Understanding the Temporomandibular Joints for Proper Assessment *and* Treatment Planning

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Abstract

Many patients who are seeking esthetic enhancements also present with occlusal issues. As a profession, we have assumed occlusal issues are due to improper tooth position, as this causes occlusal disharmonies resulting in problems that can present as wear, mobility, or sensitivity at the tooth level. Three-dimensional imaging offers new insights into many of the occlusal problems patients present with today. Many of the tooth position problems we see clinically are the result of structural changes in the temporomandibular (TM) joints. This article outlines some key points regarding occlusion and the TM joints.

Key Words: TM joints, magnetic resonance imaging, cone beam computed tomography, condylar position, occlusion

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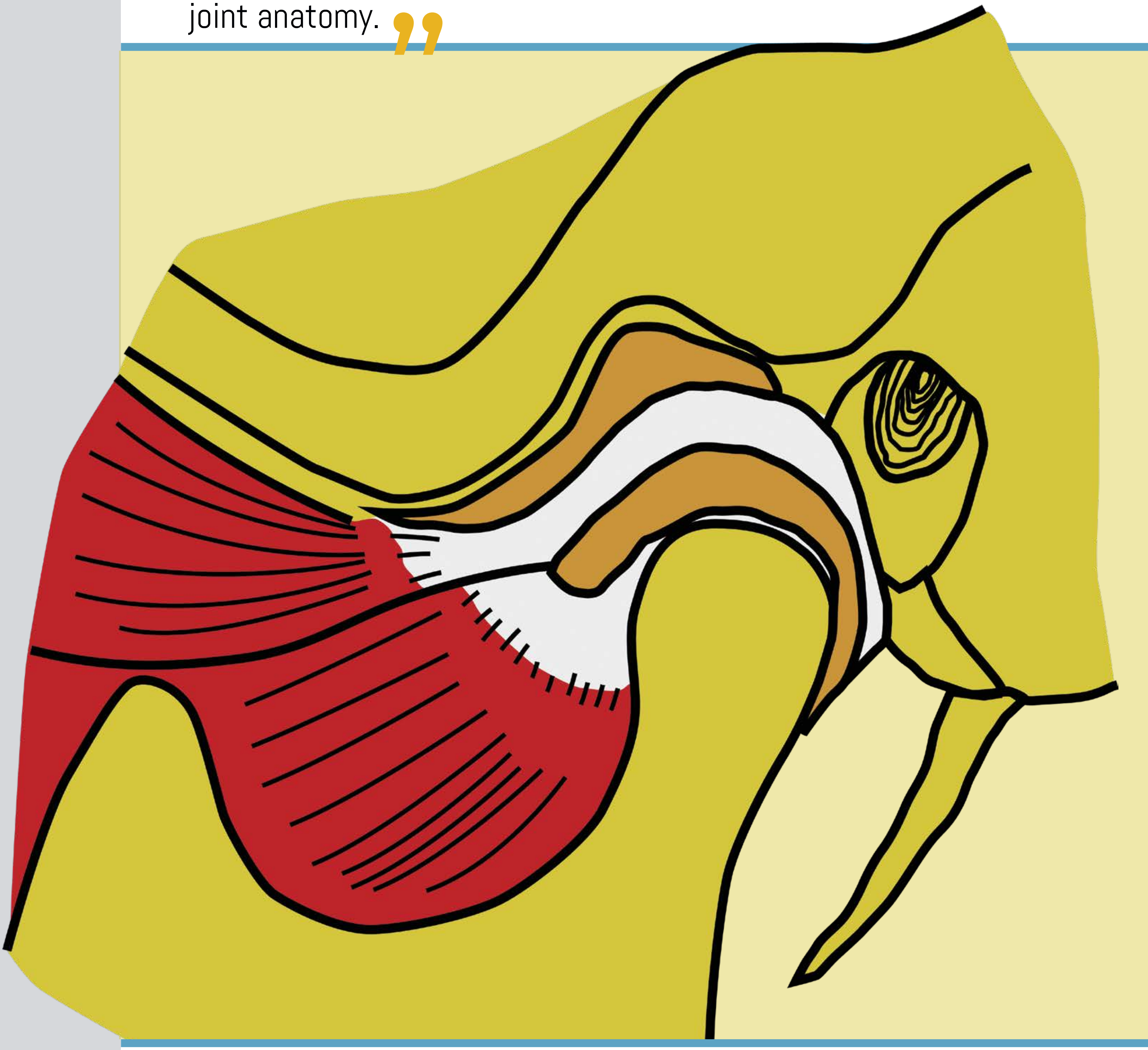

