the communication between the dental team members involved in the treatment;
- Obtain better communication and achieve better patient motivation; and
- Visualize the final esthetic result even before the treatment is started.

3D Rebel smile design plays an important role in temporaries during different steps of treatment procedures.

This method makes it possible to share the treatment plan among team members and to create a 3D visualization of the case in the patient's mouth. The digital project will be tested and approved before starting the actual treatment. Accordingly, it will allow the dentist to present the appropriate therapeutic solutions.

#### Case presentation -1

A woman of age 55 required esthetic prosthetic rehabilitation of her teeth. The patient is not satisfied with her teeth. After the full-face picture of the patient with an Intraoral view was taken (Figs.4a-c). The main complaint is the poor esthetic appearance, teeth discoloration, poor old restorations, generalized gingival recession, periodontitis with pus discharge, and inappropriate old Class III composite restorations in all anterior teeth.

In the first visit, digital impressions of both arches were taken. A complete photographic protocol was followed according to the Rebel Simplicity protocol.

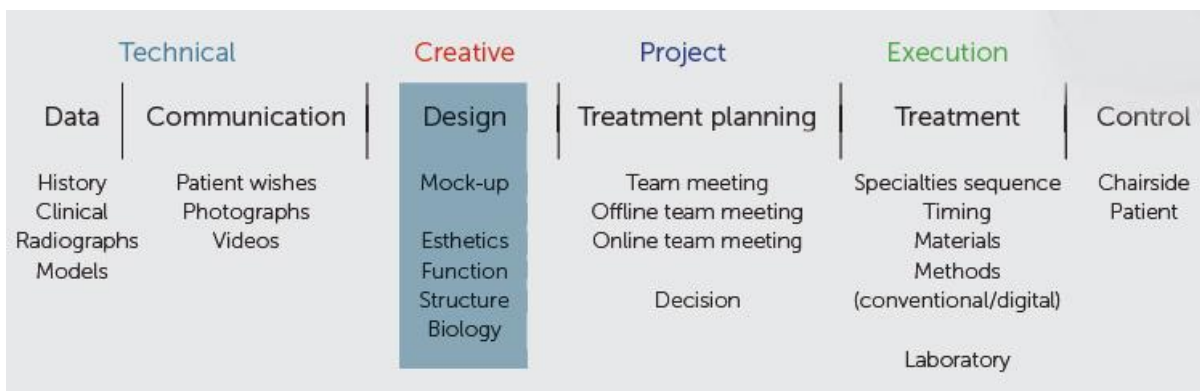


**Figure 4a-c.** Intraoral view shows the poor esthetic appearance, teeth discoloration, poor old restorations, generalized gingival recession, periodontitis with pus discharge, and inappropriate old Class III composite restorations in all anterior teeth.

**Esthetics-based treatment planning**

A workflow for an esthetic case starts with the collection of the data, history of the patient, clinical findings, X-rays, models, photos, and maybe videos. Then one of the most important parts of the whole step is to start communicating with the patient regarding their expectations from this esthetic treatment (Trushkowsky, 2020).

The most important step of the workflow is the design part; however, at this stage, verbal communication is not enough. Any esthetic procedure is very subjective, and without materializing the esthetic smile design, it will not be possible for the dentist to explain what he/she would want to deliver to the patient at the end of the treatment (Figure. 5).



**Figure 5.** The most important part of the workflow is the design part. This is the heart of any esthetic treatment that will differentiate a more committed dentist from an average one. The final esthetic smile design and treatment planning should also be based on this mockup, which should fulfill the expectations of the patient.

**The Rebel workflow**

Rebel provides the simplest steps for transferring all the necessary information to the Rebel digital laboratory.

These are the three mandatory steps:

1. Single central incisor mock-up and intraoral digital scanning.

2. A full-face photographic protocol.
3. A Simple interview/questionnaire.

**1. Single central incisor mock-up and intraoral digital scanning**

In certain circumstances, a composite mock-up is performed on one (or two) of the central incisors to identify the incisal edge position vertically



and the position of the facial surface buccolingually. In this case, the central incisor mock-up is not indicated (Figure 6).

