Functional Anatomy and TM Pathology

A Peer-Reviewed Publication
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Educational Objectives

1. Understand the functional anatomy of the temporomandibular joint (TMJ).
2. Understand what makes the TMJ a unique joint.
3. Understand TMJ pathology.

Introduction

Up to 75 percent of the population has at least one sign or symptom of temporomandibular (TM) dysfunction at any given time, and 34 percent of the population reports having a temporomandibular disorder (TMD).[1] Understanding and treating TMDs is an opportunity to help up to one-third of patients.

TM dysfunction and sleep-disordered breathing are under-diagnosed and under-treated. Amongst physicians who are not sleep specialists, only 24 percent screen for obstructive sleep apnea.

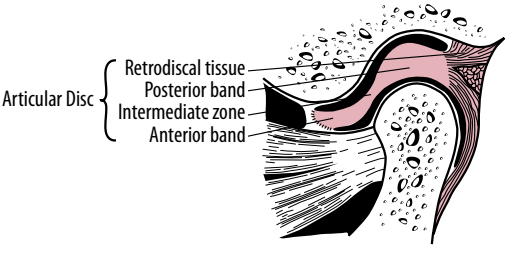
TM dysfunction is an orthopedic problem. There must be a team-oriented focus that includes specialists from multiple disciplines. According to Dr. Peter Dawson, "There is a primary tenet that embraces the entire subject of occlusion from the TMJs to smile design. It is that the teeth are but one part of the masticatory system, and if the teeth are not in equilibrium with all the other parts of the total system, something is likely to break down." A healthy joint is a pre-requisite for successful restorative work. It is imperative that dental professionals understand how to identify and properly treat TMDs and know when to refer.

Anatomy of the TMJ is complex and important in understanding the pathology and treatment of TMDs. This article is intended as a refresher on TMJ anatomy and pathology.

Anatomy of the temporomandibular joint

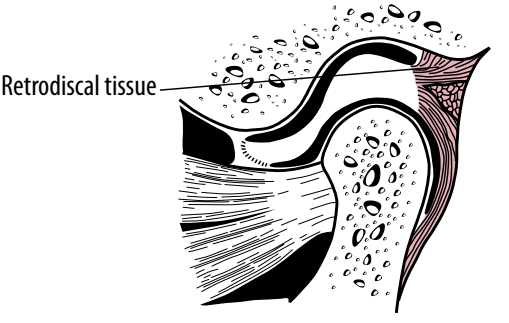
The TMJ is the most complex joint in the body. It provides for hinging movement in one plane (a ginglymoid joint), and at the same time provides for sliding movements (an arthrodial joint). Therefore, it is technically a ginglymoarthrodial joint. The TMJ is classified as a compound joint i.e., requiring the presence of at least three bones.

Articular Disc



The articular disc is composed of dense fibrous connective tissue devoid of any blood vessels or nerve fibers. Functionally it serves as a non-ossified bone that permits the complex movements of the joint. The articular disc can be divided into central, anterior and posterior regions. The central area, the intermediate zone, is the thinnest. The anterior border is generally slightly thinner than the posterior border. From an anterior view, the disc is generally thicker medially than laterally, which corresponds to the increased space between the condyle and the articular fossa toward the medial aspect of the joint. On opening, the superior surface of the articular disc has a sigmoid shape. The disc is firmly attached downward to the medial and lateral poles of the condylar head. The disc is the primary storage site for synovial fluid.

Retrodiscal Tissue



The retrodiscal tissue, or posterior attachment, consists of an area of loose connective tissue that is attached to the posterior aspect of the articular disc. It is highly vascularized and innervated, and is bordered superiorly by the superior retrodiscal lamina.

The superior retrodiscal lamina consists of connective tissue containing many elastic fibers. It attaches the articular disc posteriorly to the tympanic plate. Its function is to counter the forward pull of the superior belly of the lateral pterygoid muscle on the articular disc. When the mouth is fully opened, the retrodiscal tissue is fully stretched. The superior retrodiscal lamina prevents the disc from dislocating anteriorly, and also results in posterior rotation of the meniscus – allowing the thin intermediate portion of the disc to remain between the articular surfaces of the condyle and eminence.

The inferior retrodiscal lamina consists mainly of collagenous fibers. It is located at the lower border of the retrodiscal tissues. It attaches the inferior border of the posterior aspect of the disc to the posterior margin of the articular surface of the condyle.

Posteriorly, the remaining body of the disc is attached to a large venous plexus that fills with blood as the condyle moves forward. Anteriorly, the superior and inferior aspects of the disc are attached to the capsular ligament, which surrounds most of the joint. The superior and inferior attachments are to the anterior margins of the articular surface of the temporal bone and condyle respectively. The disc is also attached by tendinous fibers to the superior lateral pterygoid muscle, between the attachments of the capsular ligament.

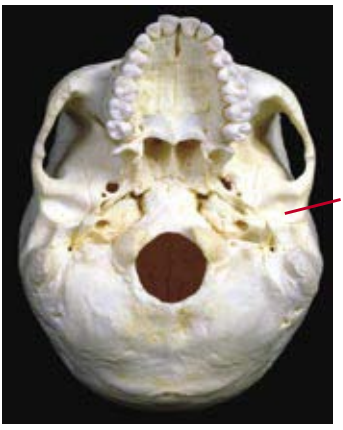
Fibrous Connective Tissue

The articular disc is attached to the capsular ligament anteriorly and posteriorly, as well as medially and laterally. This divides the joint into two distinct cavities. The internal surfaces of the cavities are surrounded by specialized endothelial cells that form a synovial lining. This lining, along with a specialized synovial fringe located at the anterior border of the retrodiscal tissues, produces synovial fluid that fills both joint cavities.

The articular surfaces of the mandibular fossa and condyle are lined with dense fibrous connective tissue rather than hyaline cartilage, as in most other mobile joints. The fibrous connective tissue in the joint affords several advantages over hyaline cartilage; it is generally less susceptible to the effects of aging and therefore less likely to break down over time, and *has a much greater ability to repair.*

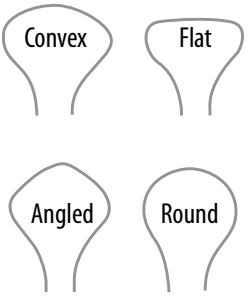
Bones

The TMJ is composed of the condyle (mandible) and the articular (or glenoid) fossa of the temporal bones, bilaterally. The temporal bone consists of five parts: squamous, petrous, internal acoustic meatus, zygomatic, and middle cranial fossa. The facial nerve (motor control over the facial muscles) and the vestibulocochlear nerve (balance and hearing) both travel the course of the internal acoustic meatus. The middle cranial fossa is the floor, which supports the brain stem from which the cranial nerves originate.



