DIGITAL TECHNOLOGY IN PAEDIATRIC DENTISTRY AND ORTHODONTICS

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Abstract

Digital dentistry is a concept getting more and more contour nowadays, due to the latest technological advancements registered in the field. This paper makes a review of the existing digital technologies in dentistry, which have proven their usefulness in Pediatric Dentistry and Orthodontics, as well. Whether they aid diagnosis, or simplify procedures for both pediatric dentist and patient, or create a friendly environment, digital devices contribute significantly to increasing the quality of the therapeutic act.
Keywords: *pediatric dentistry, digitalization, patient-friendly.*

1. INTRODUCTION

Advancements in technology have led medicine to a new era. Digital dentistry is not a concept anymore, but a full hands-on reality today, enabling patients to receive modern solutions to traditional dental problems. Among the digital technologies available for dentistry, there are some which have already proven their usefulness in Pediatric Dentistry, as well. *Digital radiography*, along with a range of modern *non-invasive caries detection tools*, aid the practitioner in diagnosis, while *computer-controlled delivery of local anesthetic or nitrous oxide, digital impressions*, *CAD/CAM restorations*, *digitally-based surgical guides* enhance treatment possibilities. *Digital photography* and *virtual reality* are particularly useful in patient management, especially in pediatry, as growth monitoring and behavioral management are two of the main concerns in Pediatric Dentistry. All above mentioned techniques incorporate the latest technological findings and aid practitioners to provide their patients a leading-edge dental treatment, with improved efficiency, precision and comfort.

2. DIGITAL RADIOGRAPHY

Early detection and diagnosis of the carious lesion is a primary consideration of the Minimal Intervention Dentistry (MID) concept, being particularly important in pediatric patients, due to the rapid caries progression in primary teeth [1,2]. As the primary enamel is thinner than the permanent enamel, its mineral content is lower, its porosity is higher and caries lesions progress faster than in permanent teeth[3]. It was suggested that radiographic examination should be included as part of the initial patient assessment and also in the process of monitoring lesion behavior over time. Radiographs are the most used detection aids using the bitewing technique. The aim of bitewings is to detect proximal caries lesions that cannot be observed by visual inspection. However, in occlusal surfaces, the contribution of radiographs seems to be minimal[4]. Lately, digital radiography has taken over the conventional radiography techniques. A digital sensor is used instead of the conventional film and the radiographic image is stored in a computer. Two types of digital receptors can be used in image acquisition: charge-coupled device (CCD) or photostimulable phosphor (PSP). Digital radiographs permit the use of computer facilities, such as image enhancement and processing, and even the possibility of sending images to other colleagues

[5-7]. The main advantages of digital intraoral radiography systems are that they result in fewer errors in the image and fewer environmental problems, since they use no chemicals. They also save time and reduce the dose to the patient, once the receptors are more sensitive to radiation. These advantages are significant when dealing with children, especially when working with a dynamic digital image. It is possible to improve images using image enhancement facilities; this could prove interesting for use with impatient children [3].

3. DIAGNOSTIC TOOLS

Improved visual detection of the carious lesions is now possible with the aid of **light-transmission devices** that use a new technology, based on tooth illumination at different wavelengths, and assessment of the fluorescence scattered by dental tissues. It is a completely non-invasive alternative to conventional bitewing radiographs. The added possibility of obtaining digital images that can be stored and later compared with images taken at certain time interval follow-ups enlarges perspective over conservative treatment success[8]. Various light-transmission devices are currently available on the market.

SoproLife® is an intraoral camera improved with a light-emitting diode (LED). It works on the principle of auto-fluorescence of the dental tissues when illuminated with a light of a certain wavelength[1]. The device combines a high-magnification intraoral camera (of more than 50×, using three illumination modes: daylight, diagnosis mode, and treatment mode) and a detection system that, according to the manufacturer, can trace and locate differences in density, structure, and/or chemical composition of a biological tissue[9].

Q-Ray® Camera from Inspektor Research Systems and **Fluorecam®** from Therametric Technologies use the QLF technology. QLF is a diagnostic aid for detection, quantification and monitoring of early enamel demineralisation. It operates on the principle of enamel autofluorescence, detecting and quantifying the loss of fluorescence associated with demineralization[4].

DIAGNOdent™and **DIAGNOdent™ Pen** by Kavouse laser fluorescence to measure the amount of bacterial metabolites (porphyrins) from the hard dental tissues. It shows a better performance in more advanced lesions [10,11].

