Review Article

Digital Smile Design

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Abstract

One of the important ways of social interaction is through verbal and nonverbal communication. The human face is capable of eliciting multi-response according to the situation; amongst them, a smile plays a significant effect in relaying a positive communication that can immensely influence societal outcomes. An important part of dental treatment is to restore the tooth to functionality and to esthetically rehabilitate it, which forms the core of esthetic dentistry. Modern advancements have led us to various esthetic treatment options. Recently, due to the boom of information technology, we are progressing into the digital age where everything has almost been made through computers and the internet. In the dental field, advanced software is being used to modify and create smiles, thereby completely revolutionizing esthetic dentistry. Digital smile design is a recently introduced concept and software which analyzes the smile of an individual through various input scanners and photographs. They provide a plethora of solutions and predictions as to how the smile can be designed, to the point it can pinpoint minor corrections. Here, we discuss the importance of smiles and the analysis using digital smile design.

Keywords: *Aesthetics, dentistry, digital smile design, smile, smile design*

Introduction

Esthetic dentistry has become one of the most sought-after disciplines in dentistry which focuses on the smile and pleasing appearance. Modern dentistry is not limited to just the repair of individual teeth. There has been an increase in the incidence of patients who give esthetic outcomes the main priority with the restoration of the tooth structure.[1]

Technological advancements have revolutionized restorative dentistry with the introduction of silicate cement, acrylic, and composite resins. Procedures such as bleaching, bonding, and veneering, all not only repair the tooth but also create an aesthetically pleasing smile.

A healthy and attractive smile represents an individual's spectrum of feelings and emotions in a positive way. This depends on the arrangement of their teeth and soft tissue structures. An attractive smile is indicative of a high societal feeling and influences their self-confidence, thereby boosting their personality.[2]

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An esthetic makeover or smile design involves creating a smile where the stomatognathic structures function without hindrance to each other,[3] a perfectly functioning orofacial structure compliments each other.[4] Designing an esthetic smile is very essential in formulating an esthetic makeover.

Historical Perspective of Esthetics

The concept of esthetics dates back to 900 BC when tusks of animals were carved to form esthetic structures that were used as ornaments and relics. They are derived from the Greek word *aisthetikos* which roughly translates to "sensitive, sentient, pertaining to sense perception."

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It was the Greek philosophers who during 490–265 B.C. described the factual existence of the golden ratio observed in nature and subjected to the interpretation of the human mind. The term "golden ratio" was coined by Euclid, the famous Greek mathematician.

Eesthetic dental restoration was given priority by upper-class citizens and royals during the second Reich in Rome around 31 B.C. to 476 A.D. Many oral hygiene products such as toothpaste and mouthwashes were used extensively by women in Rome in order to intensify their beauty rather than hygiene in mind. When a tooth was lost, the Romans often resorted to replacing it with an ivory tusk that had been carved to resemble the tooth.

An early version of the veneers was implemented by the Mayans in 1000 A.D, where ornamental fillings were restored on the incisal edges of the teeth; some of the materials that were commonly placed include iron pyrites, obsidian, and jade. Since then, evolution in esthetic dentistry has plateaued. It was not until Pierre Fauchard sparked the interest in esthetics by designing gold-facing crowns on enamel surfaces and labeled the filling material as incorruptible.

This was followed by the invention of the first direct tooth-colored filling materials using porcelain by M. Richmond and M. Logan in the 1880s. Although they were highly esthetic, they had poor mechanical properties and really showed a perfect fit and so in the 1890s veneers made from porcelain were invented which were fixed onto the tooth structure using zinc phosphate cement.

It was not until the late 1960s that Michael Buonocore introduced enamel etching and bonding, which had significantly increased the bonding strength of the restoration. The subsequent development rapidly led to their high use in restoring the tooth.

