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3D Digital Smile Design With a Mobile Phone and Intraoral Optical Scanner

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ABSTRACT

Extraoral facial scanning using a mobile phone has emerged as a viable, cost-effective option for certain applications not requiring high precision, such as patient education and 3-dimensional (3D) digital smile design. This technological development is particularly promising for general practitioners (GPs) who may not be able to invest in expensive, complex digital impressioning devices. This article describes and illustrates a relatively simple and accessible workflow that avails digital 3D facial scanning benefits to GPs.

Technology advances can have a positive impact on dentistry for both patients and dentists, especially in the quality of treatments and the simplification of procedures. Technological progress by digitalization is particularly evident in digital radiology and the field of intraoral digital impressions. Treatment planning also has benefited from advancements in technology; in esthetic cases, dentists used to plan treatments by cutting 2-dimensional (2D) intraoral photographs and placing them in the ideal position. This form later evolved into the use of digital templates for position and dimensions of reference teeth, which were overlaid on digital 2D photographs on a computer screen.

Parallel to these 2D methods, extraoral facial scanners have been in use since 1939.[1] Basic computer graphics software programs were eventually developed in the 1980s to allow practitioners to visualize and plan the outcome of treatments before starting them, especially for complex cases.[2,3] The face scanners and techniques used at that time were complicated and expensive, so their usage was extremely limited. Within the past decade, more compact systems were made available but were mostly still too expensive for everyday practice.

Very recently, mobile phone face scanners have emerged, in both software-only solutions or in the form of a small hardware add-on. This technological development is highly promising, especially for general dentists who cannot make the investment in money or time needed to acquire and learn more complex devices and procedures.

The purpose of this article is to explain a simple and accessible workflow that avails digital 3-dimensional (3D) facial scanning benefits to general practitioners.

Procedure/Workflow

An extraoral facial scan of a patient was made by using a photogrammetry and feature-tracking app (3D Creator, Sony Corporation, sonymobile.com) on a mobile phone device (Sony XZ1, Sony Corporation) in three different positions (Figure 1). The face scan of the smile was taken as a reference for the lip position during the subsequent smile design, while the retracted smile was necessary for the alignment process with the intraoral models by using anterior teeth as a common landmark. High-resolution digital intraoral color 3D impressions of upper and lower teeth were made with an intraoral scanner (Figure 2) (Condor, Condor Systems, condorscan.com).

Face models were exported as .OBJ files (object files) and .MTL files (material template library files), while intraoral models were exported as .PLY files (polygon file format). The particularity of these file formats is that besides the 3D shape information, they allow for storage of surface color information, along with esthetically important data such as texture and shading. An open-source 3D creation suite (Blender, blender.org) was then used to combine extraoral and intraoral models by a point-to-point alignment method (Figure 3).On the face scan of the smile position, the patient's teeth were hidden. Then the face midline and interpupillary line were drawn. Individual maxillary teeth were imported and positioned, and the dimensions were set to the desired values (Figure 4).

Finally, 3D propositions of different smile designs were created by changing the shapes and positions of the teeth (Figure 5).

Discussion

The proposed workflow is presented as a simple and cost-effective procedure to integrate the benefits of facial scans into daily practice for treatment planning and visualization of the patient. 2D photography has been a powerful tool to document cases and discuss treatment possibilities with patients and other colleagues. This tool became available to almost every dentist with the emergence of digital cameras and mobile phones. While mobile phones may not provide the same image quality as digital single-lens reflex (DSLR) cameras, many dentists use them because of their lower cost and acceptable image quality. Additionally, though the accuracy of the facial scan and the aligning method proposed in this workflow are not as ideal as dedicated 3D face scanners, the process may be adequate to simulate different treatments and discuss them with the patients since high accuracy for this indication is not crucial.

The current protocol for smile design consists of preparing a 2D digital photograph of the face of the patient in a smiling position, and drawing ideal shapes of anterior teeth or superimposing existing teeth layouts on the patient's smile. Despite the lack of precise accuracy and limitations of this 2D method and the subjectivity inherent to the process of positioning and dimensioning of these layouts, the ability to involve patients in the design process and show them a simulation of different possibilities may increase acceptance rates and help to avoid post-treatment disapproval.

Adding the benefits of 3D, which allows for presentation of the esthetic results from all possible view angles, will undoubtedly further increase the realism of digital smile simulations. The next step may be the ability to print the designed virtual models in 3D, and then making silicon keys and actual mock-ups for esthetic try-ins. The ensuing step beyond that will consist of the use of 3D color data of the ideal smile to automatically print polychromatic esthetic composite or ceramic restorations in 3D.

Conclusion

Mobile phone 3D face scanning can be a cost-effective and fast tool for certain applications that do not require high precision, such as patient education and 3D digital smile design. This user-friendly method will allow a larger number of general dentists to design treatment options in 3D on virtual patients and to profit from the ever-growing advantages of digital dentistry.

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