Illustrated Anatomy of the Temporomandibular Joint in Function and Dysfunction

By Samuel J. Higdon, DDS

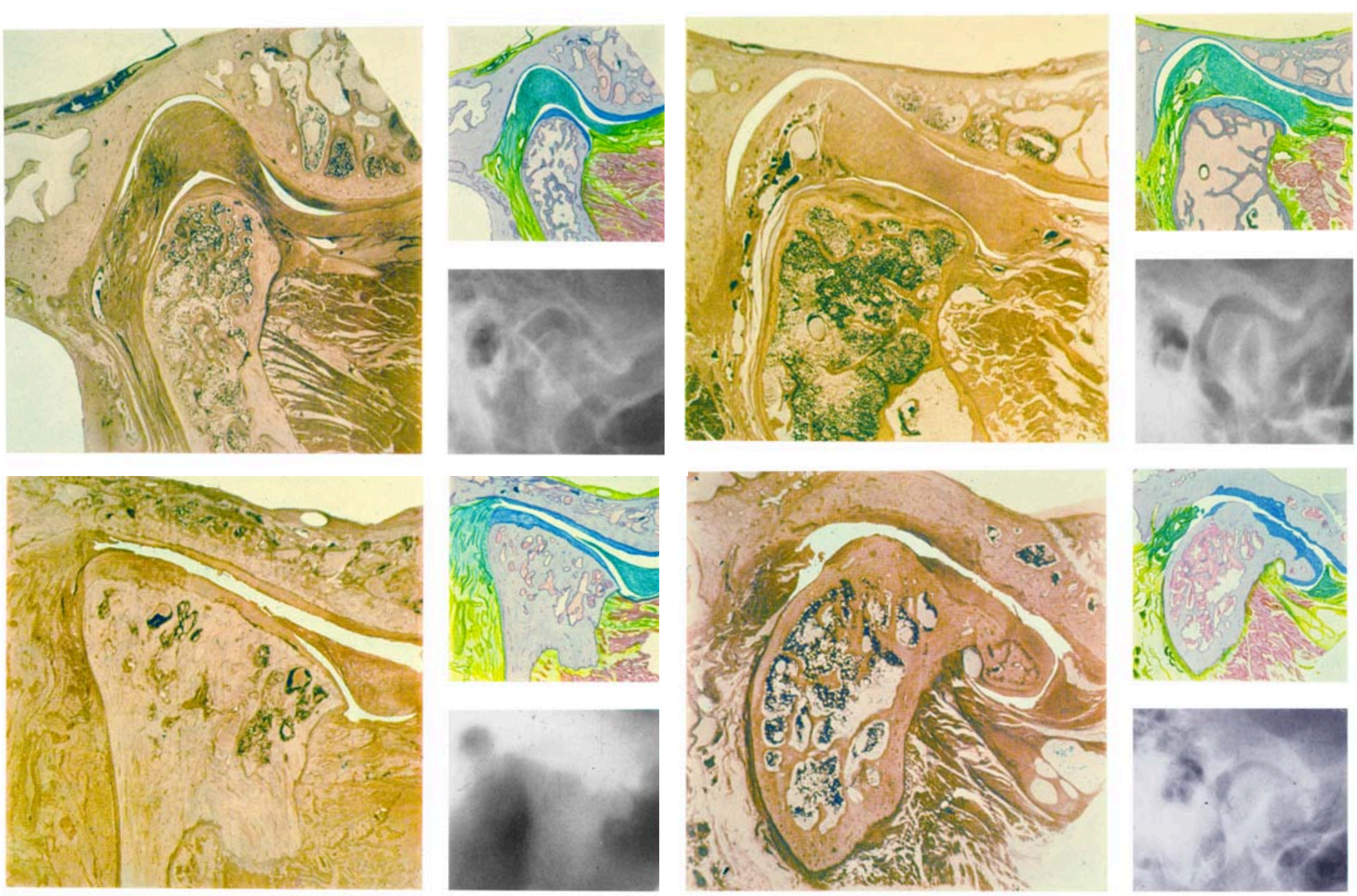
The history of the management of temporomandibular joint disorders is largely one of empiricism with a large measure of dogma thrown in. This is not so surprising when one realizes that until relatively recently the biology of the masticatory system has not been well understood. What "worked," clinically, for the early leaders in this field became the standard of care. There have been any number of approaches that have "worked" but it has been difficult at times to define the biologic basis for the "success" that has been reported for these treatment methods.

The expanding knowledge in this field has been based largely on better understanding of the functional anatomy and physiology of the complex and elegant masticatory system, for which the dental profession has primary responsibility. Of the advances of biologically-based diagnostic and treatment approaches that have occurred within the past 30 years, none is more important than the increased clinical awareness of the close relationship between the structure (form) and function of the temporomandibular joints.

Early History

Prior to the late 1970s, most dentists' awareness of the anatomy of the temporomandibular joints was based on black and white photos of histologic images or dissections of cadaver joints that appeared in textbooks. These tended to primarily demonstrate only the normal anatomical relationship of the condyle to the disc and fossa in a closed mouth position.

One exception was a series of color photographs of histologic sections, published in German in 1934 by Steinhardt, that demonstrated anatomical variations of normal and abnormal joint anatomy. But, if the text that accompanied these was ever published in English, the significance of these abnormal examples of TMJ anatomy largely escaped notice by the English speaking dental community.



However, even with these static images, the functional anatomical relationships of the temporomandibular joints remained poorly appreciated. Because all images of the temporomandibular joints up to that time presented only a two dimensional perspective, the ability to visualizes three-dimensional relationships was limited and difficult.

Prior to the late 1970s, dentists had been aware that the temporomandibular joints often clicked and popped but there was apparently little appreciation of what caused these sounds and whether they had any clinical significance. At about that time William Farrar, DDS began to achieve notice from the American dental community for his description and explanation of clicking and popping of the temporomandibular joints and the significance of these sounds to painful conditions of the joints.

Dr. Farrar was not the first to explain this phenomenon. It had earlier been described in publications by J.R. Thompson, DDS. But Thompson's publications had largely gone unnoticed. It is Dr. Farrar who deserves credit for making the dental profession aware of what was occurring within the TM joints that accounted for these joint sounds. He provided a preliminary description of what occurs within the temporomandibular joint during function. He identified how movements of the disc and condyle brought into question the prevailing concept of the border position of the joints, which, up to that point, had been limited to the interpretation of indirect evidence obtained from pantographic tracings of jaw movements.

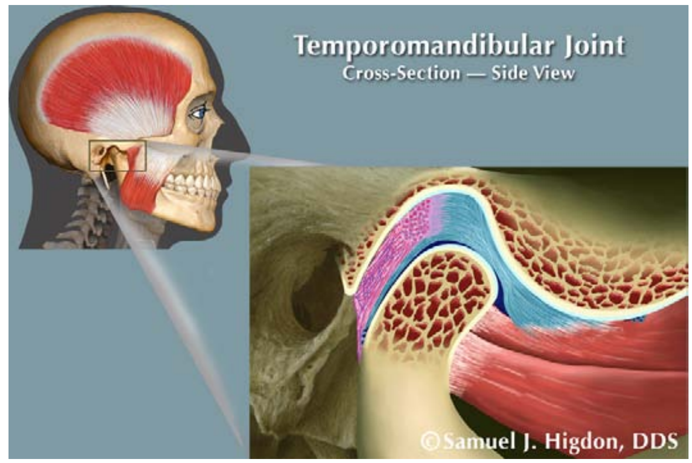
Dr. Farrar acknowledged that his observations would be subject to reinterpretation, based on further investigation. His imaging of the TM joint relied on the transcranial projection, an image that could be taken in a dental office, using standard dental x-ray equipment. Later there was recognition that the resulting images from this technique were very much subject to misinterpretation. Although we have since moved well beyond Dr. Farrar's understanding of the dysfunctional anatomy of the TM joints, as well as his thinking related to treatment of TM joint disorders, his contribution to our current understanding must be seen as a watershed, setting us on our current path.

With the advent of much more sophisticated imaging technology, the advances in our understanding in the past 30 years of the normal and dysfunctional anatomy of the temporomandibular joints has had a significant impact on our clinical approach to the management of temporomandibular joint disorders. When knowledge obtained from many studies, utilizing superior imaging, is combined with the information obtained from individual comprehensive history and examination, we now have a much greater ability to interpret what may be occurring within the joints of an individual patient and, as a result, we have the basis for a better understanding of what we can, as well as what we cannot accomplish for these patients. In this context we can also appreciate that some of the techniques that were advocated by Dr. Farrar more than 30 years ago were, perhaps, naive. But, as is true with the advances of science in all fields, with this new information have also come new questions for which we may not yet have entirely adequate answers.

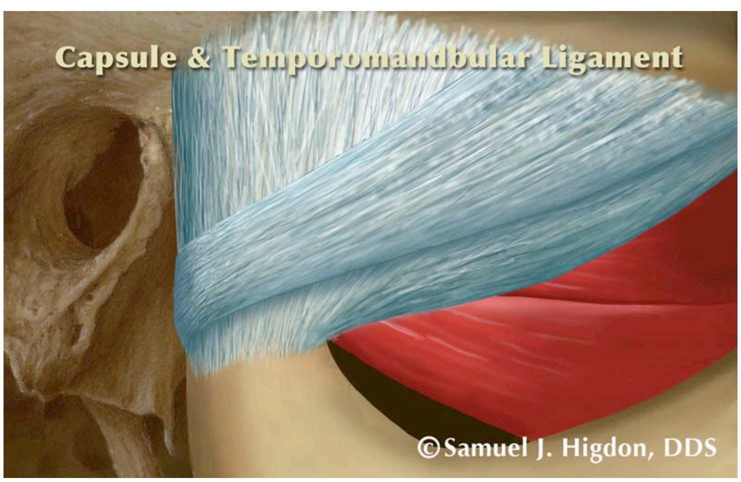
What follows does not pretend to be a comprehensive dissertation but rather it is intended to provide a basic understanding of some of the more important concepts related to normal and abnormal biomechanical function of the temporomandibular joints. Also crucial in the management of TM disorders is an understanding of the role of muscles in masticatory function. The muscles of mastication, as well as cervical musculature, play a highly important role in jaw movements and especially in the dysfunctional conditions that we call temporomandibular disorders. However, this overview does not attempt to deal with the muscular function of the masticatory apparatus.

Sagittal Orienting View

This lateral (or sagittal) view provides orientation of the right temporomandibular joint and the adjacent temporalis and masseter muscles. As is true of other synovial joints, the temporomandibular joint is enveloped by fibrous capsule with a supporting collagenous capsular ligament.



