CASE REPORT

Cone beam computed tomography as diagnostic modality in temporomandibular disorders: A report of four cases

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Abstract

A considerable number of people suffer from temporomandibular joint (TMJ) disorders. Detailed history and clinical examination are essential for diagnosing TMJ disorders. Diagnosis of temporomandibular disorder (TMD) is based on clinical and radiographic investigations, where the latter is an important part of the clinical diagnosis. There are varieties of imaging techniques modalities to visualize TMJ ranging that include TMJ projections such as transpharyngeal view, transcranial view, orthopantomography, and conventional tomographic sections of TMJ. The TMJ disorders are frequently associated with degenerative bone changes such as flattening, erosion, osteophytes, subchondral bone sclerosis, pseudophytes, and articular eminence pneumatization which can be challenging to detect on conventional radiographs. Due to superimposition of the anatomic structures, accurate evaluation of the TMJ by conventional radiography is limited. To overcome this limitation, advanced modalities such as magnetic resonance imaging, arthrography and conventional computed tomography (CT) have been used for TMJ imaging for evaluating the joint space and the position of the condyle within the glenoid fossa. Accurate evaluation of the TMJ by conventional radiography is limited by structure superimposition. CT has been extensively used and proven imaging modality to assess the contours of the cortical bone and TMJ dynamics for evaluating the osseous changes in TMJ; however, high cost, large radiation dose, and long scanning time pose severe limitations. Due to high spatial resolution characteristics along with comparatively low dose, cone beam CT (CBCT) is an emerging technique that is being widely used in maxillofacial imaging. It is superior to conventional radiographic techniques in detecting bony TMJ changes because it detects three-dimensionally the bony structures with accuracy and involves a very slight increase in dosage of radiation when compared with the newer digital panoramic imaging and cephalometric imaging. Hence, a study of 4 cases of TMJ disorders that have been diagnosed with the help of CBCT has been presented in this article.

Introduction

Temporomandibular joint (TMJ) is one of the most important joints in the body and it has a close relationship with the oral cavity and teeth. The position and function of the mandibular condylar portion of the TMJ are directly controlled by the oral structures including the associated muscles.[1] Temporomandibular disorders (TMDs) are categorized under musculoskeletal pathologies which cause orofacial pain of non-dental origin, leading to limited mouth opening, muscle pain, clicking, and crepitus. TMDs are mostly associated with degenerative bone changes involving the osseous structures of the TMJ. Degenerative bony changes comprise flattening of the cortical outline, erosion, osteophytes, subchondral bone sclerosis, and pseudocysts.[2] Various factors leading to the development of TMD include stress, trauma, muscular hyperactivity, orthopedic instability, inflammatory diseases, and degenerative diseases, which hinder the stability of the TMJ.[3] Only clinical examination cannot be used for the correct diagnosis of TMD.[4] The imaging modalities in the dental office are usually two-dimensional (2D) representations of three-dimensional (3D) objects.[5] Panoramic radiography is a very good method of imaging both TMJ and other jaw and tooth structures. The modern orthopantomography offers a wider range of projection. The projection of both joints with the mouth opened or closed in one film is convenient for the diagnosis of TMD.[4] In quite a few clinical situations, a combination of conventional radiographs can be adequate for diagnosis. However, it can be facilitated by multiplanar images including computed tomography (CT).[6] Magnetic resonance imaging (MRI) allows for evaluation of soft tissue abnormalities of the TMJ. MRI is non-invasive and avoids radiation exposure. The disc can be visualized making diagnosis possible. Multiplane views of the TMJ are available; with high-speed MRI, dynamic studies are also available. In addition to identifying disc displacement, MRI is useful in the diagnosis of joint effusion, osteoarthritic changes, bone marrow abnormalities of the mandibular condyle, retrodiscal tissue changes, and neoplasms. TMJ arthroscopy now allows clinicians to visualize degenerative changes of both the articular cartilage and disc at early stages.[7] The CT has been a very important diagnostic tool in medicine for several years, yet in dentistry, it has taken slower steps owing to its expensive equipment, high radiation dosage and greater room required for its operation.[8] The purpose to design maxillofacial cone beam CT (CBCT) was to set off some of the limitations of conventional CT along with decreasing the patients' exposure to radiation.[9] Tsiklakis *et al*. explained that CBCT is a new technique producing reconstructed high diagnostic quality images using lower radiation doses than normal CT; therefore, it may be considered as the choice of imaging modality when the investigation of bony changes of the TMJ is the task at hand.[10]

