MODERN METHODS FOR INVESTIGATING FACIAL CHANGES DUE TO ALTERATIONS IN BONE STRUCTURES - LITERATURE REVIEW

Emanuel Emiliyanov
Medical University of Sofia, Faculty of Dental Medicine, Department of Orthodontics, Sofia, Bulgaria
emanuelemilianov@gmail.com
Mirela Georgieva
Medical University of Sofia, Faculty of Dental Medicine, Department of Orthodontics, Sofia, Bulgaria
m.georgieva@fdm.mu-sofia.bg
Samuil Djenkov
Medical University of Sofia, Faculty of Dental Medicine, Department of Oral and Maxillofacial Surgery, Sofia, Bulgaria, s.szhenkov@fdm.mu-sofia.bg
Konstantin Stamatov
Medical University of Sofia, Faculty of Dental Medicine, Department of Oral and Maxillofacial Surgery, Sofia, Bulgaria k.stamatov@fdm.mu-sofia.bg

Abstract: Facial scanning technology facilitates the establishment of a definitive diagnosis and tracking of the progression of dental treatment. Facial anthropometry requires the measurement of indices and proportions and is traditionally associated with determining individual facial characteristics. While facial scanning technology in dental medicine has emerged relatively recently, its application in other domains has a considerably longer history. The integration of data from facial scanners, intraoral scanners, and cone-beam computed tomography (CBCT) systems significantly streamlines diagnostic procedures in contemporary practice. The analysis and practical implementation of current scientific advancements in the field of 3D virtual sciences offer substantial benefits for patients, providing an efficient, intelligent, and accessible method for combining data formats from various digital devices.
Facial soft and hard tissues, along with the dentition, constitute three core domains of interest and intervention for dental professionals. These components of the craniofacial system are necessary be thoroughly studied and analyzed when planning treatments in orthodontics and orthognathic surgery.
Among diagnostic tools in modern dental medicine, CBCT remains the most informative, offering high spatial resolution in delineating the boundaries between tissues and airspaces. It is also highly effective for evaluating the upper respiratory tract obstructions and its air volume. The use of 3D facial scanning (FS) has proven advantageous for diagnostics and for assessing the outcomes of orthodontic and surgical treatments. This technology facilitates the detection of soft face tissue changes or deviations before and after clinical procedures. The comprehensive clinical picture is complements through the integration of intraoral scanning (IOS) data. The analysis and interpretation of these digital datasets can be further enhanced by incorporating artificial intelligence (AI), which is increasingly utilized in the dental field for interpreting radiographic images and analyzing both soft and hard tissue scans.
Keywords: Artificial intelligence, Cone-beam computed tomography (CBCT), Facial scanner (FS), Intraoral scanner (IOS)

1. REVIEW AND ANALYSIS OF THE LITERATURE

Facial scanning technology in dental medicine has been discussed relatively recently, but in reality, facial scanning has a relatively long history. Numerous scientific publications and reviews highlight the role of this digital methodology in analyzing and studying the human face, which is rich in biological identifiers of the personality (Lee et al., 2022, Karatas et al., 2014). Various authors over the years have described how characteristics of craniofacial facial structures obtained through facial scanning can predict obstructive sleep apnea (Lee et al., 2009, He et al., 2021).
The facial soft and hard tissues and the dentition are three main areas of study and intervention for dental practitioners. These three components, which form the craniofacial system, are also referred to as the triad in orthodontics and orthognathic surgery (Plooij et al., 2011). Harmony in triad is essential in planning orthodontic or other dental treatments. Consequently, the ability to visualize these structures is one of the valuable diagnostic tools that clinicians use to determine the type and treatment plan. Facial scanning technology facilitates the collection and analysis of preliminary and ongoing treatment data, registers minor or non-obtrusive asymmetries in facial structures. This helps to detail the clinical picture in terms of extraoral changes that have occurred as a result of dental or orthodontic disease. Diagnosis and patient analysis through the combination of image files from a facial scanner, an intraoral scanner, and CBCT can streamline diagnostic procedures and enable accurate patient analysis.

These virtual datasets simplify communication and information transfer to dental laboratories and communication in consultation with other specialists. Additionally, they can simulate treatment outcomes for the patient, helping to motivate them. Thus, the cycle of 3D scanning for each part of the triad is now fully closed: 3D scanning of hard tissues with CBCT; intraoral scanning of the dentition with an intraoral scanner; and 3D scanning of facial soft tissues with a 3D face scanner.

