

ETHICAL AND MEDICO-LEGAL ASPECTS BEHIND THE USE OF DIGITAL TECHNOLOGIES IN DENTISTRY

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Abstract: Digital dentistry became a part of everyday practice in the dental profession. Despite of the extensive number of publications on digital dentistry, the ethical and medico-legal challenges, involved with integrating this technology in daily practice, were insufficiently addressed.

The aim of the present review was to assess the impact of the digital technologies on dental professionals and patients, with respect to ethical and medico-legal aspects. Challenges arising from the use of telemedicine and the virtual patient were also discussed.

Web of Science, Pubmed/Medline, Scopus (Elsevier) and ScienceDirect database were assessed for articles in English language, using the following key words, in different combinations: “digital technology”, “dentistry”, “ethical”, “legal”, and “malpractice”. A hand search in the relevant journals was also performed. Included papers have been pooled in the 5 different topics to be addressed: digital imaging investigations, digital prosthodontics, digital oral and maxillofacial surgery, digital orthodontics and teledentistry.

Regardless of the advantages and great predictability offered by the tremendous technological progresses in the last years, the practitioner should firstly use his clinical rational, be aware of the responsibility involved, and be a companion and evaluator of the technical support provided by the digital environment, instead of excessively rely only on digital devices.

Key words: digital dentistry, ethical issues, malpractice, CAD/CAM.

INTRODUCTION

Among all the medical professions, dentistry experienced, in the last years, a great amount of technological growth. Digital dentistry, defined as “any dental technology or device that incorporates digital or computer-controlled components in contrast to that of mechanical or electrical alone” [1] became a part of everyday practice in the dental profession. Some of the major areas incorporating digital dentistry are prosthodontics with the use of computer-aided design and computer-aided manufacturing (CAD/CAM) technology both from clinician and laboratory; shade matching using spectrophotometry; photography intra-oral and extra oral; occlusion and temporomandibular joint (TMJ) analysis; computer-aided implant dentistry,

including design and fabrication of surgical guides to full digital work-flow; digital radiography, including cone beam computed tomography (CBCT), widely used in all fields of dentistry; lasers; practice and patient record management, including digital patient education tools, and so on [2].

The “digital revolution” in medical and dental field also includes the use of social media, internet sites and instant messenger services for professional networking, sharing information on patient treatment outcomes, seeking advice for difficult clinical situations, discussing new products or new technologies, sharing recommendations and healthy behaviours amongst the public and communicating with patients [3].

Despite of the extensive number of publications on digital dentistry, the ethical and medico-legal

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challenges, involved with integrating this technology in daily practice, were insufficiently addressed.

Therefore, the aim of the present review was to assess the impact of the digital technologies on dental professionals and patients, with respect to ethical and medico-legal aspects. Challenges arising from the use of telemedicine and the virtual patient were also addressed.

METHODS

For this narrative review, Web of Science, Pubmed/Medline, Scopus (Elsevier) and Science Direct database were assessed for articles in English language, using the following key words in different combinations: “digital technology”, “dentistry”, “ethical”, “legal”, and “malpractice”. A hand search in Romanian Journal of Legal Medicine, Quintessence International, British Dental Journal, and in the references of the identified articles, was also performed. Included papers have been pooled in the 5 different topics to be addressed: digital imaging investigations, digital prosthodontics, digital oral and maxillofacial surgery, digital orthodontics and teledentistry.

The ethical challenges addressed by the extensively used of digital technology in dental daily practice followed the four principles proposed by Beauchamp and Childress in their classic textbook, “Principles of Biomedical Ethics”, which are: respect for autonomy; non-maleficence; beneficence; and justice [4]. The following questions were posed: Was the proposed treatment respecting the autonomy principle with a good understanding of the risks and benefits involved and consent signed by the patient? Was the treatment beneficial for the patient? Could it be harmful? Was the treatment respecting the principle of justice? Could any concerns regarding inequity be raised? Beside the ethical issues, the medico-legal aspects were also being considered.

