

## The Use of Digital Technologies for Teaching Dentistry

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**Abstract**—The study considers the possibilities of using advanced digital technologies in dental practice and training. The Digital Smile Design methodology has been characterized; this is an innovative technological solution used to perform an aesthetic analysis, plan the virtual treatment tactics, draw up a plan of necessary dental procedures, as well as visualize the preliminary therapy result. As part of the "Aesthetic Dentistry" course, the technological capabilities of the Digital Smile Design software have been studied. The study involved 25 four-year students of the Department of Prosthetic Dentistry, Sechenov First Moscow State Medical University. At the initial stage of the research, the students were provided with digital photos, including a 3D model of the dental arcade and surrounding soft tissue and video materials of the clinical case, on the basis of which a smile in accordance with the morpho-psychological characteristics of the patient was designed. The students tested the technological capabilities of the Digital Smile Design software, in particular SmileDesignerPro, AestheticDigitalSmileDesign, Cerec SW 4.2, PlanmecaRomexisSmileDesign, VisagiSMile, DSD AppbyCoachman, 3Shape SmileDesign, ExocadSmileCreator, DentalTreatmentSimulation™ PRO. Based on the results obtained, the key advantages of the Digital Smile Design methodology in aesthetic and orthopedic dentistry have been identified. Having studied the process of designing a digital smile within the framework of the "Aesthetic Dentistry" course and conducted a survey of students to determine the practical convenience of the technologies, the Digital Smile Design software was ranked according to its advantages in dental practice and training.

**Keywords**—Digital dentistry; emerging technologies; Digital Smile Design; teaching aesthetic dentistry; digital smile design concept

## **1 Introduction**

Recent advances in dental CAD/CAM technologies have not only created wide opportunities for the use of advanced equipment and software, but have also revolutionized dental practice. Digitalization has affected the whole therapy - from diagnostic assessment and therapy planning to the use of innovative restorative materials. High-tech systems create the basis for every dental and medical procedure ensuring high precision and degree of detail to improve quality and optimally solve the aesthetic and functional problems of the patient. New digital technologies have revolutionized the way we see, think and work in dentistry [1].

The innovative dentistry model combines an aesthetic element with the functional restorative one [2]. In dental practice, there is a growing demand for cosmetic dentistry, which integrates all areas of highly aesthetic treatment based on the detailed analysis of each clinical case, which involves the use of special software [3]. Immersive systems, including computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided engineering (CAE) technologies, are indispensable tools of modern dental clinics and laboratories [4]. Intraoral scanners ensure superior precision of restorative work while providing a high level of patient comfort and efficiency in the clinic.

Over the past few decades, aesthetic or cosmetic dentistry has become one of the major trends in the development of dental practice. Over the years, a number of studies and courses have been devoted to the smile design concept in order to develop a treatment plan and provide the patient with an aesthetic result [5]. The development of digital technologies and computer-aided design/computer-aided manufacturing systems (CAD /CAM) have created exciting opportunities for aesthetic and cosmetic dentistry [6].

The use of digital technologies in almost all aspects of dental practice has changed the approach to dental training and necessitated the introduction of modern technological solutions into educational programs. The use of digital technologies in teaching is a trend in modern education as in dental training immersive technologies contribute to an increase in the competence of students in the field of study and help them gain experience in an environment close to reality. Modern trends in dental practice require dentists to possess not only good theoretical knowledge but also the ability to apply advanced methods of diagnosis, treatment, and prevention of dental diseases, as well as the ability to summarize and analyze digital data. The introduction of new information technology tools and modern approaches to learning has made medical education more successful [7]. Digital technologies in dental education can optimize educational processes, make them more personalized and individual.

The purpose of the research is to study the possibilities and prospects of the use of digital technologies in dental practice and training.

In this regard, the following tasks have been set:

- To study the features of Digital Smile Design that is an innovative technological solution in the field of aesthetic and cosmetic dentistry.
- To develop a methodology for studying the adaptability of Digital Smile Design technological solutions in dental education.
- Within the "Aesthetic Dentistry" course, to test the technological capabilities of the Digital Smile Design software, in particular SmileDesignerPro, AestheticDigitalSmileDesign, Cerec SW 4.2, PlanmecaRomexisSmileDesign, VisagiSMile, DSD AppbyCoachman, 3Shape SmileDesign, ExocadSmileCreator, DentalTreatmentSimulation™ PRO.
- To rank the best Digital Smile Design software by its advantages in dental practice and training.

