Modern diagnostics of masticatory system dysfunctions using coned beam tomography with radioscopy function

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Abstract

The disorders of the masticatory system, next to caries and periodontal disease, are a huge problem in modern dentistry in developed countries, including our own. The cause is the omnipresent stress that accompanies the patients everyday, and makes them more prone to developing harmful movement habits of the masticatory system, known as parafunctions. Prolonged parafunctional movements, particularly, occlusal parafunctions, lead to the overload changes in the joint, and increased risk of developing internal derrangement disorders of the TMJ and in due time degenerative joint disease, but also distant manifestatons, like neck, shoulder belt, cervical spine pain. These symptoms are often misleading to practitioners, and falsly diagnosed as the disorders of the particular painful area, whereas the actual cause lies within the masticatory system. The following article presents an innovative imaging method, by NewTom 5G XL Tomography, which is ideal for the TMJ imaging, at the same time minimising the radiation dose, but also has many interdisciplinarily useful applications.

Key words:

Key words: computed tomography, CBCT, diagnostics, temporomandibular joints, 3D imaging

The simplest methods of imaging of the temporomandibular joints are the classic X-rays and layered photos made using panoramic imaging (Fig. 1). However, they do not include spatial information about the structures of the individual elements of the joint, thus its diagnostic value is limited. In order to obtain three-dimensional images of bony elements, we can use multi-row-detector computed tomography (MDCT) or coned beam computed tomography (CBCT). Series of images are used by the software to do the spatial reconstructions, that can be further presented in any form. The main difference between MDCT and CBCT in image acquisition is the shape of the radiation beam, detector and associated with that, possibility of manipulating the protocol. The purpose of both methods is to produce detailed images, reducing to the minimum the radiation dose.

As both MDCT and CBCT are characterised by similar diagnostic value [1,3], when choosing between these methods, the key is the radiation dose that the patient receives during diagnostics. Despite the ongoing optimisation of imaging protocols in tomography, CBCT remains as the method, requiring the lowest doses of radiation, whilst maintaining the required quality [2].

The aetiology of disorders of the masticatory system

The disorders of the masticatory system, next to caries and periodontal disease, are a huge problem in modern dentistry. The rapid increase of patients with symptoms of dysfunctions, is significantly noticeable in developed countries, including our own. The cause is the omnipresent stress that accompanies the patients everyday. In stressful situations, there is an increased activity of mimic muscles which participate in the processes of emotional distress. This happens primarily by reducing the adaptive capacity of the masticatory system, and increasing the frequency of patients' parafunctions. [8, 10, 11]

Parafunctions are harmful movement habits of the masticatory system. We divide them into occlusal and non-occlusal parafunctional movements. Occlusal parafunctions include the habitual clenching and gnashing of teeth, and take place while there is a contact between the opposing teeth. Non-occlusal parafunctions are these movement habits, within the masticatory system, during which no contact between the opposing teeth is observed, e.g. tongue parafunctions, biting of the lips or the cheeks' mucous membrane, habitual biting of nails or objects. [7, 9, 10]

Prolonged periods of parafunctional movements, may lead to the incorrect model of mandibular movement. In consequence, this causes disturbances within the TMJ and may give rise to an array of painful and/or painless symptoms. The main painless symptoms, that arise from the TMJ abnormalities, are the deviations from the standard range of motion of the mandible, tooth wear, periodontal changes and sound symptoms like popping and crackling. Painful symptoms include local and distant manifestations. Painful compression of the temporomandibular joint and masticatory system muscle pain are the local symptoms. The distant ones are muscle pain of neck, shoulder belt, cervical, thoracic and lumbosacral spinal sections. [12, 13, 15]