RESULTS AND DISCUSSIONS

Digital imaging investigations

Within the last years, the occurrence of advanced imaging techniques, such as the cone beam computer tomography (CBCT) scan, applied in various clinical situations to enhance the accurate diagnostics and treatment of patients for routine use, even for children and adolescents, raised the discussion of ethical issues.

Nowadays, CBCT has been integrated, as

a standard protocol, into the current work-flow for virtual treatment planning in dental implantology, orthodontics, maxillofacial surgery, endodontics and comprehensive cosmetic dentistry, aiming to improve the clinical predictability and treatment’s success rate [5–9]. Hereof, by recommending a CBCT scan, the dental professional is fulfilling the principle of beneficence, or the ethical duty to promote the patient’s welfare. However, prescribing a CBCT scan for all patients, regardless of whether they have indications for three-dimensional imaging, or if other methods, producing less radiation, could be used to achieve the same clinical outcome, is harmful and leads to unethical behaviour. In order to respect for the autonomy principle, the patient needs to be correctly informed regarding the risk of radiation exposure during the imaging investigation, the benefits and alternatives and written consent should be obtained [6, 10]. A smallest possible field of view (FOV), targeted on the area to be examined, should be indicated by the dentist, also, lowest intensity and shortest exposure time need to be used. For reducing the radiation dose, new reconstruction algorithms were performed and a variation of the acronym ALARA (“As Low As Reasonably Achievable”) was proposed at the National Council on Radiation Protection of United States Annual Meeting 2014, “As Low As Diagnostically Acceptable” (ALADA), to emphasize the need of dose optimization, especially for children and young adults [11].

The ethical dilemma of using CBCT scans for the diagnosis and treatment of patients is a complex one. For instance, digital work-flow for guided implant insertion is widely accepted and highly predictable, providing a minimal invasive approach and avoiding critical structures during surgical procedure. But, if the patient, dismiss the CBCT scan, without apparent consideration of the sound clinical indications, the clinician need to respect the patient’s wish and should offer him clear alternatives or additional time to seek another opinion [12, 13]. However, if CBCT is clearly recommended for bone volume and density evaluation prior to implant surgery, for postoperative assessment in the absence of complications, conventional radiographic techniques are adequate to confirm the position of an implant in relation to anatomical boundaries [14]. Even for research purpose, to evaluate accuracy of implant placement, alternate techniques could be used, such as comparing planned with post insertion digital files [15].

Another important issue for digital imaging concerns patient’s data protection. The General Data

Protection Regulation (GDPR) became law in all European member countries on 25 May 2018, and according to it, data processing including collecting, storing, using, disclosing and destroying personal information such as dental records must be done on a “legal basis” and on patient’s consent, based on the accurate understanding of the purpose for which his/hers data will be processed [16]. Sharing digital imaging between the clinician and the dental laboratory or between dental professionals should be done using secure transfers and protect patient’s privacy and also have his/hers written consent.

Malicious manipulation of digital clinical records, for avoiding malpractice litigations is also possible, in a much easier way comparing to analogue data [17]. For example, in a recent study performed by Díaz-Flores-García and co-workers, 66 dentists were invited to evaluate 20 intra-oral dental X-ray images, 10 originals and 10 modified, manipulated using Adobe Photoshop. Dentists were correct in identifying the manipulated image only in 56% of the cases. To avoid the risk of digital radiography manipulation, a protocol for detection/validation of the original radiographic images need to be establish [18].

Digital prosthodontics

The tremendous technological progresses in prosthodontics, in the recent years, due to extensive use of intra-oral scanners, complex software programs for design, milling and 3 dimensional (3D) printing machines and new materials, contributed to significantly improve accuracy and treatment outcome. Included in the digital work-flow, the Digital Smile Design (DSD) tool provides, from a facial perspective, rehabilitative aesthetic planning, better communication between specialists and improvements in the expected outcome of the treatments.

