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DIGITAL SMILE DESIGN IN PROSTHODONTICS – AN OVERVIEW

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ABSTRACT

Aim of the study An important innovation in the field of prosthodontics is represented by the emergence of computer aided design and computer aided manufacturing (CAD/CAM) technology, which allows to obtain remarkable results in terms of anatomical and functional rehabilitation. **Material and methods** This study consisted in evaluating the software available on the market, used in prosthetics respecting the technologies and concepts of digital dentistry - among them, an important role is played by the Digital Smile Design method. Articles in the scientific literature (PubMed, Google Scholar) on the use of this software were analysed, and it was observed that allows excellent communication with patients, on one hand, and on the other hand, provides the doctor with the optimal tool for a correct therapeutic option, through algorithms. **Results** Digital technologies allow accurate treatment planning and facilitate the obtaining of aesthetic, functional and predictable prosthetic structures, Digital Smile Design benefiting from the application of a digital workflow for oral rehabilitation that can be evaluated and analysed by the patient, doctor and technician. **Conclusions** The information present in the scientific papers shows a positive evolution of digital technologies.

Key words: software, digital smile design, prosthodontics

INTRODUCTION

An important innovation in the field of dental prosthetics is represented by the emergence of computer aided design and computer aided manufacturing (CAD/CAM) technology, which allows to obtain remarkable results in terms of anatomical and functional rehabilitation. Digital Smile Design is the digital way to create the new design of a smile through a simulation and preview the final result of the proposed treatment.

Digital technologies allow accurate treatment planning and facilitate the obtaining of aesthetic, functional and predictable prosthetic structures, Digital Smile Design benefiting from the application of a digital workflow for an oral rehabilitation that can be evaluated and analysed by the patient, dentist and technician.

A design created digitally involves participation of the patients on the designing process of their self-smile design, leading to customization of smile design as per individual needs and desires that complements with the morpho psychological characteristics of the patient, relating patient to an emotional level, increasing their confidence in the process and better acceptance of the anticipated treatment.[1] Coachman and Calamita described DSD as a multi-use conceptual tool that can support diagnostic vision, improve communication, and enhance treatment predictability, by permitting careful analysis of the patient's facial and dental characteristics that may have gone unnoticed by clinical, photographic or diagnostic cast based evaluation procedures.[2]

MATERIAL AND METHODS

Studies on Digital Smile Design

This study consisted in evaluating the software available on the market, used in

prosthetics respecting the technologies and concepts of digital dentistry - among them, an important role is played by the Digital Smile Design method. Articles in the scientific literature (PubMed, Google Scholar) on the use of this software were analysed, which allows excellent communication with patients, on one hand, and on the other hand, provides the doctor with the optimal tool for a correct therapeutic option through algorithms.

DSD technique is carried out by digital equipment already prevailing in current dental practice like a computer with one of the DSD software, a digital SLR camera or even a smart phone.[3] A digital intraoral scanner[4] for digital impression, a 3D printer and CAD/CAM are additional tools for complete digital 3D work flow.

Starting with the use of photographs and more recently with the use of simple and accessible software, virtual or digital smile design has been used to analyse patient smiles and project 2D images to provide a guide for planning and communication. An important problem developed lately was the overlapping of 2D photos and the transfer of the proposed project to obtain dental prosthetic restoration, in physical or digital format. This is because, by the classic method, information can be lost from the moment of design by wax-up until the final realization of the restoration.

Digital technology is an affordable and easy way to transfer 2D data to 3D digital projects using a 3D computer graphics program - the goal was to transform a regular 2D (JPEG) 2D image into a standard 3D (STL) variant.

In order to achieve proper digital planning, it is important to have a protocol for taking and analysing photos. They must be of the highest quality and precision, executed in a correct posture, using standardized techniques; the analysis must include reference facial lines - the commissural lines, the lip line and the interpupillary line, which are the basis of the smile design. Therefore, if a photo is not correctly taken, this will misrepresent the reference image and will lead to misdiagnosis, and subsequently, improper planning.[5]

Also, in order to get the best evaluation, there are necessary some photos, registered in static position, as mentioned in Table 1.

