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REVIEW ARTICLE

Anatomical assessment of the temporomandibular joint with magnetic resonance imaging

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ABSTRACT

A systemic and synthetic review of the anatomy of the temporomandibular joint in magnetic resonance imaging was developed for its evaluation. The temporomandibular joint is an anatomical structure composed of bones, muscles, ligaments and an articular disc that allows important physiological movements, such as mandibular opening, closing, protrusion, retrusion and lateralization. Magnetic resonance imaging is an imaging technique that does not use ionizing radiation and is more specific for the evaluation and interpretation of soft tissues, due to its high resolution, so it has an important role in the diagnosis of various maxillofacial pathologies, which is why the dentist should have knowledge of the structures and functions of the temporomandibular joint through magnetic resonance imaging. The review demonstrates the importance of magnetic resonance imaging in the study of the anatomy of the temporomandibular joint, in addition to mentioning the advantages provided by this imaging technique such as its good detail of the soft tissues in its different sequences and the non-use of ionizing radiation to obtain its images.

Keywords: Temporomandibular Joint; Magnetic Resonance Imaging; Anatomy

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1. Introduction

The Temporomandibular Joint (TMJ) is an anatomical structure composed mainly of bone, muscle and ligamentous tissue that performs important movements such as opening, closing, protrusion, retrusion and lateralization from right to left or vice versa of the mandible. It also has fibrocartilaginous tissue in the form of a disc, which divides the joint into two compartments superiorly and inferiorly, protecting it from friction and/or friction of its movements.

The importance of Magnetic Resonance Imaging (MRI) in this anatomical area is essential, unlike other imaging techniques such as Computed Tomography (CT), Panoramic and Scanography, which are more specific for the evaluation and interpretation of bone structures, making it difficult to evaluate soft tissues, as well as the pathologies that affect it.

The following study aims to review the main scientific publications that evaluate the anatomy of the TMJ by means of MR images as an auxiliary examination in the evaluation of its soft tissues in order to know the normal structures and to discern and identify when abnormalities and pathologies are present.

2. Magnetic resonance imaging

Magnetic resonance imaging is an auxiliary imaging test that allows us to have a better diagnosis, prognosis and compression of the pathologies that intervene in the TMJ, having as its main characteristic the ability to obtain images of soft tissue with greater clarity, unlike other imaging methods. In this sense, MRI can contribute decisively in the identification of the morphological characteristics of the different pathologies of the TMJ that affect all types of patients[1,2].

MRI is based on the absorption of energy by a magnetically active nucleus, which must have two fundamental characteristics: an odd number of protons and a spin; the most commonly used nucleus is hydrogen, due to its abundant presence in the human body[3]. In MRI all the images obtained are produced using a pulse sequence which are stored in the computer scanner. The most commonly used sequences are T1 and T2 (relaxation times). The T1 sequence is used to evaluate normal anatomy, while the T2 sequence allows detecting the presence of any pathology[4].

2.1 T1 or longitudinal magnetization time

It is the time interval in which the longitudinal magnetization recovers 63% of its equilibrium state. Fat presents a short T1 and is hyperintense (bright) in T1-weighted MR images[5].

2.2 T2 or transverse magnetization time

It is the time interval in which the transverse magnetization decreases by 63% of its maximum strength. Pure water and other liquids are hyperintense (bright) while fat is hypointense on T2-weighted images[5].

3. Temporomandibular joint

The TMJ is a diarthritic bicondylar joint, with movements in the three axes of space, only surpassed by the hip and shoulder joint; which is constituted by a synovial cavity, articular cartilage and a capsule that covers the same joint, inside we find synovial liquid and several ligaments, joining the temporal bone cavity with the head of the mandibular condyle[6,7].

3.1 Bone structures

The cranial surface is composed of the squamous part of the temporal bone called the glenoid fossa, which receives the mandibular condyle. The anterior part is formed by the articular eminence, being a posterior bony prominence of the zygomatic bone and the inferior part is composed by the head of the mandibular condyle, which in turn is totally covered by the articular capsule[8-10] (**Figure 1**).