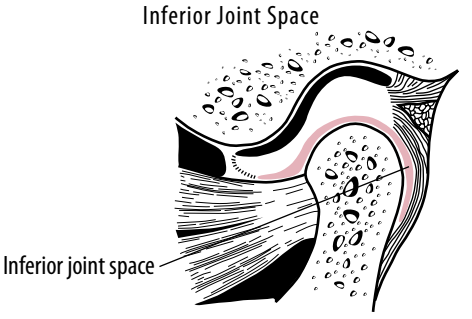
The connection between the TMJ and the middle ear is through the petro-tympanic fissure. This runs the length of the glenoid fossa.

The condyle may have several different normal shapes. The shape should be the same right to left. A flat condyle surface on one side may be pathologic if the contra-lateral side is angled. Condyles that are both angled or both flat may be normal contours.

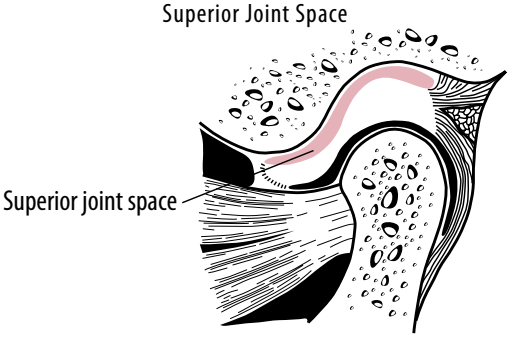


Synovial Joint

The TMJ is referred to as a synovial joint. The articular disc is the primary source of synovial lubricant within the TMJ. The synovial fluid acts as a medium for providing metabolic requirements to these tissues. There is free and rapid exchange between the vessels of the capsule, the synovial fluid, and the articular tissues. The inferior joint space contains about 0.9 ml of synovial fluid, and the superior joint space contains about 1.2 mL of synovial fluid. The synovial fluid also serves as a lubricant between articular surfaces during function. The articular surfaces of the disc, condyle, and fossa are very smooth – this minimizes friction during movement. The synovial fluid helps to further minimize this friction.



This lies on the condylar head like a cap and drapes over all surfaces, but extends most caudad to the condylar neck in its posterior aspect. When the mandible is depressed, the inferior joint space opens to a greater extent posteriorly, giving the appearance in lateral view of a teardrop in the inferior joint space posterior to the condylar head. The anterior portion of the inferior joint space forms a small fossa where the fibers of that capsular ligament and the anterior band of the disc form a concretion. This sling-like structure helps to stabilize the disc against the condylar head during function.



This is larger and more anteriorly placed than the inferior joint space. Its shape in the cephalad aspect corresponds closely to the glenoid fossa. On the caudad aspect, the concavity of the intermediate zone can be noted. The separation of the retrodiscal tissue from the posterior band is clearly differentiated when viewed from the superior joint space. The anterior fossa of the superior joint space forms a concavity in front of the condylar head. The medial fossa forms a concavity medial to the condylar head.

The precise shape of the disc is determined by the morphology of the condyle and mandibular fossa. During movement, the disc is somewhat flexible and can adapt to the functional demands of the articular surfaces. However, flexibility and adaptability do not imply that the morphology of the disc is reversibly altered during function. The disc maintains its morphology unless destructive forces or structural changes occur in the joint.

Synovial Membrane

The joint is enclosed by a fibrous capsule, which is lined by a synovial membrane. This membrane is highly vascular and is continuous with the connective tissue of the capsule. Both upper and lower joint compartments are lined with their own synovial membrane.

The synovial membrane allows diffusion of a plasma filtrate and components of its own to produce synovial fluid that fills both joint compartments. Its shape is altered during functional movement. The largest area of synovial tissue is on the superior and inferior retrodiscal lamina, where it forms small folds, or villi, that stretch on translation of the condyle and disc. The articulating surfaces of the temporal bone, the condyle, and the disc are not covered.

The synovial tissue can be divided into three layers:

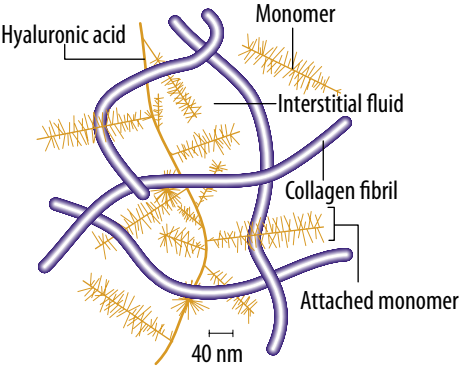
1. The synovial lining, or intima, is the most intimate with the functional joint surfaces.
2. The subsynovial tissue, which is similar to the intima but with a more developed connective tissue network.
3. The capsule, which is a relatively acellular layer with thick bands of collagen that forms the outer boundary of the joint.

Synovial surfaces are nonadherent. The cells on the surface bind to the underlying matrix but not to the opposing tissue. Constant movement against opposing surfaces is thought to break down any forming cross-links. Collagenase secretion by the synovial lining cells also helps prevent the formation of surface adhesions and ensures that fragmented collagen on the tissue surface does not activate the coagulation cascade.

Synovial tissue has the ability to regenerate when damaged. Synovial fluid is a filtrate of plasma that passes through fenestrations in the sub-endothelial capillaries into the intercellular spaces. Because there is no epithelium, and hence no basement membrane, no barrier exists between the synovium and the fluid present in the joint spaces. Movement is mainly by passive diffusion.

Proteoglycans

These are within the articular tissues on the anterior part of the condyle, in the central part of the disc, and on the lateral portion of the articular eminence.



The presence and amount of proteoglycans, specifically glycosaminoglycans (GAGs) relative to the collagen matrix in articular tissues is a measure of the resilience of the tissue and, therefore, determines the amount of compressive loading that the joint can withstand. Proteoglycans are macromolecules found in all connective tissues and extracellular matrices and on the surface of many cells. They contain a core protein

to which one or more GAG polysaccharide chains are covalently bonded.

Glycosaminoglycans

In sufficient concentration glycosaminoglycans (GAGs) cause the cartilage tissue to imbibe extracellular water, thus producing a cushion to compressive loads. The flexible, hydrophilic nature of the GAG chains and their high concentration of negatively charged fixed groups leads to a high swelling pressure, while the fine macromolecular mesh of collagen ensures a low hydraulic permeability. GAGs are ideal as a load-bearing material with low surface coefficient of friction.

A reduction in collagen concentration or an increased disorder in collagen orientation would lead to a decrease in the degree of cartilage reinforcement and also an increase in local hydraulic permeability. The three requirements for healthy cartilage are:

1. Plenty of water for diffusion of nutrients and for lubrication.
2. Proteoglycans, which, due to their anionic nature, are tremendously hydrophilic, thus serving to attract and maintain water molecules.
3. A collagenous mass in which these proteoglycans can bind.

Boundary and Weeping Lubrication

Synovial fluid lubricates the articular surfaces by way of two mechanisms: boundary lubrication and weeping lubrication.

Boundary lubrication occurs when the joint is moved and synovial fluid is forced from one area of the cavity into another. The synovial fluid located in the border regions is forced upon the articular surface, thus providing lubrication. Boundary lubrication prevents friction in the moving joint.

