A Comprehensive Assessment of Various Aspects of Digital Workflow in Prosthodontics: A Review

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Abstract

Digital revolution is changing the workflow and operating procedures in Prosthodontics. Every step from diagnosis and impression making to fabrication of prosthesis has digital replacement. Recent advances in sensor technology have markedly improved the performance of intraoral scanners. Availability of affordable three-dimensional Cone-Beam Computed Tomography systems with development of inexpensive X-ray tubes, high-quality detector systems, metal artifact reduction software has increased interest in dental Cone-Beam Computed Tomography. Indication of Cone-Beam Computed Tomography in dental implant cases may go beyond diagnostics, to designing templates for guided implant placement. Digital photography when combined with the use of appropriate software for image processing has become a valuable tool for smile designing. Currently, Computer Aided Designing software has increased applications in complete denture and partial denture framework designing. Another technology gaining much attention in recent years is additive manufacturing also known as three-dimensional printing of various dental prosthesis, surgical guides etc. Dentists have started thinking of using a "virtual patient" by integrating different file formats into a single model. This study article discusses recent technologies and workflow in a Prosthodontic Clinic

Keywords: Digital Dentistry; Prosthodontics; Implant Dentistry; Additive Manufacturing

Introduction

The digital revolution is impacting nearly every aspect of our daily life. Today, it is nearly impossible to find a person that is not connected to the internet and performing regular tasks using a mobile device. While many advantages exist with this connectivity, there are disadvantages as well. This digital technology has also boon in medical field. While diagnostic means and treatment concepts are being continuously refined, the emergence of new technologies is driving the implementation of new concepts with the goal of improving patient care and offers the new generation of physicians and scientists better learning and development opportunities.

What is the Digital Workflow?

The digital workflow in reconstructive dentistry has been described by Att and Gerard (2014)1 as comprised of three main components; starting with data acquisition, followed by data processing and planning, and finally with the execution of treatment or fabrication (Fig 1).

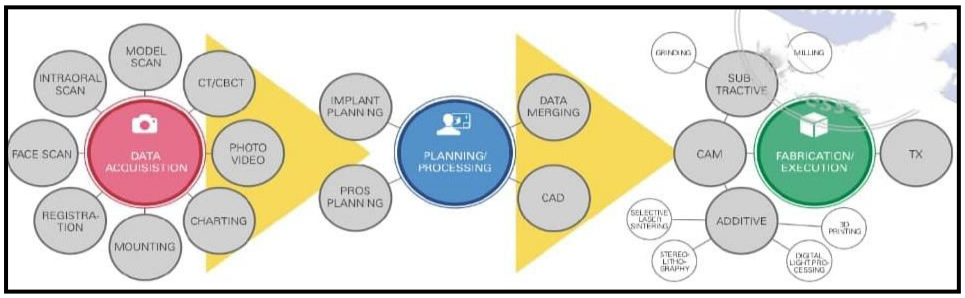

Fig: 1

For the first component "data acquisition," there are many technologies available. The goal is to transform the patient's information into digital data that can be used for further steps, such as analysis, treatment planning, and processing/planning. Some of the acquisition techniques available encompass digital charting, intraoral or desktop scanners, digital radiography, digital photography, video recordings, and so on. As an example, digital photography is considered an important acquisition tool. It is widely used today for documentation and communication purposes. Together with the appropriate software and online or cloud-based communication platforms, the photos can be used as a part of comprehensive treatment and esthetic analysis and, at the same time, as an important communication tool among the dentist, the dental lab, and the patient. In cases of smile enhancement, for example, providing photos and videos of different stages of the rehabilitation (try-ins, mock-ups, and so on) helps the dental laboratory technician to optimize the esthetic reconstruction, thus reducing the in-office patient treatment time during try-in. On the other hand, the use of intraoral scanners to perform computer-assisted impressions is considered today as a predictable and a fast tool for the purpose of digitizing and manufacturing small unit reconstructions. The next step of the workflow encompasses "processing/planning" of the data acquired in order to set a treatment plan or design a restoration. One of the important aspects here is so-called data matching, where data sets obtained from different acquisition tools (e.g., intraoral scan and cone-beam computed tomography (CBCT) or patient photos superimposed onto model scans) can be merged/superimposed together using specific planning software in order to enhance the information for the dentist or lab technician on the computer screen. Most software companies are intensively working on introducing software that can combine more than two different data sets (e.g., surface scans of the intraoral situation,CBCT, face scan, jaw movement data, and so on). The ultimate goal is to create the completely virtual patient. Such a development would push the digital workflow at an even speedier pace and allow for faster adaptation by practitioners, technicians, and teachers. For clarity in "treatment and fabrication," it is important to mention that CAD/CAM is considered as a component of the digital workflow. Per definition, CAD is the use of a computer to assist in the creation, modification, analysis, or optimization of a design. CAD software is used to improve the productivity of the designer, the quality of the designs, and the communication through documentation as well as to create a database and a three-dimensional file for manufacturing. Once the CAD process is complete, the generated files are transferred to a local or a remote CAM solution. Here, a software and process are required to enable fully automated manufacturing of dental restorations by preparation of the generated CAD files for subtractive or additive manufacturing machines. While CAM has been successfully performed via subtractive techniques, the increased use of additive manufacturing technologies, such as 3D printing, stereolithography, selective laser sintering, and other methods is remarkable.