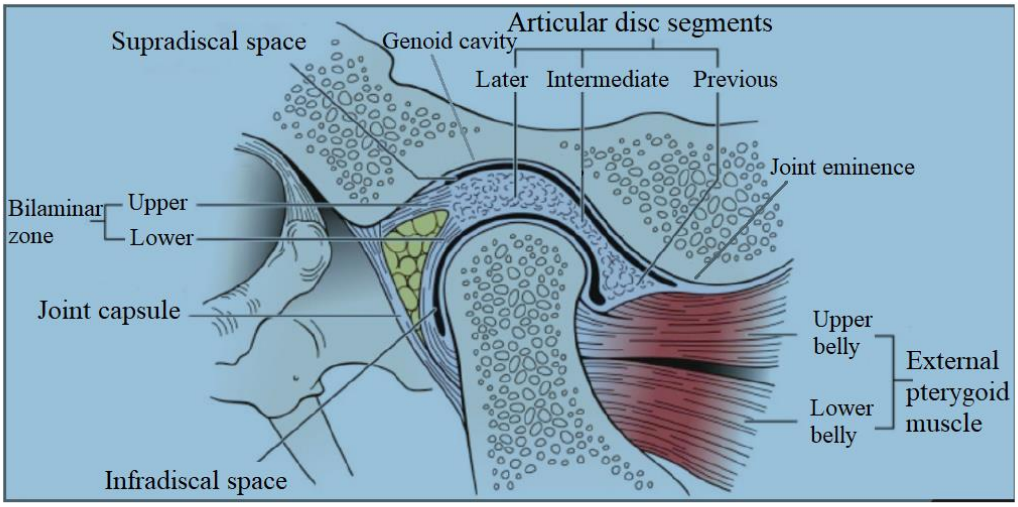

Figure 1. Illustration of the different structures that compose the TMJ. Modified from: Neumann *et al.*[8].

3.2 Avascular fibrocartilaginous structures

The joint capsule is formed by external or temporomandibular fibers, and internal fibers such as the temporomeniscal fibers (the most important, since they compose the posterior meniscal brake, as well as the bilaminar zone) and the meniscomaxillary[7,11,12].

The articular disc is biconcave and is located inside the articular capsule between the mandibular condyle and the glenoid fossa, dividing the synovial cavity into two compartments, superior and inferior. Its anterior part is in contact with the articular capsule, articular eminence, superior part of the external pterygoid muscle and the condyle, and its posterior part is related to the retrodiscal tissue, glenoid fossa, temporal bone and condyle. The disc is composed of three segments: anterior band, intermediate zone and posterior band. The anterior and posterior bands are triangular in shape and are connected by a thin intermediate zone. The anterior band is attached to the articular capsule, the head of the condyle and the superior belly of the external pterygoid muscle, while the posterior band is attached to the bilaminar zone or retrodiscal tissue[7,13-16] (**Figure 1**).

3.3 Ligamentous structures

The temporomandibular ligament is an intrinsic ligament that inserts on the external surface of the zygomatic tubercle and posterior aspect of the neck of the condyle. The extrinsic ligaments are the sphenomandibular ligament that originates from the sphenoid spine and inserts in the medial wall of the articular capsule, passes through the petrotympatic fissure and continues its descent to the mandibular lingula (sphenoid, middle ear and mandible) and the stylomandibular ligament arises from the styloid process of the temporal bone to the mandibular angle[7,16-19] (**Figure 2**).

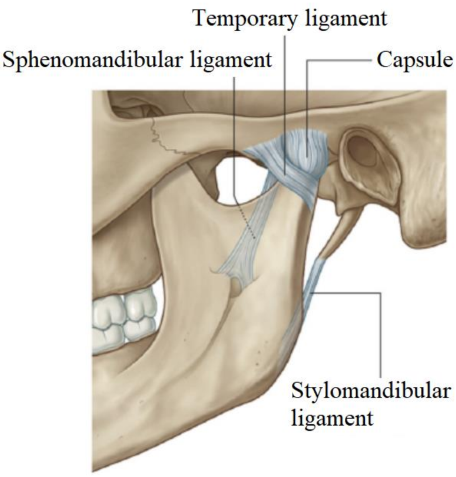

Figure 2. Illustration of the ligamentous structures of the TMJ. Modified from: Gray's anatomy for students[17].