Joint Capsule and Temporomandibular Ligament

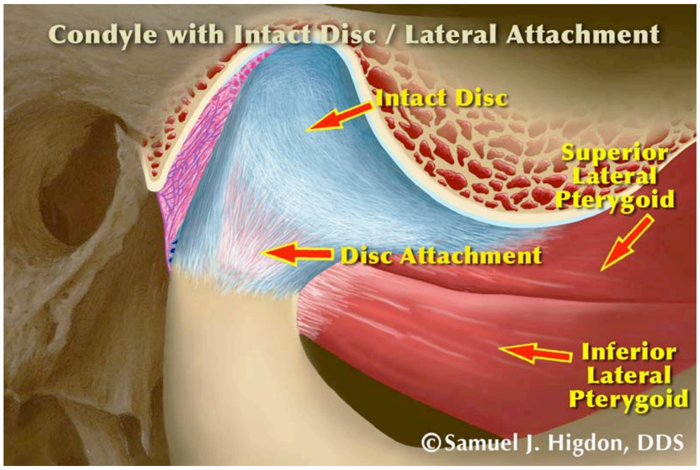


The capsular, collateral and temporomandibular ligaments restrict movement of the disc away from the condyle, thus allowing smooth, synchronous motion of the condyle/disc assembly. The capsular ligaments resist joint movement at the extreme ranges of motion. The temporomandibular ligament, with fibers directed obliquely downward and backward, is located on the lateral aspect of each TMJ and limits posterior movements of the condyles.

Intact Disc (Attachment, Muscles, Retrodiscal Tissues)

When the fibrous capsule of the joint is removed, the lateral aspect of the normal biconcave articular disc is revealed. An intact articular disc is normally formed like a bonnet or a hood over the mandibular condyle.

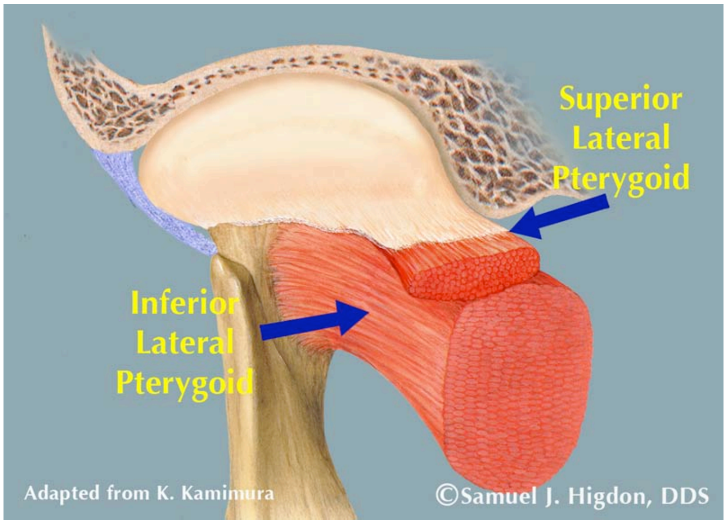
The articular disc is held firmly in place on the condyle, both medially and laterally, by the collateral ligaments. The superior head of the lateral pterygoid muscle inserts on the neck of the condyle in a depression below the articular surface called the fovea. Its fibers also blend into the medial portion of the anterior border of the articular disc and the medial aspect of the capsule. The inferior head of the lateral pterygoid muscle also inserts in the fovea of the condyle, just below the superior head.



A number of anatomical studies have documented a variable degree of insertion of the superior head of the lateral pterygoid muscle. Some have described a very small portion of the anteromedial border of articular disc being attached to the superior lateral pterygoid. Others have found no insertion directly to the disc. Our early assumptions regarding the role of the lateral pterygoid muscle in disc displacements now appears to have no validity.

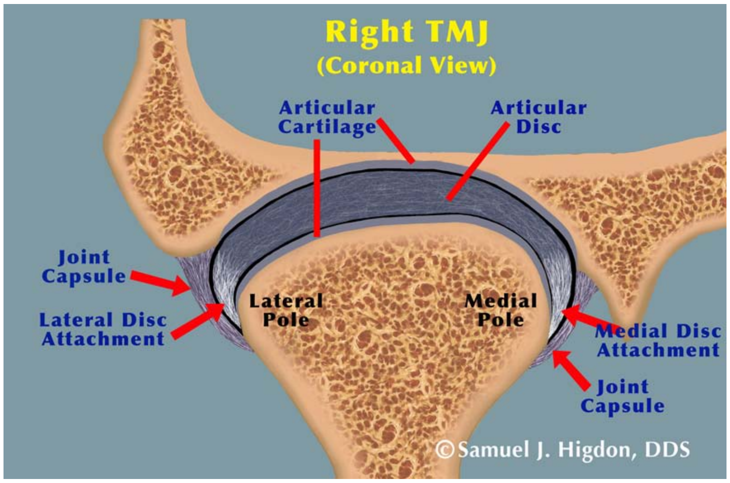
In these two-dimensional cross-sectional illustrations, the appearance is that the disc is more attached to the superior lateral pterygoid muscle than has been shown in anatomical investigations. It is not possible to correctly portray this attachment in a two-dimensional, sagittal illustration.

Front View of Lateral Pterygoid Attachment



However, if we view that attachment from the front, as seen in this view, adapted from the text by Ide and Nakazawa with Kamimura's beautiful illustrations, we get a better idea of the nature of the attachment.

Frontal View of Sectioned Disc - All Structures



In this cross-sectional view, the right temporomandibular joint is seen from the front, sectioned from medial to lateral.

Here we see the joint capsule as it attaches below the medial and lateral poles of the condyle.

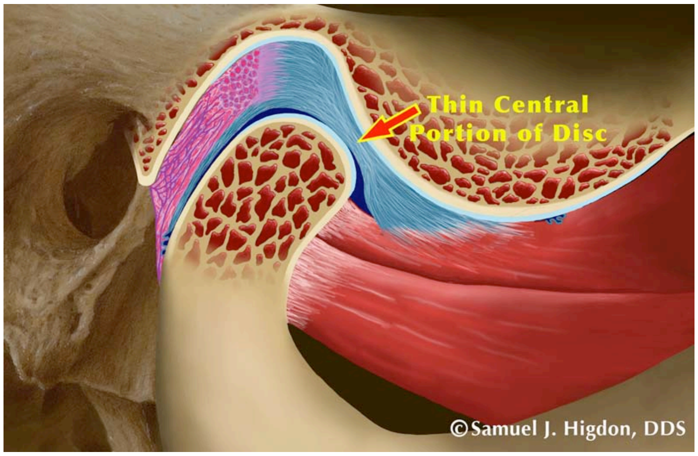
We also see the fibrous articular cartilage that covers both the head of the condyle and the articular surface of the fossa and eminence.

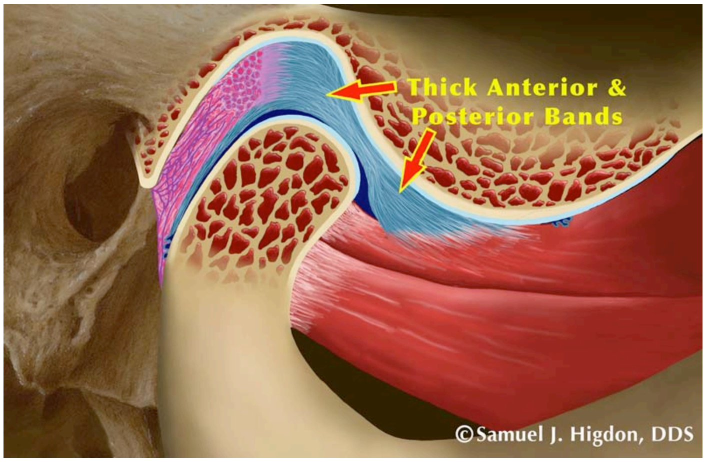
We can also see the articular disc with its medial and lateral attachments to the poles of the condyle.

Normal Disc (Thin Central Portion, Thick Posterior and Anterior Bands, Loading Arrow)

In this cross-sectional view, the articular disc and the condyle are shown cut in half from front to back. This demonstrates the normal relationship of the intracapsular structures, the condyle and the disc, of an intact joint when the jaw is closed and the teeth are in maximum occlusal contact.

The articular disc of the temporomandibular joint, in its normal relationship to the condyle, is a biconcave structure with a thin central portion, and with more thickened anterior and posterior bands.

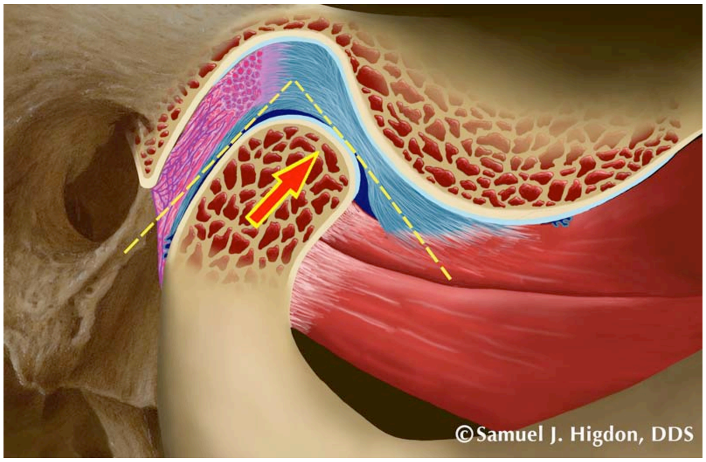




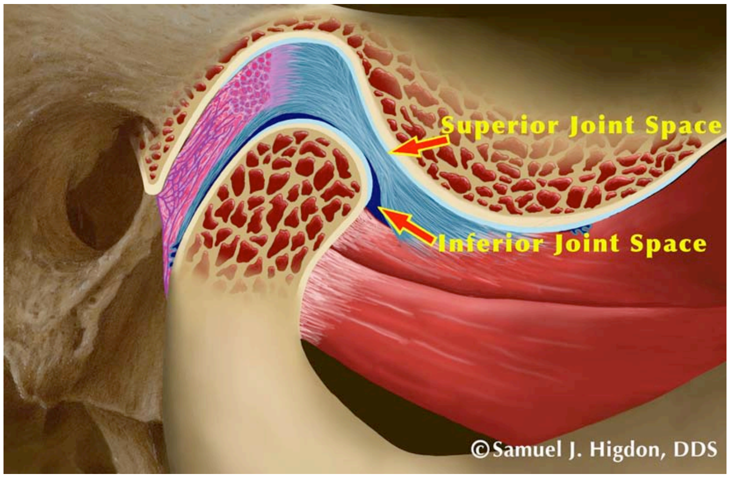
The disc is composed of dense, fibrous connective tissue and contains few, if any, blood vessels or nerves. Thus it is well-suited for accepting the load that is imposed on it during function. Due to this structural alignment, during functional loading, a joint that is structurally intact will produce no pain.

This normal relationship of the articular disc to the condyle during function is particularly important because it stabilizes the condyle during loading, as well as providing maximum congruence of joint surfaces for the distribution of the forces of loading.

Dr. Peter Dawson has referred to this position as the “apex of force” position, as demonstrated by these lines.