Factors such as dento-facial aesthetic parameters, ease of use, case documentation ability, cost, time efficiency, systematic digital workflow and organization, and compatibility of the program with CAD/CAM or other digital systems may influence the user's decision.[6]

There are many aesthetic parameters that guide smile evaluation and design such as the midline, height, and the curve of the smile and intra- and interdental proportion.[7-9]

A study conducted by Doya Omar et al.,[6] compared eight DSD softwares (Photoshop CS6, Keynote, Planmeca Romexis Smile Design, Cerec SW 4.2, Aesthetic Digital Smile Design, Smile Designer Pro, DSD App and VisagiSMile) in their capability to evaluate and digitally modify these aesthetic parameters i.e., facial, dento-gingival and dental parameter and concluded that Photoshop, Keynote and Aesthetic Digital Smile Design included the largest number of aesthetic analysis parameters.

Although the inclusion of aesthetic parameters in different DSD software varies, the basic procedure for designing a smile remains the same. All DSD software allows aesthetic design by drawing lines and reference shapes on extra- and intra-oral digital photos.

Facial analysis is done using reference lines from which uniform parameters are developed for the frontal view of the face. Horizontal reference lines consist of interpupillary and inter-commissural lines that provide a complete sense of balance and a pleasing aesthetic facial horizontal view,

while the vertical reference line includes the midline of the face, passing through the glabella, nose and chin.

The horizontal and vertical lines are crossed with each other to measure the symmetry and inclination of the face.

Table 1. Type of photos used for Digital Smile Design

Frontal views – 3 photos	Profile views – 2 photos	12 o'clock view	Intra occlusal view
○ **Full face with a wide smile and the teeth apart,** ○ **Full face at rest, and Retracted view of the full maxillary and mandibular arch with teeth apart.**	Side Profile at Rest Side Profile with a full Smile	Incisal edge of maxillary teeth visible and resting on lower lip	Maxillary arch from second premolar to second premolar.

Figure 1. Dental Treatment Solution (DTS) - https://www.dentaltreatmentsimulation.com/

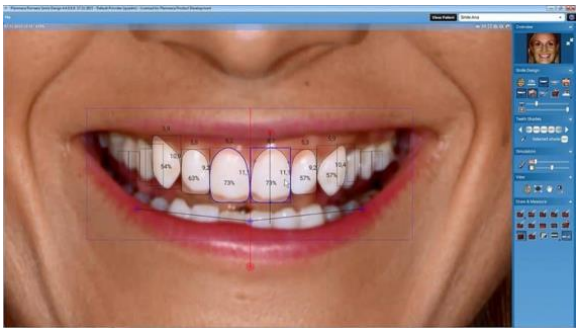

Figure 2. 3Shape Smile Design https://www.3shape.com/en

RESULTS AND DISCUSSIONS

After the facial analysis, the dento-gingival analysis is performed, checking the next protocol:

- Check the length of the upper lip at rest and smile, to determine the degree of gingival visibility.
- The curve of the smile is established by correlating the curvature of the incisal edges of the anterior maxillary teeth, and the dental contour is made according to the proportions of the lower lips and the anterior-posterior curvature of the teeth. This facial photograph is then cropped to analyse only the intraoral image.
- Three reference lines are marked on the teeth - a straight horizontal line drawn from the tip of one canine to the tip of the other canine, a horizontal line on the incisal edges of the central incisors and another vertical line passing through the interdental midline.

Few additional lines are drawn such as the gingival zenith, joining lines of the gingival and incisal battlements for complete dental analysis. For adequate teeth dimension the ideal size of dental width to length ratio can be incorporated by any one of the published theories which includes Golden proportion,[10] Pound's theory,[11,12] Recurring aesthetic dental

proportion,[12] Dentogenic theory,[13,14] or Visagism.[15]

There was established a special workflow for Digital Smile Design, with a precise algorithm:

- ➔ Step 1: Photographs and Treatment Planning using the DSD Software
- ➔ Step 2: Intraoral Scanner and Digital Wax-ups
- ➔ Step 3: 3D-Printing of the Digital Wax-up
- ➔ Step 4: Create a Silicone Index using 3D printed models
- ➔ Step 5: Carry a provisional restoration in the Silicone Index
- ➔ Step 6: Test-drive the mock-up in the patient's mouth

Discussions

In their paper, Cattoni et al.,[16] presented the way that prosthetic design/planning using a digital workflow, limited by the two-dimensional (2D) aspect - the technique offers a fully digital CAD / CAM process to minimize errors. Three-dimensional (3D) planning is sent to the dental laboratory, and the technique of combining the Digital Smile Design digital workflow with the .stl files allows the realization of these prosthetic restorations in the laboratory.