3.4 Articular synovial

Saline fluid, somewhat more viscous than in the shoulder and hip joints, produced by the synovial mucosa found inside the capsule except in the fibrocartilaginous linings of the glenoid cavity, mandibular condyle and articular disc[20-22].

3.5 External pterygoid muscle

Also called the lateral pterygoid muscle, it is composed of two parts or bellies, the upper belly and the lower belly. The lower pair of bellies are primarily responsible for moving the mandible forward, thus opening the mouth and pulling the mandible to one side. The lower belly is predominantly attached to the top of the lower jaw (mandibular condyle). The upper ventral fibers pass through the joint capsule and connect to the front of the articular disc. The superior belly is responsible for the proper movement of the disc in coordination with the movement of the lower jaw, especially when closing the mouth, just the opposite of the inferior belly. It then exerts forward pressure on both the condyle and the disc, stabilizing their relationship to each other and ensuring the last possible effective position when strong masticatory forces move the condyle backward and forward[23-27] (**Figure 1**).

3.6 MR imaging densities of the main anatomical structures of the TMJ

The following diagram shows the signal intensity of various tissues in T1 and T2 of the TMJ, we should note that the signal of the tissue varies according to the protein variety of the content; tissues with high protein concentration should have a high signal in T1 and a low signal in T2[6,28,29-32]. In T1W1 the hyperintense images are synovial fluid and fatty tissue, the tenuously hyperintense isointense images are ligamentous and fibrocartilaginous tissues such as the temporomandibular, sphenomandibular and stylomandibular ligaments and the articular disc and capsule. On the other hand, the hypointense images are the bony structures such as the temporal bone (glenoid fossa), mandibular condyle and zygomatic bone (articular eminence) and the isointense images are the muscular and vascular-nerve structures such as the internal maxillary artery and the auriculotemporal nerves, and the external pterygoid muscle. In T2W1 basically the same happens as in T1W1, but in the hyperintense images in addition to the synovial fluid, articular effusion can be appreciated (evidenced only in joint pathology, sign of intracapsular inflammatory content) (**Figure 3**).

For a better understanding of the anatomy of the TMJ by means of MRI and the detection of possible pathologies that may affect this region in particular, in addition to an important experience, anatomical landmarks are needed, and depending on the slice that is performed, a structure can be appreciated in better detail and in a specific way. The following is a description of some of these cuts.

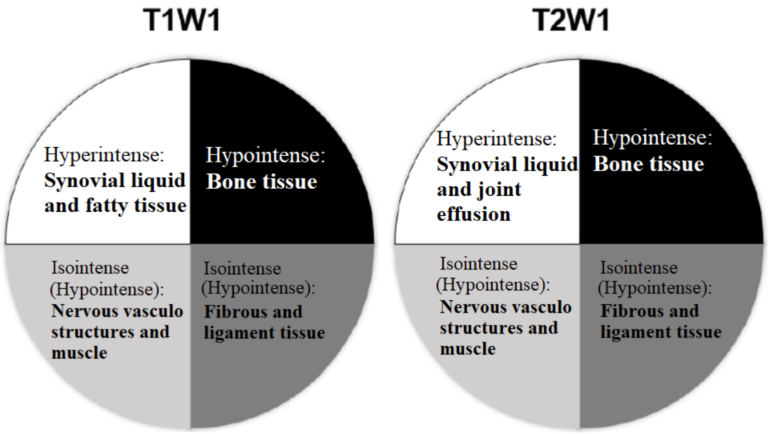

Figure 3. Diagram showing the different signals in different tissues of the TMJ.

In **Figure 4**, we present sagittal slices at the level of the middle part of the articular disc with three different images, on the right an anatomical scheme, in the middle a specimen scheme, and on the left the respective MR image at the same slice level; in these three images we can observe anatomical structures of relevance such as: the *temporalis muscle (TM)*, which inserts into the coronoid process (which is evidenced as a hypointense area for being very inorganic—corticalized—), *the inferior belly of the external musculopterygoid (IPLM)* he inserts into the pterygoid fossa (neck of the mandibular condyle), as well as the articular eminence (convex crescent-shaped hypointense band downwards), the mandibular condyle where we can evidence its cortex (hypointense band that surrounds it), and inside the cortex on the medullary space (isodense region of the hypointense cortex). Finally, the *anterior band (AB)* and *posterior band (PB)* of the disc are evidenced, configuring the ends of the disc (**Figure 4**).

