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REVIEW ARTICLE

Structural discrepancy of the TMJ disc and joint capsule on magnetic resonance imaging. Literature review

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ABSTRACT

The temporomandibular joint (TMJ) is considered a bicondylar diarthrosis type joint. Imaging evaluation is a fundamental part of its assessment, which should include both bony and soft tissue characteristics and the relationship between them. Magnetic resonance imaging (MRI) represents the gold standard for the study of soft tissues; however, up to now, its main application continues to be the visualization of the articular disc. For this reason, the present article aimed to point out the information available in the literature regarding the visualization of the joint capsule in MRI and to evaluate it as an independent structure.

Keywords: Temporomandibular Joint; Temporomandibular Joint Disc; Magnetic Resonance Imaging

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1. Introduction

The temporomandibular joint (TMJ) is considered a diarthrosis type joint due to its ability to perform translational and rotational movements, and bicondylar since it articulates two distinct surfaces. It differs from other joints in the body because it is covered by an avascular fibrous tissue or fibrocartilage instead of hyaline cartilage, and the bony surfaces it articulates (maxilla and mandible) have teeth and form a single unit from the functional point of view[1].

Among the established indications for imaging studies are failed conservative treatments, increased symptomatology, history of trauma, significant dysfunction, important changes in occlusion, bone structural abnormalities, suspected infections, sensory or motor alterations[2]. Its correct visualization in cases of pathology, planning of surgical procedures or dysfunctions is fundamental for the diagnostic process[3-6]. In order to evaluate its integrity, both the bony morphological characteristics or hard tissues (mandibular condyle, fossa and articular tubercle of the temporal bone), as well as the soft tissues (articular disc, ligaments and articular capsule) and the relationship between them, surrounding muscular tissues that surround it should not be ignored, especially those that have an intimate relationship such as the lateral pterygoid muscle (upper belly)[7]. This analysis will allow us to confirm the extent or progression of any dysfunction or disease if it exists, and also to document and evaluate the effects of any treatment already established[8]. For hard tissue evaluation, 2D visualization techniques have serious limitations with respect to the overlapping of anatomical structures, mainly the skull and zygomatic arch, which hinder the visualization of the mandibular condyle and glenoid fossa. This is why the old techniques (panoramic radiography and transcranial projection) have been replaced by computed tomography (CT)[4]. Currently, as it has a lower radiation dose, Cone Beam Computed Tomography (CBCT) is applied with a diagnostic accuracy in bone changes similar to CT[9-12]. However, neither of these two modalities provide correct visualization of soft tissues, so other diagnostic methods should be applied[9,13]. With respect to soft tissues, several technologies are used, such as arthrography, indicated for the evaluation of disc position, perforations and disc adhesions, which requires the application of intracapsular contrast[8]. So it is difficult to perform[14]. Ultrasonography allows the evaluation of soft tissues both in movements and static (open and closed mouth). It is an economical diagnostic tool, transportable, smaller in size and requires less infrastructure, providing greater comfort to the patient, but operator-dependent[4,8]. MRI provides anatomical and functional information of both hard and soft tissues[7,14]. Although it does not have great precision to visualize cortical bone tissue, most bone pathologies are detected by means of this imaging test[13,14]. Current protocols recommend the combination of auxiliary imaging exams for the study of hard tissues with CBCT and soft tissues with MRI, when necessary for diagnosis[6]. There are few studies and reviews published in the literature focused on the visualization of these soft tissue structures, defining them as independent entities[15-18]. Most of the studies focus on the study of the articular disc.

The objective of this literature review was to present the information available in the literature regarding whether or not the joint capsule of the TMJ can be visualized and evaluated on MRI and whether or not it can be distinguished from the articular disc.

2. MRI in TMJ

It is the gold-standard imaging test to this day[19]. It has excellent spatial and contrast resolution and does not provide ionizing radiation[4,19]. The whole structure of the TMJ can be clearly distinguished by the recognition of the different signal intensities of bone, cartilage, muscle structures as well as synovial fluid[20]. This makes it the imaging technique of choice for the analysis of the articular disc of the TMJ and the surrounding anatomical structures in both normal and pathological conditions[21,22].

2.1 MRI soft tissue anatomy

All the imaging techniques previously described for the visualization and evaluation of soft tissues of the TMJ are not without difficulties. The challenge lies in the correct visualization of the structures in this area, since they are small in relation to the slice thickness, also any slight variation in the plane alignment can alter the way the images are observed and finally, the structures of interest in both MRI and CT are not usually seen in their entirety, but to observe them, consecutive slices must be viewed[23]. In addition, the TMJ is close to anatomical structures such as the mastoid cells, auditory structures and the temporal bone, which can lead to confusion[19]. The suggested protocol includes sagittal and coronal oblique planes perpendicular and parallel to the major axis of the condylar head (**Figure 1**), with a slice thickness less than or equal to 3 mm and with a dual surface antenna to capture the signal from both TMJs[24-26].

