# ENHANCEMENT OF RESEARCH METHOD FOR SPATIAL LOCATION OF TEMPOROMANDIBULAR ELEMENTS AND MAXILLARY AND MANDIBULAR MEDIAL INCISORS

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**ABSTRACT** — This item reveals the analysis outcomes for craniometric and morphometric parameters of the temporomandibular joints and incisal dentofacial segments obtained through studying 157 computer tomograms and lateral skull teleradiographies from people with physiological occlusion of permanent teeth in the first mature age period. Detailed investigation of the spatial arrangement of the craniofacial structures allowed developing, substantiating and testing a method of computer tomograms combination of the mandibular joint and dentofacial segments of the mandibular and maxillary medial incisors with head teleradiographies in the lateral projection. This algorithm allowed increasing the measurements reliability (linear, angular) in the sagittal plane, identifying the degree of complexity and justifying the choice of tactics for the planned treatment, describing the facial skull growth type (horizontal, vertical and neutral), as well as evaluating the effectiveness of orthodontic treatment at all stages.

**KEYWORDS** — head teleradiography; dentofacial segments; medial incisors; temporomandibular joint; cone-beam computed tomography.

## INTRODUCTION

Recently, patients have been taking significantly higher interest in restoring the aesthetic and functional standards [1–5]. A significant technological breakthrough as well as the introduction of advanced reliable techniques in orthodontics offer us newer opportunities and prospects in diagnosing and treating dentofacial anomalies [6–10]. The close attention paid by clinicians to the development of newer diagnostic methods is due to potential of achieving stable and predictable outcomes with accurate plan correction through the dynamics of dental treatment [11–15].

Neurodentistry nowadays is based on the concept of functional occlusion, which determines the direct relationship between the temporomandibular joint anatomy, the muscle-articular apparatus, the dentition occlusal surfaces morphology, and the teeth position during joining. The reconstruction of the dental arches (rows) shape and size is closely related to proper construction of the prosthetic plane in view of the individual features of the dental system based on clinical and instrumental methods of examination as well as X-ray diagnostics methods [16–20].

Physical methods for clinical examination of patients with occlusion issues (odontometry, cephalometry, dentofacial arches measurement) and functional clinical trials may not be sufficient and reliable for diagnosing and selecting a rational orthodontic treatment method. When studying the dentofacial area, of particular importance appear x-ray methods that allow precise diagnostics, adjusting the treatment plan to prevent complications, reducing the rehabilitation time, and enhancing the efficiency of dental interventions [21–26].

Virtually no one orthodontist can do without analyzing teleradiographic data. The method allows differentiating gnathic and/or dentoalveolar pathologies. The method serves a basis for developing a treatment plan including a comprehensive one, involving maxillofacial surgeons [27–29].

Teleradiography estimate the location of the temporomandibular joint elements in relation to the

Frankfurt plane and the Turkish saddle. The joint features have been the focus through numerous research works and they determine mandibular biomechanics [30–34].

A special place in the orthodontic clinics is given to the medial incisors, which, often, determine the treatment tactics for patients with occlusion issues. Their role as key teeth has been described by experts. There have been inclination (torque) angles and angulation shown, which are used to select the type of arch orthodontic appliance braces. The said angles are typically determined by the individual characteristics of facial types and types of dental arches. For certain types of dental arches, the normal position of the incisors is retrusive, for the others, on the contrary, it is the protrusive position [35–39]. Given that, still relevant are the issues implying developing methods that allow improving the accuracy of measurements and determining the position of the joint elements and the incisors, which is of particular importance in clinical orthodontics when it comes to forecasting and evaluating the treatment effectiveness.

Nowadays, there been hundreds of methods proposed for analyzing teleradiographic data, most of them being individually designed [40–42]. However, as there appeared newer details on the dental arches morphology and the dentofacial area in general, teleradiography analysis remains a relevant issue for dentistry [43, 44]. As advanced digital technologies and improved X-ray equipment have become part of the clinical practice, it allowed a widely use of cone-beam computed tomography (CBCT). The obvious advantages of CBCT include: full scanning of the object; possible 3-D examination of the object at any angle and depth; visualization of the smallest changes in the morphological structures of the respective objects; high resolution identification of the level and amount of hard tissues in the dentofacial area in any part and at any therapeutic and diagnostic stage. A series of cross-sectional images allow now diagnosing and selecting treatment methods for congenital and acquired maxillofacial pathologies [45–50].

Given the available methods, it is now possible to apply various images and combine anatomical details using computer software, which explains the aim of this study.

Aim of study: to improve the method for studying the spatial arrangement of the temporomandibular joint elements and the medial incisors, both mandibular and maxillary.

## MATERIALS AND METHODS

The study included analysis of teleradiography lateral projections and computed tomograms of 157 people with no sign of dentofacial organic pathology and with permanent teeth physiological occlusion. The examinations were carried out in the age group related to the first mature period (21–35 years), taking into account the principles of bioethics and obtaining the patients' due consent.