Review of Literature

CT has been a valuable aid in the evaluation of the TMJ which provides excellent visualization of a broad spectrum of osseous pathological changes such as osteophytes, condylar erosion, fractures, ankylosis, dislocation, and growth abnormalities such as condylar hyperplasia. Studies on autopsy specimens found CT to have a sensitivity of 75% and a specificity of 100% for detecting bony changes with a 100% positive predictive value and 78% negative predictive value. However, the high cost, access to equipment, and the relatively high radiation dose have limited the widespread use of CT for TMJ evaluation. With the advent of CBCT, these barriers have been overcome.[11] Recently, CBCT is being considered as one of the important imaging modalities for the evaluation of degenerative osseous changes of TMJ with its major advantage over CT, which is the lower radiation dose.[12]

CBCT is a newly developed technique that can provide 3D hard tissue images of the oral and maxillofacial regions.[13] Correlated axial, coronal, and sagittal perpendicular multiplanar reconstruction (MPR) images are provided by CBCT units. The provision to add annotation and cursor-driven measurement along with visual adjustments to narrow the range of gray-scales and contrast level and magnification capabilities are the basic enhancements.[6] Because of its lower radiation dose, higher spatial resolution, and easy access when compared with multislice CT, it has been widely accepted and used for different diagnostic tasks including oral and maxillofacial surgery, oral medicine, endodontics, periodontology, orthodontics, and implantology. The technique can also provide a complete radiographic investigation of the bony components of the TMJ.[13] CBCT uses ionizing radiation with an area detector and divergent conical or pyramidal-shaped source to provide multiple transmission images that are combined forming volumetric information in contrast to CT that measures attenuation and uses limited beam geometry.[14]

CBCT as preferred diagnostic modality

CBCT can be used to provide excellent 2D images although it is primarily a 3D imaging modality. The conventional cephalometric radiograph, compresses 3D anatomy into a 2D image, whereas CBCT provides a true single plane midline image which eliminates the overlapping of head and neck structures that makes identification and specific anatomic measurements difficult apart from allowing a more precise measurement directly on a 1:1 scale.[15] It is known that digital flat-panel detector (FPDs) are capable to directly convert the energy of X-ray into high spatial resolution digital signal. The advancements in FPD technology resulted in X-ray tubes which require relatively less power and better computing power which has led to wide use of CBCT in multiple biomedical applications and industrial applications such as single-photon emission CT, image guided type of radiotherapy, neuroradiology, angiography, spinal procedures, thoracic procedures, and orthopedic procedures.[3] The technique is used with a CBCT scanner operating with a maximum output of 110 kV and 10 mA, with 0.7 mm Al-equivalent filtration and a standard 14° cone beam angle.[8] CBCT scanners use volumetric tomography, with a 2D extended digital array which provides an area detector and combined with a 3D beam of X-ray. The cone beam technique includes the patient's head being stabilized with a head holder and a single 360° scan in which the X-ray source and a reciprocating area detector synchronously move around.[6] Scanning time is 76 s and the output is automatically adjusted

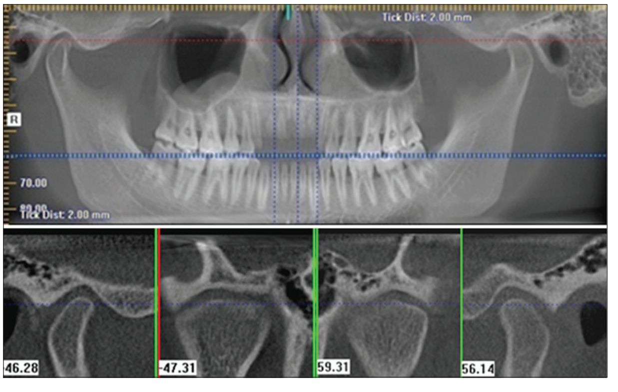

Figure 1: Cone beam computed tomography findings reveal posterior sloping of the condylar head on sagittal section and loss of cortical outline in coronal sections

