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Review Article

Digital Era of Orthodontics: A Review

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Abstract

Orthodontic treatment is a complex dental treatment which sometimes requires an interdisciplinary team where different specialists of dental medicine have to manage a vast quantity of data especially in adult orthodontics. In such complicated cases, good diagnostic tools and easy communication are essential. Computer science has an increasing impact in almost every aspect of the orthodontic practice. This review will discuss into the said aspects in the practice of orthodontics as well as evaluate the applications of computer technology in orthodontics like digital photographs, cone beam computed tomography, virtual study models, communication, three-dimensional craniofacial imaging, virtual reality softwares for prediction and treatment planning, video imaging, manufacture of orthodontic appliance, web-based digital orthodontic records and network-attached storage devices.

1. Introduction

Orthodontics and Dentofacial Orthopaedics, the most complex branch of dentistry, requires a careful acquisition and interpretation of a large amount of information to achieve a correct diagnosis and treatment planning. Imaging technology in dental field has emerged as one of the most important aspects of diagnosing and treating oral disorders, especially since the advent of three-dimensional (3D) techniques, which have found various applications in orthodontics as well as in oral and maxillofacial surgery. Methods used to examine the oral and maxillofacial anatomy have existed for many decades, dating back to the 1940s, but current technologies have allowed much faster and efficient analysis abilities. Medical imaging has become a major tool in almost every aspect of orthodontic practice, research and education.

The evolutions of orthodontics and dentofacial orthopaedics and learning about the location of malocclusions at different levels of the stomatognathic system have led to a more accurate diagnosis and a more effective treatment planning. In addition, the adult orthodontic treatment, a direction in continuous development, requires a broader interdisciplinary collaboration between Orthodontics, Oral and Maxillofacial Surgery, Periodontics, Prosthodontics and Oral Implantology. Within this collaboration, an enormous amount of information from each of the involved specialty is presented, analyzed and evaluated.[1,2] No effective therapy is possible without walking with the radiographs, photographs or models from one specialist to another. All these problems have found solutions in the present digital age with Computer-Aided Diagnosis (CAD) and treatment planning.

The 21st century will be the digital era of dental imaging much as film imaging dominated the 20th century.[3] Computer-Aided Diagnosis involves the use of imaging techniques and image processing tools. Biomedical Imaging is one of the most dynamic development directions between medicine and computer sciences and involves the creation of images of the human body for clinical, medical or scientific purposes.[4] Everyday, one sees that the introduction of digital technology has improved our lives making things better, easier to use, relatively economical and more reliable. Steadily, digital technology was introduced to manage practices in a more efficient manner. In the beginning, one used to have personal computers in the front office to manage the business part of offices which was considered a great leap which was then, later replaced by the computers on the chair-side for better communication with the patients, in educating them, for behavioural management and to increase the efficiency of the patient's record keeping. Interdisciplinary orthodontic treatment of adults and in general orthodontics, use of digital imaging technology and computerized treatment planning tools have helped the orthodontists in giving better communication and care for the patients.

2. Review

Successful orthodontic treatment is based on a comprehensive diagnosis and treatment planning. A few of the fundamental factors in the diagnosis are the spacing condition, tooth size, arch form and its dimensions, as well as the tooth-arch discrepancies. The model analysis is a time-consuming procedure. Nevertheless, it is a vital part in the diagnosis and subsequent treatment planning process. However, in a day-to-day practice many orthodontists judge the models subjectively, without applying analytical tests. Traditionally, measurements on dental casts were performed with the aid of either Vernier calipers or needle pointed dividers. But this process can be very simple, effective, reliable and less time consuming by taking digital impressions, converting to digital models and analysing them on the respective softwares.

Digital photography is widely used today to document orthodontic adult patients. The digital single lens reflex (SLR) cameras were tested for use in intra- and extra-oral photography and proved to generate perfect images when used with the recommended macro-lens and macro-flash techniques. Digital photography was introduced to

evaluate facial harmony.[5] It allows clinicians to establish a more proportional focus on all three structures of the triad to assess patient's deformity. An accurate and objective assessment of a facial deformity or a preoperative prediction of the surgical outcome in two dimensions, especially regarding asymmetry, is always a lacuna that is deficient since it does not address the volumetric changes of all the facial portions that determine neuromuscular balance and facial harmony. As a consequence, with a computer graphic two-dimensional (2D) representation of facial appearance, it is not possible to achieve a realistic and acceptable result.[6] From the 1980s, the shortcomings of these techniques induced an increase in the use of three-dimensional (3D) imaging techniques[7], such as facial surface laser scanning[8], 3D stereophotogrammetry (3D photography)[9] and (3D) video-imaging[10]. Reconstructions of digital imaging and communications of medicine (DICOM) files from multislice CT (MSCT), cone-beam CT (CBCT) imaging[11] or MRI slices[12] to display the skeletal structures and digital dental models to display the dentition[13] were also investigated 3D virtual planning software programs with a virtual operating room (VOR) were also introduced by the end of the 1980s[14] The IT revolution (2000s) has enabled significant improvements of these software modules.[15] The reconstruction of DICOM files in a VOR enables the clinician to document, analyse and plan orthognathic surgery on a facial skeleton model as often and in as many different ways as required. Programs to analyse the facial soft tissue surface [16] and dental models [17] were also introduced.