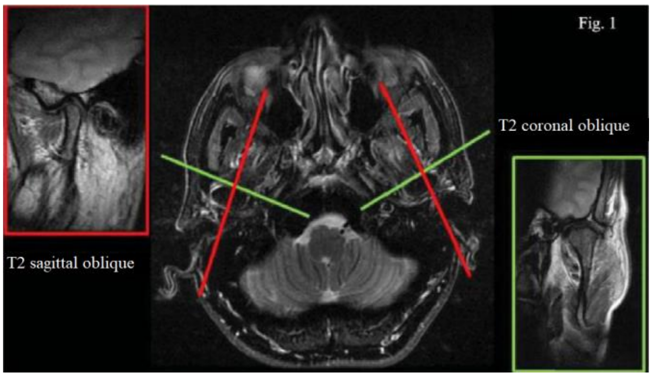

Figure 1. Illustration of MRI slices of both TMJ in T2: sagittal oblique and coronal oblique[28].

The application of T1, T2 weighted sequences with fat suppression and proton density in both open and closed mouths is recommended[26]. The application of a contrast medium such as gadolinium is used to determine the presence of arthropathies in certain patients[27]. The dynamic study, which is used mainly for the evaluation of the articular disc and its relationship with neighboring bone structures, is not very widespread[26].

The application of MRI for the study of the articular disc, not only its morphology but also its dynamics, is widely known and there are well-established protocols for this purpose[26,29,30]. The articular disc of the TMJ is formed by fibrous connective tissue, in sagittal MRI slices it is observed as a biconcave structure with a homogeneous signal of low intensity or hypointense in its anterior zone, as well as the intermediate and posterior zones are observed as slight hyperintensity in normal or healthy conditions and the bilaminar zone has an intermediate signal in weighted T1[8,26]. The upper portion of this bilaminar zone is rich in elastic fibers and the lower in collagen fibers, both separated by lax areolar tissue[1]. The tissues of the bilaminar zone and the lateral pterygoid muscle will present a moderate signal in T2-weighted images, much lower than in T1-weighted images. It has been demonstrated that parasagittal and paracoronal slices (**Figure 2**), in T1 weighted and in proton diffusion weighted in closed mouth give the best image to evaluate the anatomy of the TMJ and not so in T2 weighted[29].

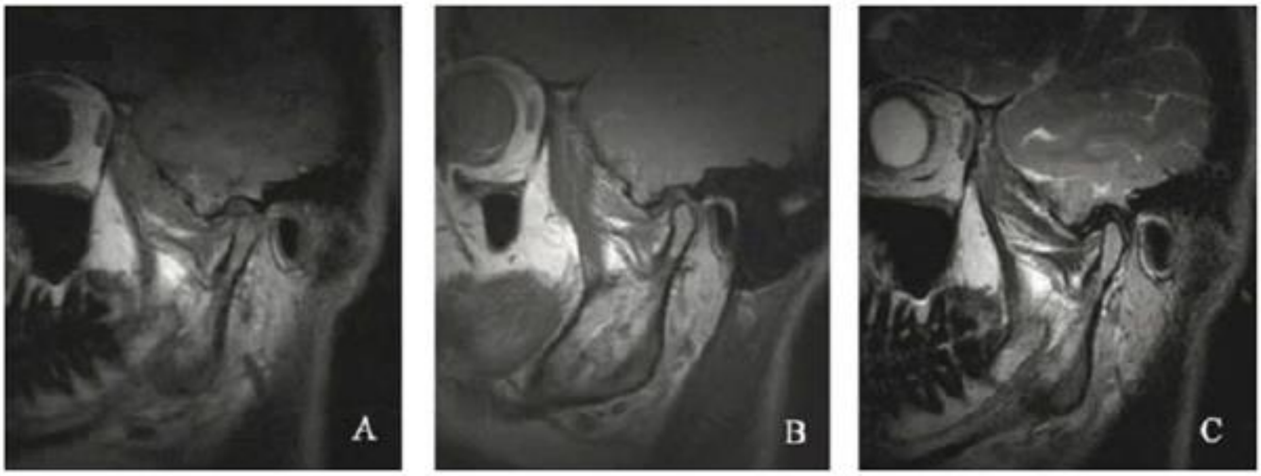

Figure 2. The different anatomical components are more easily seen in both images A and B when compared to C[31]. **A**: Examples of parasagittal view of TMJ in closed mouth. **A**: T1-weighted image. **B**: proton diffusion-weighted image. **C**: T2-weighted image.

