

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

Case-2

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Abstract

Looks are becoming a major concern in dentistry. Patients want beautiful smiles, no matter how complex their case. Dentists and lab technicians have relied on established esthetic principles for smile design, aiming for a pleasing patient outcome. Ideally, a well-designed smile brings happiness to the dentist and the patient, exceeding expectations beyond straight teeth. However, sometimes the final results fall short. This can happen when the smile design clashes with the patient's unique characteristics. Patient desires and the need for better information are forcing dentists to rethink how customized smile design should be. Ignoring this customization can lead to disappointment, even if all the standard esthetic rules were followed.

Keywords: artificial intelligence (ai); digital smile design; rebel/ visagsmile software; esthetic dentistry

Introduction

Each smile is unique, one person surely smiles in different ways, reflecting the different shapes, textures, and colors of the teeth and their combinations. When creating a new smile design dentists need to consider the unity of the whole concept in this task, which includes bringing together biology, structure, function, and esthetics to create the fifth dimension of the smile. This approach is quite different from the traditional one. A smile reflects the personality and emotional state of the patient, and the translation of this into a new smile design occurs in various ways. This can be achieved 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 and lips; 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.

Literature suggests that dentofacial esthetics can have a remarkable influence on a person's social and psychological (Rambabu et al, 2018) well-being and can affect their self-confidence and self-esteem.

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. No matter how difficult the cases are, patients are looking for perfect and beautiful 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 aesthetic 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.

Intraoral scanning for the mock-up

Intraoral scanning was performed to prepare the mock-up. In restorative dentistry, the mock-up is a diagnostic technique that allows for the intraoral try-in of prosthetic rehabilitation. characteristics of each patient. If this aspect is ignored, it may lead to the patient's dissatisfaction with the outcome.

The fifth dimension of the smile



Figure 1: Once the digital impressions by using an intra-oral scanner that can produce an STL file has been completed the mock-up is fabricated.

The Aesthetic Pre-evaluative Temporaries (APT)

Once this preliminary design on the direct mock-up is approved by the restorative team and the patient, the case can now be sent to the laboratory, for a wax-up. When the wax-up is sent back to the dental office, a silicone impression is made.

This silicone impression is filled with a flowable resin and placed in the mouth before the patient is anesthetized, and the teeth are prepped. This is named the aesthetic pre-evaluative temporaries (APT).

Smile design and self-identification

Over the years, dentists and dental technicians have tried to use all the basic esthetic rules to correctly create new smile designs for patients. These rules represent the fundamental keys and should set the style of any smile design. However, sometimes, the final esthetic results fail to meet the patient's expectations due to a disharmony between the smile design and the patient's sense of self-identity. High patient expectations have driven this profession to reassess the customization of new smile designs, which need to take into consideration the individual psychological characteristics of each patient. If this aspect is ignored, it may lead to the patient's dissatisfaction with the outcome.

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

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 objective is always to create not just a satisfied patient response to the smile design, but one of amazement because the new smile reflects the patient's personality and emotional needs/feelings (ie, it takes into account the fifth dimension of the smile). This makes the present approach quite different from the traditional one. The key to this translation of the The patient needs to see the whole smile, including the length and position of the teeth (Figure. 1).

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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. 2a-d) and (Figure. 3a-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.