The analysis of the acoustic symptoms, in the temporomandibular joint, during free mandibular movements, prompts the diagnosis of articular disc disorders. The disturbance in the correlation between the articular disc and the condyle, causes the popping sounds in the TMJ. Owing to the MRI and CT imaging of the TMJ, we know that these acoustic symptoms mainly occur, as the articular disc is anteriorly displaced during the maximum intercuspidation of the teeth. The popping sounds may also occur during more complex movements – anterior-medial and anterior-lateral. Prolonged parafunctional movements, particularly, as shown by our results, occlusal parafunctions, lead to the overload changes in the joint. This leads to the displacement of the articular disc, lack of correlation between the disc and the condyle and consequently pathological acoustic symptoms of popping. On the other hand, the presence of crackles in the TMJ usually indicates the existence of degenerative changes in the joints. [14, 16, 17]

As the results of our previous studies show, the prolonged parafunctional habits increase the risk of acoustic symptoms during all types of mandibular movements [9,10]. The parafunctional movements that are more likely to cause acoustic symptoms are

the occlusal parafunctions. In addition to psychological stress, other risk factors, widely present in the modern society are identified. These include maloclussion, missing teeth, extensive caries and iatrogenic factors associated with dental treatment, including prosthetic restorations. Dysfunction of the masticatory system may also be manifested by pain located within the TMJ and as well as distant pain. Distant pain may occur in the muscles of the neck, shoulder belt, cervical, thoracic and lumbosacral spinal sections. Recent studies (using fluoroscopy computed tomography) show that the occurrence of the distant symptoms is mainly associated with complex anterior- medial, anterior-lateral and simple movements of articular discs in the frontal plane. It also indicates fibromyalgia or widespread myofascial pain. [15, 19]

In another of our studies, in the study group of patients, the pain was most frequently localised in the neck, and the least frequently in the cervical spine [9,10]. According to the literature and numerous studies, parafunctions, particularly long-term ones, lead to the overload changes and may lead to pain syndrome resulting from repetitive motion, which is referred to as repetitive stress syndrome. It is important to associate pain symptoms outside of the masticatory system, with the disorders in it. It is particularly important to draw attention to eliminating intraoral factors that contribute to patients' parafunctions, to rise the awareness of the patients, about the existence of parafunctions, and help them to fight these harmful habits. This may spare the patient from time consuming, ineffective treatment. The interdisciplinary cooperation between dentists and doctors of other specialties is very important. [18, 20].

Diagnostic possibilities

The NewTom 5G XL appliance has an exceptionally large maximum range of examination, which includes the cone with a diameter of 21 cm and height 19 cm. This enables the examination to cover simultaneously, the mandible and the temporomandibular joints, maxilla, maxillary sinuses and temporal bones. This protocol is ideal for an overall dental-laryngological assessment, as the voxel size of the reconstructed volume in this protocol is 0,3 mm x 0,25 mm x 0,2 mm [manual handbook], which even allows the reliable imaging of the root canals . At the same time the image allows concurrent evaluation of the correlation of dental arches with the mandible condyles position within the TMJ. Using a construction silicone index, we can monitor the treatment progress of functional disorders of the masticatory system.

CBCT helps in differential diagnosis as it captures chronic inflammation in the facial skeleton. When diagnosing a specific medical problem, limited to a smaller area, the tomography cone can be reduced to 6cm x 6cm, which significantly reduces the patient's exposure. Table 1 presents the radiation doses, depending on the scope of the examination during standard protocol (Regular Scan Standard Dose) (Table 1).

In order to increase accuracy, the high-resolution (HiRes) and increased dose protocol (Regular Scan Boosted Dose) can be used doses shown in Table 2.