In **Figure 5** we present images at a medial parasagittal slice level with respect to the images in **Figure 4**, where in addition to the structures mentioned in the previous figure, we can also see the *superior belly of the external pterygoid muscle (SPLM)*, which is inserted in the anterior border of the capsule and articular disc (**Figure 5**).

In **Figure 6**, we present coronal slices at the level of the mid-lateral axis of the mandibular condyle where we can observe relevant anatomical structures such as: the *temporalis muscle (TM)* evidenced above and outside the articular tubercle and temporal bone respectively (adjacent hypointense band), *the posterior band of the disc (PB)*, faintly isointense due to its heterogeneous content (vascular and adipose content), we also observe the *internal capsular ligament and the sphenomandibular ligament (SFL)* (isointense) (**Figure 6**).

In **Figure 7**, we present three images in a paracoronal cut anterior to the images of **Figure 6** level of the biconvex part of the disc, at the ends specimen type schemes and in the middle an image in magnetic resonance, where we can observe anatomical structures of relevance such as: the *parotid gland (GP)*, isointense volume behind and outside the posterior border of the branch, *inferior belly of the external musculopterygoid (IPLM)*, evidenced medially from the neck of the condyle, *superior belly of the external musculopterygoid (SPLM)* and the articular disc projected medially (isointense to slightly hypointense due to its fibrous content) (**Figure 7**).

In **Figure 8**, we present axial sections at subcondylar level where we can observe: the *temporal muscle (TM)*, isointense triangle medial to the hypointense area (coronoid process), the *inferior belly of the external pterygoid (IPLM)* inserting at the level of the neck of the condyle, the internal maxillary vein and the *sphenomandibular ligament (SFL)*, more hypointense than isointense than the first than the second respectively, both medial to the IPLM (**Figure 8**).

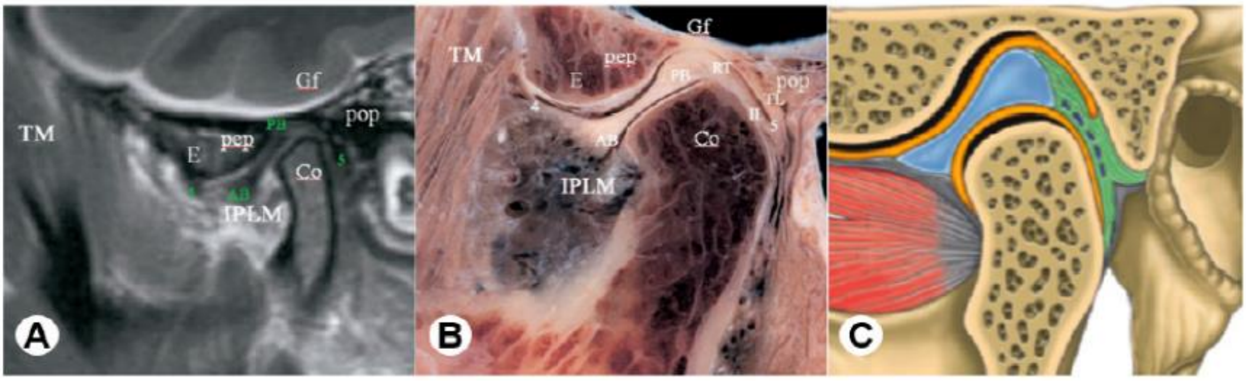

Figure 4. Strict parasagittal slices of the TMJ. **A**: MRI in T1 parasagittal view (TM) Musculotemporal muscle, (IPLM) Inferior belly of the external pterygoid muscle, (E) Articular eminence, (Co) Mandibular condyle, (AB) Anterior band, (PB) Posterior band. *Taken from: Alomar et al.*[15]. **B**: Parasagittal specimen. *Taken from: Alomar et al.*[15]. **C**: Illustration in sagittal plane. *Modified from: Gray's anatomy be anatomical basis of clinical practice*[14].

