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Assessing the Diagnostic Precision of Cone Beam Computed Tomography (CBCT) in Temporomandibular Joint Arthritis: A Comprehensive Review

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Abstract:- Temporomandibular joint disorders (TMD) are prevalent among a substantial portion of individuals. One such challenging condition is temporomandibular joint arthritis (TMJ arthritis) which is characterized by inflammation and deterioration of the TMJ. There is a wide array of imaging techniques available for the evaluation of the temporomandibular joint (TMJ), encompassing computed tomography (CT), magnetic resonance imaging (MRI), cone beam CT (CBCT), conventional radiography, and ultrasonography. CBCT, as compared to CT, offers the advantage of producing high-resolution 3-dimensional multiplanar TMJ arthritis images while requiring a lower radiation dose. CBCT provides the capability to analyze complex structures, such as bones, accurately. It additionally reduces scattered radiation, thereby enhancing image quality. The purpose of this review article is to comprehensively analyze the existing literature and research results to evaluate the diagnostic effectiveness of CBCT in detecting TMJ arthritis.

Keywords:- Temporomandibular Joint (TMJ), Cone Beam Computed Tomography (CBCT), Temporomandibular Joint Disorder (TMD), Temporomandibular Joint Arthritis (TMJ Arthritis), Osteoarthritis (OA).

I. INTRODUCTION

Dysfunction of the temporomandibular joint (TMJ) can result in temporomandibular disorders (TMD), which fall under the category of musculoskeletal pathologies [1]. TMJ arthritis, also known as temporomandibular joint arthritis, is one such TMD referring to inflammation and degeneration of the temporomandibular joint, which connects the jawbone to the skull. This condition can cause pain, swelling, and limited movement of the jaw, often resulting in discomfort and difficulty with activities like chewing and talking. It can be caused by various factors, including autoimmune diseases or wear and tear over time. TMJ arthritis can develop in individuals of all age groups, although its occurrence becomes more prevalent as people get older [2,3]. It impacts various components, including cartilage, subchondral bone, synovial membrane, and other hard tissues, resulting in alterations like TMJ remodeling, wear and tear of articular cartilage, and deterioration [2,4]. Diagnosing TMD using conventional radiographs is challenging, which is why CBCT is considered the preferred imaging technique for any TMD diagnosis. Cone beam computed tomography (CBCT) provides high-resolution 3D imaging of the temporomandibular joint (TMJ) while offering the advantage of minimal radiation exposure. Hintze et al. and associates merged CBCT with traditional methods and, in general, observed no noteworthy disparities in diagnostic precision between the two approaches [4,5]. Therefore, CBCT is regarded as a superior imaging technique when compared to other 2D imaging modalities.

II. PRINCIPLE

CBCT consists of a collimated X-ray source and a detector that revolves around the patient. The detector determines photon depletion by computing the cumulative photon count as it emerges from the patient. This data is collected at numerous angles along a rotational arc, typically covering several hundred angles. This data, in its raw form, is processed by a computer algorithm to reconstruct a 3D

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dataset consisting of volumetric elements, and it is from this dataset that images are generated [6].

III. DISCUSSION

Osteoarthritis (OA) affecting the temporomandibular joint (TMJ) often presents a range of significant bony alterations. These changes include irregularities in the bony cortex of the condylar head, erosions, the formation of bony outgrowths known as osteophytes, and the development of subchondral cysts within the joint. These osseous modifications that accompany TMJ arthritis ultimately led to several distinct consequences, such as a reduction in the space within the joint, the development of subchondral bone sclerosis (increased bone density), and the flattening of critical structures such as the condylar head, glenoid fossa, and articular eminence. When it comes to visualizing and assessing these structural changes associated with TMJ arthritis, CBCT imaging stands out as the preferred diagnostic tool [7,8]. CBCT provides highly detailed and precise visualization of these bony alterations, allowing for a more accurate assessment of the extent and severity of TMJ-arthritis related changes. This enhanced imaging capability is particularly beneficial for staging the disease and closely monitoring its progression over time [7,8].

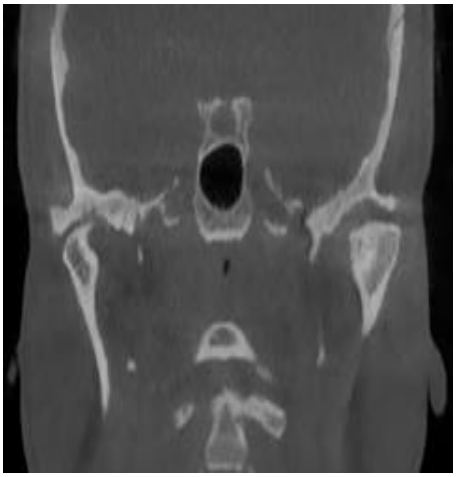

Fig 1 Depicts the Presence of Localized Marginal Bony Overgrowth Observed in the Right Condyle

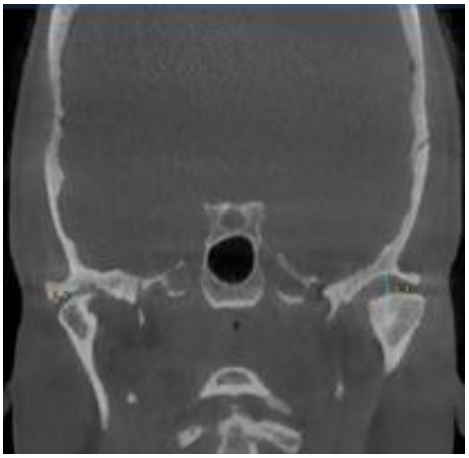

Fig 2 Illustrates the Joint Space Measurements for the Right TMJ at 1.8 mm and for the Left TMJ at 5.4 mm.