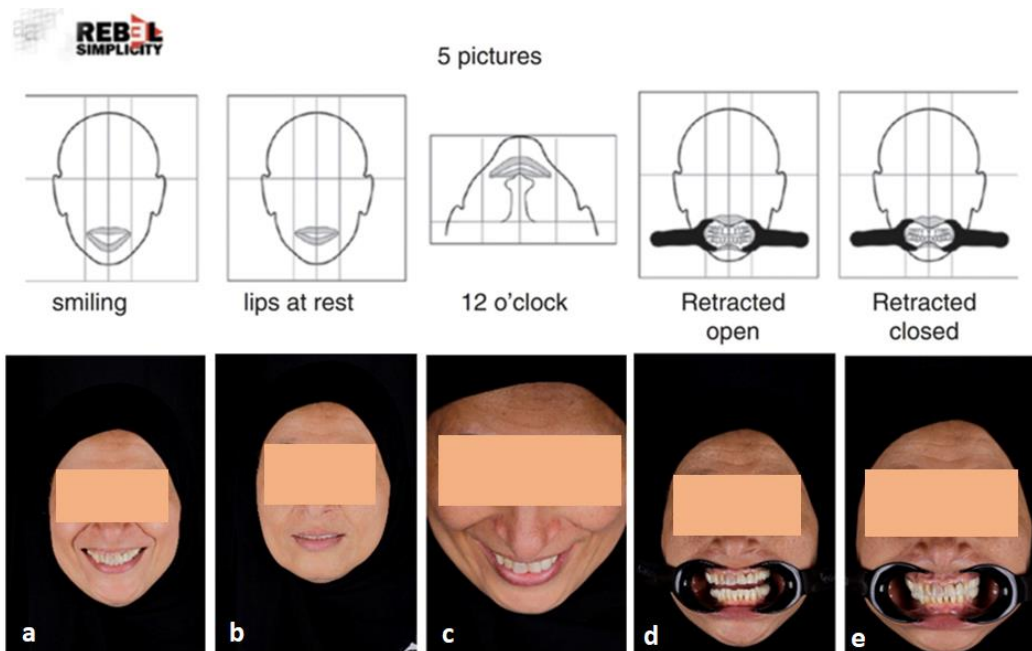


**Figure 6.** This figure illustrates the intraoral digital scan.

## 2. Full-face photography protocol

The software needs to have a five full-face photography protocol to get the facial recognition of the patient and relate the 3D intra-oral digital

scan to the facial features. The mandatory five full-face pictures are the following (Figure. 7a–e).



**Figure 7a–e.** The full-face photography protocols. Five mandatory photos need to be taken: (a) smiling; (b) lips at rest; (c) 12 o'clock position; (d) retracted mouth open, and (e) retracted mouth closed.

### a- Full-Face Smiling

Keep the patient in the same position with the eyes open and parallel to the horizon and keep the head upright (NOT tilted to the right, left, up, or down). This time ask the patient to keep the lips apart with a soft smile (if possible, show the incisal edges of the maxillary incisors).

### b- Full-Face Rest Position

This photo is for the automatic facial recognition part of the software, and part of the new REBEL smile design will be based on this facial perception of the patient.

Technically, the forehead and the ears of the patient must be visible. If the patient has long hair, please keep it away from the face. It is crucial to keep the head upright (NOT tilted to the right, left, or up and down), preferably position the eyes parallel to the horizon, and keep the lips apart.

### c- Face 12 O'Clock Position

There are two simple ways of taking this specific photo.

The first and easiest choice will be to keep the patient in the same position and ask him/her to bend the face 45° forward while having a full smile and take a photo that will show the relationship to the upper centrals and the displayed arch position to the lower lip line.

Or the dentist can lay down the patient into a supine position on the dental chair and move him/herself to 12 o'clock position ask for a full smile and take a photo from 45°.