Introduction

It is always exciting when patients seek treatment to improve the esthetic appearance of their teeth. The excitement, however, often turns to uncertainty—and, in some cases, anxiety—when the patient also reports having "clicking" jaw joints. Several questions arise in this scenario: Are the clicking joints a problem? Do they need to be treated? *Can* they be treated? Is magnetic resonance imaging (MRI) or cone beam computed tomography (CBCT) necessary? Is it possible to fabricate an occlusal appliance to treat the clicking joints?

Assessing the Joints

The uncertainty about clicking jaw joints is related to how we have been taught to assess temporomandibular (TM) joint condition. The common clinical exam to assess the joints includes taking a history; measuring range of motion; palpating muscles; and load testing and listening to the joints using a stethoscope, doppler auscultation, or joint vibration analysis. While these diagnostic modalities offer valuable information, they have one common trait: They all are based on an indirect visualization of TM joint anatomy **(Fig 1)**. As a result, there is uncertainty about what to tell patients regarding both treatment options and the prognosis of these treatment options, because we do not have a clear understanding of the anatomy we are treating.

Imaging

Imaging provides direct visualization of the TM joints. The ability to directly assess the soft tissue (disc) with MRI[1-7] and hard tissue (condyle/joint socket) with CBCT[8-10] offers both dentists and patients a clear understanding of joint anatomy. This leads to a more realistic discussion about treatment options and the prognosis for successful treatment.

MRI: The TM joint MRI begins with assessing disc position. Historically, normal disc position was determined as $12:00 \pm 10^0$ [11] from the superior surface of the condyle **(Fig 2)**. However, the definition of "normal" changed in 1997 from 12:00 ± 100 to $12:00 \pm 30^0$ [12] **(Fig 3)**. In reality, disc position is best evaluated based on the disc's ability to dissipate the load that is applied to the TM joints. The optional load-bearing position of the disc is 11:00, with normal anterior and posterior aspects of the disc on each side of the 11:00 load-bearing position.[13] With this optimal anatomy for load bearing, the posterior attachment for a structurally intact or normal TM joint is at approximately the 1:00 position, as opposed to the assumed normal 12:00 position **(Fig 4)**.

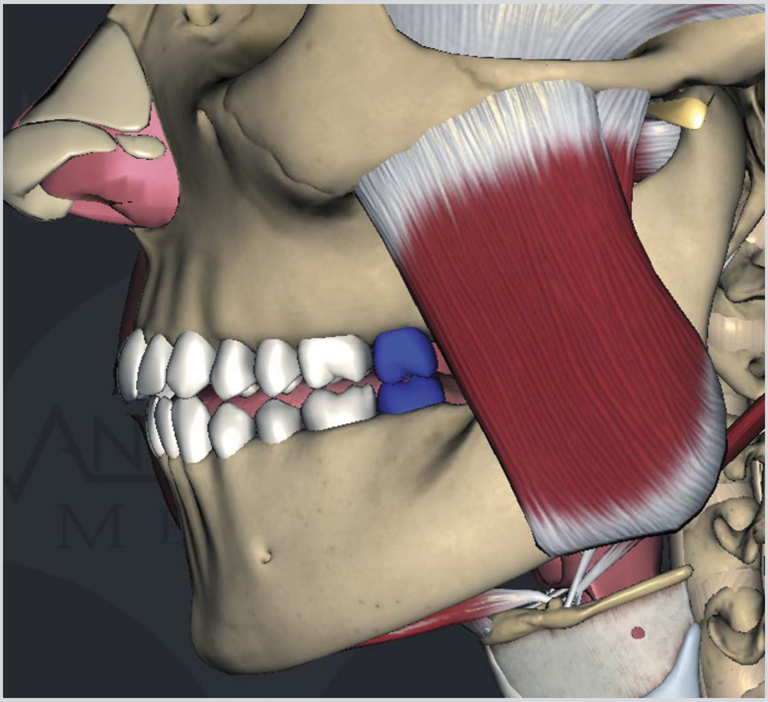

Figure 1: TM joint diagram.

