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Introductory Chapter: Computer Vision in Dentistry

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1. Introduction

Innovative visualization techniques are becoming systematically the subject of not only academic research, but also commercial production, finding use in many areas of dentistry. This is conducive to the digitalization of dentistry and its increasing treatment and diagnostic demands. In many areas of dentistry, such as orthodontics and maxillofacial surgery, and also periodontics or prosthetics, only a correct diagnosis allows for the correct treatment plan, which is the only way to restore the patient's health. The diagnosis and the treatment plan are based on the specialist's knowledge, but are subject to a large, multifactorial risk of error. Therefore, the introduction of digital visualization is a great hope for both the physician and the patient.

This book presents a review of the latest attempts to use the applications of newest methods of visualization, taking under consideration all of the main dental specialities. Work on the introduction of computer vision has been continued for years. This book presents the latest achievements in this field, analyzing their real application and credibility.

Digitalization in dentistry has increased significantly in the last 10 to 20 years. In most developing countries, the shortage of medical and dental professionals and, most of all, perfect diagnosis increases the need for technology. This can reduce the time and the number of medical errors.

Applications in the field of dental science vary according to the needs—from dental emergencies through differential diagnosis of pain in the mouth, interpretation of radiographic images, analysis of facial growth in orthodontics, to planning the optimal prosthetics for a particular patient.

2. Application of cone-beam computed tomography in dentistry

A huge breakthrough has become universal access to very advanced visualization techniques such as tomography in an ordinary dental office. Common access to radiovisiography as well as cone-beam computed tomography (CBCT) in dental surgeries resulted in a significant increase in the quality of treatment and, most importantly, in enabling multifaceted diagnostics of a quality that earlier could only be carried out in hospitals. CBCT is a fast and safe method of imaging in dental radiology. The CBCT allows to obtain a three-dimensional image of the craniofacial region at a much lower dose of radiation in relation to conventional computed tomography (CT). CBCT is the most accurate imaging method in dentistry, maxillo-facial surgery, and laryngology.

The resulting image shows nerve canals, blood vessels, teeth, and nasal sinus. CBCT allows the imaging of all anatomical structures with accuracy impossible

to obtain in another type of radiological examination. The obtained image can be repeatedly processed, measured, and visualized. Currently, advanced tomographs are produced with an increased number of imaging fields from a small S (use of endodontics and retained teeth) to the largest XL + (found in maxillofacial surgery and laryngology for imaging of the paranasal sinuses, nose, ear, and throat), also performing film visualization of the course respiratory tract, auditory canal, endoscopy of the paranasal sinuses, and assessment of the respiratory tract (treatment for snoring). The choice of the field of imaging, determined in millimeters (FOV), depends on the diagnostic needs of the physician. The patient receives the results of the tests on a CD.

The full scope of dental and laryngological diagnostics covers the field of implantology due to the assessment of the quality and quantity of bones, assessment of the location of future implants in relation to anatomical structures of nerves, maxillary sinuses, tooth roots, postoperative control, and assessment of bone graft success and implants, visualization of the planned implant placement, computerized navigation in implantology. In the field of dental and maxillofacial surgery, CBCT enables precise location of detached, supernumerary teeth, changes in the bone, assessment of pathological conditions in the upper and lower jaw, assessment of the status of paranasal sinuses, and evaluation of fractures and facial and orthognathic treatment results [1].

During endodontic treatment, the tomography helps in determining the morphological structure of roots, their number, the presence of canals, and additional channels, determining the working length and degree of root and canal curvature, evaluation of root canal fillings, periapical changes, evaluation of dental root fractures, and assessment of inflammatory root resorption [2].

In orthodontics, CBCT allows simultaneous diagnosis and cephalometric analysis, assessment of facial growth, age, respiratory function and tooth erosion disorders, and assessment of the proximity of important anatomical structures that may interfere with the course of orthodontic treatment; it is useful before embedding orthodontic mini-implants and even indispensable during attending to of the retained teeth and during functional treatment to assess the temporomandibular joint and possible disorders in its region [3].

CBCT allows to determine the location and functioning of temporomandibular joint structures and what is very important in the treatment of this joint visualization of soft tissues surrounding temporomandibular joints [4].

Periodontological patients should also be diagnosed in this way. Periodontal evaluation in the tomographic image enables detailed assessment of bone morphology (type of bone defects, etc.), assessment of seizures with tooth furcation, accurate measurement of intraosseous defects, and evaluation of dehiscence, fenestration and periodontal cysts. After the treatment is completed, it is possible to assess the effects of regenerative treatments [5].

3. Three-dimensional scans

Directly at the dentist's chair, more and more often, intraoral 3D scanner is being used allowing with exceptional accuracy to transfer the current occlusion of the patient (via digital to the computer) instead of standard and uncomfortable for the patient dental mass impressions. The study (3D scan) takes only a few minutes. Excellent quality of devices and its precision, when scanning teeth, allows you to take 20 photos per second. A few moments after the teeth have been scanned, a perfectly accurate three-dimensional model of the patient's teeth is created on the screen. Thanks to modern diagnostic technology, the 3D scanner

makes a seven-mile step forward, not only in the imaging of irregularities requiring treatment, or treatment planning, but most of all simulating the effects of potential treatment. The doctor, thanks to the scanner, on the screen, prepares for the patient a digital visualization of the treatment effect in 3D, and all within 1 min. This allows the patient to see how his teeth will look after treatment before he begins. All this happens during a single visit, based on the patient's actual bite, and not, as before, only on the traditional model of impressions. What is more, the initial proposal of planned treatment can be sent to the patient by e-mail, thanks to which the patient has access to visualization of the effects of his orthodontic or prosthetic treatment at any time. Thanks to modern 3D diagnostics, the patient can safely and more comfortably go through all treatment procedures. The use of a 3D scanner is effective during teeth diagnostics and planning of the orthodontic, implantological, prosthetic, surgical, and periodontal treatment process [6].

When the patient is satisfied with the presented effects of the planned treatment, you can immediately begin the process of straightening the teeth using invisible, thermoformable caps enabling advanced and very esthetic orthodontic treatment or planned prosthetic treatment.

Orthodontic overlays are made by thermoforming in specialized laboratories, using modern technologies and digital analysis. As a result, the treatment is precise and carefully planned.

The overlays are transparent, almost invisible and therefore extremely esthetic. They are made of soft materials, without any metal elements for fixing or twisting, which makes them comfortable and does not cause pain or crease. They can be easily removed for food and cleaning, so keeping hygiene is extremely easy. They are perfectly matched to the teeth, which is why patients can laugh and talk without being embarrassed.

The computer visualization of the occlusion of the patient after using digital impression is pictured in **Figure 1**.

In this chapter, I presented shortly only a section of knowledge and possibilities related to the usage of computer visualization in dentistry. This was to give a foretaste of the chapters in the book, which are exploring this topic. I believe that the following reading will be interesting and will become a valuable source of knowledge in the described field.



Figure 1.
The computer visualization of the occlusion of the patient after using digital impression (Courtesy of Prof. Tomasz Gedrange).

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