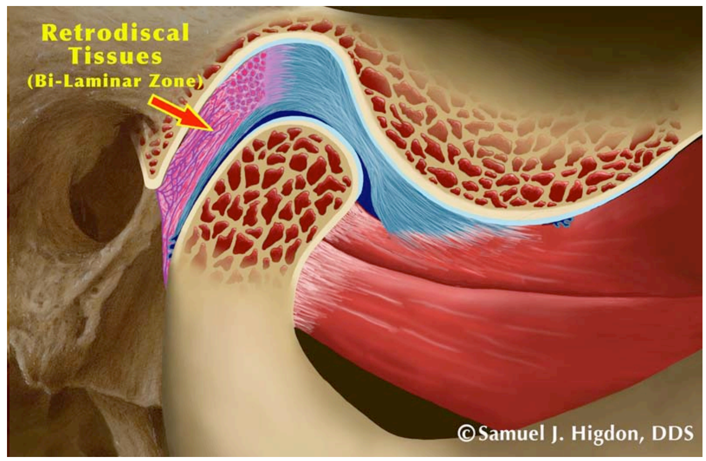
Normal Joint (Two Joint Spaces, Retro-Discal Tissues)



The articular disc divides the joint into two narrow spaces, above and below the disc. This division allows for both rotation and translation of the condyles.

These spaces contain synovial fluid that is produced by synovial tissue at the periphery of the articular surfaces of each joint. The thin layer of synovial fluid provides lubrication for the articular surfaces of the joints and can be compared to the amount of saliva that lubricates the interface of the mucosa against the teeth.

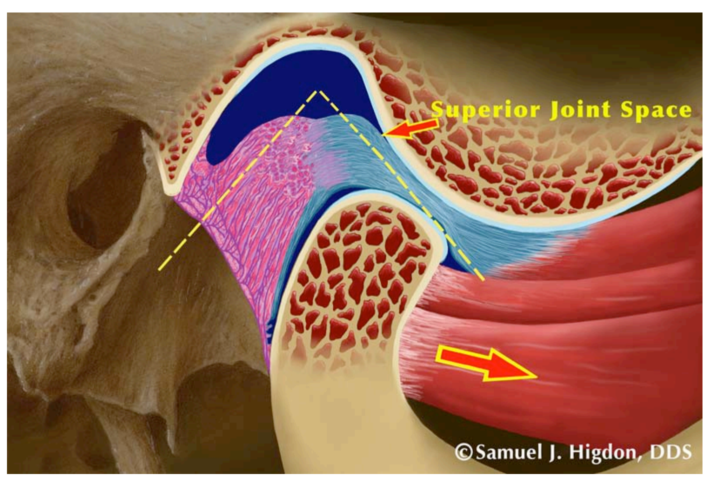
Posterior to the condyle and continuous with the articular disc is the bilaminar zone or retrodiscal tissue. The bilaminar zone is so named because it is made up of superior and inferior strata or layers. It has long been thought that the superior stratum exerted an influence on the positioning of the articular disc because it contains a protein called elastin. However, recent careful analysis of joints from cadavers has shown that the superior stratum does not become taught until maximum translation is achieved. The actual role of the elastin in the superior stratum remains uncertain for now.

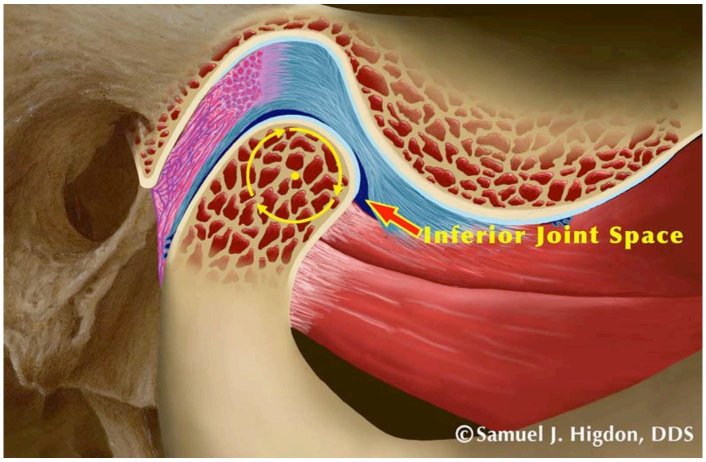


The inferior stratum is composed primarily of collagen and, similar to ligamentous tissues, it is able to elongate only slightly under loading without permanent stretching or deformation. This inferior layer is continuous with the posterior-inferior border of the articular disc and inserts on the posterior aspect of the condylar neck. It functions as a tether, limiting anterior movement of the disc. Between these two strata is loose, areolar connective tissue that is highly vascular and highly innervated. It is thought to serve as a hemodynamic or hydraulic cushion for the condyle on closure.

Division of Joint Function (Translation, Rotation)

Translation, or sliding movements of the joint, occurs primarily in the superior joint space, as the superior surface of the disc slides against the articular tubercle.



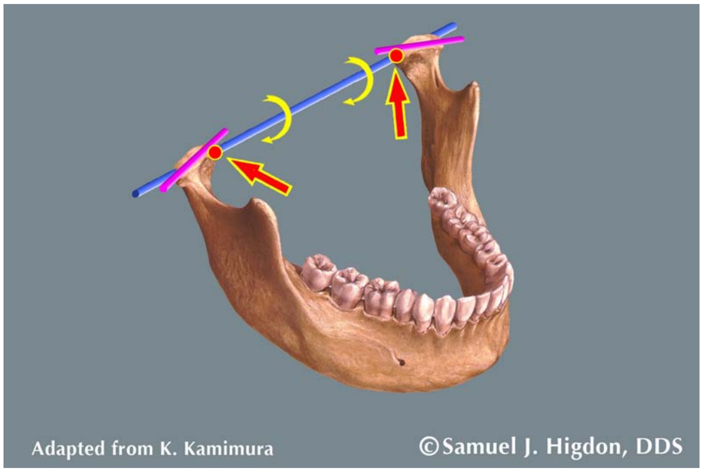


Rotation occurs primarily in the inferior joint space, against the inferior surface of the articular disc. Pure rotation, without translation, can be created by guided manual manipulation and will allow for up to 25 mm of inter-incisal opening.

Research has demonstrated that pure rotation does not occur during normal joint function. Temporomandibular joint movements during normal function are a blend of translation and rotation with the degree of translation increasing with greater mouth opening.

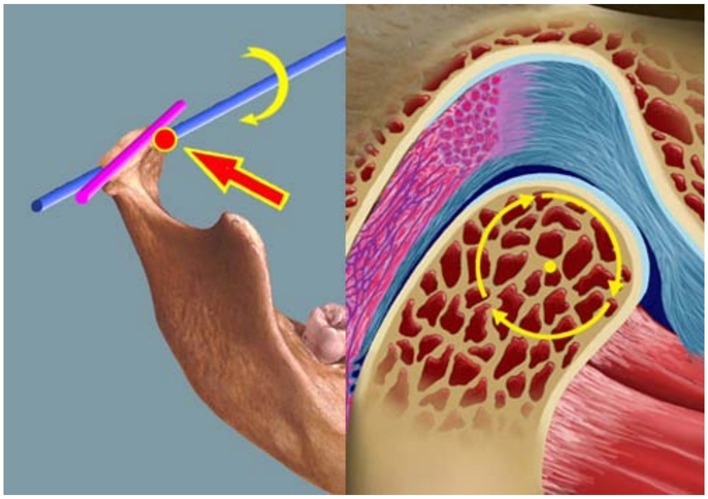
Pure rotation might be seen, clinically, when there is a severe restriction of the potential for the joint to translate, as when the articular disc has become stuck to the articular eminence by adhesions. This type of intracapsular restriction makes apparent the diagnostic importance of understanding the degree of rotation and translation that can occur in each joint space, even though pure rotation does not typically occur in isolation during normal joint function.

Mandibular Axis of Rotation, Rotation around Medial Poles



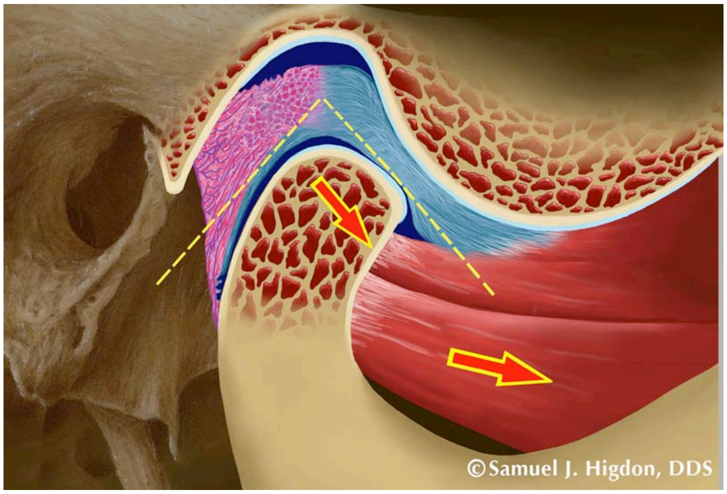
Because the two joints are connected by the mandible, when pure hinge mandibular rotation does occur (during manual manipulation), it occurs in both joints simultaneously around a common axis. That axis (blue rod) runs through each condyle at approximately the medial pole, the point at which the condyles (with the medial aspect of their discs interposed) contact the medial wall of the fossae.

It is important to be aware that the long axis of each condyle is not parallel to the axis of rotation. For this reason, it is not possible for condylar rotation to occur around the long axis of the condyles, as the sagittal illustration on the right suggests. Here, again, we encounter the limitations of a two-dimensional illustration.



The normal relationship of the articular disc to the condyle in the closed mouth position is particular important in that it provides a stable position for the condyle and maximum congruity of joint surfaces to maximize distribution of the forces of functional loading.

Translation

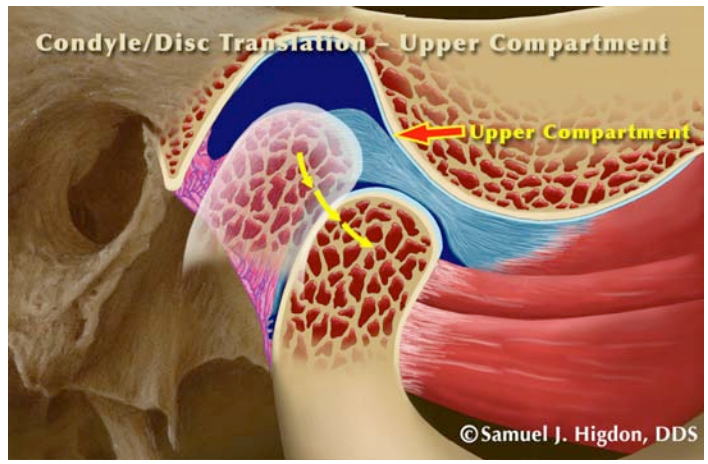


Translation of the condyles occurs with several types of jaw movement; opening/closing, protrusion/retrusion, and with lateral jaw movements. Some degree of translation within the joints will occur with all functional movements of the jaw and is primarily the result of contraction of the lateral pterygoid muscles.