The articular disc is attached at both ends to the joint capsule that surrounds it, dividing the joint into two compartments: supradiscal and infradiscal[25]. The ligamentous apparatus of the joint is composed of the capsule and ligaments. Within the ligaments, the temporomandibular or lateral external ligament secures the joint capsule laterally and is known as the main reinforcement. The sphenomaxillary and stylomaxillary ligaments have an accessory role, as well as the mandibulomalleolar, fibroelastic ligament which shares embryological origin with the hammer and anvil bones, which may explain the fact that in cases of temporomandibular dysfunction these are accompanied with cases of auditory symptomatology. However, it is complex in sagittal sections of the articular disc to determine whether this ligament is an independent element or a lateral extension of the sphenomaxillary ligament. All these elements are composed of compact connective tissue with a predominance of collagenous fibers. Both disc compartments (supra and infradiscal) are internally covered by synovial membranes, these are located only in the periphery without having any relation with the articular disc[1]. These have an intermediate signal intensity[15]. The capsule is a lax fibrous structure that surrounds the entire joint except in its anteromedial side because at this point is the fusion of the tendon fibers of the upper bundle of the lateral pterygoid muscle with the articular disc[1], which can often give an image of double articular disc in MRI[16].

Regarding the latter structure, it is controversial whether or not it is observed in MRI. Most studies do not specify[8,25,32], few state that it is not observed in MRI[24], others only in cases of pathology or effusion distention[23,28,29,33], very few say that it can be seen in cases of pathology or effusion distention[15,17] (**Figure 3**).

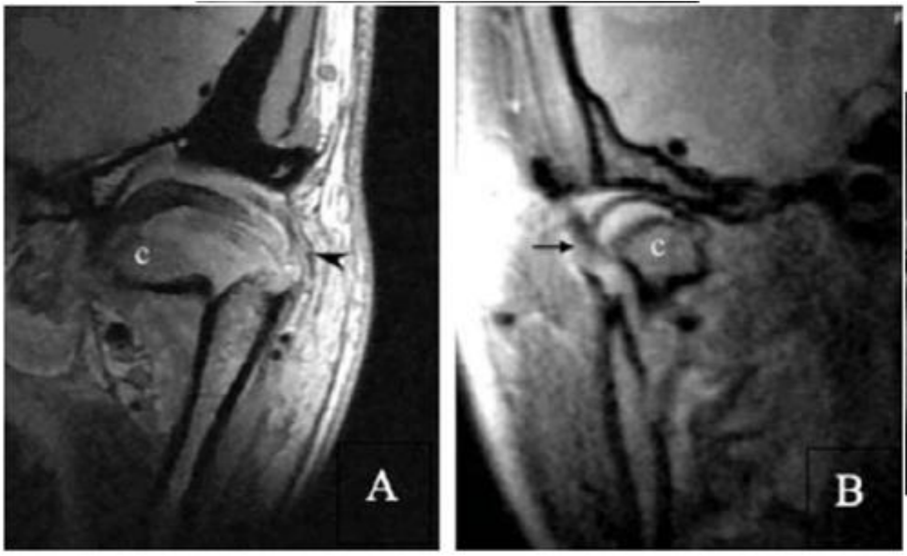

Figure 3. Weighted images with proton attenuation in coronal view.

Others as a result of fracture cases such as Kim *et al.*[34], only mentioned that it can be seen as an oblique line (**Figure 4**), but do not specify where it is located; Sun and Wan mentioned its rupture and presentation as an expandable mass in the ear canal (**Figure 5**)[18].

Figure 4. This sagittal T2-weighted image shows the disruption (white arrow) of the oblique line representing the capsule. Note: It is speculated that it corresponds to a tear of the capsule. In addition, effusion and hamarthrosis can be observed in both articular compartments[34].

Figure 5. MRI coronary reformation, showing the lateral displacement of the articular disc (white arrows)[42].

However, neither specifies what it looks like. Sakhavalkar *et al.*[35], in the year 2016 published a study evaluating and measuring the width of the joint capsule based on indirect parameters, but they also do not specify how it is observed. In image A, it is mentioned that in (c) a condylar fracture fragment and a well-defined image of the articular capsule (arrow head) are seen. Image B shows the well-defined image of the articular capsule (black arrow) and in (c) the fracture of the condyle in the medial area of the mandibular ramus[17].