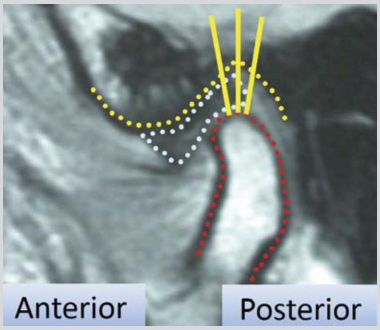

Figure 2: TM joint MRI (12:00 ± 10°).

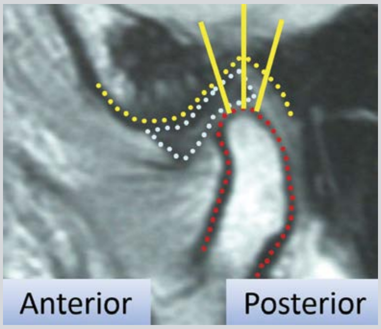

Figure 3: TM joint MRI (12:00 ± 30°).

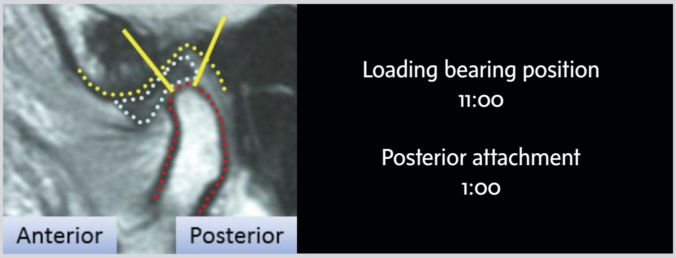

Figure 4: TM joint MRI (11:00 load bearing/1:00 posterior attachment).

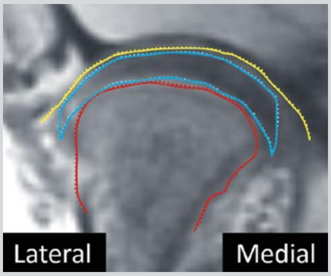

Figure 5: MRI, coronal view.

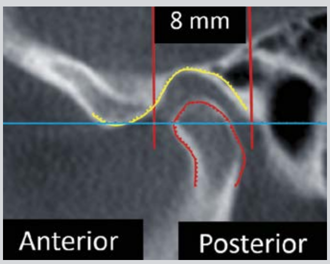

Figure 6: CBCT, sagittal view.

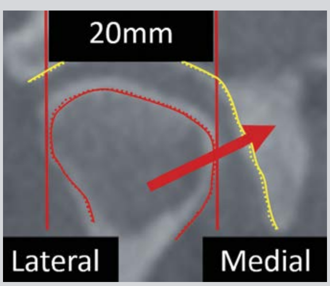

Figure 7: CBCT, coronal view.

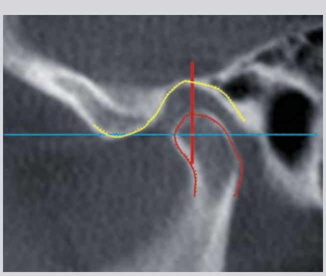

Figure 8: CBCT, sagittal view.

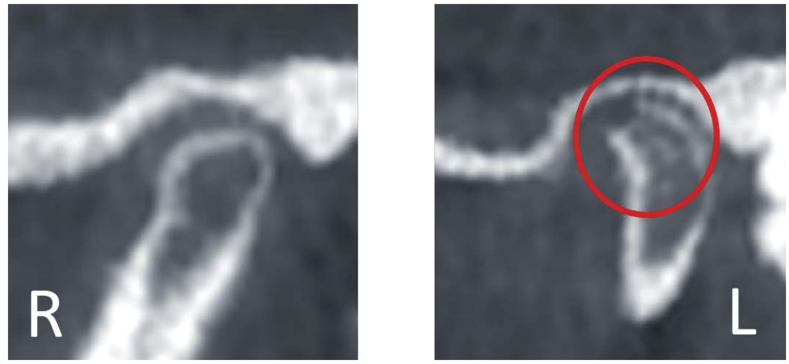

Figure 9: CBCT showing intact and non-intact cortical plate.