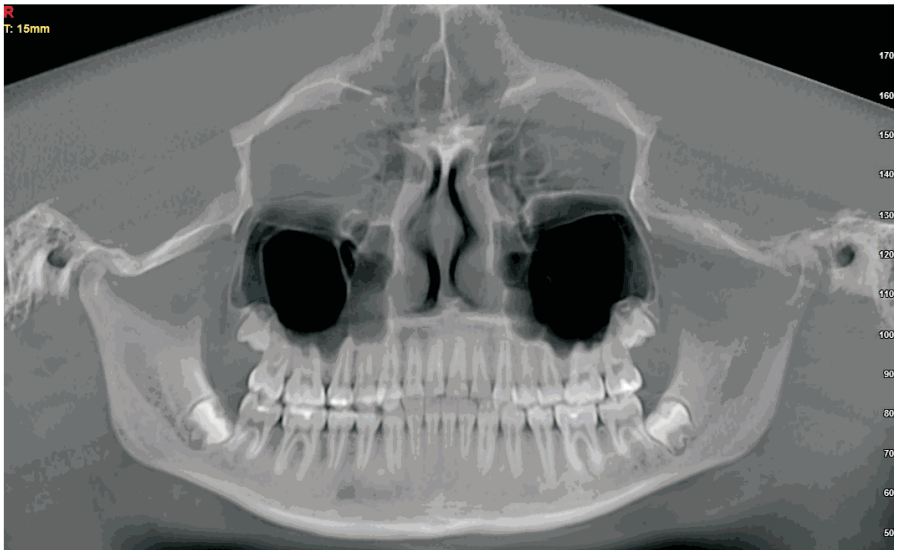

Fig. 1.
Panoramic radiograph reconstructed from 3D imaging, covering the entire facial skeleton.

Table 1.
Dose of radiation given in mGy for a scan depending on the imaging field (FOV). Protocol Regular Scan Standard Dose. *Source: NewTom 5G XL – Dose declaration and acceptance test annex*

FOV (cm)	6x6	8x5	8x8	10x5	10x10	18x8	15x5	18x16	21x19	średnia
Dose (mGy/ skan)	2.8	3.6	3.1	3.8	3.0	3.6	4.9	3.2	3.3	**3.47(7)**

Table 2.
Dose of radiation given in mGy for a scan depending on the imaging field (FOV). Protocols HiRes and Regular Scan Boosted Dose. Source: NewTom 5G XL – *Dose declaration and acceptance test annex*

FOV HiRes (cm)	6x6	8x5	8x8	10x5	10x10	18x8	15x5	średnia
Dose (mGy/ skan)	9.9	12.8	11.4	15.3	12.7	15.4	18.4	**13.7**

The relatively large difference in the radiation dose, shown in tables, proves that the appropriate selection of the examination area, its size and scan mode is very important, as far as the patient's radiological protection is concerned. In any case, these doses are still much lower in comparison to reference levels [4] and for example the reference dose for the facial skeleton and maxillary sinuses CT is 360mGy*cm. These are the levels for multi-row-detector tomography, and therefore one scan dose is expressed in mGy and is multiplied by a scan length in centimetres.

NewTom 5G XL Tomograph with its maximum examination area of 21x19 centimetres, is the perfect appliance for the diagnosis of the TMJ. Unlike most imaging solutions, where covering both TMJs on one scan is mostly impossible, this appliance allows simultaneous visualisation of the entire width of the skull. This is not only convenient for comparative assessment, but also allows for single radiation exposure. Even in the lowest radiation mode, the Eco mode, the mandibular condyles and the articular surfaces of the temporal bones are shown with great accuracy. The CBCT allows one, to analyse the anatomy of the mandibular condyle, as far as the shape, as well as the potential erosion of the surface. From the examination, we can obtain a lateral cephalometric radiograph which is necessary for the orthodontic or orthognathic treatment planning. The cephalometric radiograph obtained from CBCT scans is not enlarged as in the classic one. The software allows to accurately measure distances e.g.: joint spaces and comparing them after the treatment (Fig. 2). [7]

This appliance, compared to its predecessor, has been upgraded, with the radioscopy function, which allows saving a series of images as a movie. This makes it possible to analyse, the continuous movement of the mandibular condyle, and not just static images at a maximum intercuspidation and full mouth opening. One can measure the respiratory track and also, by introducing barite or other contrasting agent, the entire swallowing process can be observed. Radioscopy can also be performed in the frontal plane, which is useful to evaluate the lateral condylar movements during protrusion and track the movement throughout its entire course (Fig. 3).