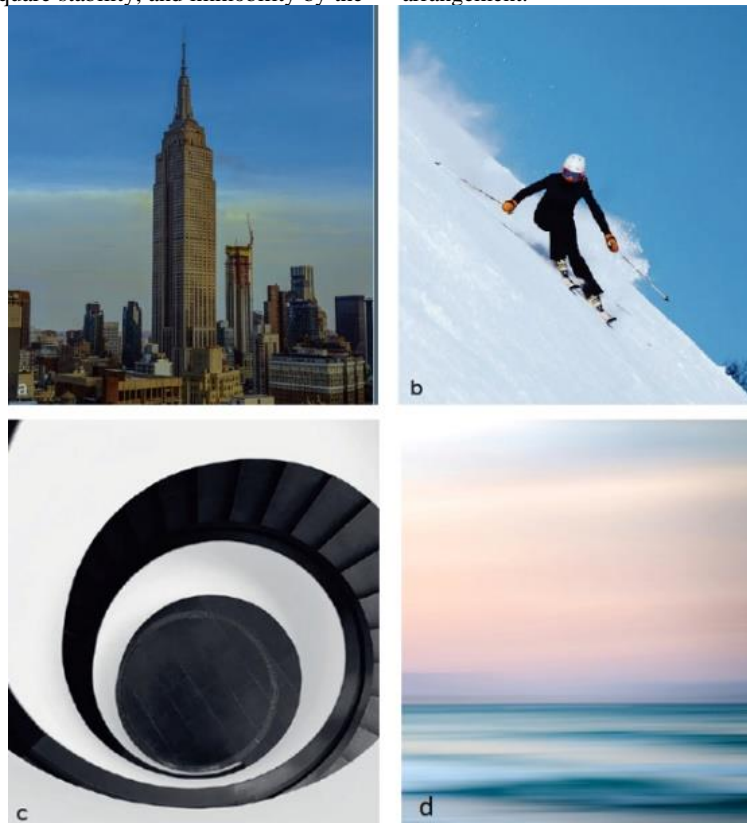


Figure 2a-d. (a) vertical lines and rectangular shapes express strength due to the predominance of the vertical element on the horizontal the inclined lines and triangular shapes express dynamism (b). the oval and round shape express delicacy (c), and the horizontal line expresses stability and immobility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

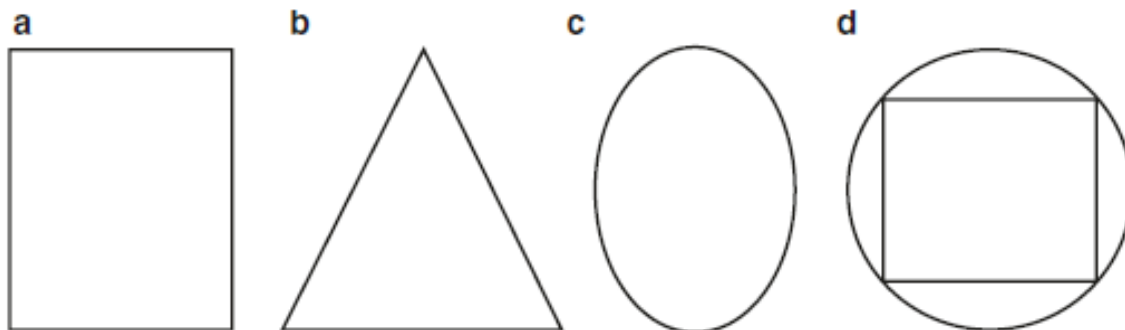


Figure 3a-d. (a) vertical lines and rectangular shapes express strength due to the predominance of the vertical element on the horizontal the inclined lines and triangular shapes express dynamism (b). the oval and round shape express delicacy (c), and the horizontal line expresses stability and immobility 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. 4).

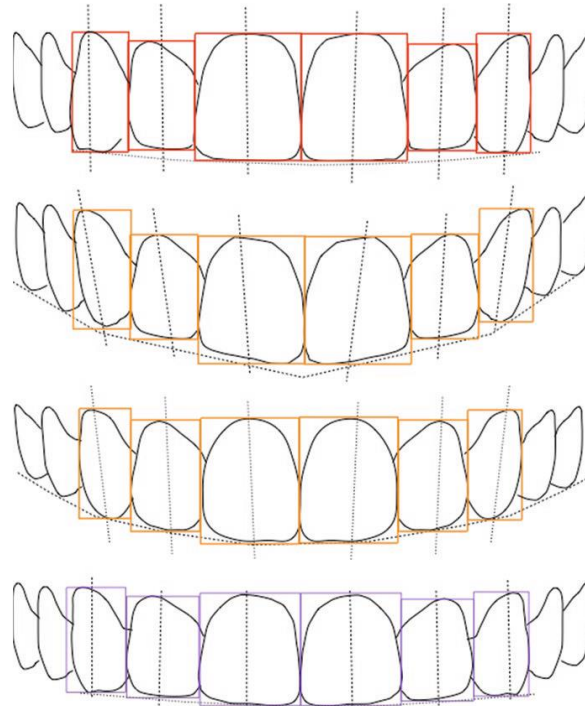


Figure 4. The visual language knowledge applied to the main expressive elements of smile design such as dental shapes, incisal edge, interdental ratio or dominance, and 3D positioning of the teeth in the arch determined four smile design types with primary expression, from top to bottom: strong, dynamic, 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 (Figure 11a1 and a2).