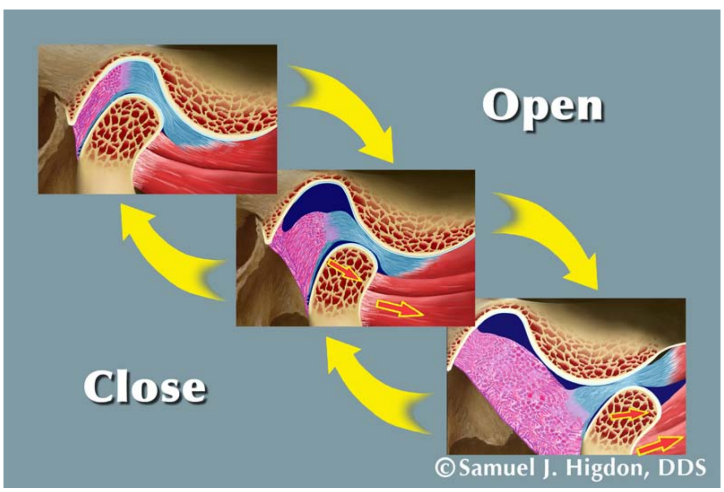
With the articular disc in its normal relationship to the condyle, and with intact ligamentous attachments of the disc to the condyle, these two structures form an important functional unit, referred to as the condyle/disc assembly. During all translatory movements the disc moves with the condyle and these sliding movements take place primarily in the superior joint space or compartment.

The surfaces involved in translation are the superior surface of the articular disc against the posterior slope of the articular eminence.

With full mouth opening, the disc pivots posteriorly relative to the anteriorly translating and rotating condyle, with the forward movement of the disc limited by the pull of the stretched fibers of the retrodiscal tissue.



Open/Close Sequence

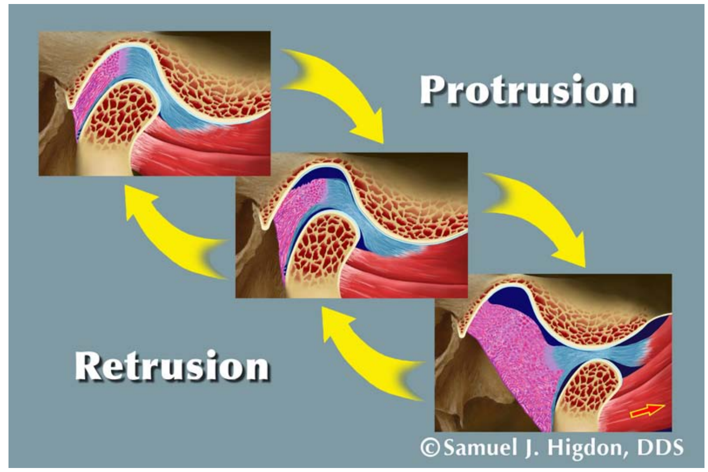


This sequence of three illustrations demonstrates the normal relationship of the condyle to the articular disc during opening and closing movements.

Note that as the condyle leaves the fossa, the retrodiscal tissues, which are a continuation of the disc, not only follow after the disc, but also enlarge, due to engorgement with blood. Then, as the closing movement occurs, the blood is forced out of the retrodiscal tissue and that tissue collapses back into the retro-condylar space.

Assuming that all of the intracapsular structures are intact and optimally aligned, it is important to recognize that during the movements just described, no load is imposed on the retrodiscal tissues. Thus, a joint with normal structural relationships should not produce pain, either with loading or during jaw movements.

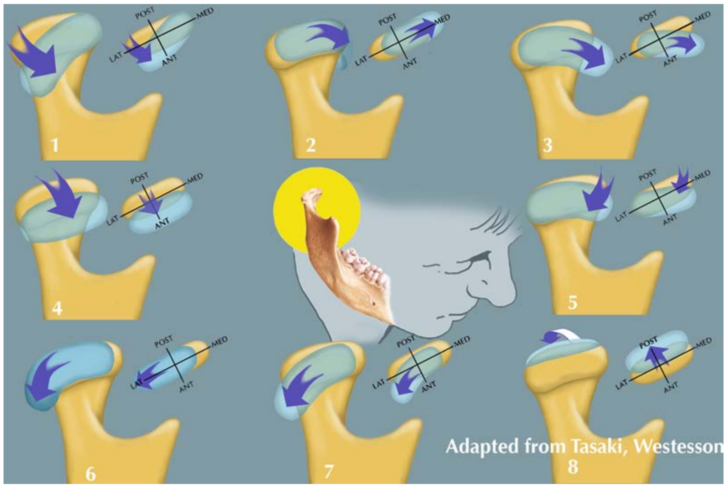
Protrusion /Retrusion Sequence



This sequence of three illustrations demonstrates the normal relationship of the condyle to the articular disc during protrusive and retrusive movements. At first glance, these illustrations look very similar to the opening and closing movements. However with open/close, the condylar position at maximum opening achieves a greater forward position than during protrusion. With maximum protrusion, the condyle typically travels only to the height of the articular eminence or slightly beyond. You will also notice the difference in the condylar position. With pure protrusion, since the mouth opens minimally, very little rotation of the condyle takes place, whereas, with wide opening, a significant amount of condylar rotation is evident. As is true with the closing movement, retrusion also causes the retrodiscal tissues to collapse into the retro-condylar space.

Internal derangements of the temporomandibular joint represent a loss of the normal structural integrity of the joint. Although the prevalence of these structural changes within the general population is surprisingly high, and although most individuals who have these conditions do not seem to experience any adverse effects from them, in patients who **are** experiencing pain and/or dysfunction of the jaw mechanism, internal derangements are very frequently involved. Therefore, understanding the anatomy and physiology involved in internal derangements is crucial to understanding temporomandibular disorders.

When the dental profession first began to recognize the phenomenon of disc displacement, as a result of Dr. Farrar's initial description of this phenomenon, the common perception of what was happening within the TM joints was fairly limited and perhaps somewhat naïve. For instance, it was commonly assumed that, when the articular disc became displaced, it displaced in an anterior-medial direction due to the pull of the superior lateral pterygoid muscle. Based on these perceptions, some of the early attempts to treat these disorders were certainly simplistic, to say the least, involving attempts to "capture" the articular disc by moving the condyle onto the displaced disc.

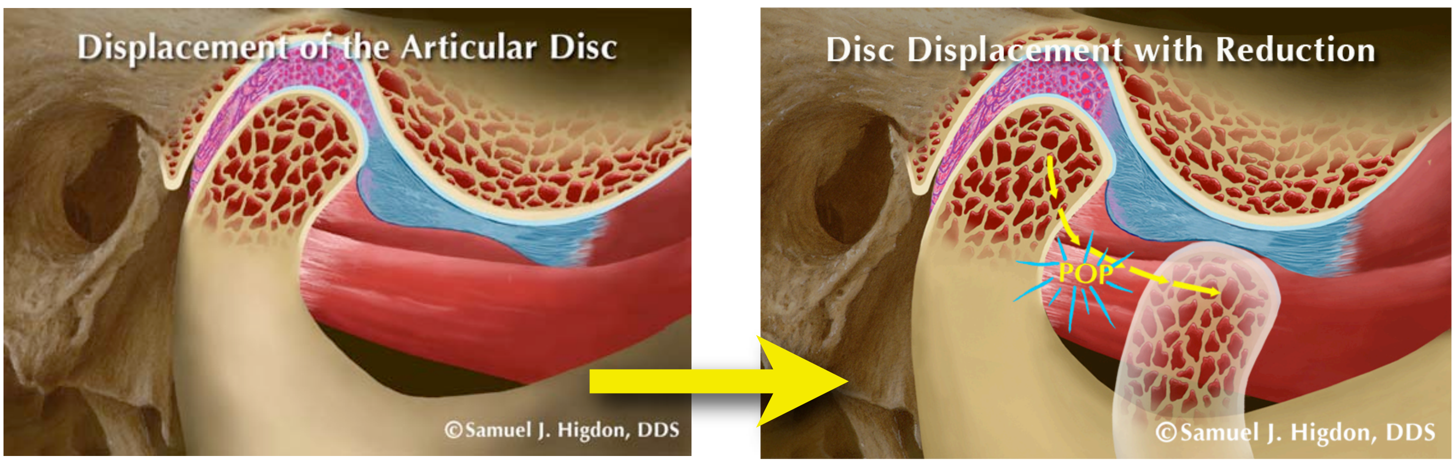


Recent research related to disc displacement within the temporomandibular joint has been done with the use of magnetic resonance imaging (MRI). This imaging technology has the ability to demonstrate the relationships of both hard and soft tissue within the TM joints.

There is great variability that can occur in the direction of displacement the articular disc. This series of illustrations is adapted from an article by Tasaki, Westesson, et al in 1996 (Am J Orthod Dentofac Orthoped) that examined bilateral temporomandibular joints, using MRI, in 243 patients and in 57 symptom-free volunteers.

In addition to the normal, superiorly-positioned disc position, this study identified 8 different types of disc displacement, as seen here. In the patient group, only 18% had both discs in the normal position. In the symptom-free volunteers, 80% had normal disc position.

Disc Displacement with Reduction



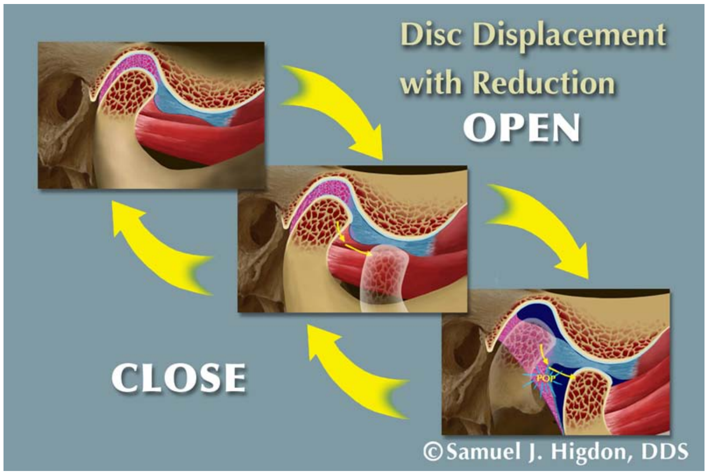
In the first of these two views, on the left, the articular disc is no longer situated between the condyle and the articular eminence. This representation of a displaced disc appears to show the disc fully, bodily displaced in a forward direction. It should be remembered that we are considering a three-dimensional relationship and that a two-dimensional image such as this can be misleading. This illustration of a forward displacement is **not** a true representation of what happens to the articular disc in every instance of disc displacement. The variations that can occur in disc position, as previously visualized, must be understood.

When the articular disc is displaced and the condyle is able to translate onto the disc, this is referred to as disc displacement with reduction. When this occurs, reduction is commonly accompanied by a click or pop on opening, as seen here in the illustration on the right. There may also be a click or pop on closing. The click or pop occurs when the condyle snaps over the thickened posterior band of the disc, whether on opening or on closing.

The click or pop may occur early in the opening movement or at a later stage of opening. The position of the click in the opening movement is primarily determined by both the position of the disc and the degree of disc deformity when the click/pop occurs. It is thought that the longer a disc has been displaced, the more the disc will be pushed forward as a result of progressive stretching of the attachment tissues that hold the disc in place. Thus, with time, the click often occurs later in the opening cycle.