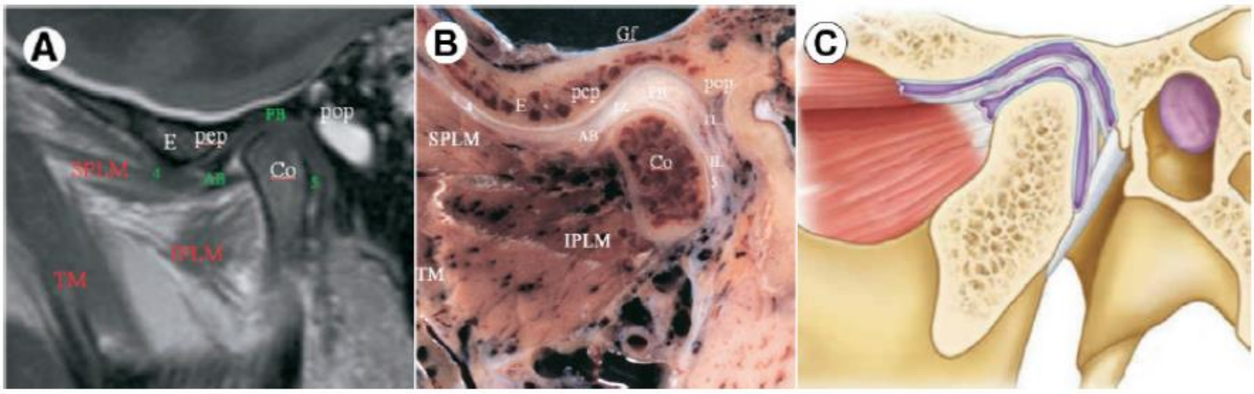

Figure 5. Medial parasagittal slices at the level of the external pterygoid insertion. **A**: T1-slice MRI (TM) Temporal muscle, (SPLM) Superior belly of the external pterygoid muscle, (IPLM) Inferior belly of the external pterygoid muscle, (E) Articular eminence, (AB) Anterior band, (PB) Posterior band (Co) Mandibular condyle. *Taken from: Alomar et al.*[15]. **B**: Parasagittal specimen. *Taken from: Alomar et al.*[15]. **C**: Illustration in sagittal plane. *Modified from: Moore clinically oriented anatomy*[10].

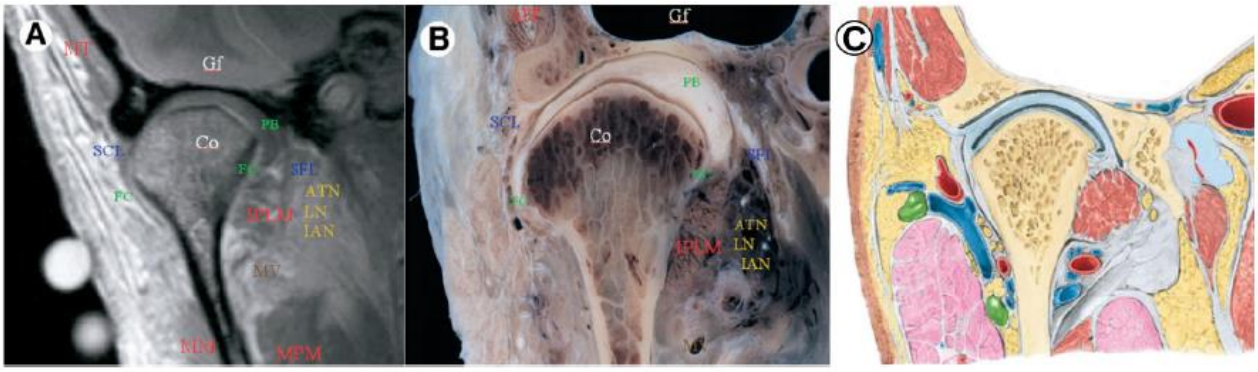

Figure 6. Strict coronal slices of the mandibular condyle. **A**: MRI in T1 coronal slice (MT) Musculotemporal muscle, (MM) Masseter muscle, (IPLM) Inferior belly of external pterygoid muscle, (SFL) Sphenomandibular ligament, (SCL) Lateral collateral ligament, (Co) mandibular condyle, (MPM) internal pterygoid muscle, [(IAN) inferior dental nerve, (LN) lingual nerve, (ATN) auriculotemporal nerve, the MRI does not show the nerves, it only indicates the place where they would be]. *Taken from: Alomar et al.*[15]. **B**: Coronal specimen. *Taken from: Alomar et al.*[15]. **C**: Coronal plane illustration. *Modified from: Moore clinically oriented anatomy*[10].