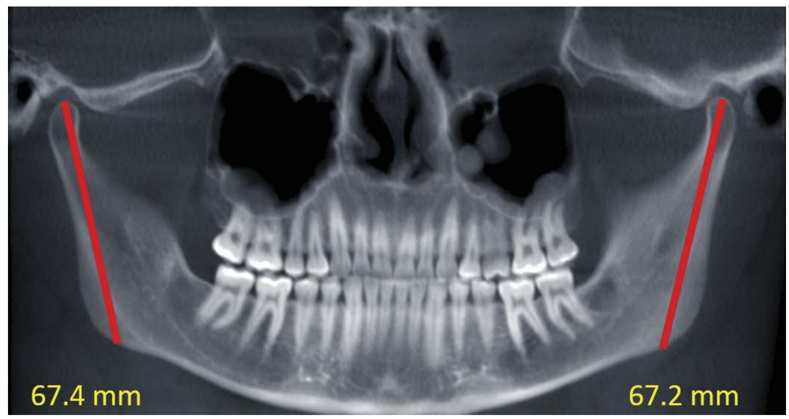

Figure 10: Normal ramus length.

The disc is designed to be compressed during function. As a result, it receives its nutritional components through synovial fluid. In order for the disc to receive nutrition, it must be in the correct position. Disc position is dictated by the ligament attachment of the disc to the condyle **(Fig 5)**. The disc attaches at the condyle's lateral, medial, and posterior aspects. Normal disc anatomy serves to correctly position the condyle in the joint socket. In the adult patient, normal disc anatomy also maintains the vertical dimension of the TM joint, which maintains the occlusion. In growing patients, normal disc position fosters growth to the full genetic potential.

CBCT: CBCT imaging enables assessment of the hard tissue in the TM joint. Normal condyle size is approximately 8 mm in an anterior-posterior dimension **(Fig 6)** and 20 mm in a medial-lateral perspective **(Fig 7)**. CBCT imaging also allows for an appreciation of the heavily buttressed bone at the medial aspect of the joint socket. This bone provides ideal anatomy in the joint socket for load distribution from the masticatory muscles. In addition, CBCT imaging facilitates evaluation of condylar position in the joint socket **(Fig 8)** as well as the ability to analyze the integrity of the condylar cortical plate **(Fig 9)**. Lastly, CBCT imaging allows for an evaluation of the ramus length. Normal ramus length is approximately 60 to 70 mm **(Fig 10)**.

TM Joint Structural Changes

Ligament Injuries

Structural changes in the TM joints begin with an injury to the soft tissue attachment of the disc to the condyle. The ligament injury typically is caused by either a compression, a stretch, or a whiplash injury to the TM joint.[14,15] The ligament damage can result in a clicking joint if the disc maintains its shape despite not being in the correct position to receive synovial fluid. This type of injured joint is referred to as a *clicking joint* or a *disc displacement with reduction* **(Fig 11)**. Clicking joints can stop clicking when the disc loses its natural biconcave shape due to a lack of synovial fluid compression. This type of injured joint is referred to as a *locking joint* or a *disc displacement without reduction* **(Fig 12)**. In both scenarios, the condyle compresses the retrodiscal tissue as opposed to disc tissue. The advanced stage of joint breakdown occurs when the condyle perforates the retrodiscal tissue and there is direct bone-to-bone contact between the condyle and the joint socket **(Fig 13)**.

In addition to assessing the ligament attachment from a sagittal perspective, it is important to assess it from a coronal perspective. Some patients will present with an injury to the lateral pole ligament attachment while maintaining the medial pole attachment. Injuries at the lateral pole can result in a clicking joint (lateral pole disc displacement with reduction) or a locking joint (lateral pole without reduction). Other patients will present with a lateral and medial pole displacement with or without reduction.[16-22]

Risk Levels

From a clinical perspective, normal joints present with the least amount of risk for both the patient and the dentist. Patients with normal TM joints have normal hard and soft tissue. The likelihood for significant pain issues or bite instability is low. Patients also can present with joint injuries confined to the lateral pole. These patients tend to have relatively low risk factors since the medial pole of the condyle is still covered by normal disc tissue.