### d- Full-Face Retracted Open Mouth

The patient should be asked to hold the full mouth retractors, again keeping the position of the eyes parallel to the horizon, keeping the head upright (NOT tilted to the right, left, or up and down), and keeping the mouth open (upper jaw and lower jaw) separated.

**e- Full-Face Retracted Open Mouth**

The same protocol above should be repeated, however, this time with the teeth (upper jaw and lower jaw) closed.

The result of the facial analysis for this case was a combination of dynamic, delicate, and calm, and the dominant temperament was dynamic (Fig. 9).

**3. Simple interview/questionnaire.**

The interview was performed which indicates the character and the personality of the patient and was completed in less than a minute through a questionnaire in the software and gave the primary and complementary character of the patient.

The temperamental type of everyone is defined by a unique combination of diverse characteristics of the four main temperaments. Therefore, for a precise and practical evaluation of it, it is necessary to apply a specific questionnaire.

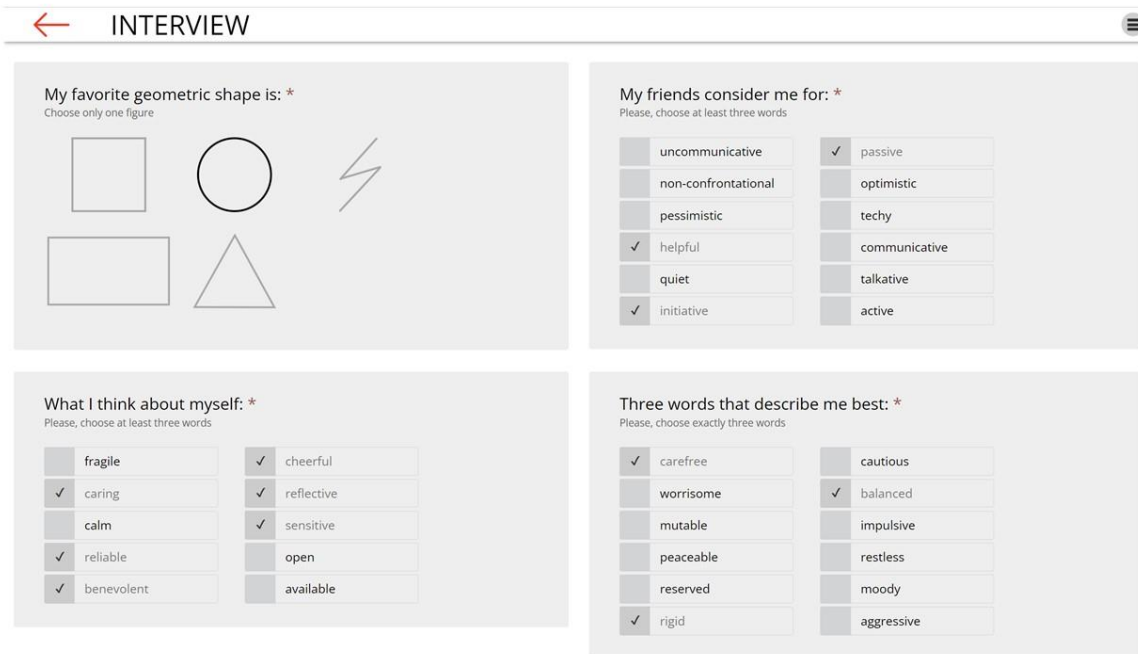
The optimal tooth shape is determined with the help of the interview. The questionnaire is based on popular psychological tests for personal self-assessment.

The first question is an adapted test by Dellinger, and the other three questions concern personality traits based on the theory and questionnaire by Eysenck (Yankov et al. 2016).