DIAGNOcam by Kavo, using a Digital Fiber Optic Transillumination (DIFOTI) technology, is a useful tool in the detection of approximal caries, based on a light scattering phenomenon, for increasing the contrast between normal and carious enamel. With the aid of a CCD sensor, images are acquired and stored into a computer. A dedicated software is used to visualize and process data[4].

4. COMPUTER-CONTROLLED NITROUS OXIDE SEDATION

Sedation for pediatric patients is an essential tool in anxiety management, being used as an adjunct to behavior management. The combination of inhaled nitrous oxide (N_2O) and oxygen (O_2) is a safe and effective means of managing pain and anxiety in pediatric dentistry, when appropriately used. Indications for use of nitrous oxide/oxygen analgesia/anxiolysis include: fearful, anxious, or obstreperous patients, special-needs patients, patients with gag reflex that interferes with dental care, cooperative children undergoing lengthy dental procedures [12-14].

The usual analgesia equipment used by dentists includes a N_2O and O_2 delivery system, a gas mixing bag, and a nasal mask or nasal canula with a positive pressure relief valve. The nitrous oxide delivery system must be connected to an appropriate scavenging system. The inhalation equipment must have the capacity for delivering 100%, and never less than 30% oxygen concentration, at a flow rate appropriate to child's size. The gas concentration delivered routinely through the nasal mask for a dental procedure ranges between 25%-50% N_2, mixed with O_2. Nitrous oxide delivery systems allow the practitioner to control the mixture of gas a child is receiving, in order to provide the appropriate dose for the patient and the procedure. While some of these systems are controlled manually, the latest units on the marked benefit from a digital flow control unit. Significant and recent changes in safety protocols relate to the technology used to control the precise flow of gases delivered through the inhalation sedation unit. Although the old flow tube flowmeter technology is still available, it is being replaced by the new state-of-the-art digital electronic flow control devices. They are equipped with a digital display of the total flow and percent of oxygen, and with built-in alarms for all gas depletion conditions, ensuring patient safety and simplifying practitioner's work. Furthermore, electronic digital administration heads (gas mixing heads) for delivery of conscious sedation advance the art of dentistry. Various models of the electronic gas mixing head allow mounting as a wall unit, portable unit, countertop unit, or as a flush-mount unit in modern cabinetry. Digital heads, once considered the wave of the future, are the standard today. Digital accuracy and exact control are highly recommended for patients' comfort and safety [15-18].

5. COMPUTER-ASSISTED LOCAL ANESTHESIA

In clinical dentistry and medicine, pain is synonymous with significant discomfort. Painful procedures experienced during childhood have proved to be one of the most important factors behind fear, anxiety and behavior management problems in connection with dental treatment. Local analgesia is an efficient and safe method to control pain[19]. However, administering local analgesia to young patients is a challenge for all pediatric dentists, and is highly technique-sensitive, depending much on operator's skill and experience in working with children. There are a few tips and tricks described in literature for distracting the child from the injection by different means [20,21], especially while performing palatal infiltrations, known as especially painful, due to rapid tissue distension of the adherent mucosa. Regardless of the technique applied, one of the most important factors for attaining a pain-free local analgesia is a slow administration rate of the anesthetic solution. The use of computerized delivery systems permits a very slow delivery of the solution, which is particularly useful when injecting into tissues of low compliance, such as the palatal mucosa and periodontal ligament[22]. Computer-assisted local anesthesia, although it is by far not a new concept, dating from the 1980s[23], has only increased in popularity in recent years. Systems like **STA™ (the Wand)** and **CALAJECT™**,as advertised by the producers, help to deliver pain-free injections. The computerized system ensures a smooth and gentle flow of the analgesic solution at constant speed, which minimizes the pressure during injection and therefore significantly reduces pain [24,25]. Allen *et al.* conducted an investigation to evaluate the efficacy of a computerized injection device (Wand) on reducing pain behavior during injections in preschool-aged children, the results demonstrating that Wand can significantly attenuate disruptive behaviors in a population of young children who are traditionally more difficult to manage, appearing as a method creating a more positive experience for both young child and practitioners[26].