Dynamic: Triangular or trapezoidal dental shapes, standard dominance, inclined incisal edge, and angled 3D dental positioning on the arch (Fig 11b1 and b2).

Delicate: Oval dental shapes, medium dominance, curved incisal edge, and standard 3D dental positioning (Figure 11c1 and c2).

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 (Fig 11d1 and d2).

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).

Case presentation -2

A man of age 25 required esthetic prosthetic rehabilitation of his teeth. The patient was dissatisfied with his smile due to his discolored and chipping teeth. The aim of the esthetic treatment was therefore to enhance his smile (Figure. 5a-c) by utilizing the Rebel software as described above to create the most natural and personalized smile design possible, following a minimally invasive approach.



Figure 5a-c. Intraoral view shows the discoloration of teeth and fractured upper right central incisor.

Esthetic Analysis and Rebel Simplicity

Esthetic design can be challenging for clinicians and dental technicians. Rebel (Visagismile) 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 the overall treatment planning and will guide the actual clinical treatment.

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.

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 treatment planning then should be based on the final expectations of the patient. And the treatment should be sequenced and executed accordingly.

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 6).

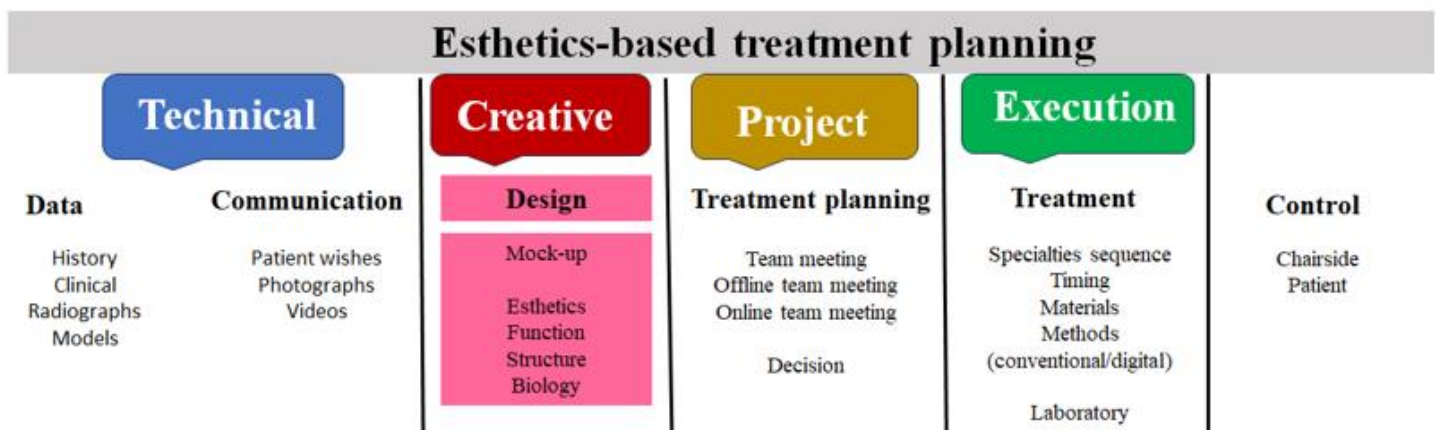


Figure 6. The most important part of the workflow is the design part. This is the heart of any esthetic treatment that will differentiate a more committed dentist from an average one. The final esthetic smile design and treatment planning should also be based on this mockup, which should fulfill the expectations of the patient.

The Rebel workflow In certain circumstances, a composite mock-up is performed on one (or two) of the central incisors to identify the incisal edge position vertically Rebel provides the simplest steps for transferring all the necessary and the position of the facial surface buccolingually. In this case, the information to the Rebel digital laboratory. central incisors mock-up is not indicated.

These are the three mandatory steps:

2. Full-face photography protocol

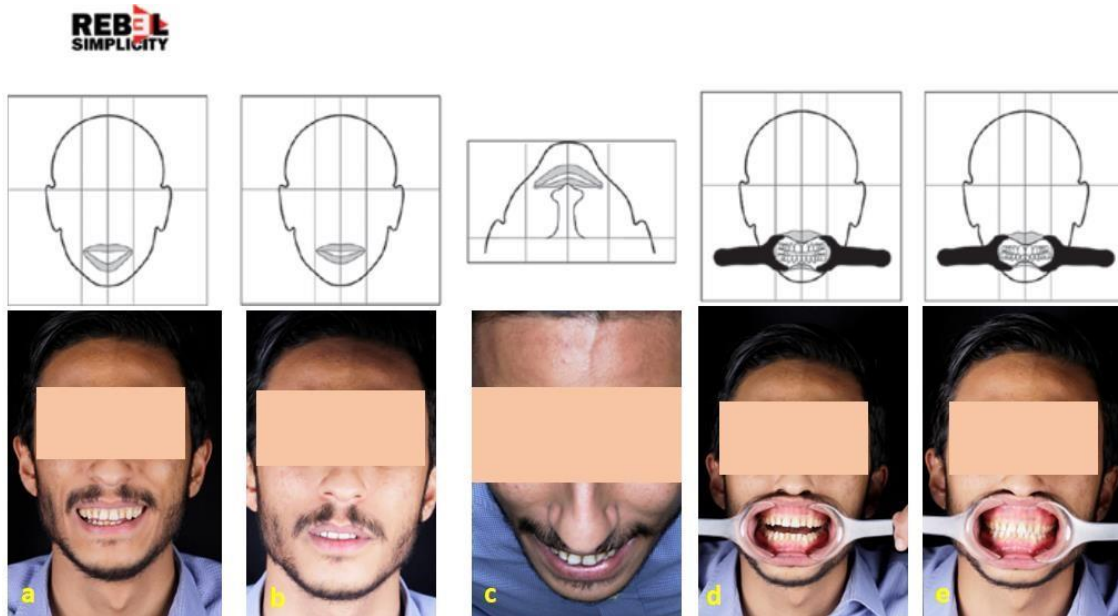


Figure 7a–e. The full-face photography protocols. Five mandatory photos need to be taken: (a) smiling; (b) lips at rest; (c) 12 o'clock position; (d) retracted mouth open, and (e) retracted mouth closed.

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).

a- 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.

b- 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°.

c- Full-Face Retracted Open Mouth

1. Single central incisor mock-up and intraoral digital scanning. The software needs to have a five full-face photography protocol to get
 2. A full-face photographic protocol. 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
 3. A Simple interview/questionnaire. following (Figure. 7a–e.).
1. Single central incisor mock-up and intraoral digital scanning

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. d- Full-Face Retracted Open Mouth

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

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 (Figure. 8).

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

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. 2026).

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 temperament will be a combination of strong, dynamic, delicate, and calm. After this procedure, the dentist and

dental technicians will have a complete assessment of the patient's facial perception and personality (Figure 9 and 10).

When the entire Rebel workflow is completed, the software guides the dentist to exit, and with a mouse click, the file is immediately sent to the Rebel digital laboratory.

← INTERVIEW
☰

My favorite geometric shape is: *
Choose only one figure

⚡

My friends consider me for: *
Please, choose at least three words

<input type="checkbox"/> uncommunicative	<input type="checkbox"/> passive
<input checked="" type="checkbox"/> non-confrontational	<input checked="" type="checkbox"/> optimistic
<input type="checkbox"/> pessimistic	<input type="checkbox"/> techy
<input checked="" type="checkbox"/> helpful	<input type="checkbox"/> communicative
<input type="checkbox"/> quiet	<input type="checkbox"/> talkative
<input checked="" type="checkbox"/> initiative	<input type="checkbox"/> active

What I think about myself: *
Please, choose at least three words

<input type="checkbox"/> fragile	<input checked="" type="checkbox"/> cheerful
<input type="checkbox"/> caring	<input type="checkbox"/> reflective
<input type="checkbox"/> calm	<input type="checkbox"/> sensitive
<input checked="" type="checkbox"/> reliable	<input type="checkbox"/> open
<input checked="" type="checkbox"/> benevolent	<input type="checkbox"/> available

Three words that describe me best: *
Please, choose exactly three words

<input type="checkbox"/> carefree	<input type="checkbox"/> cautious
<input checked="" type="checkbox"/> worrisome	<input checked="" type="checkbox"/> balanced
<input type="checkbox"/> mutable	<input type="checkbox"/> impulsive
<input checked="" type="checkbox"/> peaceable	<input type="checkbox"/> restless
<input type="checkbox"/> reserved	<input type="checkbox"/> moody
<input type="checkbox"/> rigid	<input type="checkbox"/> aggressive

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.