For the first time, these programs gave the clinicians true insight into all three structures of the triad, albeit separately and routinely on a 2D computer screen. Since most of the 3D imaging techniques only display one of the three structures with optimal quality, it is evident that these imaging techniques are more powerful when they are used together.[18] This emphasises the importance of image fusion of 3D image modalities to document and analyse the triad of a patient's face accurately. This has enhanced a search for an 'all in one'assessment of the face. The three methods that have been used to display the facial skeleton and the dentition include the life-sized stereolithographic (STL) or milled models augmented with dental casts [19]; digital dental casts integrated in cephalograms[20]; and a 3D reconstruction of the (CB)CT with integrated digital dental casts[21]. Amongst these, the first two methods are actually considered to be obsolete and outdated. The third method virtually displays the facial soft tissue surfaces and the facial skeleton in all the three dimensions.

The integration of digital dental casts into the CBCT reconstruction establishes an augmentation with improved visualisation of the dentition. After impression taking, models, 3-D reconstruction and photography, the introduction of digital radiography is another important digital tool in the actual concept of virtual reality in orthodontics. Sometimes, on the way, the documentation is deteriorated or lost and there is no possibility to see again the initial or intermediary clinical situation. For this reason, sending digital images directly over phone lines virtually eliminates the chances of losing or destroying this vital piece of information during the course of treatment. The actual possibility to send images electronically to another dental office allows for consultation between different dental professionals in almost instantaneous fashion and this interoperability is very important for the success of the interdisciplinary team. The digital storage of the information allows printing copies for patients and dentists at the same quality after many years. Also, specific annotations can be printed on each image.

The digital cephalometric radiograph can be analyzed more precisely using dedicated, digital software. Because of the ability to optimize the display of an image the orthodontist may choose to enlarge areas of greatest diagnostic interests, for example in the positioning of the specific landmarks. This was done until now manually using a magnifier. What is really amazing at this software is that after pointing the requested landmarks on the cephalometric radiograph, one can choose a lot of measurements and analysis that can be done to a particular case and can get a final label with the actual value, the deviation from the standard values and also, the clinical significance of the findings. Another important tool, Cone Beam Computed Tomography (CBCT), is ideally suited for dentomaxillofacial scanning and offers a lot of useful information for the interdisciplinary consideration of orthodontic diagnoses, with the risk from ionizing radiation that results from this examination, especially while working on growing children, is the only concern that needs a little attention.

In a recent study, the authors had concluded that depending on the size of the scanned field, the effective doses with CBCT vary significantly. The authors had proposed that a scan of 13 cm height, which was sufficient in most growing child patients, in a fast scanning mode, results in a dose approximately two times than a conventional set of orthodontic radiographs. Even in the digital decade, always when indicating a radiographic examination, one must follow the ALARA principle (of "as low as reasonably achievable"). The digital radiography has a lot of benefits over the classic one beginning with the elimination of the requisited darkrooms, processors and flatbed scanners, all capital expenses. With no need for chemical processing, the monthly costs of chemicals, maintenance of the processors, film mounts and films are all eliminated with the use of digital equipments. There is also a significant environmental benefit to this technology since the heavy metal waste stream that results from chemical processing gets eliminated.[22]

Today, with the use of computerized imaging techniques and the CAD/CAM technologies, the orthodontists can integrate the computer in the manufacture process of the orthodontic appliances. The best example is the Invisalign system where the series of trays are made using a computer-assisted simulation of the needed movements.[23] In education, the introduction of computer sciences has a tremendous effect. Virtual reality in orthodontics by creation of diagnosis web sites provides the undergraduate and postgraduate students in orthodontics an accessible source of complete, good-quality study materials. Web-based digital orthodontic records are as effective in teaching clinical orthodontic diagnosis as were conventional records.[24]

In the orthodontic research, one cannot imagine any important result without the use of computer sciences even for epidemiological studies and/or, for biomechanical and material studies. All this big quantity of information needs to be protected, else, it can be destroyed as easily as the previous versions of the clinical records. The digital tools have a lot of advantages over the classical diagnostic tools but are equally vulnerable to loss as the last ones. For this reason, if we want to have success with this paperless work environment and innovative imaging technology, we have to apply adequate backup protocols for this crucial data. Respecting the TEAM (together everyone achieves more) principle from interdisciplinary orthodontics, one can say that today, the computer and the computer science is the first partner in every team that tends to optimize the treatment effects for every patient.[1]

3. Conclusion

Orthodontics is undergoing a gradual transition from plaster decade to digital decade, mainly due to advancements in computer technology, bringing the dental specialists to a new way of imaging, diagnosing, documenting and communicating between them and with the patients, thereby, mandating each specialist in orthodontics as well as from other specialties of dental medicine to have a sound knowledge in bioinformatics and should be trained to use these new digital devices in order to provide better medical care for the complex cases.