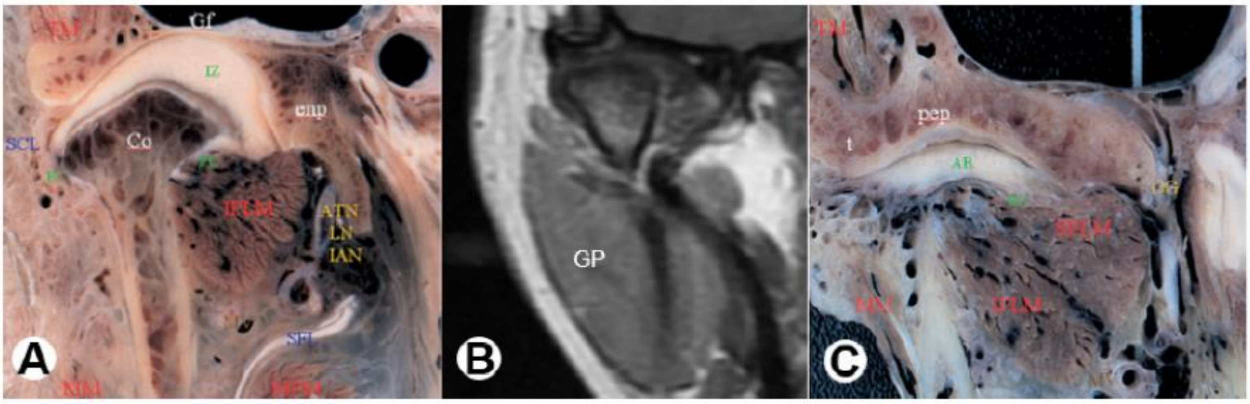

Figure 7. Cuts at the level of the articular disc. **A**: Specimen in coronal (TM) Temporal muscle, (MM) Masseter muscle, (IPLM) Inferior belly of the external pterygoid muscle, (SFL) Sphenomandibular ligament, (SCL) Lateral collateral ligament, (Co) Mandibular condyle, (IAN) inferior dental nerve, (LN) lingual nerve, (ATN) auriculotemporal nerve, the MRI does not show the nerves, it only indicates the place where they would be, (MPM) internal pterygoid muscle. *Taken from: Alomar et al.*[15]. **B**: MRI in coronal slice (GP) Parotid gland. **C**: Coronal specimen (SPLM) Superior belly of the external pterygoid muscle. *Taken from: Alomar et al.*[15].