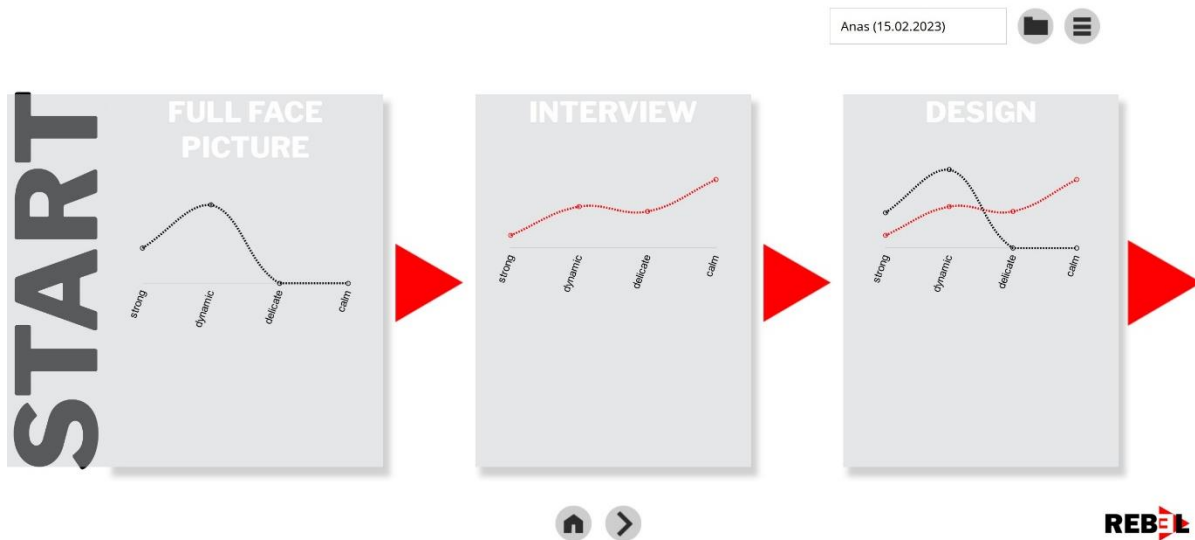


Figure 9: The software dictates the perception of the face through recognition of the full-face photographs and the reflection of the personality according to the questionnaire, which immediately demonstrates in graphics (visually) the strength of the characteristics 'strong, dynamic, delicate, calm' 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:

Please write your comments

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, ie, the dentist should evaluate the new design (as the APT or final mock-up) well before starting the tooth preparation (Figure. 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, some adjustment was carried out on the occlusal surfaces, the final functional digital wax-up was completed with digital software that can deliver these additional changes, using the esthetic smile design (created by Rebel) as a base.

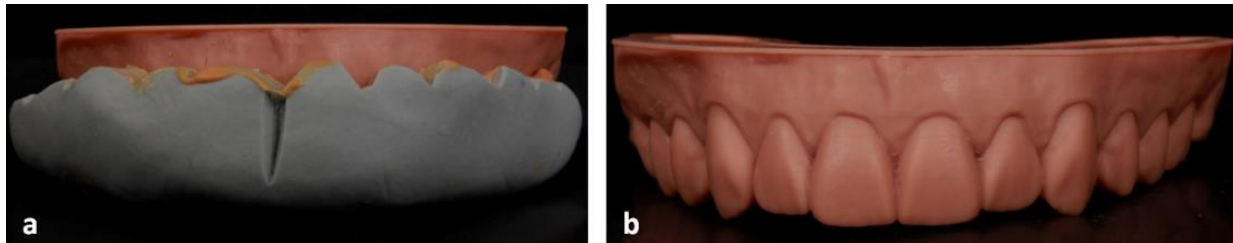


Figure 11. a and b. The STL file is received via email from Rebel Digital Laboratory and is 3D printed.