Weeping lubrication refers to the ability of the articular surfaces to absorb a small amount of synovial fluid. When the articular surfaces are placed under compressive forces, this small amount of synovial fluid is released. Weeping lubrication helps eliminate friction in the compressed but not moving joint. Only a small amount of friction is eliminated as a result of weeping lubrication and prolonged compressive forces to the articular surfaces will exhaust this supply.

Ligaments

The function of ligaments is to hold the skeleton together. Ligaments attach to bone and are made up of collagenous connective tissue, which does not stretch. They act as passive restraining devices to limit and restrict joint movement. They prevent joint laxity. They transfer tensile strength from bone to bone. They are virtually identical to tendons. *They have a poor vascular supply.*

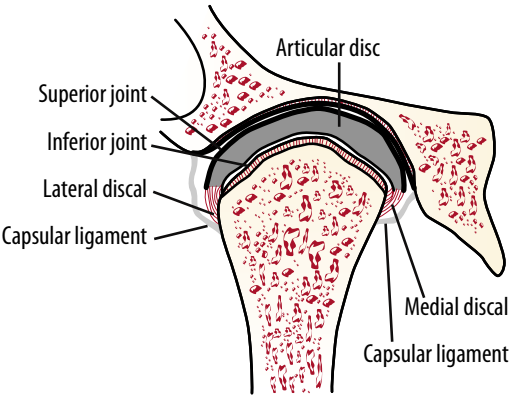
The three functional ligaments that support the TMJ are:

1. The collateral ligaments.
2. The capsular ligament.
3. The temporomandibular ligament.

The two accessory ligaments of the TMJ are:

1. The sphenomandibular ligament.
2. The stylomandibular ligament.

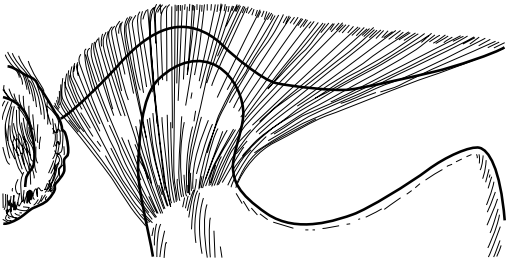
Collateral (Discal) Ligaments



The collateral, or discal, ligaments attach the medial and lateral borders of the articular disc to the poles of the condyle. The medial discal ligament attaches the medial edge of the disc to the medial pole of the condyle. The lateral discal ligament attaches the lateral edge of the disc to the lateral pole of the condyle.

The collateral ligaments are true ligaments, composed of collagenous connective tissue fibers, and therefore do not stretch. They divide the joint mediolaterally into the superior and inferior joint cavities. They function by restricting movement of the disc away from the condyle and causing the disc to move passively with the condyle as it glides anteriorly and posteriorly. These ligaments permit the disc to be rotated anteriorly and posteriorly on the articular surface of the condyle, and are responsible for the hinging movement of the TMJ. They are vascularly supplied and are innervated; this innervation provides information regarding joint position and movement. *Strain on these ligaments produces pain.*

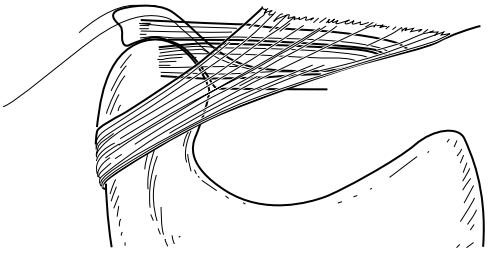
Capsular Ligament



The entire TMJ is surrounded and encompassed by the capsular ligament. The fibers of the capsular ligament are attached superiorly to the temporal bone along the borders of the articular surfaces of the mandibular fossa and the articular eminence.

Inferiorly, the fibers of the capsular ligament are attached to the neck of the condyle. The capsular ligament acts to resist any medial, lateral, or inferior forces that tend to separate or dislocate the articular surfaces. A significant function of the capsular ligament is to encompass the joint, thus retaining the synovial fluid. The capsular ligament is well innervated and provides proprioceptive feedback regarding position and movement of the joint.

Temporomandibular Ligament



The lateral aspect of the capsular ligament is reinforced by strong, tight fibers that make up the lateral ligament or the temporomandibular ligament. The temporomandibular ligament is composed of two parts:

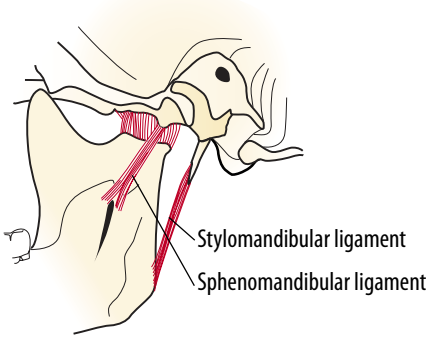
1. The outer oblique portion, which extends from the outer surface of the articular tubercle and zygomatic process posteroinferiorly to the outer surface of the condylar neck.
2. The inner horizontal portion, which extends from the outer surface of the articular tubercle and zygomatic process posteriorly and horizontally to the lateral pole of the condyle and posterior part of the articular disc.

The oblique portion of the TM ligament resists excessive dropping of the condyle and therefore limits the extent of mouth opening. This portion of the ligament also influences the normal opening movement of the mandible. During the initial phase of opening, the condyle can rotate around a fixed point until the TM ligament becomes tight as its point of insertion on the neck of the condyle. When the ligament is taut, the neck of the condyle cannot rotate further. If the mouth were to be opened wider, the condyle would need to move downward and forward across the articular eminence.

The inner horizontal portion of the TM ligament limits posterior movement of the condyle and disc. When force applied to the mandible displaces the condyle posteriorly, this portion of the ligament becomes tight and prevents the condyle from moving into the posterior region of the mandibular fossa. The TM ligament protects the retrodiscal tissues from trauma created by the posterior displacement of the condyle. The inner horizontal portion also protects the lateral pterygoid muscle from over-lengthening or extending.

Sphenomandibular Ligament

This arises from the spine of the sphenoid bone and extends downward to a small bony prominence on the medial surface of the ramus of the mandible called the lingula. It does not have any significant limiting effects on mandibular movement.



Stylomandibular Ligament

The second accessory ligament is the stylomandibular ligament. It arises from the styloid process and extends downward and forward to the angle and posterior border of the ramus of the mandible. It becomes taut when the mandible is protruded and is most relaxed when the mandible is opened. The stylomandibular ligament therefore limits excessive protrusive movements of the mandible.

Tendons

Tendons are the connective tissues that attach muscle to bone. They are composed primarily of collagen. Tendons are nonelastic but flexible. *They have a poor vascular supply.* Tendons are attached to bone via either periosteum or fasciculi of fibers (Sharpey's fibers). Their tensile strength is similar to bone (i.e., half that of steel). Golgi tendon organs are tension sensors located in the tendons. Some tendons are contained within a synovial sheath (e.g., tensor veli palatini). Tendons heal in two stages:

1. A scar or callus (disorganized collagen) forms, which may take up to five weeks.
2. The scar is remodeled and replaced with new collagen, which may take up to three years.