The main points for the teleradiography included: N (Nasion), located at the junction of the frontal and nasal bones; C (Condylion), the articular head highest point; Ar (Articulare) — distal contour of the neck of the mandible articular head; T1 — posterior superior bulge of the mandible angle; T2 — posterior lower bulge of the mandible angle; Me (Menton) — the lowest point on the mandible contour, at the symphysis; Pg (Pogonion) — the mental protrusion front point. In addition, conditional medial verticals were drawn through the incisors cutting edge and the tooth root apex, which served as a reference lines for identifying the interincisal angle as well as for aligning the maxillary incisal lines with the facial skull plane.

The teleradiography and cone-beam tomograms were obtained on a 21-section digital panoramic X-ray unit PaX-i3D SC featuring the functions of a computed tomograph and an FOV cephalostat with accessories (VATECH Global, South Korea) following the scanning protocol for Sim Plant. Processing, storage and export of the X-ray images involved the Ez Dent-iTM software, a multiplanar reconstruction and a three-dimensional (3D) reconstruction — using the Ez 3D-iTM tomograph software for 3D diagnostics; viewing the saved data with an importing option was performed using the Viewer™ software. The thickness of the tomographic section was 1 mm, the reconstruction step was 1 mm, the rotation step — 1 mm.

## RESULTS AND DISCUSSION

When analyzing the teleradiographic data, we found that the obtained images failed to clearly display the temporomandibular joints boundaries, where the shadows of the adjacent anatomical structures were applied, in particular the temporal bone zygomatic process. Besides, the central incisors boundaries on both jaws, on which the antimers relief is applied, were not clearly seen. At the same time, the teleradiographies featured high content accuracy for the main planes location (skull base, Frankfurt, occlusal and mandibular). The positions of the subspinal (A) and supramental (B) points were clearly visible. It was possible to measure the upper medial incisors inclination angle in relation to the Frankfurt and/or craniofacial plane, and the lower ones — to the mandibular plane. As for the computer tomograms analysis, they are significantly better compared to the teleradiographies in terms of the image clearness displaying boundaries at different levels. It is quite possible to make precise measurements for linear and angular parameters using a package of applied mathematical software incorporated in the equipment. However, the view field of individual elements does not embrace other anatomical landmarks, which are necessary to analyze the spatial location of the studied organs. The tomograms make it hard to identify the medial incisor torque in relation to the occlusal plane. At the same time, the interincisal angle can be identified rather accurately.

Given that, we proposed a method for tomograms computer alignment for the mandibular joint and medial antagonist incisors with the lateral projection of head teleradiographies. The main references included the C points at the top of the articular process and the acoustic meatus of the tomograms, which were aligned relative to the craniofacial horizontal. When applying the incisors tomogram, the reference was the incisors conditional median verticals, which were combined with the lines shaping the teleradiography interincisal angle, as well as the face front vertical (N – Pg) and the Pg point. As a result, the study allows proposing an algorithm for comparing teleradiographies and some tomogram fragments, in particular, a fragment of the temporomandibular joint and medial incisors in an occlusal relationship. The algorithm included the following steps.

Firstly, the common points were applied: N (Nasion), C (Condylion), Ar (Articulare), T1, T2, Pg (Pogonion). These points served as a guideline for holding reference lines (planes), which we used as a reference for comparing tomogram fragments with the teleradiography. Horizontally, two lines were drawn. The upper line, which ran through the N and C points, separated the facial skull from the backskull, and we designated it as the facial skull plane or the craniofacial line (CFL). The mandibular plane (ML) passed through the Gn and T2 points. The intersection of these lines shaped the maxillofacial angle, which can be used as an indicator of the face growth type (horizontal, vertical and neutral). In the vertical direction, the N and Pg points were connected and a line resulted, which we marked as the vertical facial line. The line tangent to the mandible ramus bone (Ar – T1) with the mandibular plane shaped the mandibular angle (Fig. 1).

Secondly, the tomograms fragments were selected (Fig. 2).

Third, a combination of fragments was performed.

When combining the dentofacial incisal fragment of the tomogram, the Pg point of the tomogram was combined with the similar point of the teleradiography located on the face anterior vertical (N – Pg). At the same time, the medial incisors conditional median verticals connecting the cutting edges with the teeth roots tips coincided with the interincisal lines. When combining the temporomandibular joint fragment, the C point of the tomogram was combined with the similarly named teleradiographic reference. During that, the location of the Ar points was used for conformity (Fig. 3).

This means that the obtained images allow performing linear and angular measurements, as well as transferring the computed tomogram data to teleradiography.