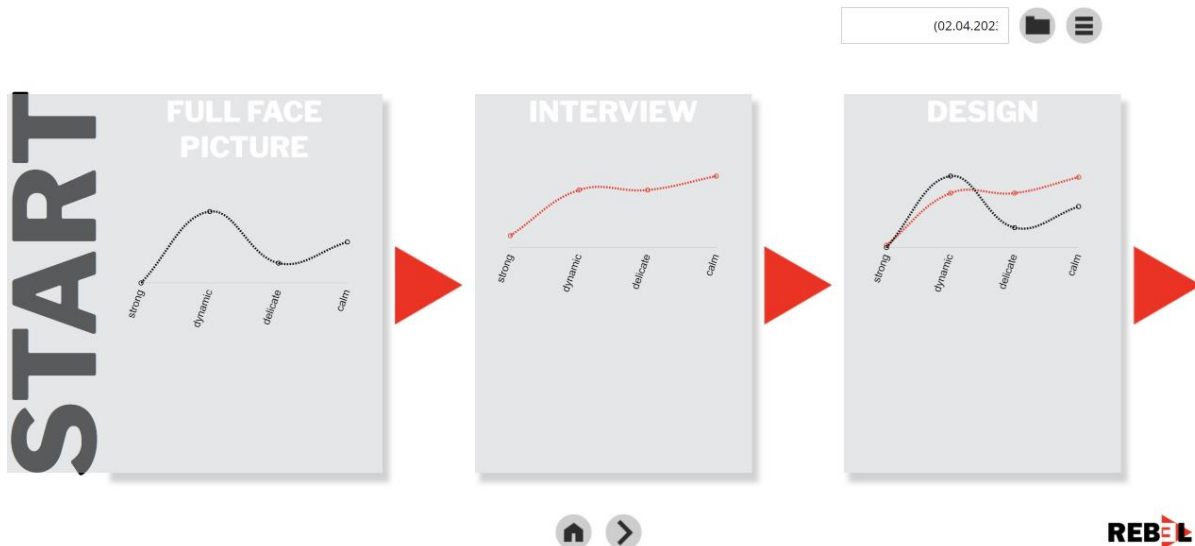
The data resulting from the interview/questionnaire are checked by an algorithm in the software, which automatically calculates the patient's temperament and personality.

The result of the questionnaire for this case was a combination of strong, dynamic, delicate, and calm, and the dominant temperament was calm (Figs 8 and 10).

The Rebel workflow was completed, the software guided the dentist to exit, and with a mouse click, the file was immediately sent to the Rebel digital laboratory.



**Figure 8:** Based on the data from the interview, the software algorithm automatically calculates the temperament (personality), and the way the patient wants to be perceived. The temperament combines strong, dynamic, delicate, and calm.



**Figure 9:** The software dictates the perception of the face through recognition of the full-face photographs and the reflection of the personality according to the questionnaire. which immediately demonstrates in graphics (visually) the strength of the characteristics 'strong, dynamic, delicate, calm' and their relation to the patient's face and personality. The software uses this information to create a new smile design based on the visual language.

Please discuss with the patient the following details:

**Incisal edge contour**

flat  inclined

rounded

**Incisal embrasures**

sharp  uneven

rounded

**Surface texture**

almost smooth  idealised

strong

Please discuss with the patient the following details:

**Buccal corridors**

open the arch  narrow the arch

keep existing

**Please write your comments:**

the teeth will be prepared for full coverage zirconium crowns. the thick of the incisal third should be thin as possible as you can.

**Figure 10:** At this stage, any specific designs such as the expected position of the buccal corridors, perfect imperfections that need to be emphasized, the intensity of the surface texture, etc. are chosen by clicking as the dentist is guided by the software. Any extra optional features or comments can be added in the text box, if necessary.