As mentioned previously, many individuals experience internal derangements (disc displacements) of the temporomandibular joints and have no symptoms that seem to be associated with this structural change. However, the potential for these conditions to produce pain must also be appreciated. A patient may or may not be aware that the clicking, popping, or other sounds from their joints are related to their pain complaint. When a patient describes joint sounds or when joint sounds are detected in the course of other dental procedures, including routine prophylaxis, a screening examination is indicated.

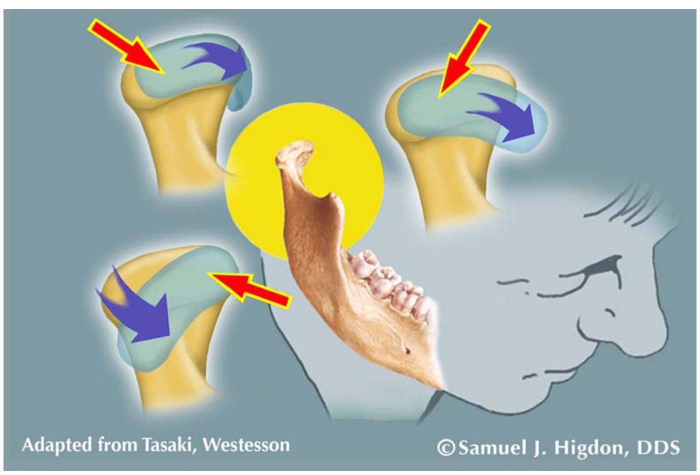
Disc Displacement with Reduction Sequence



We see here that when the disc is displaced in a forward direction, the condyle is no longer centered on the disc. Frequently there will also be a displacement of the condyle, as seen here. When this does occur, the direction of condylar displacement may be posterior-superior, posterior, or even posterior-inferior. The direction and degree of displacement of the condyle can vary, from fairly minimal to rather significant.

It can also be seen that when the disc is displaced, there is a potential for the condyle to load against the retrodiscal tissues. However, in pointing this out, it is again important to appreciate that this is a two-dimensional illustration of a three-dimensional relationship.

Why Many Disc Displacements Don't Hurt

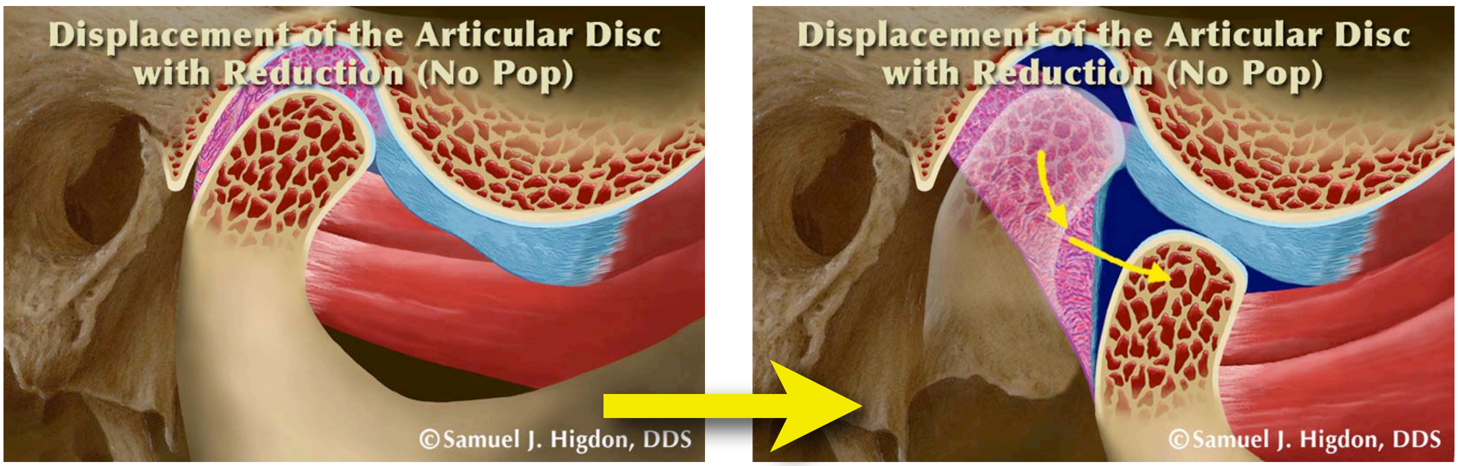


It would seem likely that when condylar displacement occurs, there would be loading by the condyle against the retrodiscal tissues. If that should occur it could potentially result in TMJ pain. As we previously saw in the illustrations from the Tasaki and Westesson study, the direction and degree of disc displacement can vary a great deal. These illustrations demonstrate that with several types of disc displacements, only a portion of the disc is displaced, while some of the disc may still remain between the condyle and the articular eminence. With partial disc displacement, loading may continue to be partially against the disc, thus minimizing the load on the retrodiscal tissues. This may explain why many people with clicking or popping TM joints do not experience any pain from the joints.

In summary, with certain types of disc displacement there is loading against the retrodiscal tissues and this will often be the source of intracapsular pain. Perhaps the most important thing to realize about TMJ internal derangements is that there can be a great deal of variation. Therefore, not all joints that click and pop require treatment. Only a careful examination will reveal when treatment is indicated.

In the majority of cases involving disc displacement, in the absence of known trauma, it can be assumed that disc displacement most often develops progressively, over time. If this assumption is correct (to date there is no scientific documentation as to how this occurs) one can assume that condylar displacement also takes place as a simultaneous, progressive process.

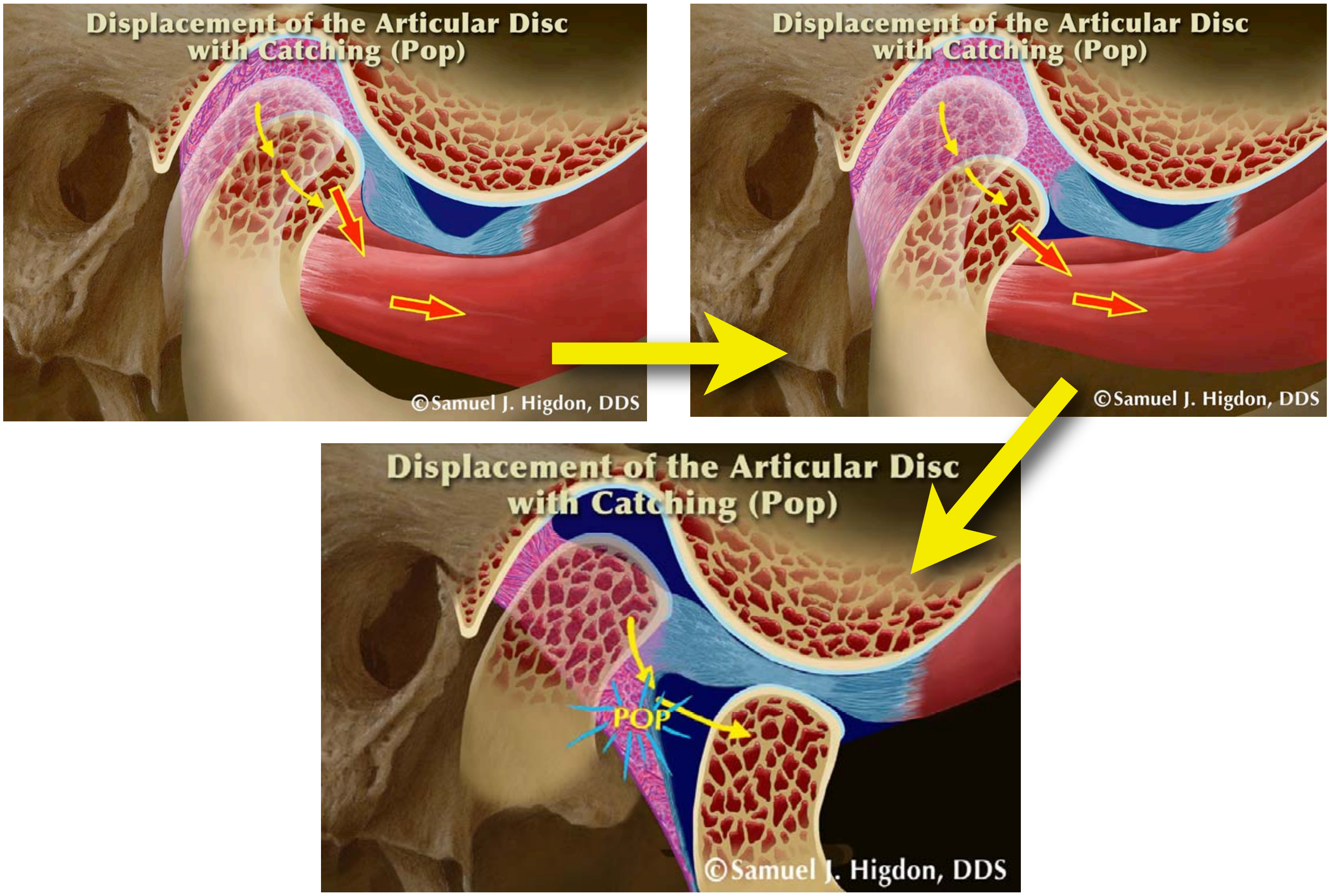
The position of condylar displacement can be documented with the use of imaging and mounted diagnostic casts. At this time it cannot be said with scientific certainty what role the dental occlusion plays as a potential contributor in the progressive displacement of the articular disc and the simultaneous displacement of the condyle. However, recognizing that for disc displacement to occur, there would need to be loading forces on the TMJ that would contribute to lengthening of the ligamentous attachments of the disc, as well as to the displacement of the condyle. Other factors, such as systemic ligamentous laxity could potentially also play a role. Plausible educated speculation for adverse joint loading would have to include adverse loading on the TMJs by dental occlusal factors.



Over time, as the condyle moves on and off the disc, the intensity of a click or pop may diminish and may eventually completely vanish, at least from the subjective perception of the patient. This change over time results from a change in the morphology of the disc – an “ironing-out” or flattening of the thicker posterior band of the disc so that the condyle is able to more easily achieve an “on disc” position without producing the characteristic click or pop. Auscultation of the joints for joint sounds can be done with a stethoscope. Others have also recommended more sophisticated technology such as Doppler units and joint vibration analysis.

Disc Displacement with Reduction/No Click or Pop – Sequence

The patient’s response, when asked if their TM joints click or pop, is not always reliable. Even if the patient says that there are no joint sounds, not uncommonly a subtle click or pop can be detected by altering joint dynamics. This can be accomplished by applying pressure under the angle of the jaw, from the lateral aspect, or by placing the small finger in the ear canal and, with the pad positioned forward, applying forward pressure while asking the patient to open and close. This procedure will also change the dynamics of joint mechanics by compressing the retrodiscal tissues against the condyle. This should be done cautiously since it might also produce joint pain.