Beside for excellent communication with the patients and between dental professionals, DSD offers the clinician a tool to make the correct therapeutic decision through mathematical algorithms [19]. The treatment for giving an “aesthetic smile” to patients, by simulating and pre-visualizing the therapeutic result, is addressed to the different anatomical areas involved in the treatments, like the teeth, gingiva, mucosa, lip, skin, and so on, and rely on symmetry, shape, and golden proportions [20]. With its minimal invasiveness and predictability, DSD is beneficial for the patients. Moreover, the digital visualization of the final outcome of the treatment, before any intervention, makes it comprehensive and easy acceptable to the patient

who can take informed decisions in accordance to the respect of autonomy ethical principle. By sharing decision making with a patient who fully understands the treatment plan, a true consent form can be given, after assessing the implications of the decision being made.

An ethical problem arises when the patients are not receptive, “not-adopting” or without affinity for technology. Such patient will need to cope with digitalization, or rely on the decision taken by the dentist [2].

Some other shortcomings of the use of smile design in aesthetic dentistry were addressed in the editorial published in 2011 by Stephen Hancocks, who stated, regarding the unrequired aesthetic makeover for a “Hollywood” perfect smile, with frontal teeth enamel “sacrifice on the altar of vanity”, that “the less we do, the less likely there is to be a disappointment, a scene, a failure of expectation, the threat of litigation, the need for further intervention and most crucially the lack of impetus for more dentistry”[21].

Aesthetic treatment comes with important ethical dilemma: What are the patients who will really benefit of aesthetic improvements? Is it worth doing “aesthetic good” with the risk of long-term, collateral biologic damage? Or, beside aesthetics, are there some serious occlusive problems or loss of vertical dimension of occlusion (OVD) and so on, in the need to be solved prior to the aesthetic makeover? Over-treatment, any unnecessary, inappropriate, or excessive treatment decisions, based on the economic needs of the dentist rather than the clinical needs of the patient is a serious ethical issue, leading, many times, to malpractice litigations [22, 23].

Another important progress in treatment planning was obtained, by integrating facial scanners in the prosthodontic work-flow, with applicability for the fully edentulous patients. Facial scan integration was proposed to accelerate the rehabilitation procedure starting from immediate denture to final implant-supported prosthesis and leading to more predictable functional and aesthetics outcomes. Using digital designed files and subtractive or additive CAD/CAM technologies, the prosthodontic treatment of the elderly patients became shorter, more accurate and greatly predictable [24–26].

The virtual patient is already an adopted concept in dentistry, obtained through the superimposition of intra-oral scan (digital impression), CBCT, and extra oral face scan, with important advantages such as: simulation of treatment planning and discovering

patients expectation; facilitating for more effective patient and colleague communications as well as implementation in dental education; non-invasive imaging technique for high-precision anatomical documentation; and wide-range use in the fields of maxillofacial and plastic surgery [27]. The procedure is beneficial for the communication with the patient, increasing his understanding and acceptance of the proposed treatment, but, to date is mainly applied for research purpose in removable prosthodontics and not yet accessible to all cases. However, the autonomy principle is mandatory to be followed, privacy concerns need to be taken care, and obtaining informed consent is required for sharing patients' data with the dental laboratory and colleagues from other specialties.

Digital oral and maxillofacial surgery

Digital technological developments in oral and maxillofacial surgery aimed to reducing invasiveness in surgery, allowing for smaller incisions, decreased blood loss, decreased pain/analgesic use, and faster patient recovery. In this respect, surgery could be planned or assisted in an efficient manner using different tools such as: customized 3D printed anatomical replicas, cutting guides for osteotomy design used in orthognathic surgery, implant placement guides or new techniques. An example is the Transoral robotic surgery (TORS), a computer assisted surgery where the surgeon controls the movement of various robotic arms distantly from a console. The use of this technique has reported to eliminated the need for mandibulotomy for the resection of tumors in the oropharynx [28].