## **2 Research Design**

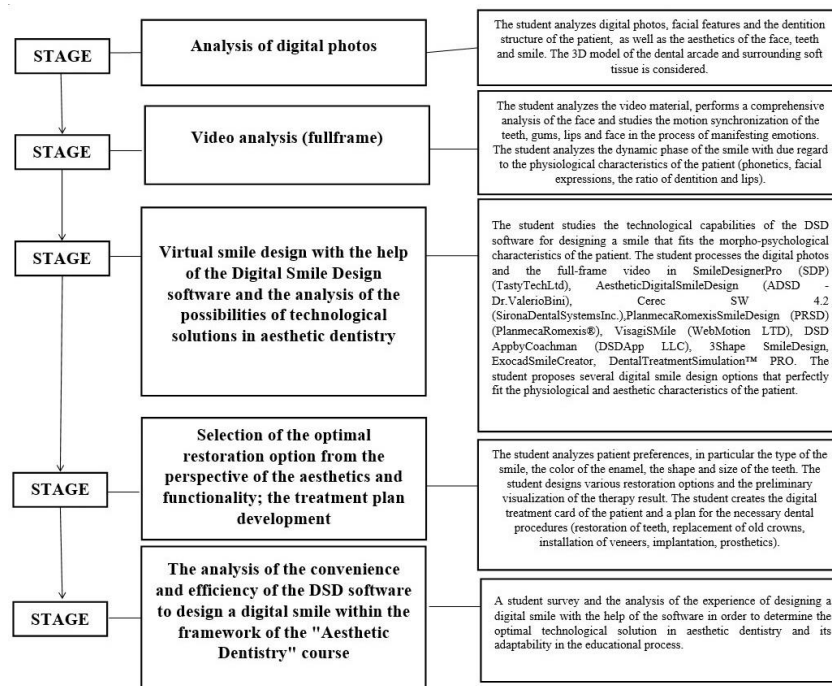
Digital Smile Design (DSD) is a software-based technology used to plan the aesthetic treatment of anterior teeth. DSD is an innovative technological solution that is used to perform an aesthetic analysis, plan the virtual treatment tactics, draw up a plan of the necessary dental procedures (restoration of teeth, replacement of old crowns, installation of veneers, implantation, prosthetics), as well as visualize the preliminary therapy result. In addition, DSD ensures quality communication between the dentist, dental technician and patient, thereby ensuring a predictable result in each clinical case.

The Digital Smile Design methodology was introduced in 2007 to ensure the communication between the patient, the dentist and the dental laboratory to obtain an optimal treatment result. The DSD technology uses a photograph of the patient to develop a virtual model of the restoration with due regard to the patient preferences. While modeling, the software takes into account facial features and the dentition structure; therefore, the result is characterized by a high level of precision and customization.

As part of the "Aesthetic Dentistry" course, the technological capabilities of the Digital Smile Design software have been studied. The study involved 25 four-year students of the Department of Prosthetic Dentistry, Sechenov First Moscow State Medical University.

At the initial stage of the research, the students were provided with digital photos, including a 3D model of the dental arcade and surrounding soft tissue, video materials of the clinical case and patient's preferences, on the basis of which the smile model was designed. The students studied the digital images of the patient, analyzed facial features, the dentition structure, and the aesthetics of the face, teeth, and smile. They also considered the 3D model of the dental arcade and surrounding soft tissue. Based on the full-frame video, the participants diagnosed the dynamic phase of the smile with due regard to the physiological characteristics of the patient and carried out a comprehensive analysis of the synchronicity of the teeth, gums, lips, and face of the patient. In order to design a smile that fits the morpho-psychological characteristics of the patient, the students tested the technological capabilities of the Digital Smile Design software, in particular SmileDesignerPro, AestheticDigitalSmileDesign, Cerec SW 4.2, PlanmecaRomexisSmileDesign, VisagiSMile, DSD AppbyCoachman, 3Shape

SmileDesign, ExocadSmileCreator, DentalTreatmentSimulation™ PRO. Based on the results obtained, the students proposed several digital smile design options that perfectly fit the physiological and aesthetic characteristics of the patient. Taking into account the wishes of the patient, in particular the type of the smile, the color of the enamel, the shape and size of the teeth, the students designed the restoration model and suggested a preliminary visualization of the therapy result. The digital treatment card of the patient and a plan for the necessary dental procedures (restoration of teeth, replacement of old crowns, installation of veneers, implantation, and prosthetics) were also created. In order to identify optimal digital solutions in the DSD methodology and aesthetic dentistry, a survey of students was conducted to analyze their experience in designing a digital smile with the help of the Digital Smile Design software. Fig. 1 shows the methodology for studying the adaptability of the Digital Smile Design solutions in aesthetic dentistry within the educational course.



**Fig. 1.** The methodology for studying the adaptability of technological solutions of the Digital Smile Design methodology in aesthetic dentistry within the educational course

### 3 Results

The evaluation of the Digital Smile Design software within the framework of the study made it possible to identify the key technological possibilities of their application in dental practice.