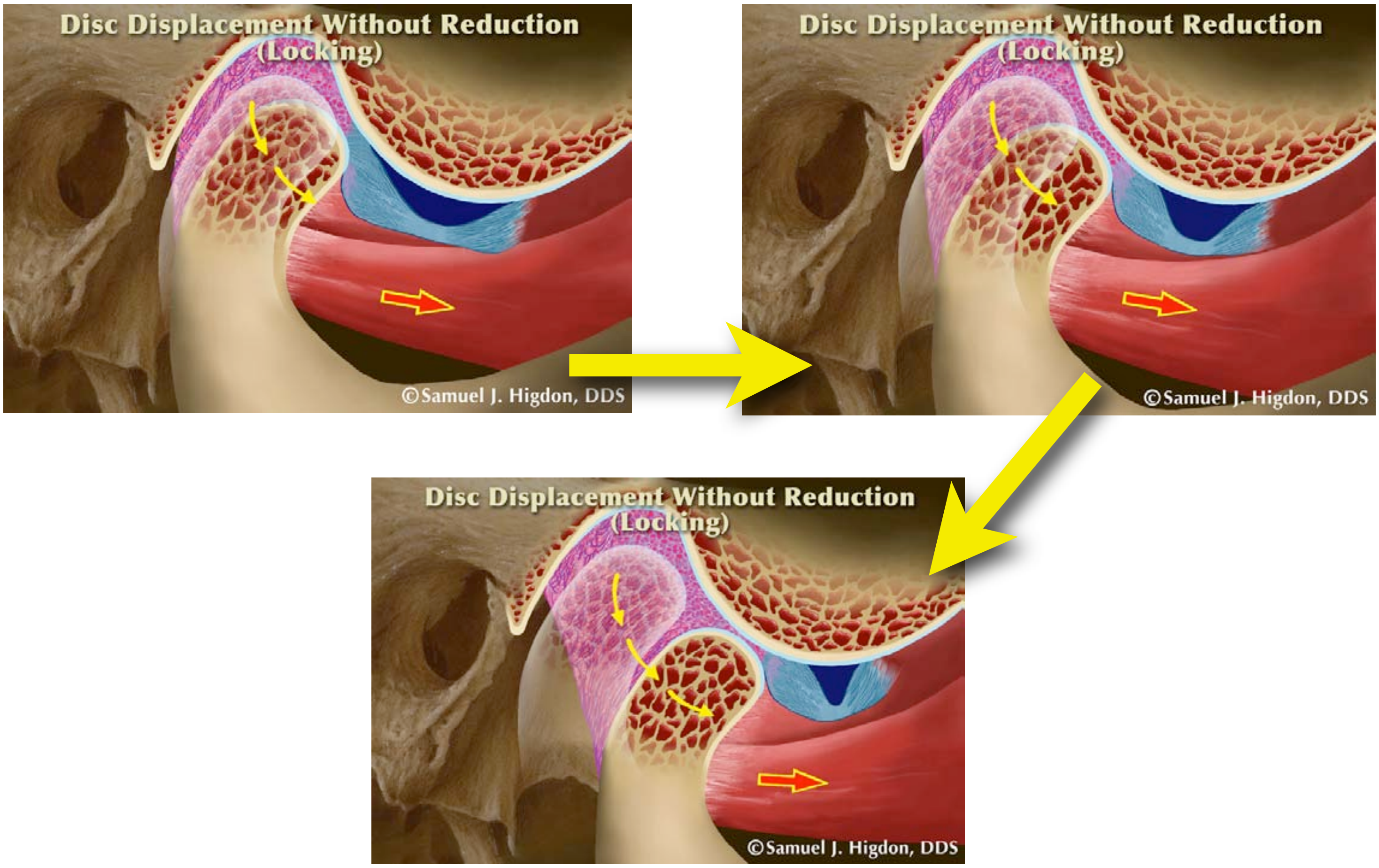
Disc Displacement with Reduction — Catching Joint

A large percentage of individuals who have had clicking or popping joints live with it successfully and never seek help for pain or dysfunction. However, changes in disc shape and position as well as alterations in the attachment tissues and underlying bone can occur over time.

The patient can experience jaw joint catching during function. When this occurs, the patient will usually be aware of having had clicking/popping before the catching began. At some point they will notice that when opening their mouth, they experience a brief hesitation to opening but the interference may be overcome by making a small lateral movement of their jaw, which is then usually accompanied by a pop as the condyle moves on to the disc and then they are able to open further. This experience may or may not be accompanied by pain.

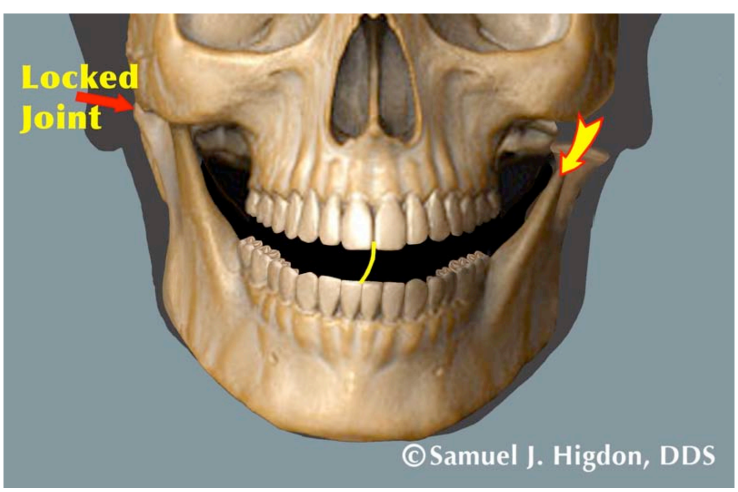
If this catching were to remain the same over time, particularly if it is not accompanied by pain, they might be able to live with it without difficulty. However, as seen in these illustrations, catching usually results from a change in the morphology of the disc, such as folding. When catching begins, it can, and often does progress to locking of the joint. If a patient reports increased frequency of catching or progressively greater difficulty in overcoming the catching, the associated changes in the disc and it attachments may eventually lead to locking. The progression from catching to locking may take place quickly, while for other patients the catching may progress gradually, worsening over time.

Disc Displacement without Reduction



Locking of the temporomandibular joint is referred to as disc displacement without reduction. Locking typically results from not only displacement of the disc but also from morphologic distortion of the articular disc, such as folding of the disc when condylar translation takes place. This prevents movement of the condyle onto the disc during translation, as shown here. Not uncommonly the altered joint surfaces and friction associated with locking may also be accompanied by the development of adhesions within the joint which can further restrict translation of the disc.

[Disc Displacement without Reduction — Skull, Front View, Deflection

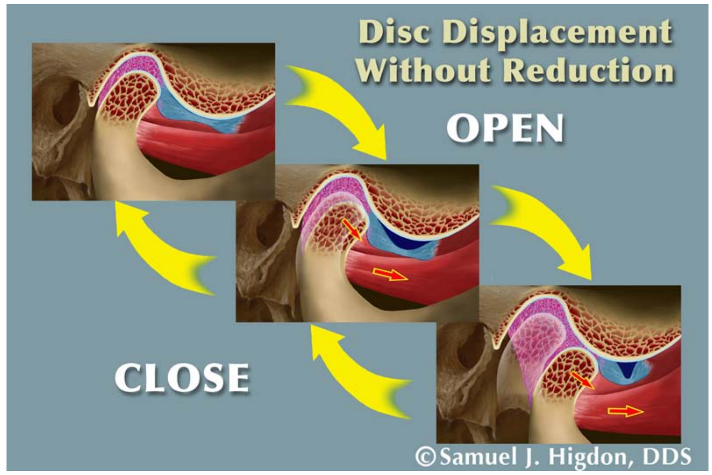


When joint locking occurs, what is seen clinically will typically be not only a limited ability of the patient to open fully, but also a deflection of the mandible toward the affected side. In other words the affected condyle cannot translate while the opposite condyle, if it is unaffected, will translate normally. This results in a deflection of the mandible toward the affected side.

The same deflection is likely to be seen with protrusion and when lateral jaw movements are measured, the affected joint will translate less than the unaffected side.

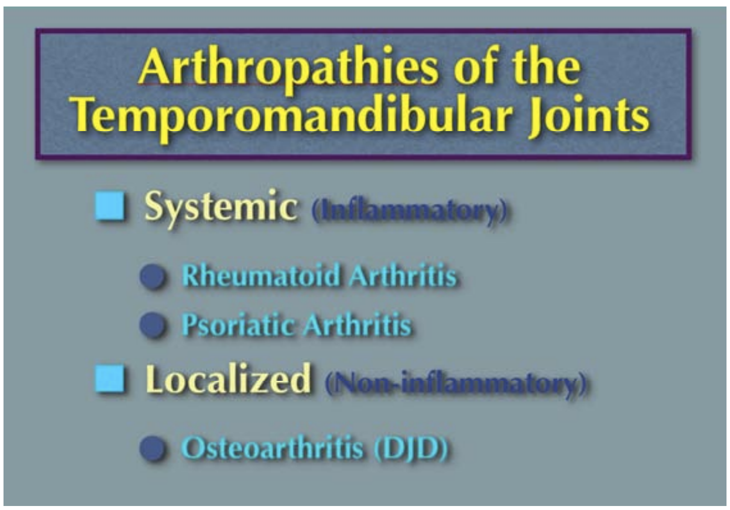
Disc Displacement without Reduction — Sequence

This sequence shows the disc folding and simultaneously being pushed forward. However, with an acute locking of the joint, most typically in a younger person, the disc will not move forward to the same degree during translation as is seen here and, as a result, translation of the joint will be much more restricted.



Locking, or non-reduction, can also occur in a more occult manner, sometimes without the awareness. For patients who may have lived with this condition without pain or other awareness, similar but often more subtle clinical findings, such as deflections, will be present and the opening range of motion may approach normal.

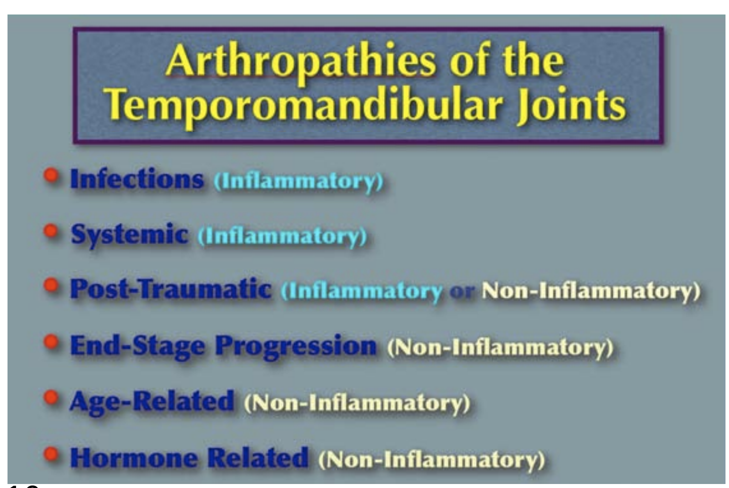
Arthropathies of the Temporomandibular Joint



Arthropathies of the temporomandibular joints, as in other joints of the body, can be of several types with over 100 distinct types of arthropathies that occur in humans. The major categories of arthropathies are non-inflammatory (osteoarthrosis), inflammatory arthritis (several types), traumatic arthritis, and infectious arthritis. By far the most common is the non-inflammatory type, osteoarthrosis, which is referred to as degenerative joint disease. This type of arthropathy is considered localized rather than systemic. Examples of systemic arthropathies are rheumatoid arthritis, psoriatic arthritis, gout, and those associated with infectious diseases.