A study conducted by Omar and Duarte, in 2018 analysed several programs used for Digital Smile Design and for treatment planning - Photoshop CS6, Keynote, Planmeca Romexis Smile Design, CEREC SW 4.2, Aesthetic Digital Smile Design, Smile Designer Pro were evaluated, DSD App and VisagiSMile, for their reliability, for the possibility to analyse oral structures, dental arches or soft tissues.[6]

In 2016, Arias et al., [17] performed an additional study using Digital Smile, to perform and plan a periodontal surgery in order to solve a "gummy smile".

Perez-Davidi conducted a study on prosthetic rehabilitation with CEREC CAD/CAM systems - there is the possibility to make an immediate model and then to combine the data provided by Digital Smile Design and CEREC SW4, for the manufacture of prosthetic restoration.[18]

Dental Treatment Simulation (DTS) is one of the simplest and fastest dental simulation software developed by Artificial Intelligence. DTS is a useful tool for dentists in clinical practice to provide patients with optimal treatment. The main features of this software are structured as follows

- ➢ Realistic Natural Simulations within minutes
- ➢ Powered by Artificial Intelligence
- ➢ Digital smile designs for the desired personality
- ➢ Quick and easy dental restoration
- ➢ Tooth Whitening
- ➢ Extraoral changes after Orthodontics/ Orthognathic surgeries
- ➢ Different types of braces
- ➢ Orthodontic Tooth Movement
- ➢ Replacement of missing tooth/teeth
- ➢ STL Overlapping

3Shape Smile Design is one of the most exceptional software available on the market. The tool is built on the principles of Digital Smile Design - the software helps the dentist to create completely aesthetic smile models, based on the critical requirements of the patient. Using 3Shape Smile Design, 2D images can be processed and the proposed restorations drawn, directly from the patient's photo.

Exocad Smile Creator software involves creating custom images for the identity and facial orientation of the patient. The tool allows dentists to design a smile based on the patient's emotions, behaviour, self-esteem and identity. The workflow for Exocad involves identifying the features, design and correct realization of the dental restoration:

- ○ Predictable results for your restorative treatments

- Massive library of numerous natural teeth
- Seamless communication among dental labs, dentists, and patients
- A 3D tooth set up for providing the personalized experiences
- Fast and easy to use. No extensive knowledge or training is necessary
- Creator generates realistic result previews based on patients' photos

A study conducted by Gabriele Cervino et al.[19] reviewed as much as 24 articles on DSD published up till the year 2018 with the purpose to evaluate the effectiveness of the use of Digital Smile Design techniques and whether Digital Smile Design is bringing any improvements in the comfort of patients and in their treatments. It took into consideration, the "communicative" utility of the software, the therapeutic planning, and, of aesthetic and functional rehabilitation of the patients. The authors concluded from all of the articles present in the literature regarding Digital Smile Design, that, this tool provides important information to the clinician and patient. Patients can view their rehabilitations even before they start, and this can also have important medico-legal functions.[20]

In some studies, were evaluated and compared some of the most used systems for Digital Smile Design, by their main features – we mentioned them in Table 2.

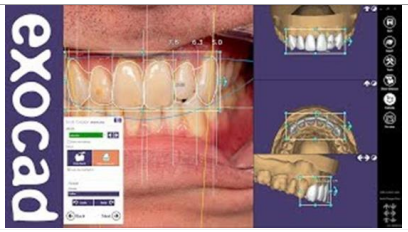

Figure 3. Exocad Smile Creator software - https://exocad.com/our products/exocad-dentalcad/smile-creator

Table 2. Software and their features, most frequently used

Software	Features
DTS Pro	Realistic Natural Simulations within minutes Powered by Artificial Intelligence Quick and easy dental restoration
Planmeca Romexis	Easy to install and use to design a new smile Allows patients to design their own smile Cloud-based digital smile database
Smile Designer Pro	Real-time smile simulation CAD/CAM overlay features Full automation assistance
3Shape	Easy and completely guided workflow Simple to use smile designing tool A faster way to achieve desired outcomes
Exocad	Massive library of numerous natural teeth Seamless communication Fast and easy to use

CONCLUSIONS

1. Digital Smile Design represents a multi-

use conceptual tool that can support diagnostic vision, improve communication, and enhance treatment predictability.

2. In order to achieve proper digital planning, it is important to have a protocol for taking and analysing photos.

3. The software involves creating custom images for the facial orientation of the patient, can allows dentists to design a smile based on the patient's emotions, behaviour, self-esteem and identity.

4. The workflow for Digital Smile Design software involves identifying the features, design and correct realization of the dental restoration.

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