## CONCLUSIONS

1. Improving the existing methods for the diagnosis of dentofacial anomalies resulted in developing a method of computed tomogram combination for the mandibular joint and dentofacial segments of the medial incisors with the head lateral teleradiographies. The method is based on aligning the C point, located at the top of the articular process and the acoustic meatus of tomograms, with the cranio-facial horizontal. When applying the incisors tomogram, the reference point was the conditional median vertical lines of the incisors, the vertical line of the face and the Pg point, which were combined with the lines shaping the interincisal angle of the teleradiographies. Using this algorithm will allow not only minimizing the errors associated with instrumental measuring techniques, yet will also lead to optimal functional and aesthetic results due to the predictability of orthodontic treatment.

2. The sum of the four angles (tetragonal indicator) including the value of the maxillofacial angle (between the ML and CFL lines), as well as the sizes of the angles shaped by the incisor lines with the ML and CFL (upper incisal, lower incisal, interincisal), may be recommended to be used as an indicator of the facial skull growth type (horizontal, vertical and neutral). An identical value, i.e. the sum of the five angles (pentagonal index), as a resultant for the upper incisal, interincisal, lower incisal, mandibular, and articular angles can also be used to describe the facial growth types.

3. Imposing the incisive dentofacial segment of a computed tomogram on a teleradiography located on the face anterior vertical allowed calculating the torque (vestibular-lingual) angles of incisors inclination towards the occlusal plane (OL). A perpendicular line drawn vertically on both sides of the OL line is a guideline for measuring the inclination angles (torques) with respect to the occlusal plane.

4. The clear (X-ray contrast) images of the temporomandibular joint elements allowed identifying the dimensions of the articular fossa in the anteroposterior and vertical directions, evaluating the ratios of

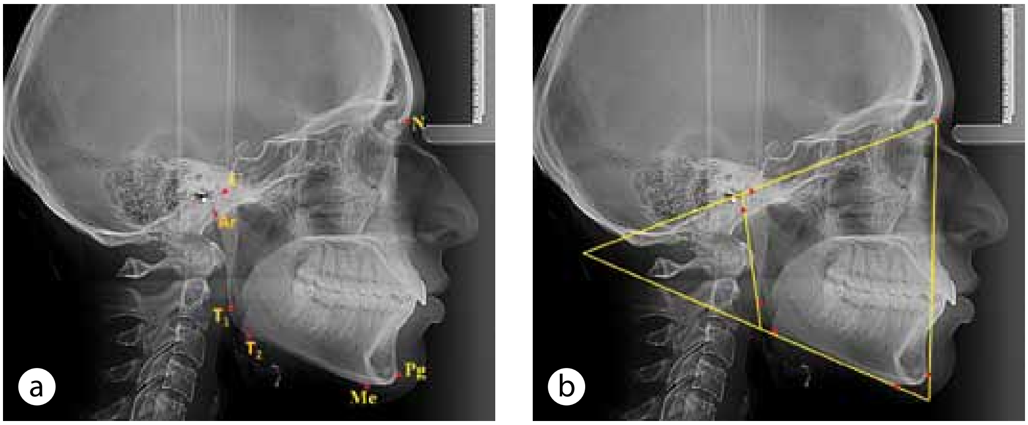


***Fig. 1.*** *The main points (a) and the line (b) used as the major reference points for comparing radiographs.*


***Fig. 2.*** *Tomogram at the medial incisors level (a) and the selected fragment of the dentofacial segments (b); tomogram at the joint level (c) and the isolated joint fragment (d).*

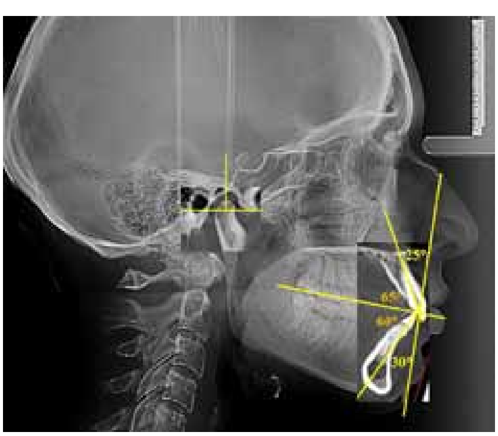


***Fig. 3.*** *Measurement of the incisors inclination angles and evaluation of the joint position on the combined radiographs*

these values, calculating the index of the articular fossa, and the articular head and articular fossa size ratios.

5. The introduction of cone-beam computed tomography into integrative anatomy and dentistry can be explained by the high efficiency of this method for various in-vivo cephalometric measurements. The measurements allow analyzing the size, the shape, and the volume differences in the paired symmetric structures of the skull.

6. Using the capacity of cone-beam computed tomography in comprehensive evaluation of morphometric parameters of craniofacial structures in the axial, frontal and sagittal planes (maxillary bones, temporomandibular joint, orbits, nasal cavity, paranasal sinuses) will allow expanding the database for medical craniology, forensic medicine, pathological anatomy, neurosurgery, otolaryngology, and radiology.

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