6. DIGITAL IMPRESSIONS AND CAD/CAM RESTORATIONS

Nowadays, not only adult patients, but also pediatric patients are being treated by CAD-CAM systems with great success. Especially primary molars and broken-down permanent first molars are placed utilizing the chairside CAD/CAM technology. Placing indirect composite restorations in place of preformed stainless steel crowns in pediatric patients is preferred by some practitioners for several reasons: a better marginal integrity of an indirect composite, longevity of the restoration, higher aesthetics and a much faster procedure than the lengthy try-in one, that implies determining the proper size of the stainless steel crown, festooning, and cementing. Preparing the tooth, taking the optical impression, milling the restoration using a CAD/CAM technique, and then cementation can be accomplished in about 20 minutes. Generally, these pediatric restorations mill in about 2 minutes, primarily due to their small size [27-29].

Digital technology has also impacted the fabrication of metallic fixed space maintaining appliances, such as the band and the loop [30], and metallic orthodontic appliances, such as the hyrax[31]. Fixed metallic space maintainers can be obtained without making the classical impression or cast, using only a digital technology, for all steps. The entire procedure consists of: a digital impression taken using an intraoral scanner, information processing by specialized software, a 3D print of a transparent resin, which can be checked in the mouth of the patient for proper adaptation, and sent to the lab for packing, for obtaining an analogous metal appliance. The final metallic space maintainer is then fixed intraorally using a resin cement. The clinical outcome shows excellent adaptation of the appliance and points out that the digital approach has definitely proved to be an efficient and predictable method for manufacturing fixed space maintainers[30]. Although, at present, a relatively small number of oral health providers are using CAD/CAM systems in their clinical practice,[32]the numerous advantages of this technology will probably determine more and more dentists to incorporate it in their work.

7. DIGITAL OCCLUSION SCAN

The **T-Scan® System** is an occlusal analysis system designed to measure and record relative biting forces over time, being successfully used in orthodontics[33], prosthodontics [34,35], implant dentistry and patients presenting bruxism or other craniomandibulardisfunctions. The latest model, the 3rd generation system, includes intraoral sensors, scanning electronics (handle) and intuitive software. The mouth-shaped sensor fits into a sensor support that inserts into the sensor handle connected to the USB port of a PC and is easily movable among operatories. The **T-Scan***s*oftware records and stores occlusal data in a patient database, while providing occlusal analysis features that allow dental professionals to determine the first and last contact, the balance of occlusal contacts present at any given moment, as well as to view multiple scans to compare bites. Graphic displays on computer's monitor are also an aid to patient education [36,37].

8. DIGITALLY-BASED SURGICAL GUIDES

Surgical tooth extraction is a common procedure in dentistry. However, in practice, numerous extraction cases show a high level of difficulty, usually related to an inadequate visualization, improper instrumentation, or other factors related to the targeted tooth. With the aid of 3D imaging, computer planning and 3D printing, a new surgical guide was developed to help surgeons overcome the routine complications in dental surgical extraction procedures. Due to the precision of this technology, the accuracy and predictability of surgery is increased. The surgical guide is specifically tailored for each patient with one or multiple teeth that need surgical extraction. The final outcome is a surgical guide fabricated to provide access to the surgical field. Visibility is not important, as the stent is capable of providing direct access to the target area. Surgical extraction using the surgical guide could minimize postoperative bleeding, tissue laceration, and pain. It has recently been used with success in maxillofacial surgery in mesiodens removal, in children and adolescents [38-40].

9. DIGITAL PHOTOGRAPHY

Photography has become an easy and accessible way of educating and documenting our patients. Digital technology has changed the perspective of a dentist toward data collection, academics and treatment aspects. Digital photography is described as images stored in a computerized file format referred to as a digital image file. Digital images are usually acquired by a DSLR (Digital Single Lens Reflex) camera, through a CCD (Charge-Coupled Device) sensor, and can be easily stored and kept for future use for legal or academic purposes [41]. Digital facial photography used for facial growth assessment has significant advantages compared to other techniques. It is non-invasive, bi-dimensional, less time-consuming, it can be subsequently re-evaluated each time it is needed. To obtain precise photographic measurements, the photographic technique has to be standardized [42].

A new innovation has arrived in the field of dentistry, namely **photogrammetry**, through which the geometric properties of objects can be determined from photographic images. Three-dimensional face or dental arch reconstructions are possible using this technology[41]. A photogrammetric system includes two digital high resolution cameras, a high resolution-structured light projector and a PC-controlled rotation positioning stage for plaster's reconstruction. The system uses specially designed hardware for generating 3D models of the dental arch and a software for models setting up, occlusion analysis and individual wire design in the orthodontic treatment[43]. Furthermore, it was demonstrated that three-dimensional digital stereo-photogrammetry can be used as an objective, non-invasive method for quantifying and monitoring facial growth and its abnormalities[44]. Based on a similar principle, **OnyxCeph3™**is a Windows software for visual diagnostic imaging, treatment simulation, surgical predictions, documentation, and online communication in orthodontics and orthognathic surgery[45]. A very useful feature of this software for Pediatric Dentistry is the possibility to determine the dental age on a digital radiograph and to follow the stages of dental eruption. Based on a prediction table, the dental age is directly calculated by the software. All information is stored in a database and can be revisited any time[42,46].