3D imaging in orthodontics is used to assess pre- and post-treatment outcomes of dental-skeletal and craniofacial relationships, facial aesthetics, and treatment results concerning soft and underlying hard tissues, as well as to predict treatment outcomes. A significant number of diagnostic methods have been developed for visualizing facial structures and dentition. The most popular method in modern dental medicine is cone-beam computed tomography (CBCT). CBCT determines the boundaries between tissues and void spaces with high spatial resolution. It is accurate and reliable for evaluating the upper airways (Di Francesco et al., 2012, Galeotti et al., 2019). Various software programs are used for interpreting and visualizing these images. The data from these studies are stored in a format that allows processing and manipulation at any time. CBCT with a large imaging field enables numerous analyses and assessments that cannot be performed with smaller volumetric images, such as 3D cephalometric analyses, upper airway volume assessment, image superimposition, asymmetry diagnosis, and orthognathic surgery planning, identification of impacted and supernumerary teeth.

In orthodontic patients, the etiological factor is often oral breathing. Therefore, during the diagnostic phase, it is essential to analyze data related to changes in the nasal-pharyngeal airway, as well as changes in the soft facial structures, alongside the changes in the hard facial structures and the patient's dentition. A significant portion of this data can be obtained through CBCT examination. CBCT allows measurements in three planes of both the bones and the airways, enabling volumetric analysis. The analysis in the axial plane, which is not visualized on a lateral cephalogram, is the most significant for measuring the upper airway (UA), as it determines the width of the airway. This allows for the determination of the cross-sectional area of any slice (airway level) of interest (Fraga et al., 2018). Therefore, scanning bone structures enhances the ability to evaluate the airways in children with oral breathing. These children also exhibit specific changes in facial parameters that were previously only described but can now also be measured. They often have reduced nostril size, a narrow nose, sunken suborbital spaces with dark circles, and an elongated face. Through extraoral assessment of facial morphology, an initial orientation about the orthodontic problem. The registration of extraoral signs points to the expected relationships between jaw relationships, facial profile, and the type of orthodontic deformation. This connection is much more comprehensive and even addresses the connection between facial changes and those in the respiratory tract. It has been proven that the morphological structure of the airways differs in patients with various craniofacial characteristics (El & Palomo 2011, Bohner et al., 2019). Several studies have established that patients with skeletal Class II have a smaller UA volume than those with Class I and Class III. Patients with skeletal Class III have a larger airway volume from those with Class I (Aluru et al., 2023, Rojas et al., 2017).

Therefore, oral breathing tends to model different skeletal changes, and only a clear understanding of the etiology can help predict and distinguish the direction of craniofacial growth. Muscular changes caused by oral breathing affect chewing, swallowing, and phonation, as the muscles involved in these functions contract simultaneously with those involved in oral breathing, influencing each other. Masticatory and other facial muscles work in harmony to achieve functions such as speech and chewing; they also help maintain the postural position of the head and body. A lack of orofacial muscular strength and changes in head posture are closely related.

Thus, studying changes in facial muscles will contribute to better diagnostics and a comprehensive understanding of the issues arising from oral breathing.

2. ANALYSIS OF CHARACTERISTICS OF ADENOID FACIES

The analysis of the features of characteristic adenoid facies, the position includes: lip position, nostril size, facial muscle tone. Identifying the correlation between craniofacial structure and airway collapse can be achieved by utilizing a facial scanner as a potential alternative diagnostic tool for individuals with oral breathing.

Facial scanning employs landmarks in three planes simultaneously, such as facial width, mandibular length, eye width, and the mandibular angle. These measurements, combined with computational algorithms, contribute to analysis facial proportions and asymmetries. Further application of such landmarks to facial scans could lead to the creation of facial morphology maps compared to conventional 2D photography (Islam et al., 2018).

Recent studies using 3D facial scans have analyzed and predicted the presence and severity of the consequences of oral breathing and the development of OSA (Obstructive Sleep Apnea) through the development of mathematical algorithms for clinical evaluation. These mathematical algorithms include linear measurements between two points and depth measurements between two points. The success rate of such predictions reaches up to 91% accuracy when linear and depth measurements from 3D images are combined into a single algorithm (Eastwood et al., 2020).

This represents an innovative step towards more streamlined and accurate diagnostic methods using facial scanners compared to 2D photographic analysis.

3. ANOTHER GROUP OF ISSUES AFFECTING CHANGES IN FACIAL BONES AND THEIR IMPACT ON FACIAL PARAMETERS - FOLLICULAR CYSTS

This pathological process affects both surgical treatment decisions and orthodontic diagnostics and treatment planning. Odontogenic lesions are a significant portion of oral lesions due to their clinical and histological heterogeneity. Their occurrence influences the comprehensive treatment of orthodontic patients. The manifestation of odontogenic lesions is most often attributed to aberrations in odontogenesis or cellular remnants of the odontogenic apparatus. Among odontogenic lesions, dentigerous cysts (DCs) are some of the most common odontogenic processes in the facial bones (Gupta et al., 2019).