The correct designation for non-inflammatory arthropathies is osteoarthrosis (non-inflammatory) rather than osteoarthritis (inflammatory). Inflammatory arthritis, regardless of whether the cause is from injury, normal wear and tear, or disease, results in the joint becoming inflamed, and is accompanied by swelling, pain and stiffness. Inflammation is one of the body's normal reactions to injury or disease and this response is usually temporary. With age, the inflammation arises because the smooth articular cartilage on the ends of bones becomes damaged or worn.

Osteoarthrosis may result from the progression of an internal derangement that could have preceded the osseous changes by many years. This type of degenerative change is sometimes referred to as "end-stage" arthrosis. It is not inevitability seen as a predictable outcome in all instances of internal derangements. Age-related osteoarthrotic changes may be due not only to structural changes (internal derangements) but also to the ravages of time.



There is also emerging evidence that, in women, hormonal effects related to birth control medications and/or amenorrhea, may contribute to degenerative changes. This type of arthropathy is typically non-painful and without any of the other classic signs of an inflammatory process. It is not currently known why some patients may develop this type of osteoarthrosis and we are not able to prognosticate as to the odds of this developing.

Inflammatory arthritis that is related to systemic disease results when, for unknown reasons, the immune system mistakenly attacks the tissue that lines and cushions the joints. This occurs with diseases such as rheumatoid arthritis and psoriatic arthritis, as well as others. Acute trauma to a joint can also produce inflammation and result in post-traumatic arthropathy. The initial tissue breakdown may be initiated by the trauma-induced inflammation. However, once the initial inflammation from the trauma has subsided, degenerative changes may continue without further inflammation secondary to the damage to the articular tissues that resulted from the trauma.

Although infectious arthritis can occur, described as arthritis caused by an enfectious organism, it is quite uncommon. The usual etiology of infectious or septic arthritis is bacterial, but viral, mycobacterial, and fungal arthritis do occur. These infections can enter a joint various ways, including spreading through the bllood stream from another part of the body, from a nearby wound or after surgery, an injection or trauma. It would, of course, be inflammatory in nature and septic arthritis should be considered whenever one is assessing a patient with rapid onset of jaw joint pain.

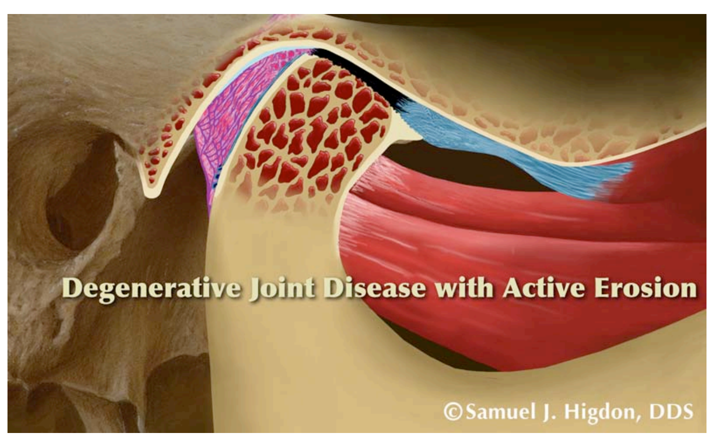
The organisms that have been reported in cases of septic arthropathy of the TMJ are *Staphylococcus aureus, Neisseria gonorrhoeae*, and *haemophilis influenzae.* Usually only one joint is affected (monoarthritis), however several joints can be affected simultaneously. In groups who are likely to be sexually active, such as adolescents and young adults, as well as homosexual men, presentation of TMJ pain with rapid onset, particularly with noticeable swelling, the possibility of gonococcal sepsis should at least be considered in a differential diagnosis of TMJ pain. Lyme disease, caused by bacteria that live in deer ticks, is often not always diagnosed immediately. When the infection is not treated, arthritis can develop in the later stages of Lyme disease

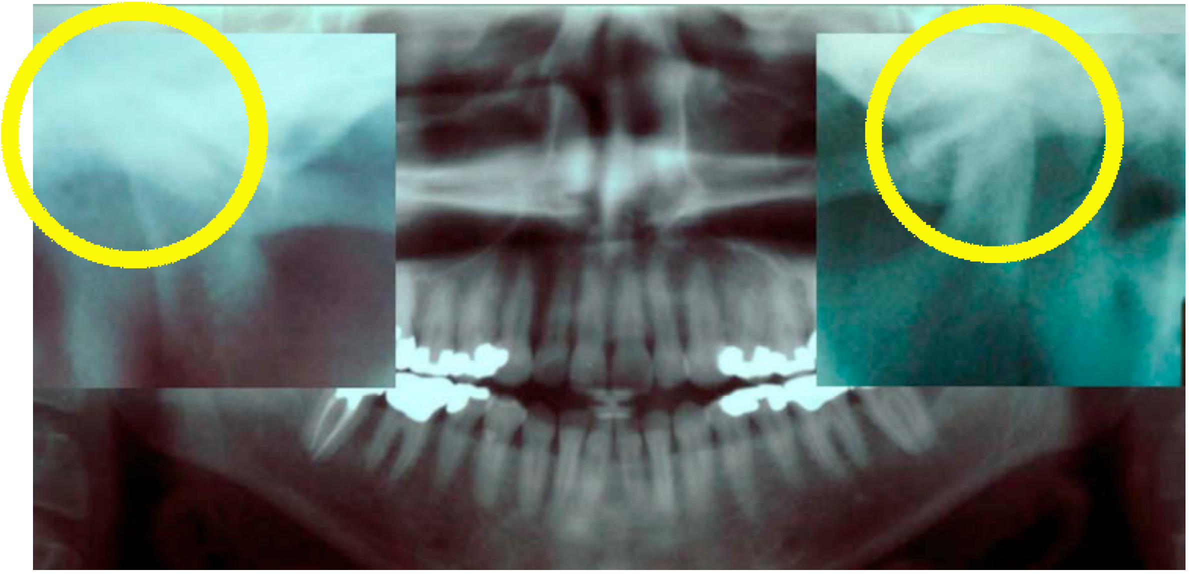
Degenerative changes in the temporomandibular joints, whatever their cause, usually produce joint crepitation sounds that can easily be heard with the use of a stethoscope. The patient will typically be aware of these sounds, particularly if the sounds are course and grating. When these sounds can be compared to someone walking on gravel, it can be assumed that this represents bone-on-bone contact.

In spite of an absence of radiographic evidence of osseous changes, some degree of soft tissue crepitation, may be heard with auscultation. These sounds typically represent soft tissue changes within the joint and may not indicate a progression toward osseous change. However, it may represent a progression from a previous clicking or popping joint, and is often heard in joints that have locked, particularly chronically locked. Although usually indicative of significant soft tissue changes, soft tissue crepitation, alone, should not be used to establish a firm diagnosis of a locked joint.

Active Osteoarthrotic (Degenerative) Change

This illustration is of a joint that is in the process of active degeneration or arthritic breakdown. The cortex of the articular surface of the condyle is missing with some loss in the height of the condyle. The articular eminence has also undergone change and has become flattened. The appearance of an actively degenerating condyle can vary, depending how much osteoarthritis has progressed.



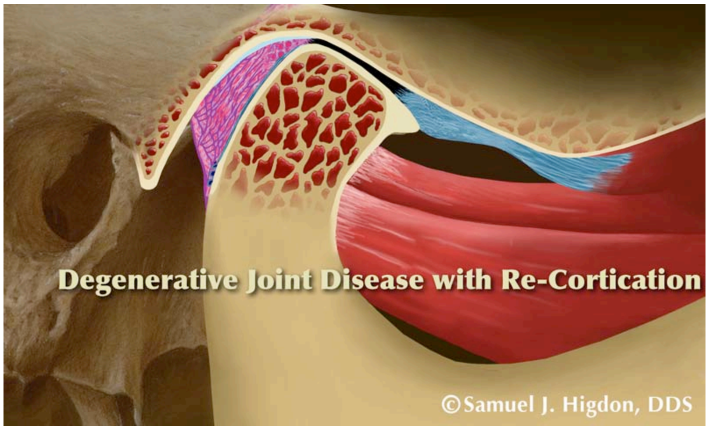


Osteoarthrotic changes within the temporomandibular joints are identified with imaging by changes in the normal contour of the condyle and by changes in the density of the cortex. The dental clinician is likely to see such changes on a good quality panoramic image that provides good visualization of the condyles. Although osteoarthrotic changes of the articular eminence may also be present, these cannot as reliably be identified on a panoramic image. To see the condyles on a panoramic film, the patient must protrude their mandible, which brings the condyles down the slope of the articular eminetia, out of the fossae, thus minimizing superimposition of other boney structures. If the patient doesn't or can't do it, the condyles may not be seen clearly.

Several limitations of conventional panoramic imaging can be overcome with the use of cone beam technology.

Inactive (Recorticated) Osteoarthrotic (Degenerative) Change

This image is of a joint that has undergone the active degenerative process. The degenerative process has stopped and recortication of the areas of breakdown has occurred.



The non-inflammatory degenerative process within the TM joints appear to be time-limited in most cases. Just how long degenerative change may continue is unpredictable but is likely to vary, depending on several possible factors, including repetitive truama (bruxism), age and heredity. In most patients the degenerative process eventually appears to "burn out", meaning that the breakdown will stop and a process of re-cortication of the areas of breakdown will begin.

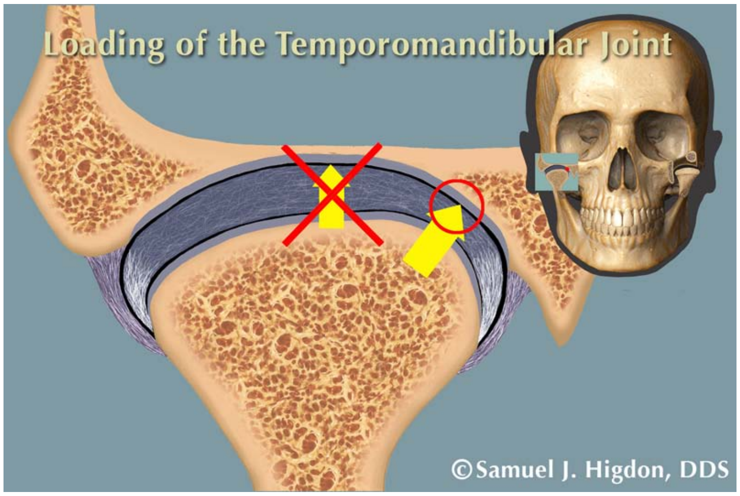
As indicated in this image, in joints that have gone through this process, on imaging there may be evident flattening of the condyle evident, perhaps an anterior osteophyte, and the appearance of an intact cortex of the articular surface.