Modern CBCT increase the safety of the patient during the examination with improved diagnostic capabilities of functional disorders of the masticatory system. The multidimensional analysis of TMJ structures is possible by creating 3D image and printing it in 3D.

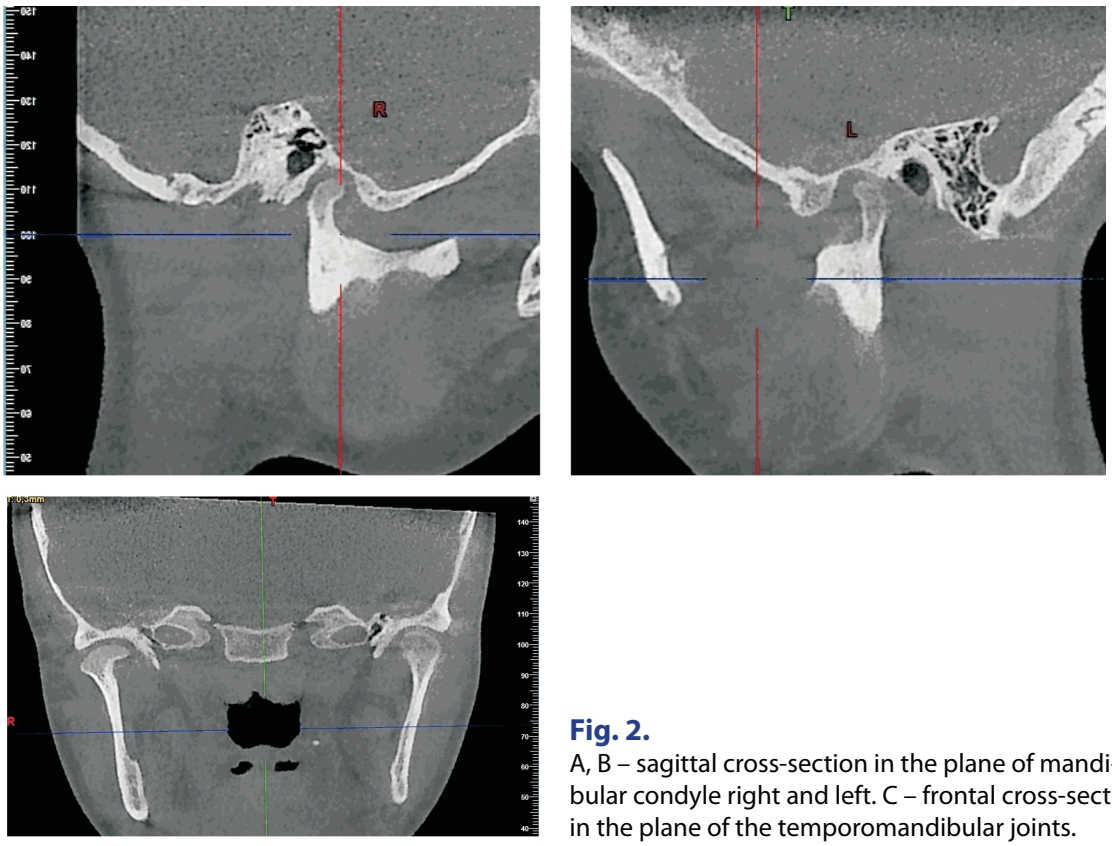

Fig. 2.
A, B – sagittal cross-section in the plane of mandibular condyle right and left. C – frontal cross-section in the plane of the temporomandibular joints.

