The diagnostic utility of dynamic Magnetic Resonance Imaging in temporomandibular joint internal derangements.

Poster No.: R-0096
Congress: 2019 ASM
Type: Educational Exhibit
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Keywords: Musculoskeletal joint, MR physics, Anatomy, MR, Imaging sequences, Education and training
DOI: 10.26044/ranzcr2019/R-0096

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Learning objectives

To review the diagnostic utility of the fast imaging with steady-state free precession (true-FISP) MRI sequence in the diagnosis of articular disc disease of the temporomandibular joints (TMJ).
Background

The temporomandibular joint dysfunction is a debilitating condition with a prevalence of 5-12% and predilection for adolescents and young females \cite{1,3}. Articular disc disease of the TMJ is defined as abnormal position and relationship between the disc, mandibular condyle and articular eminence \cite{1}. The true FISP MRI sequence complements conventional studies through the acquisition of additional information about articular disc mobility and reduction. The educational exhibit aims to review the true-FISP CINE MRI TMJ sequence and determine its diagnostic value in assessment of biomechanical dysfunctions of the TMJ.
Imaging findings OR Procedure details

• The conventional static TMJ MRI is performed in the close and open mouth positions and usually demonstrates good anatomical relationships of the condyle-disc complex, with 95% accuracy in the determination of the articular disc position\(^3\).

• **Figures 1** and **2** demonstrate normal anatomy of the TMJ and the articular complex on sagittal Proton Density (PD) images in open and closed positions. In the closed mouth position, the posterior band of the articular disc is located within 10 degrees counterclockwise from a vertical reference line drawn through the condylar head.

• Normal positional relationships of the articular disc complex with the mandible can be assessed by measuring angulations between mandibular condyle and posterior bands of the articular disc\(^{[1,4]}\) (Figure 3).

• Anterior disc displacement occurs with the posterior band of the disc displaced greater than 10 degrees counterclockwise from the reference line.

• Disc displacements are often multidirectional. Medio-lateral displacements can be appreciated on the coronal T2 Fat Sat acquisitions (normal in this case) (Figure 4).

• The retrodiscal soft tissues consist of an elastic superior layer and a collagenous inferior layer, both are vital in maintaining the dynamic stability of the articular disc. **Figure 5**.

• The anatomical features of two slips of the lateral pterygoid muscle with its attachments to the articular disc (superior slip) and to the condylar neck (inferior slip) are shown in **Figure 6**.

• However, the conventional TMJ MRI may fail to appreciate the dynamic interactions of the articular disc complex. This may be better assessed with real-time imaging\(^1\).

• Biomechanics of the TMJ is complex and in certain circumstances, a step-by-step analysis of the TMJ dynamics and its surrounding tissues is crucial in the differentiation of the TMJ pathology. The step-by-step dynamics of the TMJ movement and its surrounding structures is demonstrated in **Figure 7**.

• The true-FISP (Siemens\(^®\) CINE sequence has been a part of our MRI TMJ protocol for many years and, from time to time, it complements the existing conventional open and closed mouth MRI acquisitions at various stages of jaw motion\(^6\).

• The true-FISP utilises a very large steady-state magnetization to provide an intrinsically high SNR, through use of an ultrashort TR/TE, which improves tempo-spatial resolution and reduced fluid artefacts in short scanning times\(^{[1,7,8-9]}\). The true-FISP is a steady-state gradient echo sequence with balanced T2/T1 properties. However, due to its short TR, it has predominantly T1
contrast weighting [9]. The true-FISP sequence has a temporal resolution of 255 milliseconds.