The aim of this article is to postulate the fact that the articular disc is often confused with the joint capsule when evaluated in MRI and cannot be determined as an independent structure. Contrast is defined as the visual difference between the different black, white and gray shades contained in the same image. It can alter the density seen between two adjacent structures, either by the composition of these structures or by elements external to them[36]. Any imaging diagnosis must demonstrate contrast between normal and pathological anatomical features, and without this, it is unfeasible to identify or detect abnormalities[37]. In MRI, the contrast between two different tissues depends on the inherent or intrinsic properties of the tissues and on the essential pulse or extrinsic parameters determined by the user[38]. The former include the T1, T2 sequence, proton density, flux and apparent diffusion coefficient, and the latter include the repetition time, echo time, b-value, turbo factor, flip angle and inversion time[37]; it has been postulated that the first two are the ones that most affect the appearance of the tissues. It should be noted that only one feature in the composition can prove to be determinant in the appearance of a tissue in an image, independent of the contrast intent provided by the selected pulse sequence[38]. One of the challenges in evaluating fibrocartilaginous tissues of the TMJ in MRI is that they have a short T2 that drops sharply when compared to hyaline cartilage, due to the fact that the equipment does not turn out to be very accurate[39]. This is due to the fact that the equipment is not sensitive to these components, giving a low or even zero intensity signal in all sequences; finally translating into gray or black images. This would be useful to demonstrate abnormalities that have a high signal, however, it generates confusion when it is used to detect abnormalities that have a high signal[40]. However, it generates confusion when one wants to individualize nearby anatomical structures, especially when they share the same composition[38]. An improvement to this technique would be given by the application of ultra-short echo times, which would preserve the fibrocartilage signal and minimize artifacts[28,40]. However, this sequence is still reserved for research.

Furthermore, it should be taken into consideration that up to now most of the resonators used are 1.5 tesla resonators, while those with higher magnetic field strength provide images with greater diagnostic precision[41]. Therefore, we believe that several articles have failed to differentiate these structures due to the inherent factors of the resonator equipment. To illustrate this, the image (**Figure 5**) presented by Orhan *et al.* in 2005 clearly shows how impossible it is to differentiate the disc from the joint capsule[42]. As technology evolves, authors such as Wang, Yang and Yu in 2009 already mentioned its visualization in T1 and with a density very similar to that of the articular disc, particularly when observed in the coronary reformation[17]. By 2015, Hagenkord and Basel presented images of the articular capsule where they defined it with a density similar to that of the capsule, as previously commented, since they are made up of the same tissue[43]; thus, with an archive image we want to demonstrate that the image of the articular disc can be differentiated from the articular capsule (**Figure 6**).

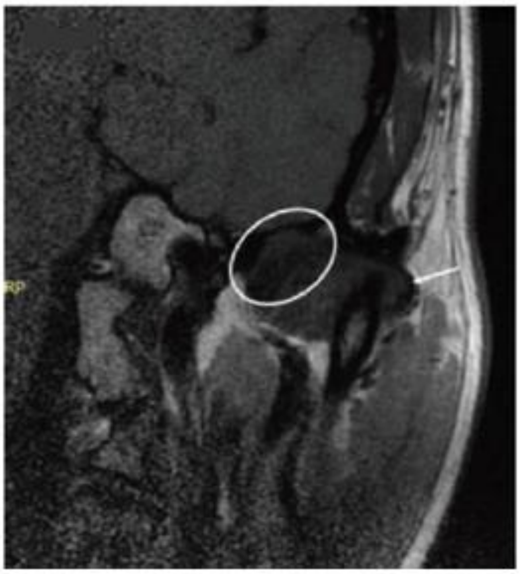

Figure 6. Archive image of the Oral and Maxillofacial Radiology Service of UPCH. Coronary reformation in MRI. The image of the articular disc (oval) and the articular capsule (white arrow), distinguishable one anatomical structure from the other.

Finally, it should be considered what was already described in 2012 by Shaefer *et al.*[44], who emphasized the importance of MRI analysis in sagittal and coronal corrected slices. Methods previously described by Steenks *et al.*[45] and Chen *et al.*[46] both showed that the application of functional parameters could improve the technique for determining the degree of disc displacement. This modification consists of observing the disc in coronal slices parallel to a line perpendicular to the most posterior inclination of the articular eminence (**Figure 1**).

3. Conclusions

It is particularly complex to distinguish the articular capsule from the disc. Even to a specialist, it is difficult to differentiate the shades of gray between a hyaline cartilage and a fibrous one, which have low contrast and can easily confuse both structures. In addition, we could add that the slices provided may not be a faithful representation of the anatomical structures of the temporomandibular joint. For this reason, it is essential to provide the complete volume of the MRI or CBCT performed in order to be able to perform an exhaustive analysis in the slices indicated in the protocols.

Conflict of interest

The authors declared no conflict of interest.

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