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Technologie komputerowe w ortopedii szczękowej – rys historyczny

Computer Technologies in Dentofacial Orthopeadics – Historical Review

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Streszczenie

Pod koiec lat 60. XX w., zaczęto wykorzystywać technologię komputerową w badaniach cefalometrycznych głowy. W 1969 r. Robert Murey Ricketts w współpracy z Rocky Mountain Data Systems opublikował artykuł, w którym przedstawił komputerowy „portal" dla ortodontów. Jedno z pierwszych doniesień na temat wykorzystania komputera do analizy cefalometrycznej pochodzą z 1972 r., kiedy to zaprezentowano metodę zaznaczania 177 punktów cefalometrycznych. Od lat 70. XX w. ewolucja w budowie tomografów dotyczyła przede wszystkim budowy skanerów oraz systemów komputerowych wykorzystywanych do sterowania całym urządzeniem oraz rekonstrukcji obrazów. Głównym kierunkiem prac było skrócenie czasu wykonania badania, eliminacje błędów związanych z poruszeniem się pacjenta oraz możliwość rejestracji organów znajdujących się stale w ruchu, np. serca. W związku z tym wzrasta liczba detektorów oraz przede wszystkim moc obliczeniowa komputerów. Wraz z rozwojem technik komputerowych i ekspansją komunikacji sieciowej radykalnie zwiększyły się możliwości i wskazania do stosowania cyfrowych metod obrazowania. Nowoczesne systemy te mają na celu przyjęcie wspólnych standardów w archiwizowaniu danych i obrazów, ich kompresji, przesyłaniu oraz kodowaniu danych pacjenta. Obecnie większość producentów cyfrowego sprzętu medycznego nie dostosowało się jeszcze do tych standardów, ale oczekuje się, że nastąpi to wraz z upływem czasu (**Dent. Med. Probl. 2008, 45, 4, 349–353**).

Słowa kluczowe: technologie komputerowe, analiza cefalometryczna, ortopedia szczękowa.

Abstract

In the late 1960s computer techniques began to be used for cephalometric studies. In 1969, Robert Murey Ricketts, in cooperation with Rocky Mountain Data Systems published an article announcing a computer „portal" for orthodontists. One of the first reports on utilization of computer for cephalometric analysis reaches back to 1972 – marking of 177 points for computer analysis were presented. Since the 70's, evolution in scanner design included mainly constructions of scanners and computer systems used to control the device and for image reconstruction. The main efforts were taken to shorten examination time, to eliminate motion artefacts and to enable imaging of organs in motion, e.g. heart. To achieve this, number of detectors, and, before all, computer power, have been increased. The development of computer techniques and widespread use of network communications have radically enhanced the capabilities and increased the need for digital imaging. The modern systems aim to elaborate common standard for patient data and images archivization, compression, transmission and encoding. As for now, most of digital medical equipment manufacturers have not yet conformed to these standards, but one expects, that these standards will gain popularity with time (**Dent. Med. Probl. 2008, 45, 4, 349–353**).

Key words: computer technologies, cephalometrical analysis, dentofacial orthopeadics.

"To the two inevitable things in human life, namely death and taxes, third one should be added – development of computer technology in orthodontics" – Wilton Marion Krogman. These were the opening words of American Association of Orthodontists annual meeting in New Orleans in

May 1971. Discussion panel, in addition to the famous anthropologist, included Geoffrey F. Walker, Bhim S. Savara and Robert H. Biggerstaff. The convention was aimed to summarize the achievements to date and to set new targets in computer technology utilization for orthodontic analysis and diagnostics [1].

One of the first reports on utilization of computer for cephalometric analysis reaches back to 1972, when Walker suggested marking of 177 points for computer analysis in American Journal of Orthodontics. He theoretically considered placing every one of these 177 points in three-dimensional space. He emphasized, that there were as much mutual correlation, as much measurements, angles and clinically relevant relationships were considered [2]. In 1969, Robert Murey Ricketts, in cooperation with Rocky Mountain Data Systems published an article announcing a computer "portal" for orthodontists [3, 4]. Until 1981, RMDS database included data of 60, 000 patients [5]. If a physician wanted to get help from the portal, he would have sent: lateral head X-rays, photocopy of impressions and diagnostic sheet. The portal would send back computed analysis of lateral head x-rays along with growth prognosis and therapy plan. Although full radiogram analysis according to Ricketts includes analysis of lateral and frontal images, it is the lateral film that provides the most information, therefore, if a frontal film is unavailable, sole lateral film is reliable enough [6]. In 1970, Beni Solow pointed out, that computer was required mainly to store and organize numerous data needed for detailed description of the craniofacial region [7]. In 1972, Krogman highlighted, that computer-aided cephalometric analysis was a guide, not a solution. Two factors remain unchanged: patient with his problem and physician with his knowledge and abilities [1]. Ricketts also wrote, that computer technology was used for some measurements, and for storing, sorting, reusing, assessing, organizing, and comparing of results, and to form conclusions. In addition, the "human error" in results stored that way was eliminated. Ricketts pointed out interdisciplinary usage of computers [8]. In 1973 Vigo Sassouni, in cooperation with Computerized Orthodontic Treatment Planning Services, Inc from Pittsburgh, COT, established another database [9]. The database of 1973 included 2000 stored examples of patient therapies and the number of reported cases was growing every year. Basing on examples of treated malocclusions gathered this way, some cases were selected and a detailed therapy plan for a potential user was created. If no therapy plans could be matched for a individual case, an original therapy plan would be developed by specialists cooperating with COT. In 1971, Godfrey N. Hounsfield announced creation of a new medical diagnostic system, which he named "Computed Axial Transverse Scanning" [10]. Firstly, Hounsfield's system [10] was called "Computed Axial Transverse Scanning", then CAT – "Computed Axial Tomography" and presently CT – Computed Tomography [11]. Computed tomography enables visualization of body sections based on series of X-ray scans taken at different angles (projections). Due to nonuniform absorption of X-rays in the examined space from different projections, a set of radiation attenuation values is created. Using complex mathematical transformations, image reconstruction is created, which represents internal structure of the examined space in grayscale. Tomographic images allow for presentation of examined tissue sections of virtually any thickness. Thanks to this possibility, and to specific software, creation 3D images became feasible. In general, a tomographic scanner consists of gantry and a computer system for image visualization. Gantry is the most important part of the device and includes: X-ray tube and collimator assembly, detector system, rotating drive and high voltage converter [11]. At first, scanners were equipped with one detector – a gas detector. X-ray tube emitted a thin X-ray beam, which scanned the patient. Scan time was about 5 minutes. Despite long exposure time, the patient dose was relatively low, because "pencil-thin" beam was very narrow and irradiated every single point for a very brief time. Since the 70's, evolution in scanner design included mainly constructions of scanners and computer systems used to control the device and for image reconstruction. The main efforts were taken to shorten examination time, to eliminate motion artefacts and to enable imaging of organs in motion, e.g. heart. To achieve this, number of detectors, and, before all, computer power, have been increased.