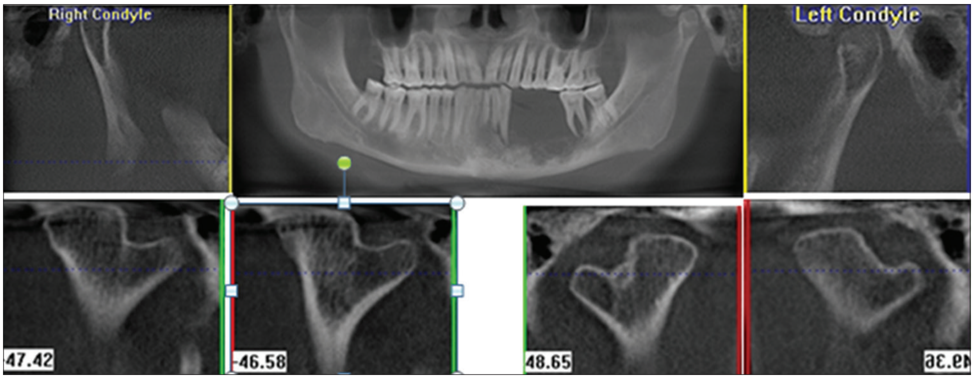

Figure 2: Cone beam computed tomography findings showed bifid condyles on coronal sections of both right and left sides

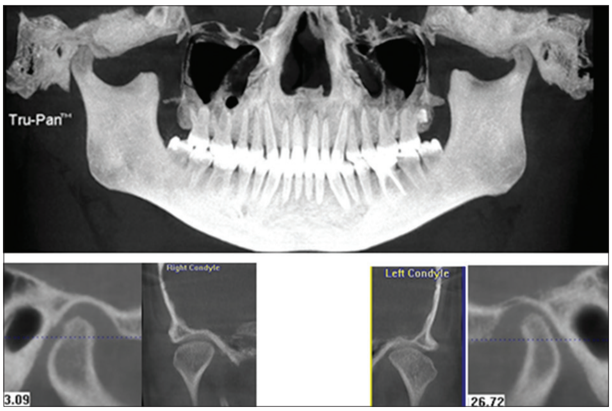

Figure 3: Cone beam computed tomography findings revealed loss of cortical outline and irregular bony surfaces on sagittal and coronal sections of both sides

during the 360° rotation according to tissue density, the so-called "smart beam technology."[8] Single projection images, known as "basis" images are acquired which similar to lateral cephalometric radiographic images, each slightly offset from one another. The series of basis images, thus obtained, is referred to as the projection data. Software programs utilizing sophisticated algorithms incorporating back-filtered projection are applied to these projection data to create a 3D volumetric dataset, which can provide primary reconstruction images in three planes, i.e., axial, sagittal, and coronal.[6] The CBCT systems dedicated for head and neck can be used for specific purposes to evaluate small regions by appropriately collimating the X-ray beam that reduces the size of the irradiated area and provides superior quality of images because of the isotropic voxel resolutions which provide sub-millimeter spatial resolution ranging from 0.4 to 0.125 mm. A quick scanning time of 10-70 s along with effective patient dosage between 30 and 80 μSv in one single rotation acquires all required basic images, which is suggestive of the significant reduction in the dosage as much as 98% on comparison with the conventional CT and 4-15 times the dose of a single panoramic radiograph. Furthermore, chair-side image analysis, volume reconstructions, and MPR can be performed owing to the unique display modes and reduced image artifacts.[3]

CBCT in TMD

The TMJ is a rather difficult area to investigate radiographically.[8] Only mineralized structures of the TMJ can be viewed in the conventional plain TMJ radiographs which are, however, difficult to interpret because of the superimpositions of the various neighboring structures which create difficulty in visualization. The imaging of TMJ by CBCT provides exact quantification of the surface of condyle as well as its volume which are important while providing treatment to the patients suffering from TMJ dysfunctions. The most common degenerative changes found in CBCT of TMD are TMJ flattening (59%) and osteophytes (29%). According to Alexiou *et al*., to detect shape changes in TMJ like the presence of osteophytes, flattening or erosion other than its size, CBCT is better when compared with that of MRI probably because of less spatial resolution and greater slice thickness (>3 mm) in MRI. Furthermore, other problems which can hamper the accuracy in MRI may include air spaces within temporal bone, fibrous tissues within TMJ, and vicinity of the lateral pterygoid muscle to the condylar articular surface. CBCT can also be used to diagnose initial stages of juvenile idiopathic arthritis amongst children which if not detected may afflict facial development leading to growth alterations.[3]

A few cases of TMD that have been diagnosed using CBCT are discussed below:

Case 1

A 21-year-old male patient had complained of intermittent pain in the right and left cheek regions in front of the ear since 8 months that had been progressively increasing, aggravating on mastication with temporary relief on taking medications. There was no history of trauma. Mouth opening recorded was 37 mm. On examination, tenderness was elicited bilaterally in TMJ region associated with a closing click on left TMJ. A provisional diagnosis of TMJ dysfunction syndrome was given (Figure 1).