The use of digital photography and virtual study models may allow a durable storage of a fully electronic patient record. This is particularly useful when patients are treated in interdisciplinary teams, with many dental specialists that need facile access to the whole documentation[47].

10. VIRTUAL REALITY

Distraction is a commonly used method by parents and healthcare professionals to help reduce pain and anxiety during painful procedures. Virtual reality (VR) is a new form of audiovisual distraction (AVD) used by clinicians in patients undergoing medical procedures, such as oncology, burn-injury, chronic pain, pruritus or in pediatric patients. Physiological measures, such as the heart rate and respiration rate, were performed. The results show lower values in the patients in whom VR distraction was used, compared to the control group, which clearly demonstrates the effectiveness of VR use in pain and anxiety reduction. Furthermore, VRI significantly reduced the pain-related brain activity, as measured by functional magnetic resonance imaging.

In Pediatric Dentistry, different forms of distraction can be used for pain management, such as listening to music, watching television (passive forms of distraction) or virtual reality (an active form of distraction). Audiovisual distraction during dental treatment is a simple and inexpensive way to facilitate cooperative behavior and achieve a high level of patient satisfaction for most children. Audiovisual eyeglasses (virtual reality) offer an effective distraction tool for alleviating the discomfort and distress that arise during dental restorative procedures. The glasses partially occlude the environment and involve children in seeing and hearing a movie appropriate to their age. At the same time, they do not interfere with the dental treatment, giving the dentist freedom in the working field.

The digital technology is frequently used in orthodontic surfaces by scanning electron microscopic examination, resulting in photomicrographs registered at different magnifications [48].

11. DISCUSSION

Digital technology has already become indispensable to modern dentistry. In terms of two universal values – time and money – digitalization shows both advantages and drawbacks. To the modern dentist and dental technician, eliminating time-consuming processes from their work with the aid of technology is a big step forward that enables them to be more efficient. On the other hand, a limitation of digital dentistry is the cost. Going digital implies a significant investment, not only in devices, but also in updates and trainings for the medical staff who works with them. Rapid progress in technology is both a plus and a minus; whereas change is good, most clinicians cannot afford to constantly keep up with the latest technology and maintain a full up-to-date digital experience in their practice. In Pediatric Dentistry, simplification of timely procedures by digital means is a welcome change, for both sides: the pediatric dentist and the child. Furthermore, children are usually thrilled about interesting digital machines. When working with young patients, selection of appropriate behavior management techniques and therapeutic protocol is essential for the success of the treatment. Monitors playing cartoons in the dental office or audiovisual eyeglasses are valuable assets in relating with children, making them feel comfortable in the dental chair. However, a negative aspect of having means of disturbing the child from the medical environment is that his/her receptivity to the pediatric dentist's commands also decreases. Unlike monitors, VR eyeglasses have the added drawback of covering child's eyes, thus preventing the dentist from anticipating possible adverse reactions during treatment. The use of nitrous oxide sedation and general anesthesia are current practices in Pediatric Dentistry. Although their contribution to the pediatric field is undeniable, there is a potential risk of technology over-use, namely the use of nitrous-oxide sedation as a first-hand behavior management technique, in patients which would not necessarily need it, thus increasing the cost of the procedure in a forced and unethical attempt to have the device paying off sooner. Another misuse of the technology regards the use of diagnostic tools as primary diagnostic means. The final diagnosis is elaborated by the clinician after performing several steps, corroborating the information and filtering it through his/her own experience. Therefore, diagnostic tools represent auxiliary means, designed only to aid the diagnosis, and not to replace the conventional examination. However, the process of diagnosis elaboration has benefited consistently from the digital technology, becoming more complex and complete, allowing the clinician to analyze a patient from far more perspectives than before.

12. CONCLUSIONS

Nowadays, digitalization in Pediatric Dentistry and Orthodontics helps specialists to provide a complex, qualitative and also patient-friendly treatment, to reduce anxiety and pain, shorten the timely procedures and enhance children's trust and enthusiasm regarding dental visits.

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