In recent years, there has been a surplus of product development and innovations that dentists can resort to based on the patient's requirements. Intraoral scanning, 3D scanning, and highly advanced photoshop labs are employed in predicting treatment outcomes preoperatively. Through this, the patient has an idea about what his expectations would look like and how outcomes suggested by the dentists would look.[5]

Smile

A smile occurs as synchronous coordination that involves contraction and relaxation of several muscles of the face, namely, the depressor anguli oris, therisorius, zygomaticus major and minor, and levator labii superioris. Some of the muscles form a confluent around lip commissures called orbicularis oris and are supplied by the facial nerve.[6]

Humans have two types of smiles: a natural smile, which occurs naturally and is brought about by the maximal contraction of the upper and lower lip elevator and depressor oris; the other type is the social smile, which is voluntary and meant as a kind gesture directed toward another individual. In the facial region, different zones were designated by Ackermann *et al*.[7] A display zone is formed by the upper and lower lips within which the teeth and the gingival apparatus are seen. The soft-tissue components of the zone include the thickness of the lip, inter-commissural width, inter-labial gap, smile index (width/height), and gingival architecture. The curve formed by the incisal edges of the maxillary anterior teeth forms the "smile arc". Smile style is the result of contraction and relaxation on muscles in the zone.[8]

Principles of Smile Designing

Designing a perfect smile using the software requires a thorough knowledge about the muscles and dimensions of the display zone along with their esthetic proportions. Since not all individuals are alike, each person should evaluate and study with accurate detail in order to come up with their perfect smile. All these elements are connected with each other. Any change will definitely affect the other element.

Although a software algorithm is used in predicting a perfect smile, clinical smile designing requires a multidisciplinary intervention that includes branches of dentistry such as orthodontics, orthognathic surgery, periodontal therapy, and plastic surgery.[9]

Facial features that are key in planning for esthetic smile redesign include facial symmetry, facial profile, and proportion of the facial structures. According to literature, an ideal facial feature should have the distance between two superciliary arches equal to the total width of the face (from one zygomatic prominence to the other). The intercanthal line or the pupillary line should be perpendicular to the Frankfurt's horizontal occlusal plane. Considering the normal verticalis part of the face, three imaginary lines drawn should divide the face into three parts: the glabella to the superciliary arch, from the arch to the tip of the nose, and from the subnasale to the mention of the chin.[10] An ideal smile should have the foundation of an ideal lip. When smiling, around 2 mm of the maxillary incisors along with the interdental papilla should be visible;[11] too much exposure reveals the gingiva, resulting in a gummy smile, while too little exposure flattens the philtrum of the upper lip and produces a frowned appearance.

Dental Composition

As previously discussed, the proportion of the maxillary incisor display holds key to the perfect smile. It has been deliberated to such an extent that even mathematical proportions have been formulated. The width: length ratio of the maxillary central incisors was estimated at 4:5 mm with a width range of 0.8–1.0 and length range of 75%–80% width being most acceptable. The morphology of the incisors teeth their incisal edges and the amount of canine exposure also play a crucial role in smiling.[12] Some of the mathematical theories that were established in predicting the correct proportion include the golden proportion (Lombardi), recurring esthetic dental proportions (Ward), M proportions (Méthot), and Chu's esthetic gauges.[13] Some of the other dental landmark points that influence the smile include the midline of the dentition, crown length of all incisors and canines, zenith points, axial inclinations, interdental papilla exposure, and contacts.[14]

Evolution of smile design

Before the invention of photoshop and advanced photo tracers, perfect smile lines were drawn by hand and then printed over the photos of the patient and would often be discussed with patients for their input. This process has now been largely replaced by smile automation software, referred to as Digital Smile Design (DSD) software, all of which with the click of a button tells us the modifications needed to be executed in order to get a perfect smile.[15] Some of the key milestones in the evolution of smile design include:

Generation 1. Manual hand drawings using pencil markers were made over the patient's full profile photographs. The drawback of this method was that if taken with a study model, the correlation between the patients full profile photo and study model was very poor.

Generation 2. With the creation of Microsoft Office, drawings were often done digitally and then correlated with the model. This helped in tracing minor modifications that needed to be done. Diagrams were often 99% accurate.