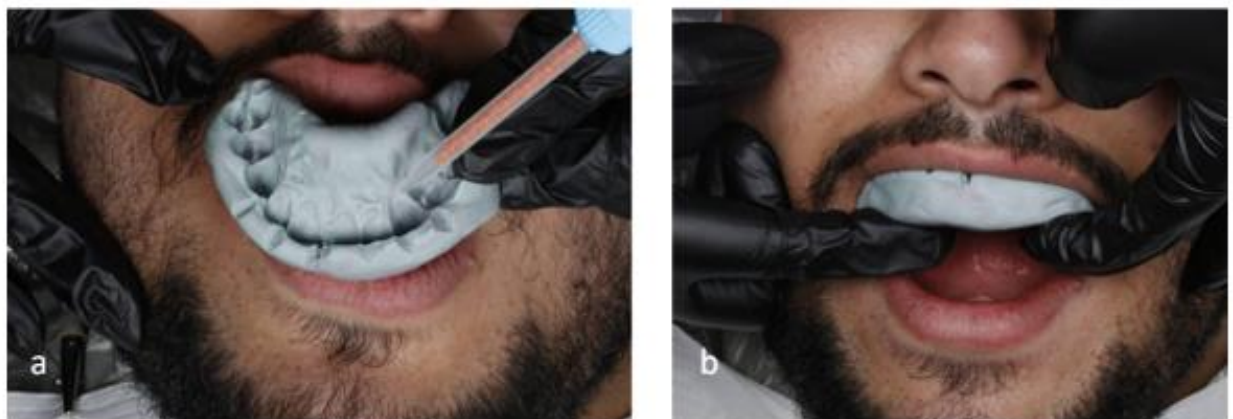


Figure 12. a and b. Once a 3D-printed model is made, then it easily transfers the design to the patient's mouth using a silicone impression of the digital wax-up that is created using a provisional material of choice.

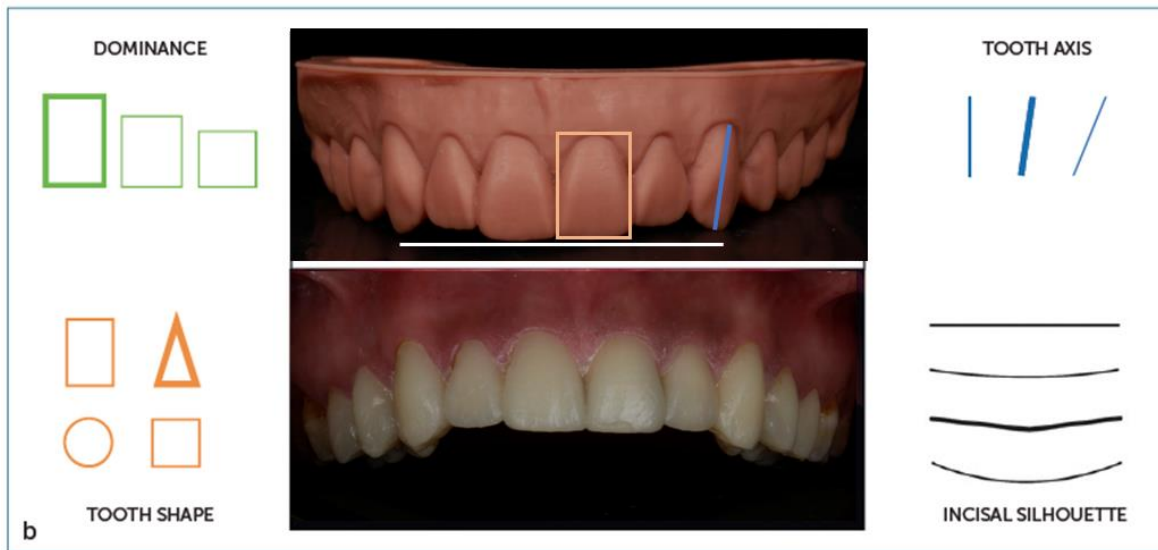


Figure 13 a and b: The visualization of the APT in the mouth and its relation to the facial appearance. The software created this design. with dominant central incisors (green). triangular-to-rectangular tooth shapes (orange). a straight incisal silhouette (white), and a slightly inclined tooth axis (blue), 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 (Figs. 14a and b).



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

Finalizing the Case

Once the teeth are prepared, the dentist can choose to continue the case digitally by creating an intraoral digital scan or continue in a conventional analog manner.

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 15: The final result: Monolithic IPS e.max porcelain laminate veneers (Ivoclar Vivadent) performed with a minor cutback technique are applied over the incisal edges. The smile flows with the facial appearance and the personality of the patient, who is extremely happy with the new smile design.

Conclusion

The combination 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 (Pashley et al. 2011).

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

design approach through the combination of the basic rules of esthetics with the reflection of the patient's facial analysis and personality (character/temperament) (Figure 15).

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. The authors' clinical experience shows a minimum of 80% success in the acceptance of the final smile design treatment. 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 alterations to adopt this design according to the patient's desires.

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