Pain: The highest level of risk occurs when the ligament attachment is injured at the lateral and the medial pole. Typically, TM joint changes are defined through pain. While pain is usually assumed to come from masticatory muscles, TM joint imaging has provided insight regarding different sources of pain. Given the insights from three-dimensional (3D) imaging, it is clear pain can come from herniated discs **(Fig 14)** impinging on different anatomic structures. Condylar changes such as eroded bone **(Fig 15)**, small bone **(Fig 16)**, or edematous bone **(Fig 17)** also can cause significant pain.[23-32] Pain can occur from structural changes in the upper cervical spine as well as from elevated sympathetic nerve conduction.[33-36]

Occlusion: Structural changes in the TM joint can cause not only pain, but also significant changes in the occlusion. The loss of vertical dimension from structural changes in the TM joint can present several considerable issues for the patient seeking cosmetic improvements from an occlusal perspective.

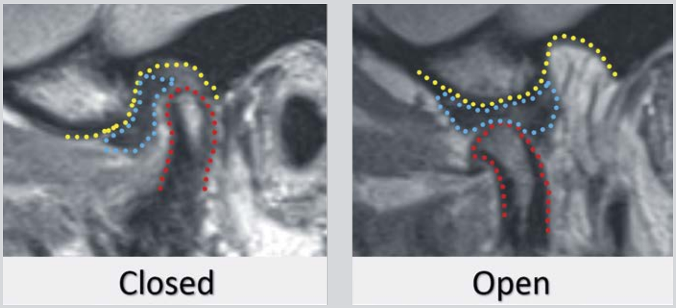

Figure 11: Disc displacement with reduction.

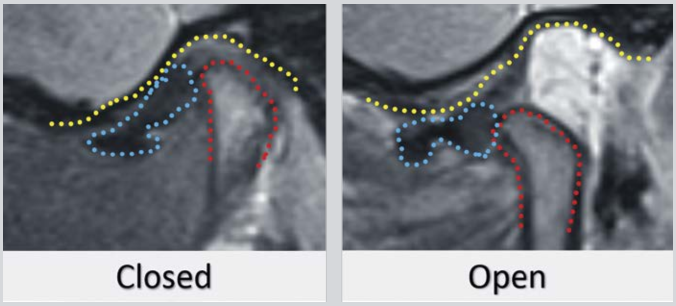

Figure 12: Disc displacement without reduction.

Figure 13: Disc displacement with perforation.

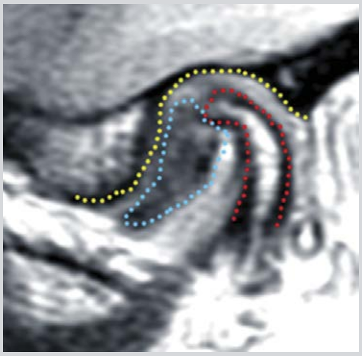

Figure 14: Herniated TM joint disc.

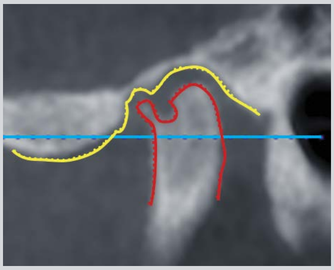

Figure 15: Eroded condylar bone.

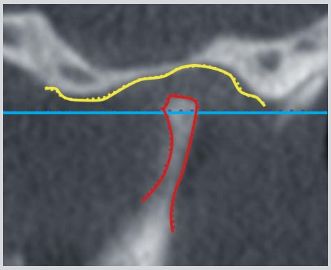

Figure 16: Small condylar bone.

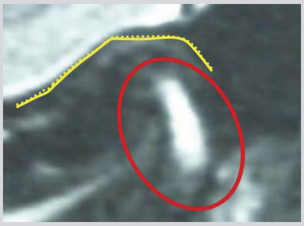

Figure 17: Edematous condylar bone.