References

[1] Alexandru S Ogodescu. "The interdisciplinary of modern orthodontics", PhD Thesis, University of Medicine and Pharmacy "Victor Babes", Timisoara, Romania, 2006.

[2] Alexandru S Ogodescu, Elisabeta Bratu, Florica Glavan, Stefan Stratul, Emilia Ogodescu, Marcel Moise. *Tratamentul ortodontic la adult, Editura Eubeea*, 2008.

[3] Stuart C White, Douglas C Yoon, Sotirios Tetradis. Digital Radiography in Dentistry: What It Should Do for You? *Journal of the California Dental Association* 1999; pp.1-14.

[4] Alexandru S Ogodescu, Cosmin Sinescu, Emilia A Ogodescu, Meda Negrutiu, Elisabeta Bratu. Digital Tools in the Interdisciplinary Orthodontic Treatment of Adult Patients. *International Journal of Biology and Biomedical Engineering* 2010; 4:97-105.

[5] Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning. Part I. *Am J Orthod Dentofacial Orthop* 1993; 103:299-312.

[6] Holberg C, Schwenzer K, Rudzki-Janson I. Three-dimensional soft tissue prediction using finite elements. Part I. Implementation of a new procedure. *J Orofac Orthop* 2005; 66:110-21.

[7] Swennen GR, Schutyser F, Barth EL, De Groeve P, De Mey A. A new method of 3-D cephalometry. Part I. The anatomic Cartesian 3-D reference system. *J Craniofac Surg* 2006; 17:314-25.

[8] Kau CH, Richmond S, Zhurov AI, Knox J, Chestnutt I, Hartles F, Playle R. Reliability of measuring facial morphology with a 3-dimensional laser scanning system. *Am J Orthod Dentofacial Orthop* 2005; 128:424-30.

[9] Ras F, Habets LL, van Ginkel FC, Prahl-Andersen B. Quantification of facial morphology using stereophotogrammetry demonstration of a new concept. *J Dent* 1996; 24:369-74.

[10] Sarver DM, Johnston MW, MatukasVJ. Video imaging for planning and counseling in orthognathic surgery. *J Oral Maxillofac Surg* 1988; 46:939-45.

[11] Groeve PD, Schutyser F, Cleynenbreugel JV, Suetens P. Registration of 3D photographs with spiral CT images for soft tissue simulation in maxillofacial surgery. *Lect Notes Comput Sci* 2001; 2208:991-6.

[12] Goto TK, Nishida S, Nakamura Y, Tokumori K, Kobayashi K, Yoshida Y, Yoshiura K. The accuracy of 3-dimensional magnetic resonance 3D vibe images of the mandible: An in-vitro comparison of magnetic resonance imaging and computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007; 103:550-9.

[13] Peluso MJ, Josell SD, Levine SW,Lorei BJ. Digital models: An introduction. *Semin Orthod* 2004; 10:226-38.

[14] Burk Jr DL, Mears DC, Cooperstein LA, Herman GT, Udupa JK. Acetabular fractures: Three-dimensional computed tomographic imaging and interactive surgical planning. *J Comput Tomogr* 1986; 10:1-10.

[15] Everett P, Seldin EB, Troulis M, Kaban LB, Kikinis R. A 3D system for planning and simulating minimally invasive distraction osteogenesis of the facial skeleton. *Lect Notes Comput Sci (MICCAI)* 2000; 1935:1029-39.

[16] Kaplan HM. A pioneer in 3-D technology for medical imaging. *Technol Commercial Alliance* 2003; 70-82.

[17] Dirksen D, Diederichs S, Runte C, von Bally G, Bollmann F. Three dimensional acquisition and visualization of dental arch features from optically digitized models. *J Orofac Orthop* 1999; 60:152-9.

[18] Ayoub AF, Xiao Y, Khambay B, SiebertJP, Hadley D. Towards building a photo realistic virtual human face for craniomaxillofacial diagnosis and treatment planning. *Int J Oral Maxillofac Surg* 2007; 36:423-8.

[19] Lambrecht JT, Hammer B, Jacob AL, Schiel H, Hunziker M, Kreusch T, Kliegis U. Individual model fabrication in maxillofacial radiology. *Dentomaxillofac Radiol* 1995; 24:147-54.

[20] Damadian R, Minkoff L, Goldsmith M, Stanford M, Koutcher J. Field focusing nuclear magnetic resonance (FONAR): Visualization of a tumor in a live animal. *Science* 1976; 194:1430-2.

[21] Gateno J. A new technique for the creation of a computerized composite skull model. *J Oral Maxillofac Surg* 2003; 61:222-7.

[22] Antonio Magni. Cone Beam Computed Tomography and the Orthodontic Office of the Future. *Seminars in Orthodontics* 2009; 15:29-34.

[23] Alexandru S Ogodescu. Invisalign: O noua tehnologie in tratamentulorthodontic al adultilor. *Cercetari Experimentale & Medico-Chirurgicale* 2003; 10:261-3.

[24] Komolpis R, Johnson RA. "Web-based orthodontic instruction andassessment". *J Dent Educ* 2001; 66:650-8.