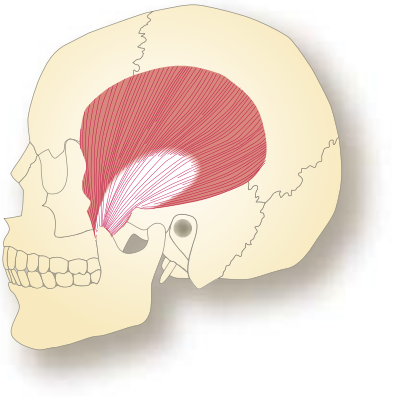
Muscles of the Cranial Mandibular Region

The position of the mandible and its craniomandibular articulation in space are mainly determined by the activity of the 27 muscles that attach the jaw.

Muscles of Mastication

Elevators

Temporalis Muscle



Origin: The temporal fossa and the lateral surface of the skull.

Insertion: The lateral head inserts on the lateral surface of the coronoid process, and the medial head attaches to the medial surface of the ascending ramus down to the level of the third molars.

Function: This muscle is divided into three distinct areas according to fiber direction and ultimate function. The anterior portion consists of fibers that are directed almost vertically. The middle portion contains fibers that run obliquely across the

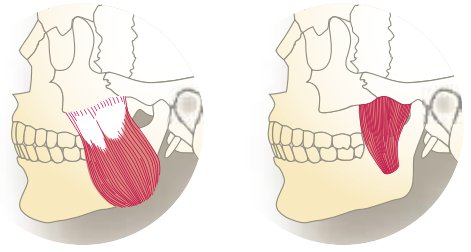
lateral aspect of the skull (slightly forward as they pass downward). The posterior portion consists of fibers that are aligned almost horizontally, coming forward above the ear to join other temporalis fibers as they pass under the zygomatic arch. When the anterior portion contracts, the mandible is raised vertically. Contraction of the middle portion will elevate and retrude the mandible. Because the angulation of its muscle fibers varies, the temporalis is capable of coordinating closing movements. It is a significant positioning muscle of the mandible.

Innervation: Cranial nerve 5 (trigeminal nerve), division III.

Shape: Fan-shaped.

Clinically: If the mandible is in the incorrect position (condyles displaced posteriorly), this muscle will be aggravated and will contract excessively. Eventually, trigger points will form.

Masseter Muscle



Origin:

a) Superior portion: Anterior two-thirds of the lower border of the zygomatic arch.

b) Deep portion: Medial surface of the zygomatic arch.

Insertion: Its insertion on the mandible extends from the region of the second molar at the inferior border posteriorly to include the angle. It is made up of two heads: the superficial portion (A) consists of fibers that run downward and slightly backward, and the deep portion (B) consists of fibers that run predominantly vertically. Together they attach to the lateral surface of the ramus of the mandible and the coronoid process.

Shape: Rhomboidal.

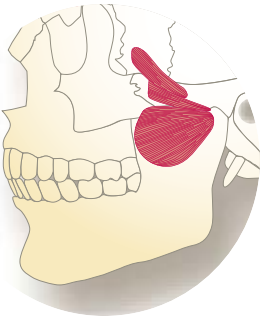
Function: As fibers of the masseter contract, the mandible is elevated and the teeth are brought into contact. The masseter is a powerful muscle that provides the force necessary to chew efficiently. Its superficial portion may also aid in protruding the mandible. When the mandible is protruded and biting forces are applied, the fibers of the deep portion stabilize the condyle against the articular eminence.

Innervation: Cranial nerve 5 (trigeminal nerve), division III.

Clinically: This muscle contracts excessively and forms trigger points in patients who have noxious habits such as bruxing or clenching. The masseter is also aggravated if the patient has a skeletal closed bite, deep dental overbite, lack of adequate vertical dimension, or short lower face height, which causes the muscles to shorten.

Depressors

Lateral Pterygoid



Superior and Inferior Head Origins:

a) Infratemporal surface of the greater wing of the sphenoid bone.

b) Lateral surface of the lateral pterygoid plate.

Insertion:

a) Articular disc.

b) Neck of the condyle.

Function: When the right and left inferior lateral pterygoids contract simultaneously, the condyles are pulled down the articular eminence and the mandible is protruded. When this muscle functions with the mandibular depressors, the mandible is lowered and the condyles glide forward and downward on the articular eminence. The superior lateral pterygoid is considerably smaller than the inferior. Whereas the inferior lateral pterygoid is active during opening, the superior remains inactive, becoming active only in conjunction with the elevator muscles. The superior lateral pterygoid is especially active during the power stroke and when the teeth are held together. The power stroke refers to movements that involve closure of the mandible against resistance, such as in chewing. When this muscle is active, the disc is pulled anteriorly and medially.

Innervation: Cranial nerve 5 (trigeminal nerve), division III.

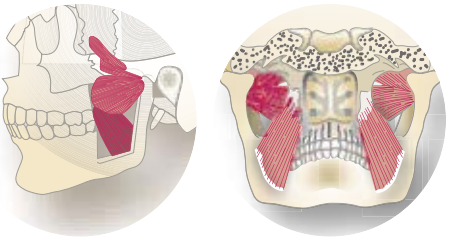
Clinically:

a) If the patient has a deep overbite, the lateral pterygoids will be overworked as the patient goes through lateral excursions.

b) It has been reported that 5 percent of the fibers of the superior head of the lateral pterygoid attach behind the eye. This certainly would account for some of the retro-orbital pain that some TMJ patients experience.

Medial Pterygoid

The lateral pterygoid plate separates the lateral pterygoid from the medial pterygoid.



Origin: Medial surface of the lateral pterygoid plate, pyramidal process of the palatine bone, maxillary tuberosity.

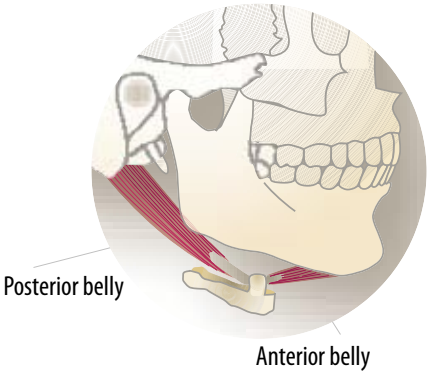
Insertion: Posterior and lower part of medial surface of ramus and angle of mandible.

Function: Protracts and elevates the mandible. Assists in the rotary movements of the mandible.

Shape: Rhomboidal.

Clinically: This muscle is frequently sensitive in patients with TMJ dysfunction, so palpate gently.

Anterior and Posterior Digastric



Origin:

a) Posterior belly: Mastoid notch of temporal bone, just medial to the mastoid process.

b) Anterior belly: Digastric fossa of the mandible, just above the lower border and close to the midline.