Generation 3. The next generation enabled the two-dimensional (2D) drawings to be linked with physical analog models which permitted a wax-up of the final smile.

Generation 4. The 2D drawings were written up into an algorithm that was then processed digitally and this step enabled the technique of facial 3D analysis, also determining the facial components and aesthetic parameters.

Generation 5. Innovation of intraoral camera which allowed us to scan and take digital impressions which were more accurate than impressions taken with any other conventional method.

Generation 6. Introduction of 4D where digital sensors placed on the patient's jaw captures the smile motion and movement inside the 3D environment using the MODJAW software and designing the smile with CAD/CAM technology. This technology reduces the need for changes, including reduced tooth preparation and other issues by testing the design with the real movement of the jaw.

Smile Analysis

Smile design has become one of the main purposes of orthodontic treatment.[16,17] This analysis enables the dentist to appreciate the ups and downs in the facial and dental components of patients' smiles. Prediction of whether orthodontic intervention is required or not depends on the malocclusion type. If implemented, whether it would be useful or not can be assessed using smile design.[18]

Digital Smile Design

Digitalization has now assumed an important aspect not only in engineering but also in the dental field. Digital Smile Design (DSD) is a modern versatile innovative dental treatment planning tool invented by the Brazilian dentist Christian Coachman in 2007 that permits the professional in digitally design the smile of the patient from a series of pre- and post-DSD photographs.

DSD software also allows the clinician to educate the patients regarding the improvements that can be done and also helps in collecting the patient's own preferences and requirements, thereby making the patient feel like he is a part of the decision-making process rather than just being on the receiving end.[18] DSD was described by its developers Christian Coachman and Marcelo Calamita as an innovative multipurpose analytical software that is capable of diagnosis, performing meticulous analysis of the patient's facial and dental traits that may have eluded conventional photography and the human eye.[19]

Requirements of digital smile design

Some of the software that can be used for digital smile design include Photoshop (Adobe), Microsoft PowerPoint (Microsoft Office, Microsoft), Smile Designer Pro (SDP) (Tasty Tech Ltd), Aesthetic Digital Smile Design (ADSD - Dr. Valerio Bini), DSD App by Coachman (DSDApp LLC), Keynote (iWork, Apple, Cupertino, California, USA), NemoDSD (3D) and Exocad DentalCAD, a digital SLR camera.

A digital impression of both the jaws is taken with a digital intraoral scanner. The impressions are then uploaded to the CAD/CAM processing machine where they are 3D-printed.[20] High-resolution full profile photographs representing the facial profile and frontal views of the patient are essential and videos that record the dynamic changes of the teeth, gingiva, lips, and facial muscles brought about by smiling and talking are essential as this documentation forms the blueprint on which smile design is executed. Three basic photographic views are fundamental in smile design, they include

1. Full facial view with a natural smile.
2. Resting face.
3. A view representing the maxillary and mandibular arch not in occlusion.

A magnification of a 1:1 view picture of the central incisor with a black background provides in-depth detail for the lab technician to work on.[20] The videographic demonstration containing documentation is imported into the slide presentation. The facial and dental components of the smile and their points previously discussed above influence the majority of smile design. Commercially available DSD software include; CEREC Smile Design (SIRONA), Digital Smile System (DSS), Smile Design Pro (TASTY TECH), G Design (HACK DENTAL), Romexis Smile Design (PLANMECA), and Smile Composer (3 SHAPE).[21]

DSD Workflow

The DSD workflow begins with digital scanning of the patient's dentition using an intraoral scanner, which is then imported to the respective DSD software. Using the various different shapes and forms available in the digital repository, we can overlap the teeth for a given esthetic procedure. The DSD workflow then proceeds as follows[22]:

1. After uploading the facial photographs, two baselines are drawn on the center of the slide so that it forms a + sign, in a way that it appears to be placed between the upper and lower anterior with the teeth apart [Figure 1]. Horizontal reference lines are achieved through the interpupillary line creating a digital facebow.
2. Soft tissue features (gingiva, lips, facial lines) and their association with other components are evaluated by grouping and transferring them to the facial photograph.
3. A template tooth that is set to be standard and exact in dimensions is placed over the original photograph so that axial inclinations, proportion in relation to adjacent teeth, and soft tissue silhouette are established. The retracted view is engaged in order to evaluate whether the intraoral photograph is concurrent with facial baseline data, where three lines are drawn [Figure 2]:
   Line 1: Intercanine width measured from the tip.
   Line 2: The middle third of the central incisor to the occlusal edge of the adjacent central incisor.
   Line 3: From the philtrum of the upper lip to the interdental papilla and the incisal embrasure.
4. Rectangular crop mode is then chosen and placed over the region of both central incisors to measure the width/length proportion of the central incisors [Figure 3].
5. Using editing tools, the template tooth can be placed over the photographed tooth, and pasted and morphed according to the best esthetic outcome. The patient's preferences and inputs can also be gathered and included during this step [Figure 4].
6. A digital ruler available in the software can be used to calibrate the real-time dimensions of the tooth by recording the measurement on the 3D model and then incorporating it into the software. Gingival contour and the proportion to attached gingiva width and incisal edges can also be calibrated [Figure 5].
7. Transferring the + sign to the cast: The measurement of baseline point till the free gingival margin is recorded and then transferred to the 3D cast with the aid of a caliper. Horizontal lines above the teeth which predict the gingival margin are marked on the cast using a pencil mark. The vertical lines are then marked using the interval between the incisal embrasures along with the facial component, which is then marked in the 3D model [Figure 6].
8. Wax up of the procedure to be performed for establishing a smile and then carried out on the cast

Figure 1: After facial photographs uploaded, two baselines are drawn on the center of the slide so that it forms a + sign and The three facial lines are grouped together to analyze the relationship between the lips, gingiva, and teeth

and evaluated using DSD, after which it is tried on the patient.

9. Once the approval of the wax-up has been sought, minor corrections, if deemed necessary, are performed.
10. Minimal intervention should be prioritized such as minimal reduction of tooth surfaces, and giving proper clearance for crowns, if required [Figure 7]. Attention to detail in each step in DSD usually results in an outcome that goes beyond the patient's expectations.

Figure 2: A template tooth is placed over the original photograph so that relationships are established and Drawing the three reference lines that will allow to evaluate whether the intraoral photograph is concurrent with facial baseline data

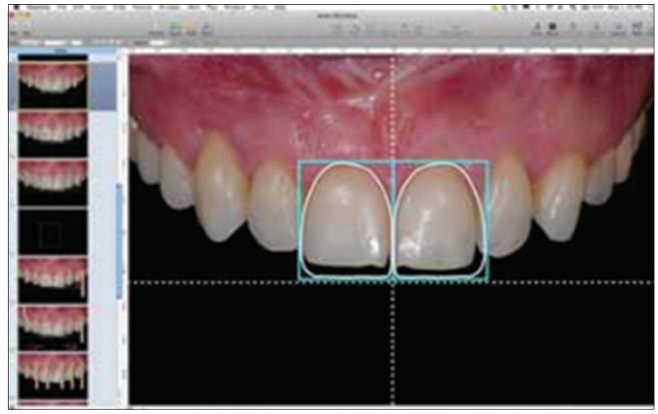

Figure 3: A rectangle guide representing the ideal tooth proportion is placed over the, teeth thereby comparing the preoperative proportion to the ideal one.[23]