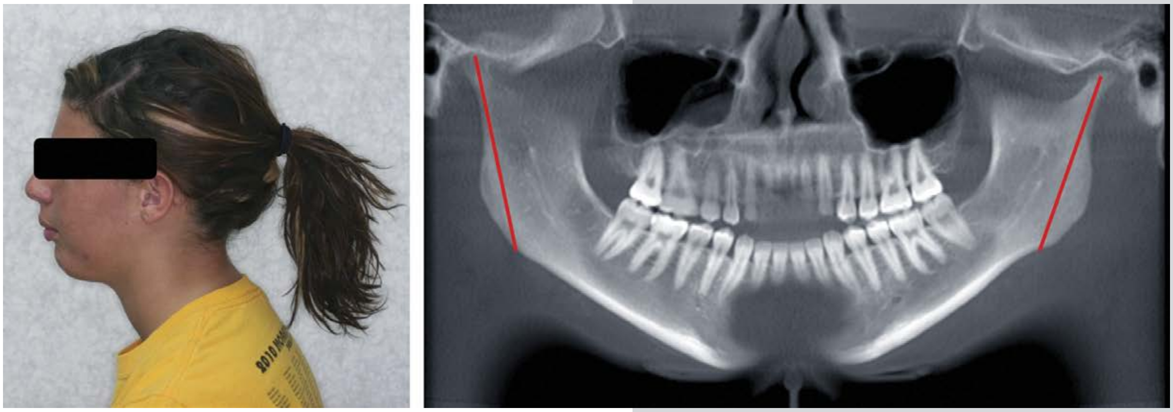

Figure 18: Class II occlusion with short rami.

Figures 19a & 19b: Anterior tooth uncoupling.

These occlusal changes usually present as a Class II bite shift due to a loss of soft tissue dimension at the disc level and a loss of hard tissue dimension at the condyle level. The greater the loss of vertical dimension, the greater the likelihood of a Class II bite shift **(Fig 18)**. Loss of vertical dimension at the TM joint level can occur though joint degeneration of a normally developed TM joint. The more common loss of vertical dimension at the joint level occurs through a lack of complete growth due to joint injuries in the growing patient.[37-48] If the disc ligaments are compromised in the growing patient, the protective nature of the disc is lost and both mandibular and maxillary growth are compromised. The typical clinical presentation is the uncoupling of the anterior teeth **(Figs 19a & 19b)**.

The key to understanding the role occlusion plays in both pain and bite issues is 3D imaging of the TM joints' soft and hard tissue. The MRI can provide diagnostic information related to disc position and disc condition as well as evaluate the condition of the marrow space to assess condylar edema. The CBCT can provide diagnostic information related to condylar size and cortical plate integrity. It also can offer diagnostic information related to ramus length, airway, and upper cervical spine issues.

The MRI is obtained using a multipositional condylar protocol developed by Dr. Mark Piper **(Table 1)**. The condylar positions are fully seated in maximum intercuspation, at incisal edge position, and at translated condylar position of 30 mm. The purpose of imaging in different condylar positions is to

> "In reality, disc position is best evaluated based on the disc's ability to dissipate the load that is applied to the TM joints."