Insertion:

a) Posterior belly: Fibers run forward, downward, and inward to the intermediate tendon attached to the hyoid bone.

b) Anterior belly: Fibers extend downward and backward to insert at the same intermediate tendon as does the posterior belly.

Function: When the right and left digastric muscles contract and the hyoid bone is fixed in position by the suprahyoid and infrahyoid muscles, the mandible is depressed and pulled backward and the teeth are brought out of contact. When the mandible is stabilized, the digastric muscles, with the suprahyoid and infrahyoid muscles, elevate the hyoid bone (a necessary function for swallowing). The digastrics are among many muscles that depress the mandible and raise the hyoid bone. Generally, muscles that are attached from the mandible to the hyoid bone are called suprahyoid, and those attached from the hyoid bone to the clavicle and sternum are called infrahyoid. The supra- and infrahyoid muscles play a major role in coordinating mandibular function.

Innervation:

a) Posterior belly: Cranial nerve 7 (facial nerve).

b) Anterior belly: Cranial nerve 5 (trigeminal nerve), mylohyoid nerve.

Clinically: Most Class II skeletal patients have retrognathic mandibles, and the posterior digastric is extremely sensitive in most of these patients. The clinician must be extremely careful when palpating this muscle.

Features That Are Unique to the Temporomandibular Joint

There are several distinguishing features that are unique to the TMJ:

1. It is a bilateral diarthrosis; the left and right sides must function together.
2. The articulating surfaces are covered with fibrocartilage rather than hyaline cartilage.
3. The TMJ is the only joint in the human body to have a rigid endpoint of closure, that of the teeth making occlusal contact. Translation occurs in the superior joint space, and rotational movement occurs in the lower, or inferior, joint space.
4. The TMJ is the last joint to start development, beginning at about seven weeks in utero, and develops from two distinct blastomas.

Pathology of Temporomandibular Joint Disorders

The term "temporomandibular disorders" (TMD) was defined by the American Dental Association (ADA) in 1982 as "characterized by regional signs and symptoms, including pain in the area of the TM joint and/or masticatory muscles, often with limited mandibular range of motion, and/or TM joint sounds (clicking and/or crepitus)". The ADA position of pathogenesis states: "The causes of TMD, and why some patients develop chronic, persistent symptoms, are not well understood".[2] The ADA feels that the most reasonable clinical diagnostic classification is that published by the American Academy of Orofacial Pain by Okeson, 1996."[3]

Orofacial pain as described by Okeson includes: "pain conditions that are associated with the hard and soft tissues of the head, face, neck, and all of the intraoral structures. The diagnostic range includes headaches, musculoskeletal pains, neurogenic pains, psychogenic pains, and pains from major diseases such as cancer and acquired immunodeficiency syndrome (AIDS)."[4]

Etiology of TMDs

TMDs result from the various types of trauma. Macrotrauma (direct trauma) is injury due to impact or extensive stretching, twisting, or compression of the mandible. It is due to sudden force and may result from indirect trauma such as acceleration-deceleration injury (whiplash). Microtrauma occurs as a result of sustained and repetitious adverse loading or continued compression due to parafunctional oral activities (clenching and grinding). This form of trauma is likely due to failure of the collagen matrix of the disc through a fatigue-like mechanism. Forward head posture has been found to be a contributing factor that leads to joint strain and musculoskeletal pain, including headache, in the TMD patient.[5]

Degenerative changes and stages of intra-capsular pathology

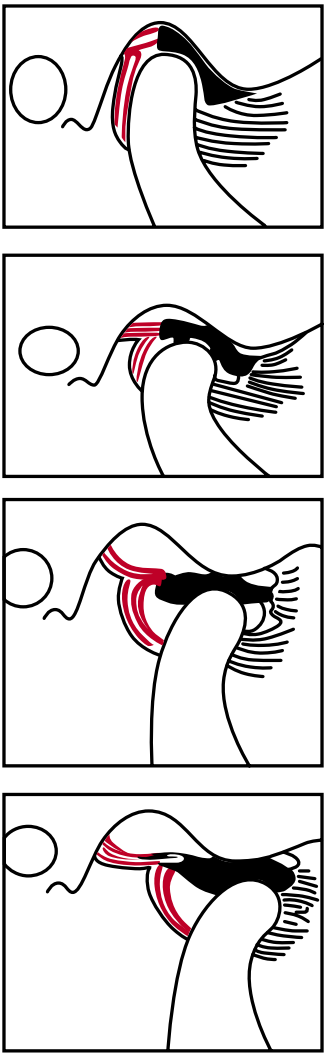
Degenerative changes may result in cartilage debris being found within the joint, following local inflammation of the lateral capsule, or the posterior joint space (retrodiscitis). Inflammation of the joint capsule can be the result of unresolved ligamentous and tendinous insertion injuries due to traumas.[6] "Capsulitis (inflammation of the outer fibrous layer of the joint capsule) and synovitis

(inflammation of the inner synovial lining) have almost the same clinical characteristics and are usually considered as one clinical entity. Both conditions may occur secondary to compressive trauma to the TMJ, after prolonged mouth opening, or after sudden stretching or sprain of capsular or discal ligaments. Capsulitis and synovitis may be associated with other coexisting TMJ disorders such as a disc displacement, hypermobility, or dislocation. It is not unusual to find degenerative cartilage debris within the joint."[7]

Normal disc movement

When the mouth is opened the condyle rotates and, at the same time, moves down the posterior slope of the articular eminence. The superior head of the lateral pterygoid muscle then moves the disc forward. This enables the disc to remain between the two bones, thus providing a cushion which keeps the two bones from rubbing together. As the jaw closes, the condyle moves back up into the glenoid fossa and the disc follows, being guided by the lateral ligament.

The biconcave shape of the disc, which is thicker at both ends, helps keep the disc in its proper relationship on the head of the condyle during opening and closing of the jaw. When the disc remains in its proper position, no popping or clicking sound occurs.



Joint noise

When the jaw opens and closes, there should be no noise. If a joint makes a noise, there is friction within the joint. This usually means that the disc is out of position anteriorly when the patient opens and closes in centric occlusion (biting on the posterior teeth). There should be no clicking, popping or grinding noises emanating from the joint when the jaw moves. Joint sounds may vary from a soft pop or clicking sound to a loud pop, or they can come in the form of rustling sounds like the crumpling of newspaper.

Open lock

Occasionally, when the jaw is opening the disc may move too far forward and get caught over the anterior slope of the eminence. This is called an open lock and will result in the patient having difficulty closing his or her mouth. To treat this, place your fingers inside the patient's mouth buccal to the lower posterior teeth and with your thumb on the chin, push the jaw slightly downward and backward. This will move the condyle and disc from underneath the anterior slope of the eminence and, hopefully, restore the joint to normal function. Care should be taken not to place your fingers between the teeth during this procedure since there is a strong reflex action that can occur when the jaw snaps back into its normal position.

