Case Report

Application of AI-Driven 3D Smile Design (REBEL) in Patient-Centered Prosthetic Treatment: A Case Report (Case 3)

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Abstract

A smile is more than just pearly whites. A unique combination of shapes, textures, and colors speaks volumes about a person. Dentists are moving beyond traditional methods to create "smile designs" that consider not just biology and function, but also aesthetics and emotional expression. This holistic approach creates a harmonious smile, the "fifth dimension," that reflects a person's personality and boosts their confidence. A beautiful smile isn't just about looks; it's about empowering a person to function better socially and psychologically.

Keywords: Artificial Intelligence (AI), Digital Smile Design, REBEL/ visagSMile software, Esthetic Dentistry.

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Introduction

A smile is more than just pearly whites; it's a unique canvas reflecting a person's individuality. The shapes, textures, and colors of the teeth, along with the lips, come together to form a masterpiece of expression [1]. Designing a smile goes beyond the traditional approach. It's a symphony of various elements – biology, structure, function, and esthetics – working harmoniously to create a visually stunning and functionally sound smile. This holistic perspective elevates smile design to a whole new level [1].

A dentist acts as an artist, translating a patient's desires and personality into a smile that complements their facial features. This translation can be achieved through creative techniques, whether by analog methods or with the aid of digital tools.

Ultimately, a smile is a powerful tool for both social interaction and emotional expression. By carefully crafting a smile design, dentists empower their patients to confidently express themselves and navigate the world with greater ease [2].

Studies [3] suggest that a balanced and pleasing smile (harmonious smile) might be linked to both higher self-esteem and stronger social skills. This implies that a harmonious smile could make someone feel more confident and interact more effectively in social situations.

Your smile is powerful! It can influence how others see you and even how you feel about yourself [4].

To create a smile that makes you shine, dentists consider what kind of look you're going for. This includes things like your personality, social life, and education level [1,3]. There are special computer programs dentists can use to design smiles, but none of them take your personality into account [5].

The secret to a perfect smile makeover starts with knowing your ideal smile. By working together, you and your dentist can create a personalized plan to bring that vision to life. 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 [3].

Intraoral scanning for the mock-up

To help you visualize your new smile, we used a special scanner to take a digital impression of your teeth. This allows us to create a temporary replica, called a mock-up, that we can place directly in your mouth. This way, you can see the full look and feel of your restored smile, including the length and positioning of each tooth, before any permanent changes are made. (Figure. 1).

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Figure. 1. After capturing a digital scan of the teeth with an intra-oral scanner that creates an STL file, the dentist can then fabricate the mock-up.

The Aesthetic Pre-evaluative Temporaries (APT)

Before any tooth modification begins, dentists can create a realistic preview of the final smile design.

1. The dentist and patient collaborate on a preliminary design using a direct mock-up.
2. If approved, a detailed wax-up model is created in the lab based on this design.
3. Back at the dental office, a temporary replica (APT) made of clear resin is crafted using the wax-up as a mold.
4. This temporary replica is placed on the patient's teeth without anesthesia or tooth preparation.

This APT allows for final adjustments to the design based on the patient's experience and appearance before any permanent changes are made.

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 [2].

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 [1].

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 patient's personality and feelings into the new smile design is visual language [1].

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

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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 conFigureuration of the dental arrangement [6].
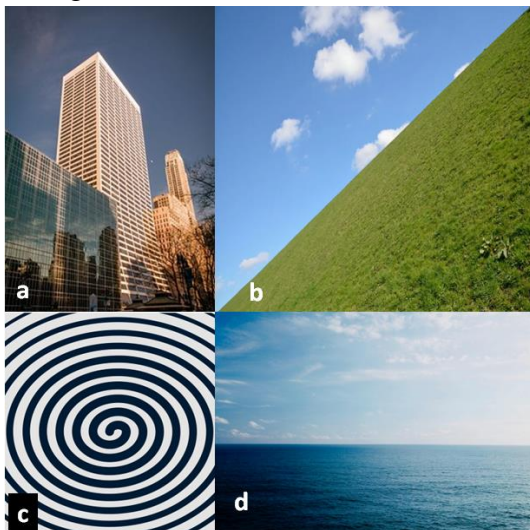