Case 2

A 58-year-old patient diagnosed with oral squamous cell carcinoma with no complaint of TMJ clicking or pain or impairment of function. CBCT scan revealed an incidental finding of bilateral bifid condyle on TMJ screen (Figure 2).

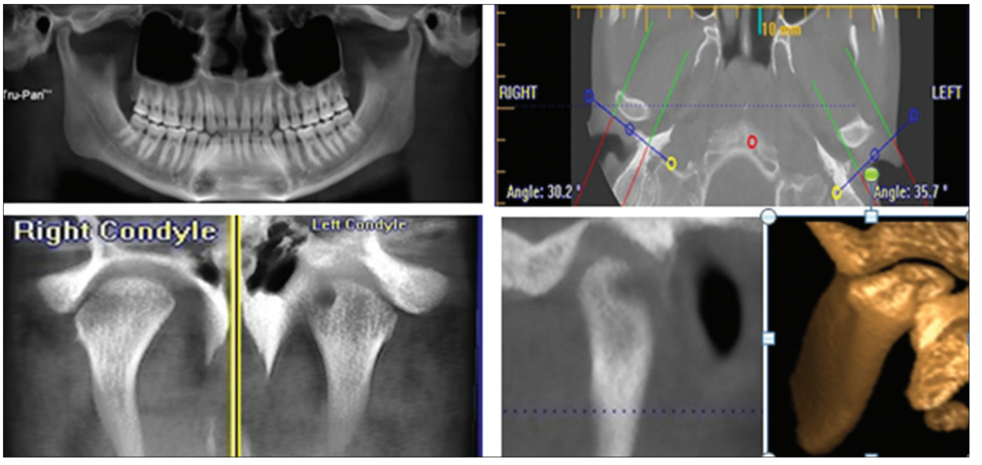

Figure 4: Cone beam computed tomography findings revealed developmental anomaly presenting as radiolucency just below the cortical outline bilaterally on sagittal sections

Case 3

A 24-year-old patient reported with the complaint of pain in the left cheek in front of the ear since 3 months that had been progressively increasing, aggravating during mastication. Mouth opening recorded was 35 mm. On examination tenderness was elicited in the TMJ region of left side associated with closing click and deviation toward left side. A provisional diagnosis of TMJ dysfunction syndrome was given (Figure 3).

Case 4

A 20-year-old male patient had reported with a complaint of pain in left cheek region in front of the ear with a history of trauma 1 year back. TMJ examination revealed clicking and tenderness of TMJ on the left side; hence, a diagnosis of TMJ disc derangement was given. Scan revealed radiolucency below the cortex, which was thought of as being a developmental disorder and not related to the episode of trauma (Figure 4).

Discussion

This study attempted to list four types of TMDs including erosions, osteoarthritis, bifid condyles, and a developmental anomaly. In a study done by Kyung-Soo Nah, 2012 where osseous changes of the condyle in patients with TMDs had been assessed, flattening of articular surfaces associated with posterior, lateral, medial, as well as superior surfaces were seen which were similar to Case 1 and Case 3 of this study.[16] Kurita *et al*. found radiographic changes where resorption in the lateral part of the condyle of the mandible was seen in 57 of 178 joints (32.0%) and correlated with 22 among them had tenderness on digital palpation. The study had included osseous erosions, concavities, and also flattening of condyles.[17] Similar clinical scenario was seen in Case 1 and 3 of the present study where the patients had complained of pain. Honda *et al*. had mentioned in their study that the CBCT is a viable diagnostic alternative for detecting erosions and osteophytes in the TMJ[18] which goes hand-in-hand with our study as well. In another study by Gunduz *et al*., among 2634 patients, 42 patients (1.7%) had been diagnosed to have bifid mandibular condyle (BMC). In the literature review by Miloglu *et al*., Neves *et al*., Menezes *et al*., Sahman *et al*., 2011, 2012; and Cho and Jung, the majority of the BMC cases was unilateral, and a bilateral pattern was rare.[19]

Conclusion

In due course of time as the machines become more available to the clinicians, the CBCT would be a very important diagnostic modality and slowly gain popularity for the same. Since it helps in visualizing all the bony components of the TMJ, CBCT aids in the diagnosis of a variety of TMD including osteoarthritis, inflammatory arthritis, trauma, and development disorders.

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