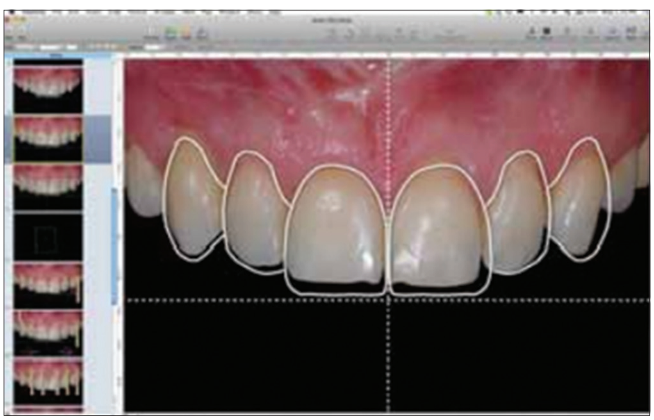

Figure 4: Using editing tools Final teeth outline showing the relationship between the preoperative situation and the ideal design is done.[24]

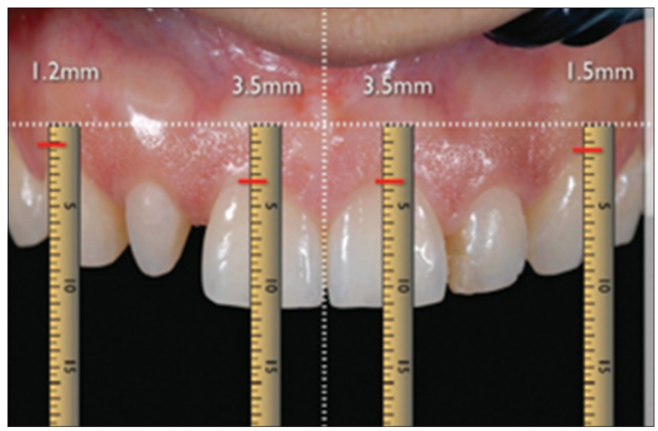

Figure 5: A digital ruler is used to evaluate the esthetic adjustments needed to be done (i.e., crown lengthening, margin placements in the veneers).[24]

Figure 6: The reference lines measured through the ruler are then transferred onto a cast with precision using a caliper device

Figure 7: Minimal dental procedure that has been done and Postoperative redesigned smile

Advantages of DSD

DSD enables the patient to actively participate in their treatment plan, resulting in much higher compliance and better motivation, as the results are evident from the 3D previsualization and simulation. The changes can be customized according to their desires. Digital scanning allows the clinician to detect any insidious disease due to the relatively high shades of gray (256 pixels) compared to a conventional radiograph (16–25 pixels).[25]

DSD shields the patient from any unnecessary radiation exposure due to the digital PSP sensors compared to the solid-state sensors. Digital imaging also saves on essential sources.[26] A study conducted by Cervino G *et al.*[27] in his review stated that DSD gives valuable feedback which can be discussed and improved upon. It drastically improves the communicative link between the patient, the clinician, and the technician in treatment planning to improve the smile line and facial features when smiling. This also gives the clinicians the comfort of avoiding any medico-legal issues as the approval of the patient pertaining to postvisualization photographs is obtained before the treatment is implemented.

Disadvantages of DSD

Although DSD presents with an attractive treatment planning tool for the patients, it has certain limitations. It poses as an expensive set-up as the costs for purchase and repair are considerably high. It cannot be operated by any person; rigorous training is required to learn the tool.[28] Sometimes, the patient disagrees with the pertaining outcome of the treatment even though the software had predicted a better outcome. In such cases, the software blame might seem illogical. This scenario has already been advertised by the manufacturers which often state "the enhanced image does not always match the original image". It is important to watermark the clinician's respective work so as to eliminate unauthorized reproduction of the images.[29,30] It is recommended that copies of the original images be stored on the computer or network server.

Conclusion

The DSD is an innovative tool that helps the clinician to create esthetically pleasing smiles. Previsualization drastically increases the patient's acceptance rate. The technology also makes the patient a part of the decision-making process by including their preferences. Although caution should be exercised that ideal case selection is always necessary in order to have a successful outcome. Patients should be enlightened about the potential ups and downs that they might face if the results are not up to their expectations. Further research into this area will definitely address and solve the issue and make this technology central to esthetic dentistry.

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Conflicts of interest

There are no conflicts of interest.

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