Data Acquisition

As already described, data acquisition is the first step of the digital workflow.While many acquisition technologies exist, the most-used components are patient management systems, including dental charting software and radiography. While dental offices performing patient registration and "conventional" charting by means of paper form are becoming history, many dental offices and dental schools are using the digital approach using different commercially available software for Electronic Protected Health Information (ePHI). With such software, different patient data and information can be obtained and stored for later use.Typically, medical and dental history as well as comprehensive charting, including radiographic analysis, can be stored. Large-scale clinics and

institutions use network-based software that facilitates access of patient data from different working stations. However, concerns remain about patient privacy and data access. For these it is highly recommended to use software that guarantee patient information (i.e., which implement the ePHI). To facilitate this, the software is required to be compliant with the Health Insurance Portability and Accountability Act (HIPPA) in the United States or with the General Data Protection Regulation (GDPR) across the European union. The goal is to protect all "individually identifiable health information" held or transmitted by a covered entity or its business associates, in any form or media, whether electronic, paper, or oral. "Individually identifiable health information" is information, including demographic data, that relates to (a) the individual's past, present, or future physical or mental health or condition; (b) the provision of healthcare to the individual; or (c) the past, present, or future payment for the provision of healthcare to the individual; and that identifies the individual or for which there is a reasonable basis to believe it can be used to identify the individual. Individually identifiable health information includes many common identifiers (e.g., name, address, birth date, ID number, social security number, and so on). Further identify -radiographs, models, intraoral scan data, face scan data, or any other identifiable data. Therefore, it is important for all staff members of any clinic or institution to understand and implement patient privacy standards and guidelines.

Data Processing/Planning and Treatment

Planning

While some software incorporate both acquisition and processing/planning capabilities, the majority of developers currently separate them in different software to avoid complexity and introduce clarity into the workflow. Data processing/planning software can be introduced by the same manufacturer of the acquisition device/tool or by another. A good example is the use of acquisition software for an intraoral scanner and CAD from the same device manufacturer (e.g., Sirona or 3Shape). Another possibility is to use processing/planning software that is developed by a different manufacturer than the acquisition software. An example here is the use of CBCT data obtained from a specific manufacturer and imported into implant planning software from a different developer. While this procedure is common, it is important to have the files/data prepared in universal way that the majority of the software can read. Here, the most commonly used universal file formats, among others, are Joint Photographic Experts Group (JPEG), Digital Imaging and Communications In Medicine (DICOM), Standard Tessellation Language (STL).

Geometry

Typically, the processing/planning software can be used for analysis and diagnostics (e.g., caries and lesion detection), treatment planning (virtual mock-up, virtual implant treatment planning, virtual orthodontics treatment planning, and so on), or CAD. In terms of caries and lesion detection, several companies are working now on introducing AI for automatic detection of caries as well as further pathological lesions from radiographs, namely periapical radiographs, panoramic radiographs, or CBCT. Also, AI is being implemented for automatic annotation of different anatomical structures, such as mandibular nerve, impacted teeth, maxillary sinus, floor of the nose, and others. Likewise, there are undergoing developments to enable automatic detection and segmentation of the teeth from CBCT and creation of separate files (STLs) of the teeth, as well as the bony structures. The implementation of such technologies in the near future will accelerate the workflow and enhance the diagnostic experience for the clinician, thus providing a better healthcare service for the patient.

Data processing/planning software for treatment planning is one of the most important components of the digital workflow. It is not only intended for communication between the patient and the treatment team, but also an important tool for treatment planning and expectations. A good example is implant planning software, where CBCT data (typically DICOM files) is imported into the software and used to plan the implant position virtually with consideration of the anatomical structures as well as the restorative needs. Another application is the use of patient facial photographs in combination with calibrated intraoral scan or model scan data to analyze and plan the future esthetic rehabilitation (e.g., smile design software) in terms of tooth length, width, and proportions, as well as shade, and share the information with the patient as well as the treatment team. While such features facilitate design capabilities, CAD is considered the last component of data processing/planning. Here, the software is used to design the form of the intended object (e.g., crown, prosthesis, surgical guide, night guard, virtual wax-up, and so on) before moving to the last component of the digital workflow.