Figure. 2a-d. (a) vertical lines and rectangular shapes express strength due to the predominance of the vertical element on the horizontal the inclined lines and triangular shapes express dynamism (b). the oval and round snape express delicacy (c), and the horizontal line expresses stability and immobility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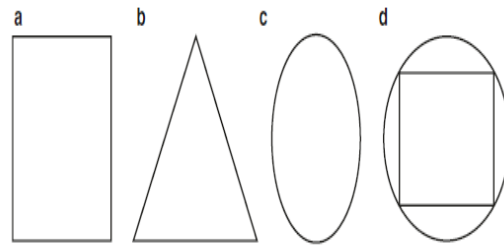

Figure. 3a-d. (a) vertical lines and rectangular shapes express strength due to the predominance of the vertical element on the horizontal the inclined lines and triangular shapes express dynamism (b). the oval and round snape express delicacy (c), and the horizontal line expresses stability and immobility due to the balance between the vertical and horizontal elements (d). (Quoted from Springer Nature Switzerland AG 2020 235 [6], Esthetic Oral Rehabilitation with Veneers)

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).
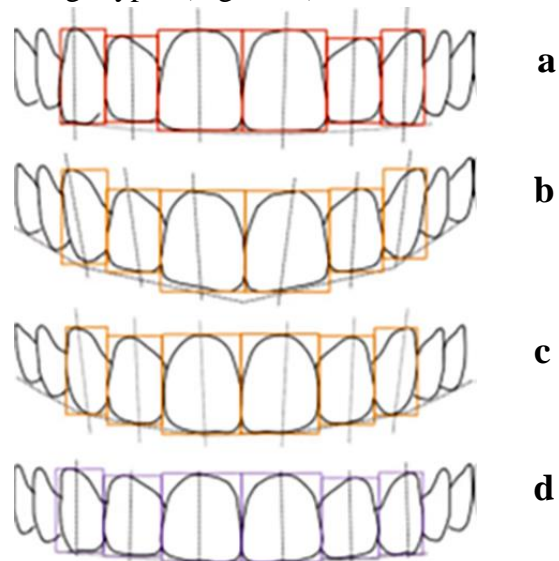

Figure. 4. The visual language knowledge applied to the main expressive elements of smile design such as dental shapes, incisal edge, interdental ratio or dominance, and 3D positioning of the teeth in the arch determined four smile design types with primary expression, from top to bottom: strong,

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dynamic, delicate, and calm (Quoted from Springer Nature Switzerland AG 2020 235 R. D. Trushkowsky (ed.) [6], Esthetic Oral Rehabilitation with Veneers).

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 4 a).

Dynamic: Triangular or trapezoidal dental shapes, standard dominance, inclined incisal edge, and angled 3D dental positioning on the arch (Figure 4 b).

Delicate: Oval dental shapes, medium dominance, curved incisal edge, and standard 3D dental positioning (Figure 4 c).

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 (Figure 4 d).

The Rebel software

Imagine a dental software that uses artificial intelligence to design your perfect smile. Rebel does exactly that! It takes into account not just your teeth and face, but also your personality.

Here's how it works:

- You take a picture and answer some questions. This helps Rebel understand your facial features and preferences.
- Rebel analyzes your personality using established tests.
- It then uses this information to create a 2D smile design that complements your unique characteristics.
- This 2D design is then transformed into a 3D model you can see on screen.

Rebel essentially translates your personality and desires into a beautiful, custom smile design [7].

Case presentation

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, badly carious, and fractured teeth.

Esthetic Analysis and Rebel Simplicity

Esthetic design can be challenging for clinicians and dental technicians. Rebel (Visagismile) is a recent digital

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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 [6, 8].

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).
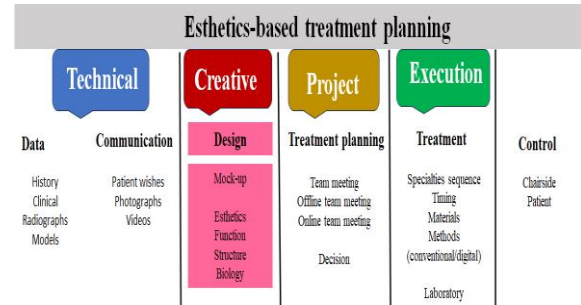

Figure. 6. The most important part of the workflow is the design part. This is the heart of any esthetic treatment that will differentiate a more committed dentist from an average one. The final esthetic smile design and treatment planning should also be based on this mockup, which should fulfill the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

The Rebel workflow

Rebel provides the simplest steps for transferring all the necessary information to the Rebel digital laboratory [10].