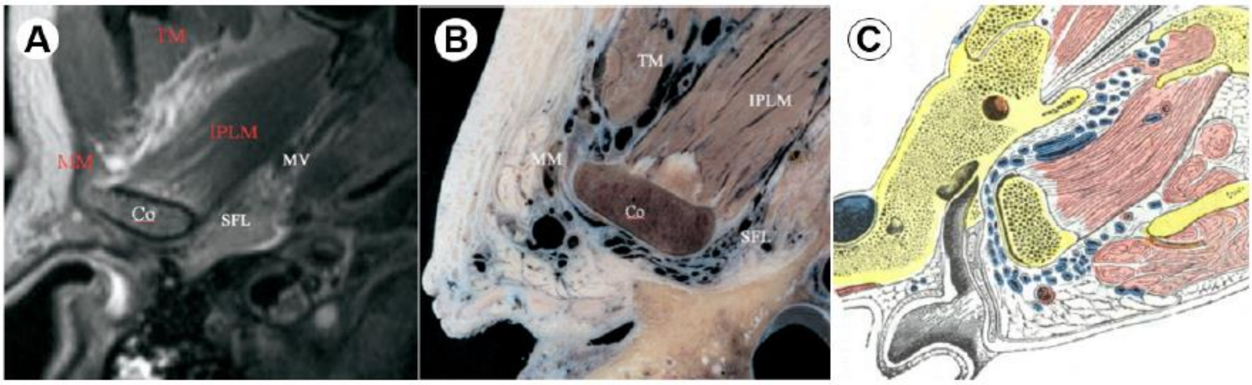

Figure 8. Axial slices at the mandibular subcondylar level. **A**: MRI in T1 axial section (TM) Temporal muscle, (MM) Masseter muscle, (IPLM) Inferior belly of the external pterygoid muscle, (SFL) Sphenomandibular ligament, (Co) Mandibular condyle, (MV) Maxillary vein. *Taken from: Alomar et al.*[15]. **B**: Axial specimen. *Taken from: Alomar et al.*[15]. **C**: Illustration in axial plane. *Modified from: Testut Topographic Anatomy*[23].

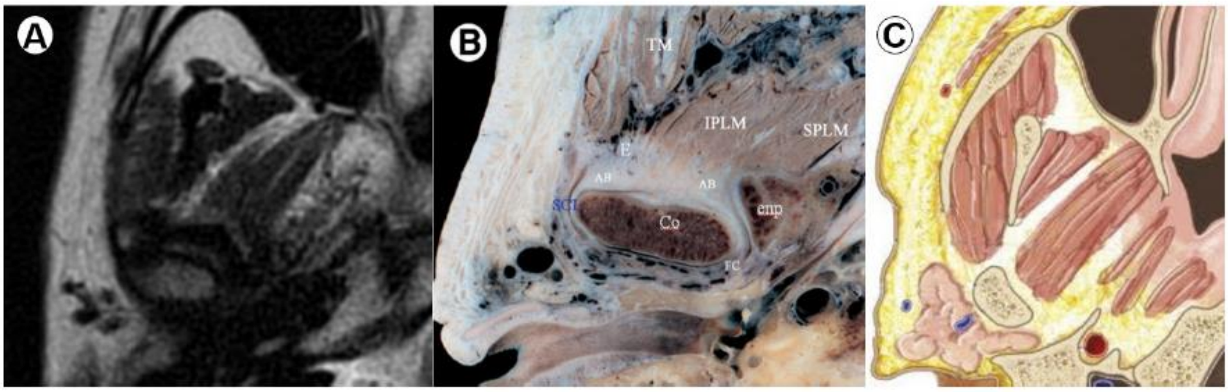

Figure 9. Axial slices at the level of the coronoid process of the TMJ. **A**: MRI in T1 axial view. **B**: Axial specimen (TM) Temporal muscle, (IPLM) Inferior belly of the external pterygoid muscle, (SPLM) Superior belly of the external pterygoid muscle, (Co) Condyle, (SCL) Lateral collateral ligament. *Taken from: Alomar et al.*[15]. **C**: Illustration in axial plane. *Modified from: Netter's correlative imaging neuroanatomy*[25].

In **Figure 9**, we present images at a lower paraaxial level with respect to **Figure 8** where we can better observe: the insertion of the *temporal muscle (TM)*, *masseter muscle (MM)* (between the zygomatic bone and the coronoid process, iso-intense muscle between two hypointense corticals) and also the *inferior belly of the external pterygoid (IPLM)* is still evident (**Figure 9**).

4. Conclusions

The temporomandibular joint is a complex anatomical structure that plays an important role in human physiology. Therefore, this review article shows the importance of having an adequate knowledge of its anatomy and that of its adjacent structures for its subsequent analysis and compression in magnetic resonance imaging.

Magnetic resonance imaging is an ideal technique for the study of the temporomandibular joint, since it allows us to study its bony and soft structures with the position and morphology of the articular disc, the latter structure being the one with the most alterations, the most common being anterior displacement without recapture.

The key to a correct interpretation of magnetic resonance imaging of the temporomandibular joint is based on a deep knowledge of its anatomy and understanding from its physiological aspect in addition to the proper interpretation of its structure, this adds to the challenge that now has for specialists dedicated to this area, because they will have to delve deeper into how to strengthen these concepts of basic science very necessary for the proper management when we are presented with pathologies.

Conflict of interest

The authors declare that they have no conflict of interest.

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