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Review Article

Advanced Perspectives in Dentistry: Digital Workflow and 3D Printing

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Abstract: The arrival of digital workflow has caused an important evolution in the way dentistry is performed nowadays. Imaging through intraoral scanning systems (IOS) and cone beam computed tomography (CBCT) combined with computer aided design and manufacturing systems (CAD/CAM), make it possible to simplify procedures in all areas of dentistry. Digital techniques are tools that allow more assertive diagnoses, as well as the planning and development of treatments with greater safety, effectiveness and speed. The purpose of this review is to learn about the application of the digital tools that give rise to the development of digital workflow and its general applications in dentistry, in the search for areas of opportunity where this technology can be useful for the development of new techniques that allow that allow for personalized patient-centered care.

Keywords: Digital workflow, CAD/CAM, CBCT, intraoral scanning, bioengineering, translational dentistry, 3D printing.

INTRODUCTION

The introduction of digital technology in medical sciences had its beginnings as a diagnostic tool decades ago and its use has been increasing in all areas, taking advantage of the wide potential for its application. Digitalization is applicable from the collection of patient data for the creation of the medical record, imageology through radiographic studies (x ray), computed tomography (CT), magnetic resonance imaging (MRI) as well as the manufacture of simulated models through computer aided design and manufacturing (CAD/CAM), among others (Tallarico M., 2020).

It is clear that digital technology, although used by healthcare professionals, has an intimate relationship with engineering science, source of the development of the software that gives functionality to these tools. It is the interaction of these physical and mathematical foundations of engineering with the medical, biological and material sciences that gives rise to bioengineering, which is the discipline that allows the design and creation of devices and other resources that contribute to the evolution of the processes of diagnosis and treatment of health conditions (Tayebi L., 2019). Thus, the implementation of translational dentistry involves the participation of multidisciplinary teams that give rise to the integration of knowledge in basic dental and medical sciences with technology, science and innovation (Simancas V *et al.*, 2022).

Digital workflow

Digital workflow is a three-phase protocol, where the first phase consists of obtaining three-dimensional digital images of the substrate on which the device will be fabricated, the second phase is the transfer of this information to a design program and lastly the fabrication of the device (Shujaat S *et al.*, 2021). The basis of this digital workflow process is to obtain accurate images that provide detailed information of the anatomical structures in question since, as the first step in the creation of three-dimensional virtual models, they are a fundamental part of the success of the following phases that will directly influence the final result.

Imaging tools

For several decades, CT has been used in the medical area with excellent results thanks to the fact that, unlike conventional and digital radiography, which yields two-dimensional images, CT provides three-dimensional information, however, cone beam computer tomography (CBCT) offers better results as an auxiliary means of diagnosis for the different areas of dentistry, since the projection of radiation, being conical in shape, covers a larger area, in addition to allowing the establishment of different fields of view (FOV) limiting

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exposure to the area of interest, moreover, it is also possible to define the size of the voxels, which eliminates the overlapping of images and offers the possibility of isolating small structures to observe them with greater clarity, perform measurements and manipulate them independently, all this with a radiation dose and exposure time much lower than that of conventional tomography (Vandenberghe B., 2020).

Intraoral scanning (IOS) technology has evolved significantly, especially with regard to scanning speed and better resolution of the images obtained. While these systems provide three-dimensional images of all structures in the oral cavity, directly from inside the patient's mouth, it is not possible to scan narrow structures such as the inside of root canals. Comparative studies have found significant differences in the measurements between various scanners determining that, in general, the scanning speed, the presence of humidity, the scanning pattern and even the size and weight of the scanner tip can influence the result of the image obtained, resulting in distortion or contraction of the image (An H *et al.*, 2022). To counteract this situation, some scanning systems use a powder that is sprayed on the surface to be scanned, with the purpose of eliminating reflections from metal restorations and humidity, however, other equipment do not require it and it is even possible to obtain colored images (Agustín R *et al.*, 2022).

CAD/CAM - Computed Aided Design / Computed Aided Manufacturing

CAD/CAM technology is used to give continuity to the next two phases of the digital workflow. There are different design software, some of them free, where the images obtained by IOS or CBCT are imported to give way to the development of the computer aided design (CAD) of what is to be manufactured. The IOS provides the images in STL (Standard Tesselation Language) format, compatible for computer-aided design and manufacturing (CAM) software, while the CBCT images come in DICOM (Digital Imaging and Communications in Medicine) format, so it is necessary to import and convert the file to a compatible format to submit the images to a segmentation process, where the anatomical region of interest is selected for the development of the design and its conversion to STL format, thus giving way to the last phase (Gerke BA *et al.*, 2019). The manufacture of digitally designed prototypes can be carried out by additive manufacturing, i.e. 3D printing, where the basic principle is the printing of the object in layers, the thickness of which is determined during the digital design process, resulting in a smoother surface the thinner the layers are. The other method is subtractive manufacturing or milling, which consists of sculpting the object from a block of the material of choice by transferring the design file to the milling machine program (Thakare A *et al.*, 2022).

Digital workflow applications in dentistry

Imaging systems provide accurate information for more assertive diagnosis in all areas of dentistry, and design and manufacturing software facilitates the process of making prototypes of all types. Digital workflow allows the acquisition of applicable anatomical models for the improvement of skills and the development of new techniques (Vasamsetty P *et al.*, 2020). In the areas of surgery, periodontics and endodontics, it allows the design and manufacture of fixation splints, surgical guides for implantology, autografts, gingivectomies and even guides for apicoectomies and endodontic access. In addition, it can be applied to the development of scaffolds and membranes for tissue regeneration tailored to the defect (Su Y *et al.*, 2021).

On the other hand, in the area of orthodontics, with additive and subtractive manufacturing methods, it is possible to manufacture retainers, orthodontic aligners and occlusal guards, while in restorative dentistry and prosthodontics, it is possible to manufacture dentures, fixed and removable prostheses, although with the additive manufacturing method it is not yet possible to print ceramic or metallic restorations that meet the optimum strength requirements (Kalberer, N *et al*., 2019, Uçar Y *et al*., 2018).

Tomography and 3D printing

CBCT provides images with excellent dimensional fidelity, which represents an area of opportunity since it can be useful for cases where the intraoral scanner does not have the necessary scope to achieve detailed information (Vandenberghe B., 2020). On the other hand, the 3D printing manufacturing process, although currently used in many areas of dentistry, its application in restorative and fixed prosthesis is limited to the printing of temporary restorations with polymers because, although there are ceramic and metallic materials for additive manufacturing that have adequate strength, they do not have the precision of fit required by fixed restorations, compared to the subtraction method (Praveena PA *et al.*, 2022, Moon W *et al.*, 2021).

CONCLUSION

Several computer-aided systems have contributed to the optimization of procedures that have traditionally been carried out by analogous methods. In dentistry in particular, the inclusion of digital workflow has allowed more precise diagnoses, simplification of techniques and optimization of time, achieving an improvement in the quality of treatments, in addition to a reduction in the margin of error that is present in manual fabrication techniques. However, there are still areas of opportunity for the application of this technology, where the benefits of imaging and the precision of digital systems for assisted design and fabrication can be fully exploited, allowing a personalized dentistry.

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