- True-FISP dynamic imaging clarifies the motion relationship between the TMJ disc, mandibular condyle and glenoid fossa. It is able to demonstrate the real-time physiological movements/reduction of the articular disc complex, mandibular condyle translation and its interactions with surrounding structures.
- Dynamic MRI is useful in demonstrating the TMJ articular disc derangements. The degree of mandibular condyle rotation and translation can be more readily assessed on the true-FISP sequence.
- Although conventional MRI sequences are superior in demonstrating medio-lateral or rotational displacements of the articular disc complex, the true-FISP dynamic studies can show anterior displacement/dislocation of the disc with great accuracy [8].
- Both anterior and posterior disc displacements can occur with/without reduction with these findings readily confirmed on the true-FISP sequence. (Figures 8 and 9).
- However, conventional MRI sequences have a higher spatial resolution, hence assessment of the morphologic shape of the disc, disc perforation or intrasubstance degeneration are better seen on these sequences.
- Finally, the true-FISP sequence may be valuable in educating patients about their TMJ pathologies. It may promote the development of stronger therapeutic doctor-patient relationships and improve patients' understanding of their TMJ pathology [1].
Fig. 1: Figure 1: Sagittal-oblique PD images of TMJ demonstrate normal condylar disc relationships in the closed mouth view. In the closed mouth position condylar head articulates with the posterior band (PB) of the articular disc within the 10 degrees counterclockwise line drawn through the condylar head. Disc can be divided into anterior band (AB), intermediate zone (IZ) and PB. AB prolongs anteriorly into connective tissue fibers (CF) which becomes continuous with superior slip of lateral pterygoids. PB merges with the retrodiscal tissue (RT), a fibroelastic neurovascular attachment covered by synovial layer and separated into the elastic elastic superior layer (RT1), collagenous inferior layer (RT3) and loose connective tissue innervated by sensory fibers (RT2). Superior layer attaches to the most posterior part of the glenoid fossa, inferior layer attaches to the posterior aspect of the condylar neck.

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Fig. 2: Sagittal-oblique PD images of TMJ demonstrate normal condylar disc relationships in the open mouth view. The articular disc assumes the biconcave morphology (bow tie) and is positioned between the condylar head and the articular eminence. Depending on the mobility of the TMJ, the condylar disc complex could be positioned anteriorly, mid or posteriorly in relation to the articular eminence. *CF: connective tissue fibers; AB: anterior band; IZ: intermediate zone; PB: posterior band; RT: retrodiscal tissue; RT1: superior layer; RT2: loose connective tissue; RT3: inferior layer.

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Fig. 3: Normal position: (A) posterior band of the disc is located within a 10 degree angle counterclockwise from the line passing through the axis of rotation of
the condylar head. Anterior displacement: (B) posterior band sits anteriorly to the area enclosed in this 10 degrees range.

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**Fig. 4:** Figure 4: Normal coronal anatomy showing articular disk (AD), mandibular condyle (MC), joint capsule (JC) and the medio-lateral discal borders. Lateral/medial displacements occur when the corresponding lateral or medial borders of the AD bulge from the borders of the condylar head. No lateral displacement is seen in this example.

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**Fig. 5:** Figure 5: Oblique sagittal PD performed in open and closed mouth position demonstrating bifid morphology of the mandibular condyle, which in this young patient is likely developmental. In the closed mouth position the disc is slightly posteriorly positioned with both the posterior band and the intermediate zone of the disc occupying the anterior half of the glenoid fossa. In the open mouth position there is bunchinching of the posterior band of the disc which partially stuck in the anterior position of the glenoid fossa. This example also demonstrates superior RT layer (SL) positioned between the posterior band and the most posterior area of mandibular fossa. The inferior RT layer (IL) runs close to condyle between posterior band and posterior condylar neck with attachment to the posterior area of mandibular fossa. The volume of the posterior attachment of retrodiscal tissue increases remarkably when articular disc complex moves anteriorly during the mouth opening. It occurs due to stretching of elastic fibers causing inflow of blood into the highly vascular intermediate layer of loose connective tissue.

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Fig. 6: Lateral Pterygoid Muscle (LP) consists of two parts: superior band of LP (SBLP) and inferior band of LP (IBLP). Thin attachment of the SBLP is beyond the anterior band (AB) if the disc. The thicker attachment of the IBLP is just below the articular disc.

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Fig. 7: As per figure 7

Fig. 8: Video 1: The true-FISP imaging of the left TMJ demonstrates the anteriorly displaced disc in open mouth position. TMJ is hypermobile with mandibular condyle displaced beyond anterior margin of articular eminence. Concurrent findings of the described TMJ displacement were confirmed on conventional acquisitions.

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Fig. 9: Video 2: The true-FISP imaging of the right TMJ demonstrates a dislocated disk in the closed mouth position and further anterior displacement in the open mouth position. There is a structural alteration of the TMJ with sclerosis of the articular eminence.

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Conclusion

The true-FISP sequence provides a unique evaluation of the dynamic movement of the TMJ disc-condyle complex and is a useful adjunct for the assessment of articular disc pathologies of the TMJ.
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References


