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Review Article

Optimization of the Digital Workflow for Obtaining Dental Rehabilitation Devices Obtained by the Cone Beam and 3D Printing

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Abstract: Digital workflow in dentistry is an innovation technique that has made great progress in recent years that provides personalized patient care incorporating CAD/CAM technology (Computed Assisted Design/Computed Assisted Manufacturing) for the visualization and digital manipulation of structures obtained from CBCT (Cone Beam Computed Tomography) or intraoral scanner. Thisallows to build structures that can help the dentist in treating patients in a personalized way. The digital flow process mainly consists of three pillars: image acquisition, visualization and manipulation of three-dimensional models and 3D printing. This clinical methodology can be usedin all fields of dentistry, where the design of anatomical posts to replace the use of conventional fiberglass poles stands out. The above allows to a predictable dynamic of treatment which influences the decrease of risk of fracture due to overload of chewing forces. The digital flow is improved with the integration of bioengineering, the technological and biological knowledge of this discipline allows increasing the effectiveness and efficiency of the process to obtain better results.

Keywords: *Digital Workflow*, CAD/CAM, CBCT, dental post, personalized posts, 3D printing,Stereolithography, *Bioengineering*, Translational Dentistry.

INTRODUCTION

The digitization of dental models and computerized imaging techniques have revolutionized clinical practice, being applicable to all fields of dentistry with a great emphasis on implants and restorative dentistry (Vandenberghe B., 2018). These new diagnostic techniques come from the adaptation of other knowledge areas, such as bioengineering, where the analysis and processing of digital information is merged with the knowledge and applications that a health professional seeks for their services (Solaberrieta E *et al*., 2015). Bioengineering is based on integrating knowledge in biology, materials science, chemistry, engineering and medicine, making it the most appropriate discipline to form a bond between biological and exact sciences (Tayebi L., 2019). This way, collective labor is created between dentistry and engineering for the development of sustainable and quality products, forming what is called transnational dentistry.

Starting in the 90's, the use of 3D interaction tools began to be studied with the advances of computed tomography, this made it possible to increase the effectiveness of implant placement by creating templates for their placement through computer programs. Furthermore, the emergence of 3D computed tomography has seen rapid adoption by healthcare professionals as an accurate tool for clinical treatment. The use of digital material has had a positive effect within the community by being more efficient, immediate and highly accurate in the treatments used. Recently, digital flow has been used in the creation of three-dimensional models in the analysis of individual dental pieces from a CBCT (Cone Beam Computed Tomography), allowing the complexity of the anatomical structure to be better observed and avoiding complications in the treatment (Vandenberghe B., 2018).

Digital workflow takes advantage of CAD/CAM (Computed Assisted Design/Computed

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Assisted Manufacturing) technology to obtain and manipulate 3D images using computer software and 3D printing personalized products in different materials to obtain precise and efficient means of orthodontic treatments. This process is based on 3 main pillars:

1. Acquisition of images of the patient's dental arch: in the field of dentistry, ionizing radiation in the form of x-rays is the most used for visualization of bone structures using a CBCT, thus obtaining images in both 2D and 3D (Vandenberghe B., 2018).
2. Viewing and manipulating images through software: Once the images are obtained, it is important to establish adequate monitoring for the processing of the three-dimensional models depending on what is planned to be designed with the computer programs. CBCT proves to be a superior and more reliable technique for obtaining images due to the versatility of diagnostic and treatment techniques that can be developed. Generally, the file format of images obtained from a tomography is usually incompatible with 3D modeling software. The technological knowledge provided by engineering sciences is very useful to be able to transform files into a compatible format in the fastest and most efficient way. This modeling software allow you to adjust the orientation of the pieces, as well as the design of adhesions to the original structures, marking important points for surgical guides or implants and the simulation of orthodontic treatments (Vandenberghe B., 2018, De Morais Alves Da Cunha *et al*., 2021., Oviedo-Quirós *et al*., 2020).
3. 3D printing: refers to the technique used to manufacture an object adding multiple layers to form said object. Recently, 3D printing works as a quick way to obtain a prototype and consists of adhering the desired material layer by layer of the object from a CAD/CAM model (De Morais Alves Da Cunha *et al*., 2021, Rivera-Gonzaga, 2021).

Currently, many clinical treatments are suitable to work in the majority of patients, a clear example is prefabricated posts made in various presentations according to the root canal of the endodontically treated tooth, however, a process that represents the final restoration of a tooth should be adequate to the specific shape of the patient to improve adaptation to the walls of the canal (Hernández Ovíes, 2021).