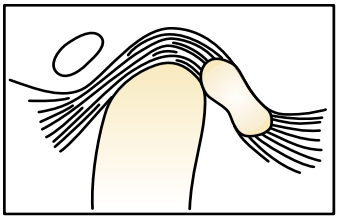
Disc displacement with reduction

An accident or incorrect jaw position (condyle located too far posteriorly or superiorly) results in damaged or stretched posterior lateral ligaments. This allows the disc to become anteriorly or antero-medially displaced in relation to the head of the condyle. As the jaw opens, the disc is located in front of the condyle and a click occurs when the condyle snaps back into position beneath the disc.

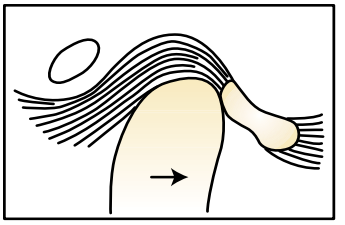
Disc displacement with reduction means that when the jaw is opened and the condyle moves downward and forward, the disc is reduced or, in other words, recaptured and goes back to its proper position on the head of the condyle. In this position, it functions as a cushion or shock absorber between the articular eminence of the temporal bone and the head of the condyle during the opening cycle of the jaw. However, as the mouth closes into centric occlusion, shortly before closure the condyle slips off the disc, creating a soft closing click or pop. This is known as the reciprocal click.

Clicking sounds which occur as the jaw is just beginning to open are called early opening clicks and are usually less of a problem and easier to treat than clicks which occur at maximum opening. In the case of early opening clicks, the disc has not slipped very far out of position. Therefore, we can assume that the ligaments holding the disc in position have not been stretched too severely and the disc can be recaptured during the opening cycle. Patients with early opening clicks respond well to anterior repositioning appliances that are designed to move the condyle down and forward so that the disc can be recaptured to its normal position on the head of the condyle.

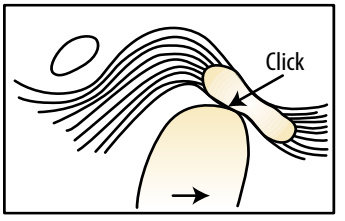
Disc displacement with reduction



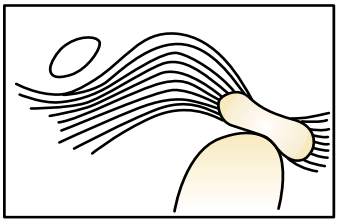
1. Jaw Closed
Disc displaced
anteriorly



2. Jaw Opening
Disc displaced
anteriorly

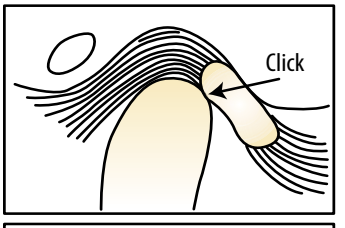


3. Disc Recaptured Click

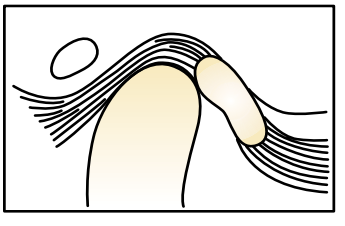


4. Maximum
Opening Disc
recaptured

5. Jaw Closing
Disc recaptured



6. Click
Reciprocal Click
Disc Displaced
anteriorly



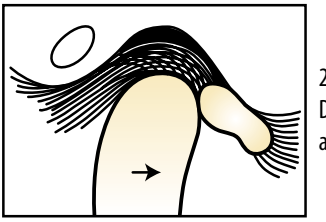
7. Jaw Closed
Disc displaced
anteriorly

Disc displacement without reduction

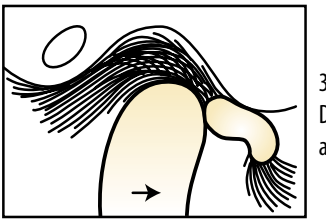
In cases with disc displacement without reduction, the posterior lateral ligaments have been severely stretched. These ligaments are designed to hold the disc on the head of the condyle. If the ligaments are severely stretched, when the jaw opens they are unable to pull the anteriorly displaced disc back onto the head of the condyle. When it is impossible to recapture the disc and return it to its normal position on the head of the condyle during jaw opening and closing movements, this is referred to as disc displacement without reduction. While the ideal situation would be to recapture the disc, some patients respond well to anterior repositioning appliances. If the posterior lateral ligaments are stretched and not perforated, they may become fibrotic over time following anterior repositioning of the condyle and the patient may function quite well on what is then termed the pseudodisc.

Disc displacement without reduction

1. Jaw Closed
Disc displaced
anteriorly

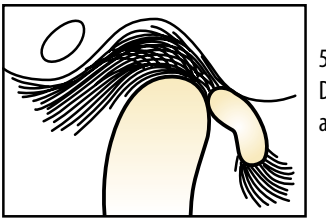


2. Jaw Opening
Disc displaced
anteriorly

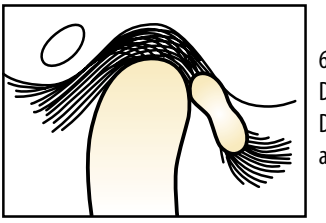


3. Disc Compressed
Disc displaced
anteriorly

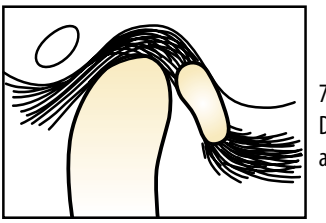
4. Maximum
Opening
Disc displaced
anteriorly



5. Jaw Closing
Disc displaced
anteriorly



6. Disc Remains
Dislocated
Disc displaced
anteriorly



7. Jaw Closed
Disc displaced
anteriorly

Acute closed lock (intermittent locking)

Most temporomandibular dysfunction patients tend to worsen with time. Slight clicking progresses to more frequent clicking and then eventually to jaw locking. This is due to the posterior ligaments continuing to stretch, allowing the disc to slip further and further out of position. Eventually, when the disc slips out of position too far anteriorly or antero-medially, the jaw will lock shut. This condition is known as a closed lock. When this first occurs it is known as an acute closed lock, and the patient reports that they heard a loud pop and could not open their mouth. The patient experiences a great deal of pain and limited jaw opening ranging between one-quarter and one-half inch.

Treatment involves trying to decompress the TM joints as soon as possible. The problem is that the patient cannot open his or her mouth wide enough to take an impression of the teeth in order to fabricate a hard acrylic splint.

In these cases, a temporary soft splint called an Aqualizer can be used. This allows for a slight separation of the teeth and will hopefully help move the condyle downward and forward so that there will be enough room for the disc to return to its normal position between the head of the condyle and the posterior slope of the articular eminence. Once the muscles have relaxed and the patient can open his or her mouth normally, a lower diagnostic splint (hard acrylic) is fabricated to help prevent the acute closed lock from recurring.