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

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the facial surface buccolingually. In this case, the central incisor mock-up is not indicated.

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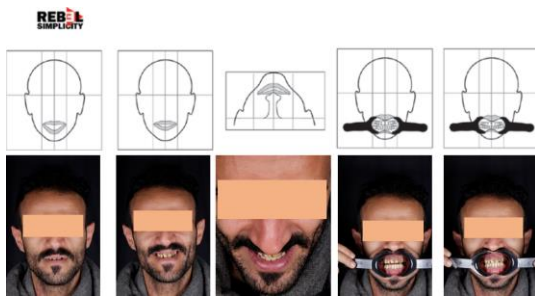
Figure 7a–e. The full-face photography protocols. Five mandatory photos need to be taken: (a) smiling; (b) lips at rest; (c) 12 o'clock position; (d) retracted mouth open, and (e) retracted mouth closed.

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

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

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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 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 [9]

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.

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.
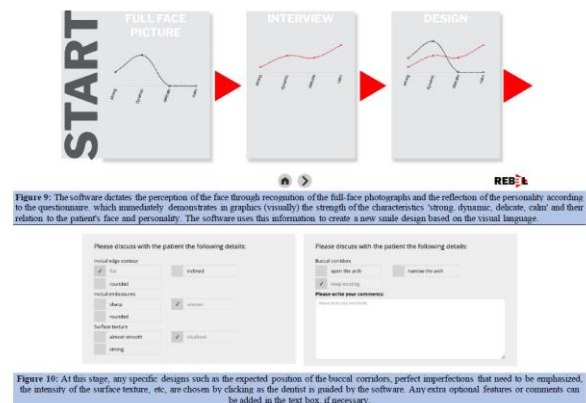

Figure 9. The software dictates the perception of the face through recognition of the full-face photographs and the reflection of the personality according to the questionnaire. which immediately demonstrates in graphics (visually) the strength of the characteristics 'strong. dynamic, delicate, calm' 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.
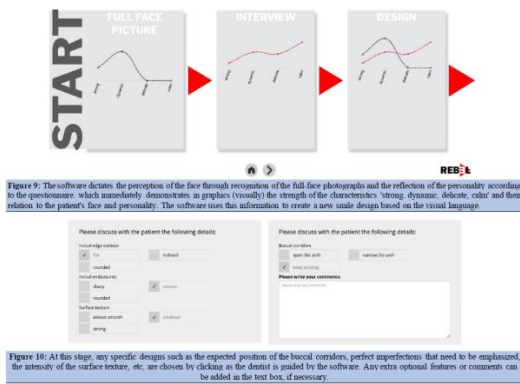
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Figure 10. At this stage, any specific designs such as the expected position of the buccal corridors, perfect imperfections that need to be emphasized, the intensity of the surface texture, etc, are chosen by clicking as the dentist is guided by the 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 Al-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 (Figures. 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 (Figures. 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.

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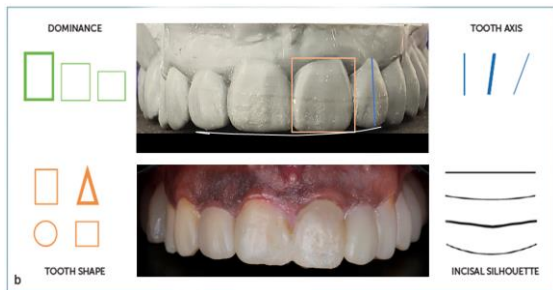

Figure. 13 a and b. The visualization of the APT in the mouth and its relation to the facial appearance. The software created this design. with medium dominant central incisors (green). Square tooth shapes (orange). Rounded incisal silhouette (white), and a vertical tooth axis (blue), are all based on 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

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 [11]

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 [10]

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

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In conclusion, this clinical study highlights the advantages of combining traditional esthetic dentistry practices with modern digital technologies like REBEL for smile design.

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, 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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