If the dental clinician has access to imaging that shows the TM joint more clearly than is possible with a panoramic film, other findings may also be seen in a joint that has undergone degenerative changes. These might include a narrowed joint space and a flattened articular eminence, as represented in this illustration. In this illustration, the articular disc is thinned and there is a perforation of the tissues behind the disc, although changes with a joint involved in this process can vary widely.

Imaging such as corrected tomography, MRI, and cone beam CT would provide additional information. However, of these imaging techniques only an MRI will demonstrate the soft tissues, including the articular disc.

Loading of the Temporomandibular Joints

Joint Loading – Frontal View

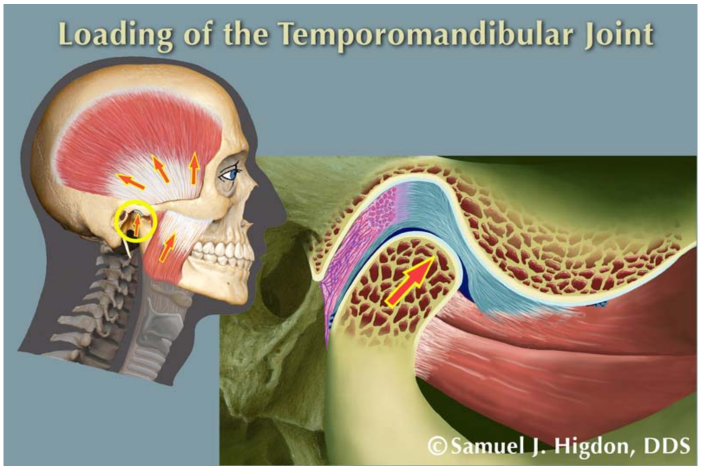


The following two illustrations of temporomandibular joint loading from the frontal and from the sagittal view demonstrate the articular disc in its normal relationship to the condyle and to the articular eminence in the seated joint position.

From the frontal view of an intact condyle/disc assembly, the articular disc is seen centered over the condyle. It is evident in this illustration that the bone in the superior portion of the fossa is quite thin. Superior to the joint is the cranial vault. Thus, it is evident that this thin area is unsuited for joint loading in the seated joint position. In this position there is maximum congruence of joint surfaces, which provides for a wide area of force distribution during loading. But this loading is buttressed by contact at the medial superior aspect of the fossa, where the bone is much thicker.

Joint Loading – Sagittal View

In this sagittal or side view, the direction of load on the TM joint results from the combined force vector of the masticatory muscles and is indicated by the arrow that is superimposed on the condyle.



In this position, maximum congruence of joint surfaces provides for a broad surface area for distribution of force during loading. The shape of the condyle, as it relates to the shape of the tubercle, (two convex surfaces) lacks congruency, with a relatively small area of potential contact. The interposed articular disc reduces this joint incongruency during movement and increases joint stability by enlarging the contact area.

The presence of the disc also reduces the potential for friction within the joint that would result from this incongruity by increasing the surface area for synovial fluid lubrication. Therefore, a broad distribution of loading forces tends to minimize the potential for biomechanical damage to the articular tissues. In this position the condyle, in its relationship to the disc, is most stable and thus, this is considered the optimum position and relationship for loading of the joint.

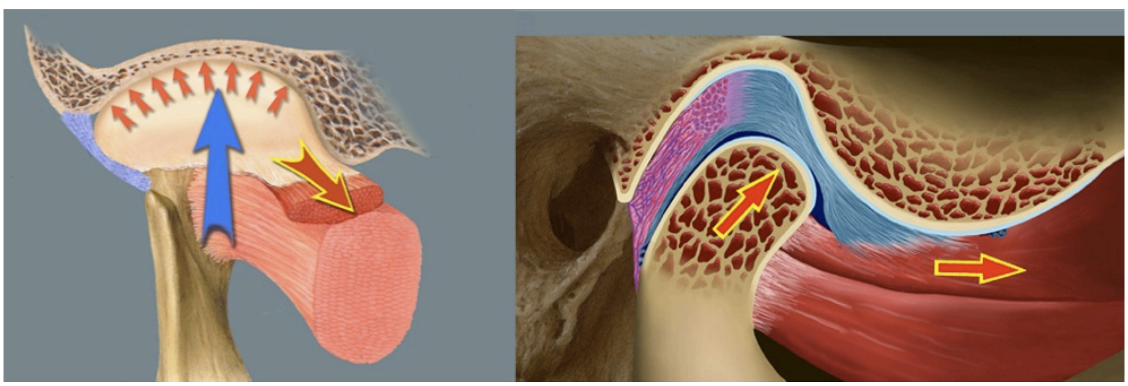
With the articular disc in its normal relationship to the condyle, the condyle is unable to move more superiorly than this position, limited by contact of the condyle against the posterior border of the articular disc. Dr. Peter Dawson has referred to this condylar/disc relationship as the “apex of force”. As has been previously suggested, if the articular disc has become displaced, the position of the condyle within the fossa may also have changed. The potential for this to occur can alter the nature of joint loading and can potentially affect the symptoms experienced by the patient.

The Significance of Joint Loading

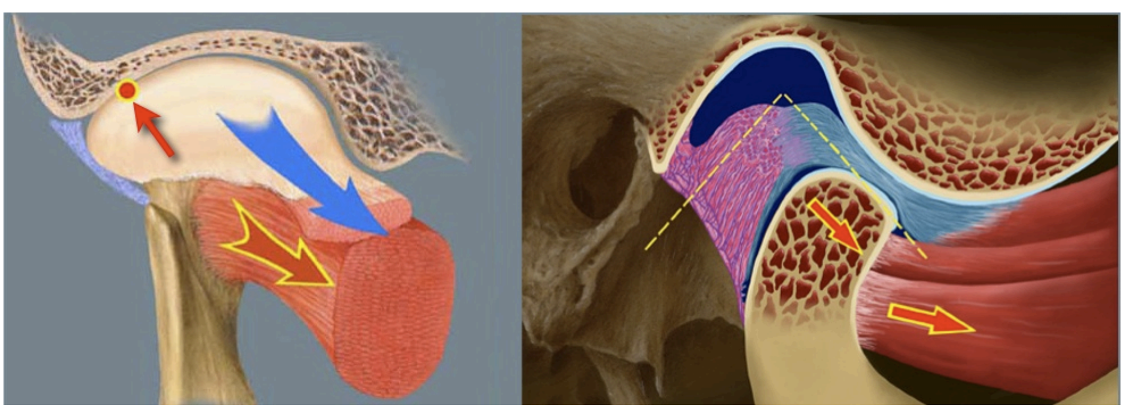
It is essential to understand that the ongoing health of the temporomandibular joints is dependent on primarily one thing — joint loading. How forcefully the joint is loaded and with what duration and frequency the loading occurs will impact joint stability, structural integrity, and intracapsular soft tissue health. As was previously described, the joint is best able to accept loading, with minimal potential for tissue damage, when it is in its seated position within the fossa with the articular disc interposed.

When these anatomical components of the joint are appropriately aligned during loading, not only is the joint stable, there is maximum congruence of joint surfaces, condyle to disc, disc to articular tubercle, to disperse the forces of loading over the widest area of tissue contact. A joint thus aligned and loaded can endure considerable loading over many years with minimal adverse effects.

However, it is equally important to understand the nature of adverse loading of the joint that has the potential to produce tissue changes and breakdown. In the illustration below (left), adapted from Kamaura’s beautiful work, we see the joint being loaded in the seated joint position and the activity of the superior head of the lateral pterygoid muscle contracting to stabilize the disc in its relationship to the condyle and tubercle.



In this seated position, the load generated by the elevator muscles is dispersed over a wide area due to maximum congruence of joint surfaces. This is also the nature of loading of other load-bearing joints, such as the hip, the knee, and the ankle joints. When load is applied to the joint, maximum force distribution is essential to assure the long-term health of the joint in response to loading.



However, unlike other load-bearing joints, such as those just mentioned, the temporomandibular joints have the potential for a movement that these other joints are not capable of – which is translation or sliding movements. Importantly, when these translatory movements take place in the TM joints, the congruence of joint surfaces is reduced and loading on the joint during these sliding movements becomes more focal. (The knee translates slightly but contact remains fairly broad across the joint.)

During translation, as seen in the illustration above, because of the more focal load on the joint, the potential for tissue damage in the area of loading is more critical. To maintain the health of the soft tissues of the joint, loading on the joint during these translatory or sliding movements should be no more than would occur during normal functional activities, such as chewing.

One of the perennial discussions regarding dental occlusion has to do with the pros and cons of non-working side (balancing) contacts. The discussion has been, and continues to be, wide-ranging. However, with regard to joint loading, the important consideration regarding these contacts is this; the determining factor influencing the degree to which the elevator muscles will contract on a given side of the mandible is primarily dependent on whether or not there is tooth contact on that side.

If there is posterior tooth contact on the side that is translating, whether it involves lateral jaw movement or a protrusive movement, there will be increased elevator muscle activity. Thus, if the translating joint is being loaded by elevator muscle activity due to posterior tooth contact, because of the more focal loading the potential for tissue breakdown at the point of loading increases. How much potential for soft tissue injury may exist will be a function of not only the amount of force but also the frequency and duration of the load.

If tooth contact does occur during chewing, it is more likely to occur predominantly on the chewing (working) side unless, as is occasionally seen, the non-working contacts are so heavy that, during empty-mouth jaw movements, they would override the working side. However, the relative degree of non-working side loading during chewing is of lesser importance compared to the influence of joint loading during parafunction by non-working contacts. The primary basis for concern regarding non-working tooth contacts and the potential for excessive and potentially-damaging loading has to do primarily with what can occur during parafunction.

While there may be other considerations regarding the influence of non-working (balancing) tooth contacts, from the standpoint of maintaining optimum health and physiologic function of the joints while minimizing the potential for tissue breakdown, the potential for undesirable loading effects on the TM joints by non-working side contacts supports the long-held contention that these contacts are undesirable.

It is the hope of this author that the text and illustrations provided here will foster further appreciation of the critical relationships between structure and function regarding the role of the temporomandibular joints in the harmonious, physiologic function of the masticatory system. When considering what has traditionally been referred to as “dental occlusion”, we are now more aware than ever before that the study of dental occlusion must take into account the role of both normal and dysfunctional TMJ anatomy in the static and dynamic relationships of the teeth, as well as their equally important role in muscle function.

Whether you are a dental professional or a patient who is experiencing the signs and symptoms of a temporomandibular disorder, more commonly referred to as “TMJ”, we hope that this discussion of the anatomy of the temporomandibular joint in function and dysfunction is helpful to your understanding of these often-misunderstood disorders.

The author and illustrator of this paper, Samuel J. Higdon, DDS, can be contacted at, TMJOregon@easystreet.net.