In the dental industry, digital smile design is supported by specially developed software, in particular SmileDesignerPro (SDP) (TastyTechLtd), AestheticDigitalSmileDesign (ADSD - Dr.ValerioBini), Cerec SW 4.2 (SironaDentalSystemsInc.),PlanmecaRomexisSmileDesign (PRSD) (PlanmecaRomexis®), VisagiSMile (WebMotion LTD), DSD AppbyCoachman (DSDApp LLC), 3Shape SmileDesign, ExocadSmileCreator, DentalTreatmentSimulation™ PRO.

Smile Designer Pro and Aesthetic Digital Smile Design are specialized digital design software solutions used in dental cosmetology. Cerec SW 4.2 and PlanmecaRomexisSmileDesign are CAD / CAM applications that are used to design anterior restorations. They require frontal photographs and intraoral digital impressions to design ceramic restorations. VisagiSMile and DSD AppbyCoachman share the makeup art concept, which suggests that the temperament of the person is an important factor in smile design [8].

The full version of the SmileDesignerPro software [9] reflects all parameters and corrections of the tooth shape and volume, smile lines and facial proportions. SmileDesignerPro is an effective tool for dental practitioners that allows them to create the desired smile within the space of a few minutes. The automation tool reduces about 90% of manual work minimizing treatment time. Real-time smile simulation allows the practitioner to create the desired smile within 10 minutes based on the characteristics of the patient personality.

AestheticDigitalSmileDesign [10] is an innovative method of the aesthetic digital smile design, which is used for diagnostics and planning of dental treatment, as well as in plastic and maxillofacial surgery. The treatment guidelines provide for the use of digital photographs and a full-frame video to analyze the dynamic phase of a smile taking into account physiological characteristics (phonetics, facial expressions, the ratio of dentition and the lips). The digital aesthetic treatment card of the patient complements the medical history and is an integral part of the objective analysis.

3 Shape SmileDesign [11] is a software application that helps the dental practitioner create aesthetic smile designs based on critical patient requirements.

ExocadSmileCreator [12] is a software application for the virtual planning of highly aesthetic restorations based on the combination of patient photographs, tooth contours and 3D images. SmileCreator is available as a DentalCAD 2.3 Matera add-on and as a standalone software. The software includes the creation of personalized images based on the patient personality and facial orientation. This tool allows dental practitioners to create smiles based on the emotions, behavior, self-esteem and personality of the patient.

VisagiSMile [13] is a multi-platform web application which analyzes the patient face shape and personality when designing a smile; this can ensure a more harmonious result of dental procedures.

DSD App [14] is a mobile application designed to simulate a smile that fits the patient's morpho-psychological characteristics. The application involves the patient in the design of their own smile. To design a model that suits a patient, photo and video materials are used and a comprehensive analysis of the face and the motion synchronization of the teeth, gums, lips and face in the process of manifesting emotions is carried out. DSD Facial Analysis analyzes the characteristics and proportions of the face.

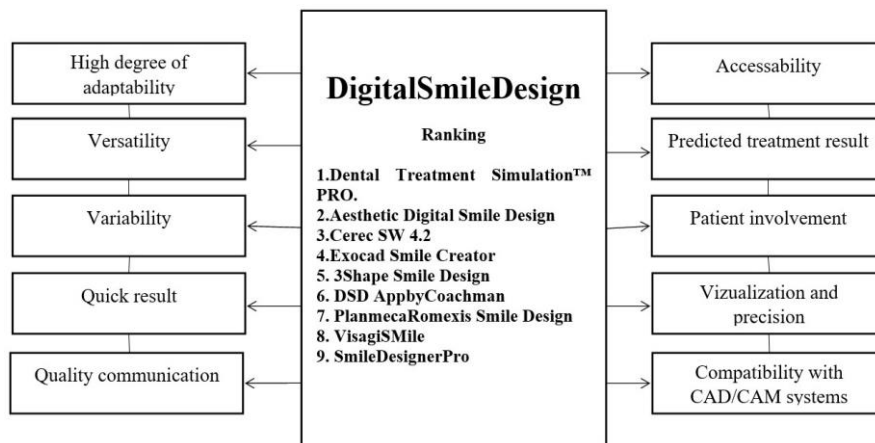
DSDApp automatically calibrates images and calculates a smile frame. DSDApp offers a library of natural tooth shapes and colors.

Planmeca Romexis ® Smile Design [15] is a user-friendly software that provides a desired result in a few minutes. The visual design options are sent to the patient with the help of the PlanmecaRomexis® Cloud service or the PlanmecamRomexis™ and PlanmecaRomexis™ mobile apps. The finished smile design projects can be exported to CAD/CAM software, in particular PlanmecaPlanCAD® Easy, PlanmecaRomexis® 3D OrthoStudio or to the PlanmecaRomexis® 3D software module for their further implementation [16].