Radicular cysts are the most frequently encountered type of odontogenic cyst, typically arising in response to inflammation and subsequent tissue necrosis. These lesions are usually detected through routine radiographic examinations of endodontic issues in deciduous teeth. However, some long-standing lesions can lead to significant cortical bone expansion, presenting clinical signs and symptoms such as swelling, tooth mobility, and displacement of adjacent teeth or dental germs. Due to increased osmotic pressure within the cyst lumen and the pressure exerted on the periosteal bone during radicular cyst enlargement, facial swelling is often observed.

Clinically, treatment of this type of cyst is limited to its extirpation or decompression. From an orthodontic perspective, follicular cysts are among the potential causes of tooth eruption disturbances, as they form a physical barrier along the eruption path. The problem stems from existing pathology in the soft or hard tissues in the region of the developing tooth germ. However, the increase in lesion size can lead to serious consequences, including mobility of adjacent teeth, root resorption, extensive deterioration of bone structure, facial asymmetry, and inflammatory symptoms (Nawrocka et al., 2022).

Screening and diagnostic strategies depend on the size of the lesion and the patient's age. In cases of mixed dentition, when the cyst is associated with an unerupted tooth, the preferred treatment should be minimally invasive to preserve the tooth germ and create favorable conditions for its further development and emergence into the oral cavity. Specific indications observed in orthodontic practice include abnormal tooth positioning or retention, facial swelling or asymmetry, abnormal growth, or ectopic eruption (Dedeoğlu et al., 2021).

Therefore, 3D facial imaging may prove beneficial for diagnostics and evaluating the effectiveness of orthodontic and surgical procedures.

4. THE TECHNOLOGY OF FACIAL SCANNING

Creating an accurate diagnosis through the combination of imaging files from a facial scanner, intraoral scanner, and CBCT in modern practice streamlines diagnostic procedures (Mangano et al., 2018). Research and practical application of the latest scientific knowledge in the field of 3D virtual science benefit patients by offering an easy, intelligent, and accessible method for combining various file formats obtained from different digital devices.

The modern digital analysis of an orthodontic patient involves data obtained from at least two different digital devices (Yordanova et al., 2023). The process of overlaying data from CBCT, IOS, and FS is now feasible, making it possible to create a 3D "virtual patient" for improved diagnosis, treatment planning, and communication with patients (Quinzi et al., 2022, Mai et al., 2020).

The technology of facial scanning facilitates the establishment of a definitive diagnosis and the monitoring of treatment progress. Dental facial scanners are extraoral scanners that take precise 3D pictures of a patient's facial structures. They use structured light to recreate facial features and a smile. Patients must be still in front of the facial scanner and the device moves around the patient's face, achieving remarkable accuracy. Scanning a face with a handheld scanner takes longer than scanning a face with a desktop face scanner. They have to manually walk around the patient's face during the scanning process. The final category is phone dental face scanners. in particular, apps for iPhone. Using this technology patients with facial asymmetries can be monitored for active growth on the affected side, which might reduce in the future the need for multiple TMJ x-rays. Facial scanners can also be used to record mandibular movements. The ability of the facial scanner to superimpose two sets of data allows showing the patient the improvement that happened after the treatment.

Facial anthropometry involves measuring indices and proportions and is traditionally associated with determining the individuality of the face. Therefore, these procedures require practitioner expertise or the use of reliable software. Artificial intelligence (AI) is increasingly being utilized in clinical practice for analyzing radiographic images (Kostov 2023, Kostov & Georgieva, 2023). AI algorithms consistently mark identical locations for bone or soft tissue landmarks, which can be an additional asset for its use. Errors in reading two-dimensional images with AI can result from image pixilation, improper calibration, system training levels, and other factors. However, with CBCT's high-resolution imaging, AI achieves much greater precision.

Artificial intelligence can be used with the same success in analyzing facial scans. Clean scans are required to recognize marker points. Facial scanning is more challenging with children for several reasons. Firstly, they may be uncooperative patients. For optimal facial scanning, the subject must remain still throughout the entire capture process, which can be difficult with a child. All these factors can affect the accuracy of facial scanning, necessitating the use of technologies that overcome these challenges and reduce the time required for image acquisition while enhancing diagnostic accuracy. Patients are increasingly fascinated by new devices and perceive doctors who use them as more modern and competent.

5. CONCLUSION

The technologies entering dental practice continue to improve, making dental care more comfortable, personalized, and patient-focused. Understanding their capabilities and clinical advantages encourages dental practitioners to integrate them into their practices. A key challenge remains training teams to work with numerous new software and digital technologies. Dental practices also face the issue of the high initial investment required for acquiring new equipment and software, but in the long term, this is the path to expanding clinical practice.

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