In spite of the great benefits for the patients, most of these technologies require a great amount of initial investment, a certain learning curve, and must be carefully applied. The ability to perform open approach may be necessary as a result of equipment failure or intra-operative complications.

Digital and computer assisted technologies have been particularly helpful in reconstructive surgery following trauma or ablative surgery, by offering customized implants and rapid rehabilitation of the patients in an area with challenging esthetic and functional demands, with the result of significantly increasing their quality of life. The CAD/CAM 3D printed maxillofacial prosthesis could solve an important ethical issue raised for patients with reserved prognosis, by offering them a chance for social re-integration, with high psychological impact and great beneficence to the individual's well-being.

Digital orthodontics

By introducing 3D imaging (CBCT and facial scanning) with the optical impression (intra-oral scanning) in various software platforms, a complete three dimensional virtual representation of the orthodontic patient could be obtained. Moreover, the virtual models could be used to simulate various treatment effects, facial changes in real time and perform linear and volumetric measurements [29]. These digital tools facilitate the communication with the patient as well as the acceptance of the treatment, increasing their motivation.

Clear aligner therapy, introduced two decades ago, based on digital designed aesthetic appliances with attachments for control of tooth movements, digital lingual appliances combining virtual set-ups, customized printed bracket and robotic wire bending, virtual bracket positioning and the constructions of indirect bonding trays, are examples of the digitalization of orthodontic appliances manufacture [29,30]. These digital devices are claimed to be highly efficient but are not free of complications. For example, the undesirable effect of apical root resorption [31], a iatrogenic effect of orthodontic treatment, also occurred in patients treated with clear aligners [32]. Beside the fact that digital appliances are more prone to be accepted by the patients due to pre-visualization of the results, the esthetic appearance and the claimed shortening of treatment's duration, long-term randomized clinical studies with these new technologies are necessary for their validation.

Telemedicine / Teledentistry

Teledentistry, defined as the remote provision of dental care, advice, or treatment through the medium of information technology, rather than through direct personal contact with any patient(s) involved [33], is applied in preventive dentistry, orthodontics, periodontology, oral surgery, oral medicine, patients education. Some examples are: distance-diagnosis of oral diseases, referrals for periodontal surgery, screening schoolchildren for signs of early caries, referrals of orthodontic cases, or educate orthodontic patients in relation to minor emergencies encountered during the course of treatment, among others.

Teledentistry was conceived to be an accessible tool for decreasing the disparity and ensuring equality in providing oral healthcare services. However, due to the misunderstanding of the concept, some ethical concern occurred. An example with ethical issues is the Do-it-yourself (DIY) orthodontic treatment, claiming

to provide aesthetics and functionality for patients and a beautiful smile at reduced financial costs, in the comfort of his home. After answering several questions and sending impressions, a series of clear aligners are provided and the patients are monitored by general dentists or orthodontists through teledentistry. Without being priority evaluated by a dental professionals, the applied treatment could be harmful to the existing dental problems. For example, caries or periodontal disease could be worsened by wearing DIY aligners [34].

To overcome the ethical challenges posed by this type of medical care, regulations and protocols were proposed by American Dental Association. Firstly, the treatment of patients who receive services *via* teledentistry need to be properly documented. Also, dentists who deliver services using teledentistry must establish referrals protocols when necessary [35].

In conclusion, a great number of positive effects of digital dentistry were seen in all specialties, in the form of better communication between the dental professional and the patient, qualitative improvement of treatment, better accessibility to dental care. However, risks and ethical challenges are frequent and need to be identified.

When the final treatment decision relies only on digital technology and, due to some technical errors, the clinical results are inadequate and harmful to the patient, the clinician is the final legal authority responsible.

Regardless of the advantages and great predictability offered by the tremendous technological progresses in the last years, the practitioner should firstly use his clinical rational, be aware of the responsibility involved, and be a companion and evaluator of the technical support provided by digital environment, instead of excessively rely only on digital devices.

Conflict of interest

The authors declare that they have no conflict of interest.

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