Digital workflow applications

Applications of digital workflow in the area of dentistry have seen an increase in prosthodontic, orthodontic treatments and maxillofacial surgeries, where the need for a model of the patient's dental arch is an important part of the diagnosis and corresponding treatment. An advantage of these new procedures is that it is not necessary to have scanning equipment; traditional methods for obtaining the patient's dental arch can continue to be used and then send the arch model to a laboratory where they have this imaging, modeling and printing equipment to obtain the digitized model to continue with the treatment. It can also be useful for creating models for educational purposes, where students, instead of requiring extracted teeth, resin blocks or dental replicas, use these three-dimensional impressions to understand the complexity of the structures in the oral cavity. It can even be a method to improve communication between the patient and the practitioner, where this last one can explain where the treatment that the patient will take is heading (Pillai S *et al*., 2021, Tian Y *et al*., 2021, Nešić D *et al*., 2020).

Technological foundation

As previously mentioned, the digital workflow is a series of steps involving traditional manual and modern digital techniques. One of the most common methods for obtaining a three-dimensional image is the use of the CBCT technique, which uses X-rays to take a stack of 2D images making a curved path of the anatomical structure without image overlapping, so that by browsing the images in a specific program it is possible to understand and observe the 3D nature of the piece. This type of radiation can be harmful to the health of exposed people, due to this the term ALARA has been coined, which means "As Low As Reasonable Achievable", referring to the use of the smallest amount of radiation on the patient, but sufficient to obtain a quality 2D or 3D image depending on the desired image (Vandenberghe B., 2018).

In general, the image programs are closed software (where a payment is needed for a license in order to use the program) so it is not possible to open them in an interface of some three- dimensional design program, consequently the need for additional software that transforms the CBCT image file to an STL format, where the dental arch model is represented by a mesh of triangulated points, which allows the use of specific 3D manipulation tools and thus observe and analyze the anatomical characteristics to identify sites of anchoring for implants and thus designing surgical guides and obtaining dental models for the manufacture of implants (De Morais Alves Da Cunha, 2021).

Finally, the printing of 3D models is carried out mainly with two different techniques, stereolithography and extrusion of thermoformable material. Stereolithography consists of the use of mirrors that move beams of ultraviolet light that fuse a surface with the photoreactive liquid resin, adding layer by layer that covers the already cured surface. The advantages of this 3D printing method are: high resolution and printing precision; It is suitable for printing with fine details and adapts to a wide variety of materials. However, the printing cost is quite high, the part is mechanically weak and the laser constantly requires maintenance. The

material extrusion method consists of continuous stacking of material from a nozzle by means of pneumatic or mechanical forces. A thermoplastic is usually used as the main material; it is subjected to a specific temperature to melt it and allow the extrusion of the filament with moldable and bonding characteristics between the layers. This technique is used to obtain a rapid and low-cost prototype and there is a greater variety of materials that can be used, such as PLA, polypropylene and polycarbonate (Pillai S *et al*., 2021, Tian Y *et al*., 2021).

The decision to take one or another printing method will depend a lot on the expected cost per piece, the size, the printing precision wanted and the material to be used. The materials vary with respect to the application that will be given to the piece, which is why in dentistry the use of ceramics, hydrogels, plastics and even cells for regenerative treatments is being explored (Pillai S *et al*., 2021).

Actual trends

In general, certain advantages such as rapid production, high precision and customization make 3D printing a very useful technique for some clinical treatments by reducing costs, creating personalized parts and simplifying the production of dental appliances. The aesthetic and comprehensive improvement in the placement of implants and cases of reconstruction surgeries have shown better results in procedures assisted by biomedical methods than those performed with traditional techniques (Tian Y *et al*., 2021).

In the area of dentistry, Hernández (2021) in her experimental model establishes that it is possible to use CBCT to obtain images of teeth that have undergone an endodontic procedure in order to design anatomical posts as an exact replica of the canal, her results were pieces that clearly need improvement; Here bioengineering techniques to optimize the design process in the appropriate software and choosing the 3D printing method are of great help to continue with the production of prototypes, as well as the search for biomaterials that more adequately represent the composition and resistance of a healthy tooth (Hernández Ovíes, 2021).

CONCLUSION

The digital workflow methodology represents the bridge that unites dentistry with bioengineering, it seeks to optimize clinical procedures through the use of computational processes coming from engineering, but also understanding the anatomical function of the pieces designed and manufactured.

Within the area of bioengineering, the digital flow technique can separate into its three bases and improve each of them, the correct maintenance of image taking devices, the improvement of file manipulation and three-dimensional models to avoid losing details in the structures by transforming the formats of the acquired images, and continue exploring 3D printing methods to improve the quality of the results, as well as the use of different materials that can further correspond to the ideal characteristics of the dental pieces.

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