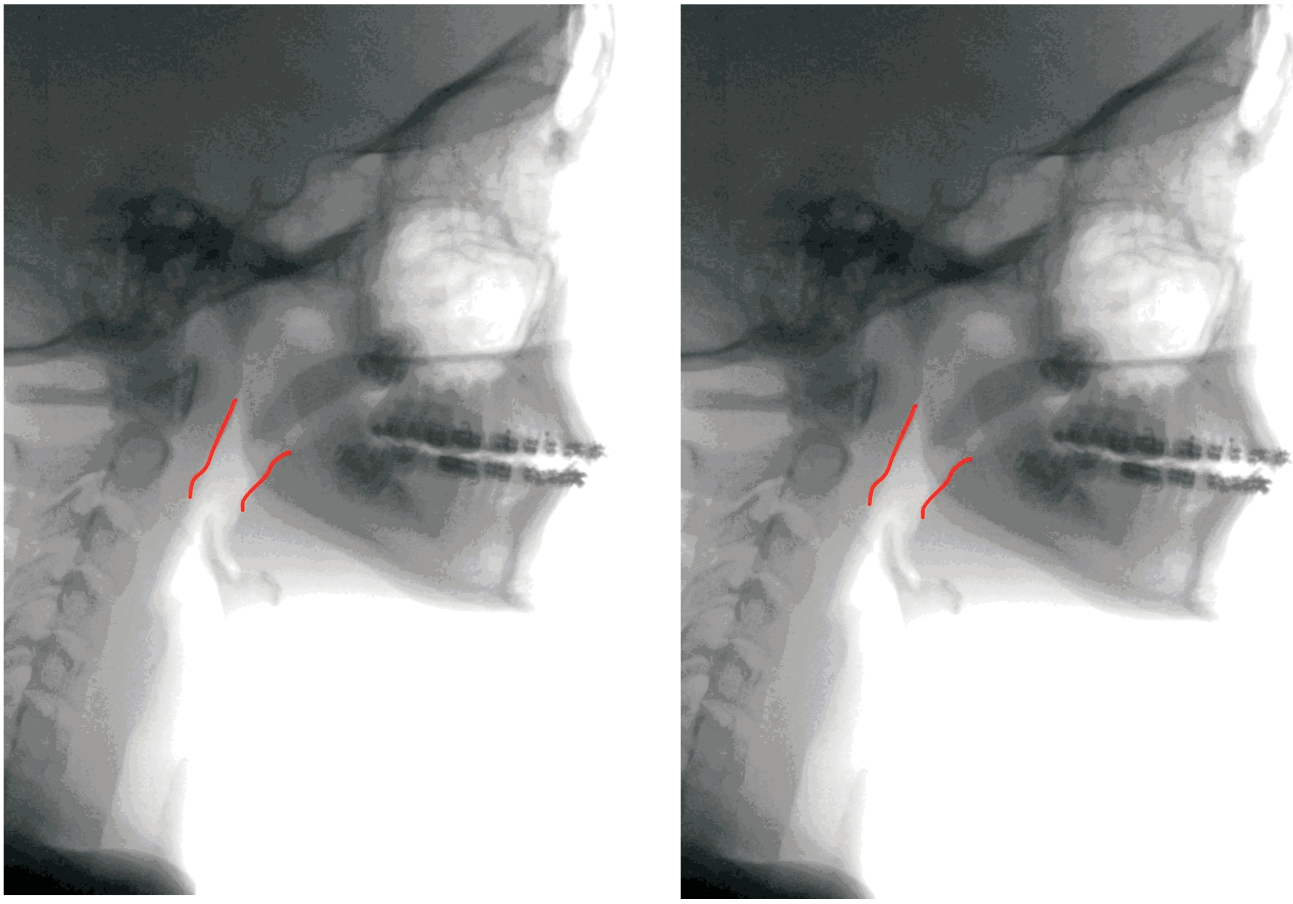

Fig. 3.
Breathing track-altitude of laryngopharynx. A – by intercuspidation, Photos obtained from the radioscopic recording. B – at its maximum aperture. Photos obtained from the radioscopic recording.

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