### Rebel digital laboratory

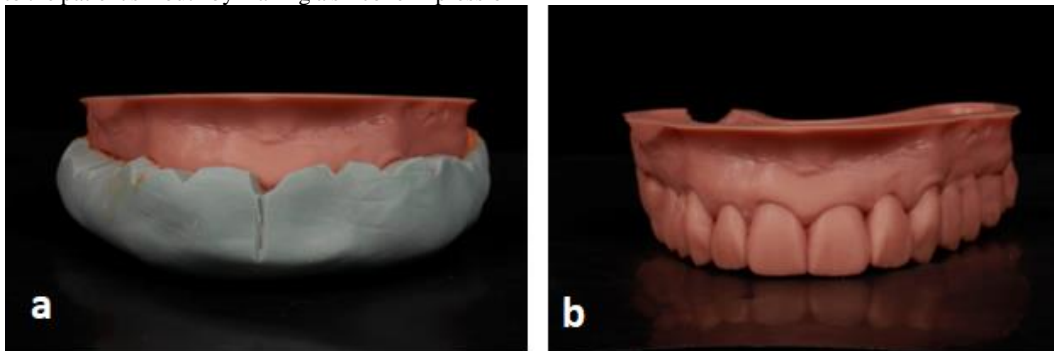
The next step was the conversion of the 2D digital project into a 3D mock-up through the Rebel digital laboratory and the creation of a digital wax-up. The AI-based algorithms of the software decided on the main elements of the new smile, it also chose the ideal (most natural) individual tooth shape relative to the facial perception and personality of the patient. Once this design is automatically placed over the digitally scanned original maxilla of the patient and rendered, an STL file of this new digital wax-up is made.

### Back to chairside/3D printing

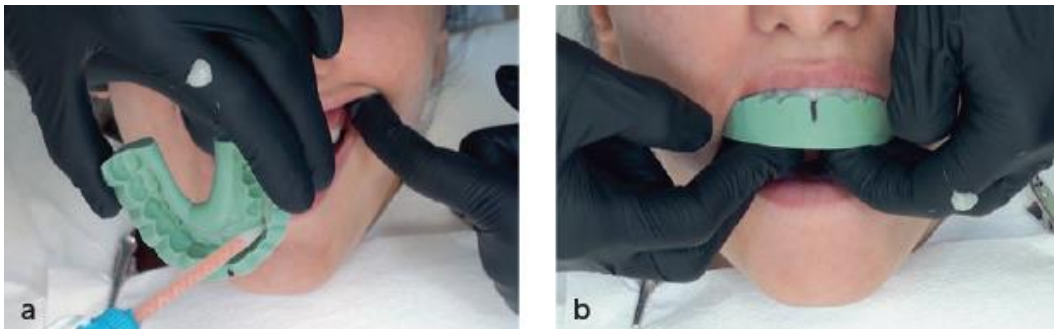
The STL file was then sent to the dentist via email, ready to be 3D printed (Figs. 11a and b). Once a 3D-printed model is made, then it easily transfers the design to the patient's mouth by making a silicone impression

of the digital wax-up, duplicating all the details such as the line angles that give the teeth their ideal shape, surface texture, etc. The harder this silicone transfer impression, the more precise the transfer will be (Figs. 12a and b). This transfer should be done before anything else, and the dentist should evaluate the new design. The APT or final mock-up was conducted before starting the tooth preparation (Figs. 13 a and b), Not only does this achieve the ideal 3D smile design, but it also creates a great opportunity for the dentist to communicate the 3D smile design to the patient, The final esthetic design was approved at this point.