Chronic closed lock

A patient with chronic closed lock has had the problem longer than six months. The disc is permanently dislocated anteriorly or antero-medially to the condyle during opening and closing of the jaw. The disc is never positioned between the bones during the opening and closing cycle. If the patient is not treated within the first few weeks, the disc will begin to degenerate and lose its shape and the patient will gradually begin to open wider and wider as the disc is slowly destroyed. Once the disc is permanently out of position, the stage is set for continued pain and significant arthritic degeneration of the joint. As the joint becomes more arthritic due to the constant rubbing of bone on bone, the sounds may resemble the rustling of newspaper. The pain is often worse after the jaw works the hardest, i.e. at mealtimes.

Mechanism of TMJ destruction

Stretched Ligaments

Elongation (stretching) of the ligaments can occur following macrotrauma or microtrauma.

When the capsular ligaments are stretched beyond their elastic limit, they remain permanently elongated and distorted. When ligaments are lax, the balance shifts to the muscles for stabilization; and a change occurs in the trajectory of mandibular movement and point of dental contact (occlusion). The ligament elongation results in disc movement, which leads to posterior band flattening. This results in reduced condyle-fossa distances and changes in occlusion.

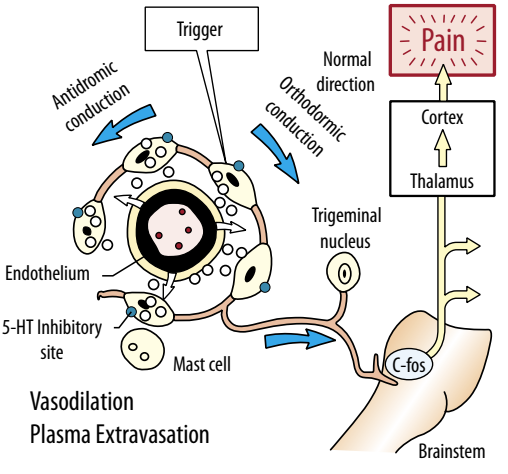
The changes in condyle-fossa relationships result in reduced joint spaces that compress the vascular bed of the retro-discal tissues. The arterial blood flow in this region is the source of synovial fluid for the joint. The synovial fluid is the medium for nutrition of articulating structures as well as the vehicle for waste removal and lubrication. Compression of these structures results in inflammation – breaks in the glycosaminoglycan structure occur, the disc surface cracks, and synovial fluid is lost.

Scanning electron microscope of TMJ disc

Courtesy of Dr. Kurt D. Stormberg

Inflammatory Response

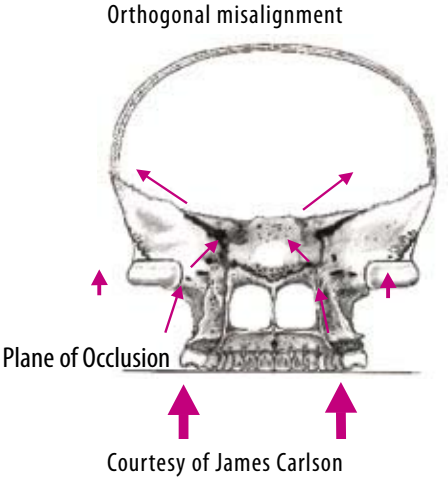
Following microtrauma or macrotrauma, when the condyle and temporal surface translate over the disc, pieces of collagen and glycosaminoglycan may tear off the edges of the disc and then enter the joint space. Synovial fluid is lost from the disc (the primary storage site of synovial fluid) and then produces free radicals that initiate an inflammatory response with the introduction of mast cells to the area.



The mast cells release serotonin (5HT), which regulates the release of inflammatory neuropeptides

(i.e., calcitonin gene related peptide, bradykinins, and substance P). These travel up the nociceptive nerve endings of the joint to the brain stem. An increase in tonus of the elevator muscles occurs and results in increased load on the TMJs.

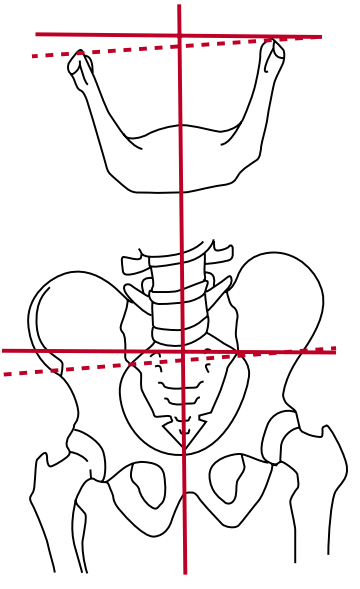
The increased load on the TMJ resulting from increased muscle tonus is magnified when there are uneven vectors of force on the TM joints. This happens when the plane of occlusion is uneven. The forces are heavier on the low side (the side that occludes first) than on the high side.



This overload of supporting tissue may result in partial or total disc displacement with or without reduction.

Whole Body Connection

Chronic forward head posture results in increased load. Correct head posture with the center of the ear sitting directly over the center of the shoulder results in a head that weighs 10 pounds, producing a 10 pound load on the spine and its tissue. However, for each inch forward, the load increases by 10 pounds.[8] Thus, a head posture that is three inches forward of normal would result in a 30-pound increase in load on the spine and its tissues. Abnormal anterior rotation of ilium causes anterior rotation of mandible.



Mandibular cant of the head (mediolaterally) produces a shift in the spine and consequently a shift in the pelvis with rotation that may produce symptoms in the low back. If the mandible is canted (mediolaterally), then C2 is also canted and the patient will not be able to rotate his or her head equally left to right.

Summary

TMJ anatomy comprises the bones, ligaments, tendons and muscles of the region. In addition, an understanding of the joint spaces, articular disc, synovial tissues and fluids, and the role of proteoglycans is necessary to understand the factors involved in TMJ health and disease. With an understanding of TMJ anatomy and pathology, it is possible to examine, diagnose, and triage patients. Following appropriate patient selection, patients can be treated with oral appliances.

Endnotes

1 American Dental Association. Future of Dentistry: Dental and Craniofacial Research. Ch.7, 116. Available at www.ada.org. Accessed November 2006.

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6 Oleson J, Felt-Hansen PT. *The Headaches*. 2005.