Execution of Treatment or Fabrication

The last component of the digital workflow is to perform the planned treatment or production of the intended object by means of computer-aided

manufacturing (CAM). CAD data is imported into CAM software, where details of the production process can be simulated and executed (e.g., placement of supportive structures or simulation of the milling/grinding process). Both the subtractive and the additive manufacturing technologies are available for CAM. The subtractive technologies can be subcategorized into milling and grinding. It is considered as the most widely spread manufacturing technology. The manufacturing machines can be divided into chair side or lab units. In the former option, the unit is typically intended for the manufacture of single-unit restorations during the same office visit. For a larger-scale production and more demanding units/restorations, the latter option is selected. The milling machine can be either in an office, a laboratory, or a central manufacturing facility. On the other hand, additive manufacturing is becoming increasingly popular. Here, several methods are available for manufacturing of an object, including but not limited to selective laser sintering (SLS), digital light processing (DLP), stereolithography (SL), and three-dimensional printing (3D printing). The latter technology is considered to be the most up to date and improving day by day. However, the scientific evidence about its accuracy and efficiency is still limited. Comparatively, the other additive manufacturing technologies are well established. For example, SL is considered for a long time as the method of choice for central manufacture of surgical guides or models with a predictable accuracy. Also, SLS is being used to produce nonprecious alloy frameworks of crowns and fixed partial dentures with a predictable accuracy. While many techniques already exist, significantly further technologies and materials for additive manufacturing are expected to be introduced within the next few years.

Conclusion

Digitization started to influence dental fraternity with the form of audio visual aids in both teaching and patient education. Digitization has become part and parcel of contemporary prosthodontics with the probability of most of the procedures being based on digital techniques in near future. Let us think of X-rays or photographs, making impressions, recording jaw movements or fabricating prosthesis, educating and training new dentists or patient motivation for practice build up, all has become digital. Today a practicing dentist needs to be equipped with the latest fast changing technology so as to pose a great challenge. The literature regarding recent techniques helps us assimilate latest trends for benefit of patient and expansion of dental profession as whole. The transition from old to new occurs with the basic aim of making patient's life better.

References

1. Ueda Y and Yamaguchi T. "History of and current situation regarding dental CAD/CAM systems and future perspectives". Hokkaido Journal of Dental Science 38 (2017): 104-110.
2. Joda T., et al. "The complete digital workflow in fixed prosthodontics: a systematic review". BMC Oral Health 17.1 (2017): 124.
3. Mangano F., et al. "Digital Dentistry: New Materials and Techniques". International Journal of Dentistry (2016).

   4. Bhambhani R., et al. "Digitization and Its Futuristic Approach in Prosthodontics". The Journal of Indian Prosthodontic Society 13.3 (2013): 165-174.
4. Prithviraj DR., et al. "Revolutionizing Restorative Dentistry: An Overview". The Journal of Indian Prosthodontic Society 14.4 (2014): 333-343.

   6. Cooper F L and Ludlow M E. "The Current Impact of Digital Technology in Prosthodontics. Digital White Paper". ACP Digital Dentistry Resources (2016): 1-11.

   7. Shah N., et al. "Recent advances in imaging technologies in dentistry". World Journal of Radiology 6.10 (2014): 794-807.
5. 8. S Ting-Shu and S Jian. "Intraoral Digital Impression Technique: A Review". Journal of Prosthodontics 24.4 (2015): 313-321.
6. 9. Zimmermann M., et al. "Intraoral scanning systems - a current overview". International Journal of Computerized Dentistry 18.2 (2015): 101-129.
7. 10. Mangano F., et al. "Intraoral scanners in dentistry: a review of the current literature". BMC Oral Health 17.1 (2017): 149.
8. 11. Martin CB., et al. "Orthodontic scanners: what's available?". Journal of Orthodontics 42.2 (2015): 136-143.
9. 12. Sakornwimon N and Leevailoj C. "Clinical marginal fit of zirconia crowns and patients' preferences for impression techniques using intraoral digital scanner versus polyvinyl siloxane material". Journal of Prosthetic Dentistry 118.3 (2017): 386-391.
10. 13. Imburgia M., et al. "Accuracy of four intraoral scanners in oral implantology: a comparative in vitro study". BMC Oral Health 17.1 (2017): 92.
11. 14. Aragón ML., et al. "Validity and reliability of intraoral scanners compared to conventional gypsum models measurements: a systematic review". European Journal of Orthodontics 38.4 (2016): 429-434.
12. 15. Ahlholm P., et al. "Digital Versus Conventional Impressions in Fixed Prosthodontics:

A Review". Journal of Prosthodontics 27.1 (2018): 35-41.