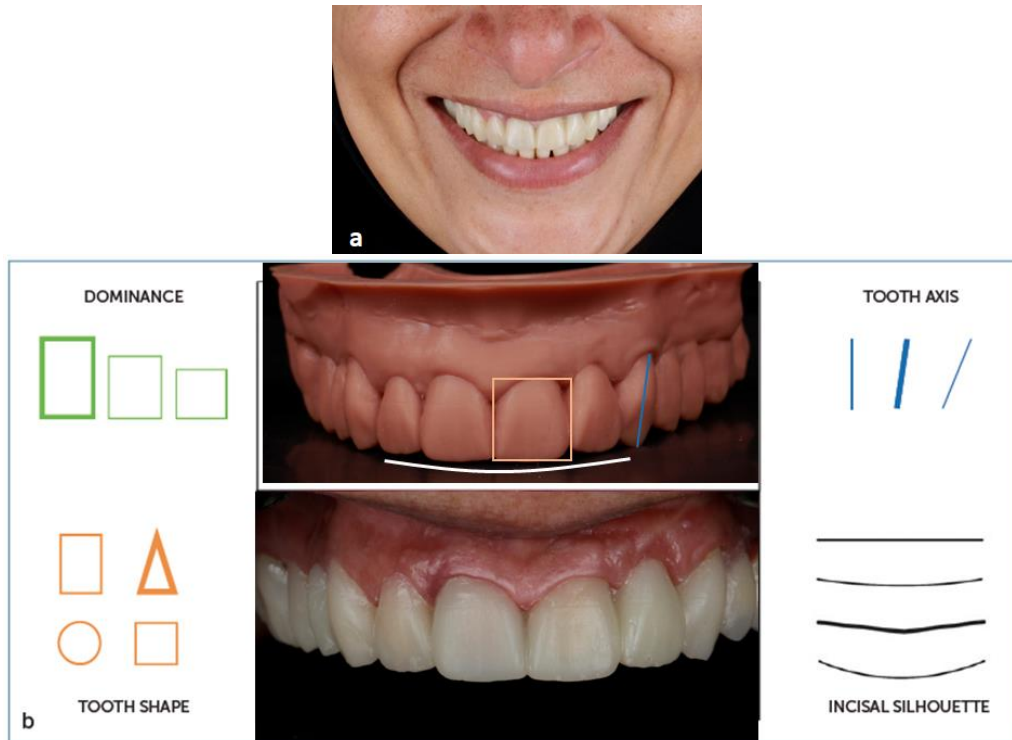
After this esthetic approval, the final functional digital wax-up was completed with digital wax-up, using the esthetic smile design (created by Rebel) as a base.



**Figure 11. a and b.** The STL file is received via email from Rebel Digital Laboratory and is 3D printed.



**Figure 12. a and b.** Once a 3D-printed model is made, then it easily transfers the design to the patient's mouth using a silicone impression of the digital wax-up that is created using a provisional material of choice.



**Figure 13 a and b.** The visualization of the APT in the mouth and its relation to the facial appearance. The software created this design. No group of teeth is dominant. Square tooth shapes (orange), a rounded incisal silhouette (white), and a slightly inclined tooth axis (blue), are all based on the facial perception and personality of the patient. As can be seen in this illustration the software can create a smile design with many different combinations of the different shapes, lines, and line angles.

**Tooth preparation through the Aesthetic Pre-evaluative Temporaries (APT)**

The APT restoration was used as a precise guideline to prepare the tooth structure based on the planned final tooth contours. The tooth structure

undergoes only the more conservative preparation or even no preparation in certain areas using depth cutter burs through the APT restoration according to the pre-established goals. The previous silicone index is also used to check the preparation depths (Figure. 14a and b).



**Figure. 14.** (a) the APT restoration. (b) Preparation depths are marked with a pencil.

**Finalizing the Case**

After teeth preparation, the case was digitally scanned.

The patient is dismissed with the provisional restoration, the case is sent to the laboratory, and the veneers are produced. These veneers were then bonded on the patient's teeth.





**Figure 15a–c.** The final result: The zirconia-based porcelain layered veneer demonstrating natural, lifelike details was performed and applied over the teeth. The smile flows with the facial appearance and the personality of the patient, who is extremely happy with the new smile design.

## Conclusion

The Merge of the basic rules of esthetics together with the reflection of the facial analysis and the personality of the patient in the smile design creates a more natural and personalized smile (character/temperament) (Fig 15). (Pashley et al. 2011).

This principle supposes harmony between the smile design and the patient's personality. The new smile creates more natural and personalized smiles

The Rebel concept, which can be applied very easily and rapidly, can help the dentist or ceramist to achieve this goal in the most simplistic, practical, and personalized way. Finally, before any further investigation and research is done, if the result of applying this technique does not satisfy the patient due to the subjectivity of the matter, the dentist can always make minor modifications to adopt this design according to the patient's wishes.

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