Systems with multiple rows of detectors are gaining popularity. This solution enables multiple slices to be scanned simultaneously. Until May 2003, the only 8-slice scanner in Poland was in Lublin Medical University. Such a scanner can scan whole body within less than 30 seconds [11]. Multislice tomography, along with volume rendering technique, are currently the most sophisticated methods for facial skeleton visualization.

Nevertheless, due to the cost of a tomographic scanner and higher X-ray dose compared to classic teleradiography, these examinations are rarely used in maxillofacial orthopedics [12]. Therefore, studies on usage of CT in orthodontics and 2- and 3D cephalometric analysis have been performed separately.

Because development of computer-aided cephalometric analysis follows development of information technology, the reports published until mid 80's, despite being fundamental for this branch of science, were focused rather on different applications of computed tomography in orthodontics, than on cephalometric analysis [2, 4, 6, 7]. In cooperation with Carl Gugino, pioneer in Ricketts' bioprogressive technique in Europe and one of the first in Europe to utilize computer technology in orthodontics, a program with brilliant graphic features was created. This was possible due to good data compression algorithms [13]. Since mid 80's, with the beginning of personal computer era, publications and scientific reports on computer-aided cephalometry have made a great progress, both in quantity and quality. These included papers on: new programs for computer-aided cephalometric analysis [14–18], comparing results of computer identification of cephalometric points to classical methods [19–23], comparing results of two and three-dimensional cephalometric analysis [24–28] and focused on direct implementation of computer-aided analysis in maxillary surgery, maxillo-orthopedic therapy, therapy of congenital facial disorders, growth forecasting [5, 20, 29–32] and as educational programs [33] and for dental displacement control [34].

Automatic analysis of films was mentioned as early as 60/70's of 20^{th} century, however, only in mid-80's first publications on non-subjective (automatic) identification of cephalometric points [35, 36] began to appear. Despite opinion, that fully automated systems for cephalometric analysis may dramatically reduce or even eliminate "human error" in determination of individual points [37], comparison studies of automated identification of craniofacial structures and manual techniques (also computer-aided) still demonstrated imperfections and inferiority of the former. Only very recently some reports, which stated progress in this field, started to appear. The authors emphasize, that possibilities of automated cephalometric points acquisition, while still being not accurate enough for research, became appropriate for clinical applications [16, 38]. Since early 90's, in addition to studies upon the aforementioned subjects and issues, more and more precise techniques for craniofacial region and head visualization have been utilized. First fully digital images appeared [39–41]. Until then, computer-aided cephalometry was based on manual introduction of individual measurement points coordinates to computer memory using a digitizer, and an algorithm calculated required angular and length measurements.

Digital cephalometry is still not very popular. Curtis et al. [42] reported, that despite over 80% of American dentists use computers, and only 10% take advantage of digital lateral head x-ray analysis, digital imaging methods are becoming more and more often used for craniofacial analysis.

Another milestone in digital radiography was the initiation of development of TACT system (Tuned-Aperture Computed Tomography) on National Institute of Dental Research USA session in 1990. The purpose of this system is to obtain 3D tomosynthetic images. This system utilizes 2D digital images taken in various projections. After superimposing these using appropriate software, 3D images are created. Error in individual cephalometric point localization in different projections increases with increase of angle between projections, therefore at present 20^{o} angle between projections is used. The advantage of TACT system is that X-ray detector and imaged object (head) do not have to maintain fixed position – source of radiation may be freely positioned. The TACT system is a step up from cephalometric stereoscopic films. Until then, diagnostics of dental caries, periodontium, paraapical regions and maxillary fractures have been the most used applications of tomosynthetic imaging [12, 43].

From 1998, a draft on usage of DICOM (Digital Imaging and Communications in Medicine) in dentistry was adopted. This standard is an improvement of the PACS system, which dates back to early 90's [5, 43]. DICOM utilizes Ethernet TCP/IP for network transmission. These systems aim to elaborate common standard for patient data and images archivization, compression, transmission and encoding. As for now, most of digital medical equipment manufacturers have not yet conformed to these standards, but one expects, that these standards will gain popularity with time.

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