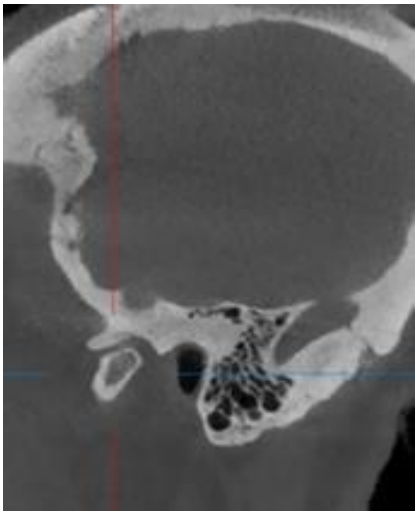

Fig 3 Depicts Flattening of Bone Contour Noted on the Anterior Slope of Right TMJ

High-quality imaging with a narrow field of view (FOV), like an 8x8 scan, ensures complete coverage of the TMJ area and allows for excellent visualization of any bone changes in the TMJ region [9]. CBCT devices with a wider field of view can also be used to diagnose the temporomandibular joint. The image volume's coverage of the temporomandibular joint can vary based on the selected field of view (FOV). However, it is important to consider that using a wide field of view and high voxel size reduces the image resolution, which may impact the ability to detect early bone changes [10,11]. CBCT offers enhanced diagnostic capabilities for detecting bony articular abnormalities in the TMJ, especially when employed in conjunction with complementary imaging modalities like MRI [8,12].

Multiple research investigations have employed CBCT scans to study osteoarthritis (OA) within the temporomandibular joint (TMJ). Among the earliest significant patient series, published in 2009 and focused on assessing age-related changes in TMJ OA using CBCT, it reaffirmed a well-known finding in OA research. Specifically, it demonstrated a strong correlation between age and both the occurrence and severity of OA in the TMJ. The primary radiographic observations consistently included flattening, erosion, and osteophyte formation, with sclerosis being another frequently observed characteristic [12,13]. Based on a study conducted by Kyung Soo Nah et al. regarding condylar bony changes in patients with TMJ disorders using CBCT, the research findings indicated that the most observed condylar bone changes were sclerosis, followed by surface erosion. This led them to the conclusion that the increasing prevalence of CBCT usage in dentistry and maxillofacial imaging underscores the growing importance of developing precise and comprehensive guidelines for the assessment of osteoarthritis in the temporomandibular joint (TMJ) [14].A study conducted by Sumit Yadav et al. and Ledjo Palo et al. focused on assessing the diagnostic accuracy of two distinct cone-beam computed tomography (CBCT) protocols used to identify arthritic changes within the temporomandibular joints [15,16].

In the current study by Ahmad et al. He examined a group of 54 individuals, consisting of 48 females and 6 males. The study reported an average age of 71.3 years, with a standard deviation of 5.2, spanning from 61 to 83 years [17,18]. Out of the total of 108 joints analyzed, 53 of them (49%) were diagnosed with osteoarthritis [17,18]. The most common signs included flattening of the joint surface, the development of osteophytes, and the presence of subcortical sclerosis in the condyle. As a result, the imaging characteristics primarily revolved around bone-related changes. As surface flattening and subcortical sclerosis lacked diagnostic certainty, it became apparent that osteophyte formation emerged as the predominant and conclusive radiological marker in osteoarthritis diagnosis [17,18].

Pontual and Freire et al.'s 2012 study found that flattening was the most frequent degenerative alteration observed in the TMJ on CBCT scans, occurring in 59% of cases, followed by osteophyte formation, which was seen in 29% of cases [19].A multitude of in-vitro investigations have been undertaken to explore the potential of CBCT in identifying bone abnormalities and osteophytes in cadaveric TMJ samples [20].Librizzi and Tadinada et al. (2011) found that utilizing a 6-inch FOV in CBCT is more advantageous for the diagnosis of erosive changes in the TMJ when compared to a 12-inch FOV [21].

IV. CONCLUSION

Cone beam computed tomography (CBCT) stands as a valuable imaging tool in the diagnosis and evaluation of TMJ arthritis and related bone changes. Its capacity to offer highly accurate and detailed visual representations greatly facilitates the precise diagnosis and ongoing monitoring of this condition. The advancement of additional research and the establishment of standardized protocols have the potential to further enhance its clinical applicability in the field of TMJ disorders.

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