Table 1. Piper MRI Protocol

PIPER CLINIC TMJ MRI SCAN PROTOCOL FULL

Orientation	Sequence	Occlusion	Starting Side	View	Starting Point	Ending Point	Qty	Trs	Hfs Sp
Axial	T1 Localizer	None	Bilateral	Inf To Sup	Mandibular Ramus	Superior Orbit	16	240/4.0	5.0
Axial	T2	None	Bilateral	Sup To Inf	Superior Orbit	Mandibular Ramus	20	180/3.0	3.0
Coronal	T2 Localizer	None	Bilateral	Post To Ant	Eac Anterior	Orbit Posterior	14	200/4.0	4.0
Sagittal	T1	Bite 1 Fscp	Left Then Right	Lat To Med	Lateral To Condyle	Medial To Condyle	16	140/3.0	2.8
Coronal	T1	Bite 1 Fscp	Left Then Right	Post To Ant	Eac Anterior	Anterior To Eminence	18	140/3.0	2.8
Sagittal	Stir	Bite 1 Fscp	Left Then Right	Lat To Med	Lateral To Condyle	Medial To Condyle	16	140/3.0	2.8
Coronal	T2	Bite 1 Fscp	Left Then Right	Post To Ant	Eac Anterior	Anterior To Eminence	18	140/3.0	2.8
Sagittal	Proton Density	Bite 2 Iep	Left Then Right	Lat To Med	Lateral To Condyle	Medial To Condyle	16	140/3.0	2.8
Coronal	Proton Density	Bite 2 Iep	Left Then Right	Post To Ant	Eac Anterior	Anterior To Eminence	18	140/3.0	2.8
Sagittal	Proton Density	Prop Open Tcp	Left Then Right	Lat To Med	Lateral To Condyle	Medial To Condyle	16	140/3.0	2.8
Coronal	Proton Density	Prop Open Tcp	Left Then Right	Post To Ant	Eac Anterior	Anterior To Eminence	18	140/3.0	2.8
Sagittal	Proton Density	Closed Mouth Mip	Left Then Right	Lat To Med	Lateral To Condyle	Medial To Condyle	16	140/3.0	2.8

PIPER CLINIC TMJ MRI SCAN PROTOCOL BASIC

Orientation	Sequence	Occlusion	Starting Side	View	Starting Point	Ending Point	Qty	Trs	Hfs Sp
Axial	T2	None	Bilateral	Sup To Inf	Superior Orbit	Mandibular Ramus	20	180/3.0	3.0
Sagittal	T1	Bite 1 Fscp	Left Then Right	Lat To Med	Lateral To Condyle	Medial To Condyle	16	140/3.0	2.8
Sagittal	Stir	Bite 1 Fscp	Left Then Right	Lat To Med	Lateral To Condyle	Medial To Condyle	16	140/3.0	2.8
Coronal	T2	Bite 1 Fscp	Left Then Right	Post To Ant	Eac Anterior	Anterior To Eminence	18	140/3.0	2.8
Sagittal	Proton Density	Bite 2 Iep	Left Then Right	Lat To Med	Lateral To Condyle	Medial To Condyle	16	140/3.0	2.8
Sagittal	Proton Density	Prop Open Tcp	Left Then Right	Lat To Med	Lateral To Condyle	Medial To Condyle	16	140/3.0	2.8
Sagittal	Proton Density	Closed Mouth Mip	Left Then Right	Lat To Med	Lateral To Condyle	Medial To Condyle	16	140/3.0	2.8

PIPER CLINIC TMJ MRI SCAN PROTOCOL SCREEN

Orientation	Sequence	Occlusion	Starting Side	View	Starting Point	Ending Point	Qty	Trs	Hfs Sp
Axial	T2	None	Bilateral	Sup To Inf	Superior Orbit	Mandibular Ramus	20	180/3.0	3.0
Sagittal	Stir	Bite 1 Fscp	Left Then Right	Lat To Med	Lateral Condyle	Medial To Condyle	16	140/3.0	2.8
Coronal	T2	Bite 1 Fscp	Left Then Right	Post To Ant	Eac Anterior	Anterior Eminence	18	140/3.0	2.8
Sagittal	Proton Density	Bite 2 Iep	Left Then Right	Lat To Med	Lateral Condyle	Medial To Condyle	16	140/3.0	2.8

Figures 20a-20c: Piper MRI condylar positioning indices.

assess the positions' condyle–disc interface. The images in different condylar position are obtained using occlusal indices to position the mandible during the MRI **(Figs 20a-20c)**. The CBCT is obtained in a fully seated condylar position, as are the diagnostic study casts and digital photographs. Obtaining diagnostic records in the same condylar position allows for cross-referencing the different information that can be gained from the different diagnostic modalities.

Summary

Understanding TM joint condition allows for an increased level of confidence when discussing potential cosmetic changes with patients. The dentist's ability to assess the risk from structural changes in the soft and hard tissue provides invaluable data when developing a treatment plan and enables the dentist to help patients make treatment decisions based on accurate, precise information. Gaining knowledge of the anatomy through 3D imaging can help dentists have confidence when patients ask about their "clicking" jaw joints.

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