DentalTreatmentSimulation™ PRO is a smile design software that is an effective tool in the dental practice and includes the latest technological advances such as artificial intelligence and machine learning. The software analyzes dental occlusion, the shape of the teeth, the position of the lips when smiling, and determines the ration between lips and teeth [17].

The major advantages of DSD technologies in dental treatment planning is the ability of the software to model restorations of various complexity in a short period of time (consultation length) taking into account the preferences of the patient and meeting the aesthetic requests. The software is also exported to any CAD/CAM system.

Based on the results obtained, the key advantages of the Digital Smile Design methodology in aesthetic and orthopedic dentistry have been identified. Having studied the process of designing a digital smile within the framework of the "Aesthetic Dentistry" course and conducted a survey of students to determine the practical convenience of the technologies, the Digital Smile Design software was ranked according to its advantages in dental practice and training (Fig.2).



**Fig. 2.** The Digital Smile Design software ranking by its advantages in dental practice and training  
\*Developed by the authors

## 4 Discussion

Current trends in aesthetic dentistry and the media coverage of innovative opportunities in dental practice have raised public awareness of the cosmetic treatment aspects. Due to the fact that people believe that smile aesthetics is crucial for their well-being, social acceptance, self-confidence, successful career and private life, many dentists use different smile design guidelines to meet the growing aesthetic needs of their patients. However, in order to ensure a higher degree of patient satisfaction, any smile design procedure should be structured as follows: good knowledge of psychological aspects, the restoration and improvement of functions within their normal limit, and subsequent improvement of aesthetics [18].

Until recently, traditional recommendations for aesthetic assessment and treatment were based on 2D models. The combination of 2D images with 3D digital models has stimulated the transition to a completely digital format to verify and develop aesthetic parameters in three dimensions [19]. Clinical studies involving a three-dimensional analysis of the scanned teeth and faces have revealed that faces and smiles are not completely symmetrical, but rather dynamic; this must be taken into account when designing and planning natural and harmonious smiles [20]. The concept of creating a digital smile is a practical diagnostic procedure that allows the practitioner to visualize and evaluate facial asymmetry. Therefore, a digital smile analysis is an important step in the diagnosis and planning of an aesthetic restoration. Due to the digital accuracy of photographs, digital planning offers simple steps for assessing and predicting the size, shape and position of the tooth, as well as the contour of the gums [21, 22].

The innovative DigitalSmileDesign methodology is used in restorative dentistry, periodontal surgery, implantology, orthodontics, and maxillofacial surgery [6]. Cone beam computed tomography, as well as intra- and extra-oral optical scanners allow a detailed three-dimensional assessment of all structures and tissues of the oral cavity. Special computer programs and software tools allow digital planning and visualization of the aesthetic results creating a plan for subsequent restorative, orthodontic, and surgical therapy [23].

Digital Smile Analysis software is a practical tool that can improve aesthetic diagnostics and facilitate communication with the patient, dental specialist and other clinicians. Their practical use reduces treatment time, enhances clinical efficacy, increases patient satisfaction and improves predictability of treatment [3].

## 5 Conclusion

Based on the results obtained, the key advantages of the Digital Smile Design methodology in aesthetic and orthopedic dentistry have been identified. The Digital Smile Design methodology is used to perform an aesthetic analysis, plan the virtual treatment tactics, draw up a plan of necessary dental procedures, as well as visualize the preliminary therapy result. Having studied the process of designing a digital smile within the framework of the "Aesthetic Dentistry" course and conducted a survey of students to determine the practical convenience of the technologies, the Digital Smile Design

software, in particular SmileDesignerPro, AestheticDigitalSmileDesign, Cerec SW 4.2, PlanmecaRomexisSmileDesign, VisagiSMile, DSD AppbyCoachman, 3Shape SmileDesign, ExocadSmileCreator, DentalTreatmentSimulation™ PRO, was ranked according to its advantages in dental practice and training.

The major advantages of DSD technologies in dental treatment planning is the ability of the software to model restorations of various complexity in a short period of time (consultation length) taking into account the preferences of the patient and meeting the aesthetic requests. In addition, DSD software is characterized by a high degree of adaptability, versatility and accessibility, variability and predictability of the treatment result, visibility and precision, quick result, compatibility with CAD/CAM systems, the possibility of high-quality and effective communication between the patient, dental practitioner and technologist, as well as patient involvement in the treatment process.

Digital technologies in dental training optimize educational processes, make them more personalized and individual, develop students' competencies in an environment close to reality, including the ability to apply advanced methods of diagnosis, treatment and prevention of dental diseases, summarize and analyze digital data.

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