7 Pertes R, Gross S. Clinical Management of Temporomandibular Disorders and Orofacial Pain. 2005; Quintessence.

8 Cailliet R. Head and Face Syndromes. Ed. 1.

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Questions

1. Up to _____ of the population has at least one sign or symptom of temporomandibular joint disorder (TMD).
   a. 25 percent
   b. 45 percent
   c. 75 percent
   d. 85 percent

2. A healthy joint is a prequisite for successful restorative work.
   a. True
   b. False

3. The TMJ is the most complex joint in the body.
   a. True
   b. False

4. The TMJ provides for _____movements.
   a. Hinging and sliding
   b. Hinging and rotating
   c. Rotating and sliding
   d. None of the above

5. The TMJ is classified as a compound joint, requiring the presence of _____.
   a. At least two bones
   b. At least three bones
   c. At least three bones and five tendons
   d. None of the above

6. The articular disc is composed of _____.
   a. Dense fibrous connective tissue
   b. Hyaline cartilage interspersed with connective tissue
   c. Bone with a cartilage coating
   d. None of the above

7. From an anterior view the articular disc is thicker _____.
   a. Medially
   b. Distally
   c. Superiorly
   d. Inferiorly

8. When the mandible opens, the inferior joint space _____.
   a. Opens more anteriorly
   b. Opens more posteriorly
   c. Opens more superiorly
   d. None of the above

9. The precise shape of the articular disc depends upon the morphology of _____.
   a. The mandibular fossa
   b. Condyle
   c. Hyoid bone
   d. a and b

10. The retrodiscal tissue is _____.
    a. Located posterior to the articular disc
    b. Highly innervated
    c. Highly vascular
    d. All of the above

11. The articular surfaces of the condyle and mandibular fossa are lined with hyaline cartilage.
    a. True
    b. False

12. Compared to fibrous connective tissue, hyaline cartilage _____.
    a. Is more susceptible to the effects of aging
    b. Is more liable to break down
    c. Has less ability to repair
    d. All of the above

13. Synovial fluid in the TMJ acts as a medium providing metabolic requirements to the surrounding tissues.
    a. True
    b. False

14. The synovial fluid _____.
    a. Acts as a lubricant
    b. Helps to minimize friction
    c. Is too thick to move around
    d. a and b

15. No barrier exists between the synovium and the fluids present in the joint spaces because _____.
    a. There is no epithelium or basement membrane
    b. There is no space for fluid to pass through anyway
    c. Chemicals in the region ensure the fluid passes through by osmosis
    d. None of the above

16. GAGs can produce a cushion to compressive loads by _____.
    a. Causing the cartilage to imbibe extracellular water
    b. Causing the cartilage to imbibe intracellular water
    c. Causing the cartilage to imbibe extra and intracellular water
    d. None of the above

17. Requirements for healthy cartilage include _____.
    a. Plenty of water
    b. Proteoglycans
    c. A collagenous mass
    d. All of the above

18. The functional ligaments that support the TMJ are _____.
    a. The collateral ligaments
    b. The capsular ligament
    c. The temporomandibular ligament
    d. All of the above

19. The accessory ligaments for the TMJ are _____.
    a. Stylomandibular
    b. Sphenomandibular
    c. a and b
    d. None of the above

20. The muscles of mastication include the _____.
    a. Temporalis and Masseter
    b. Lateral and Medial Pterygoid
    c. Anterior and Posterior Digastric
    d. All of the above

21. Temporomandibular disorders result from _____.
    a. Macrotrauma
    b. Microtrauma
    c. a and b
    d. None of the above

22. Microtrauma occurs as a result of _____.
    a. Sustained adverse loading
    b. Sudden forces
    c. Repetitive adverse loading
    d. a and c

23. Inflammation of the joint space can be the result of _____.
    a. Unresolved ligamentous insertion injuries due to traumas
    b. Unresolved tendinous insertion injuries due to traumas
    c. Resolved tendinous insertion injuries due to traumas
    d. a and b

24. Capsulitis and synovitis may be associated with _____.
    a. A disc displacement
    b. Hypermobility
    c. Dislocation
    d. All of the above

25. If a disc is reduced, _____.
    a. It cannot be recaptured
    b. It can be recaptured
    c. It is removable

26. In cases with disc displacement without reduction, _____.
    a. The ligaments have not been stretched enough
    b. The posterior lateral ligaments have been severely stretched
    c. The tendons are suspect
    d. None of the above

27. Mast cells release _____ as part of the inflammatory response.
    a. Serotonin
    b. Prolactin
    c. Nothing
    d. a and b

28. Disc surface cracks can occur as a result of _____.
    a. Compression
    b. Elasticity
    c. Depression
    d. All of the above

29. Bradykinin and substance P are _____.
    a. Inflammatory neuropeptides
    b. Inflammatory biopeptides
    c. Important for joint lubrication
    d. None of the above

30. Abnormal rotation of the ilium can cause _____.
    a. Posterior rotation of the mandible
    b. Posterior retrusion of the maxilla
    c. Anterior rotation of the mandible
    d. Any of the above

ANSWER SHEET

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1. How would you rate the objectives and educational methods?
   5 4 3 2 1 0
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   5 4 3 2 1 0
7. Do you feel that the references were adequate?
   Yes No
8. Do you feel that the educational objectives were met?
   Yes No
9. If any of the continuing education questions were unclear or ambiguous, please list them.

   _____

10. Was there any subject matter you found confusing? Please describe.

    _____

11. Would you participate in a program similar to this one in the future on a different topic? Yes No

12. What additional continuing dental education topics would you like to see?

    _____

1.	①	②	③	④		16.	①	②	③	④
2.	①	②	③	④		17.	①	②	③	④
3.	①	②	③	④		18.	①	②	③	④
4.	①	②	③	④		19.	①	②	③	④
5.	①	②	③	④		20.	①	②	③	④
6.	①	②	③	④		21.	①	②	③	④
7.	①	②	③	④		22.	①	②	③	④
8.	①	②	③	④		23.	①	②	③	④
9.	①	②	③	④		24.	①	②	③	④
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11.	①	②	③	④		26.	①	②	③	④
12.	①	②	③	④		27.	①	②	③	④
13.	①	②	③	④		28.	①	②	③	④
14.	①	②	③	④		29.	①	②	③	④
15.	①	②	③	④		30.	①	②	③	④

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All participants scoring at least 70% (answering 21 or more questions correctly) on the examination will receive verification of 4 CEUs. The formal continuing education program of this sponsor is accepted by the AGD for Fellowship/Mastership credit. For current terms of acceptance, please contact the ADTS. "DANB Approval" indicates that a continuing education course appears to meet certain specifications as described in the DANB Recertification Guidelines. DANB does not, however, endorse or recommend any particular continuing education course and is not responsible for the quality of any course content. Participants are urged to contact their state dental boards for continuing education requirements. The cost of this course is $59.00.

EDUCATIONAL DISCLAIMER
The information presented here is for educational purposes only. It may not be possible to present all information required to utilize or apply this knowledge to practice. It is therefore recommended that additional knowledge be sought before attempting a new procedure or incorporating a new technique or therapy. The opinions of efficacy or the perceived value of any products or companies mentioned in this course and expressed herein are those of the author(s) of the courses and do not necessarily reflect those of the ADTS.

RECORD KEEPING
The ADTS maintains records of your successful completion of any exam. Please contact our offices for a copy of your continuing education credits report. This report, which lists all credits earned to date, will be generated and mailed to you within five business days of receipt of your request.

CANCELLATION/REFUND POLICY
Any participant who is not 100% satisfied with this course can request a full refund by contacting the Academy of Dental Therapeutics and Stomatology in writing.

COURSE EVALUATION
We encourage participant feedback pertaining to all courses. Please be sure to complete the survey included within the answer sheet.