Normal and Abnormal Findings in Temporomandibular Joints in Autopsy Specimens

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Muy cordialmente
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Normal and abnormal findings in the temporomandibular joint were observed in autopsy specimens and criteria were established to determine normal and abnormal joints.

The results of clinical examinations of numerous temporomandibular joints (TMJ) reveal that they are frequently unhealthy. Common findings include an opening click, locking, reciprocal clicking, osteoarthrosis, and rheumatic arthritis.

Improved knowledge of functional anatomy and the study of human TMJ sections enables researchers to explain clinical pieces of evidence.

The purposes of this investigation were to *(1)* Study the anatomical and the pathological characteristics of the TMJ in order to better understand some types of craniomandibular disorders. *(2)* To study the percentage of both normal and abnormal TMJs found in 100 human cadavers selected at random. *(3)* To then correlate TMJ dysfunctions with malocclusion abrasion, loss of posterior teeth, edentulism, etc.

Materials and Methods

The observation of a large number of normal and abnormal TMJs is essential for the interpretation of pathological problems of the joint. A total of 100 cadavers were used in this study.

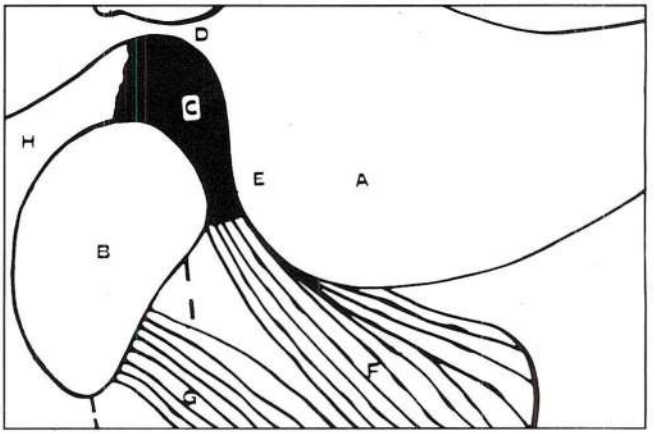
For the preparation of human parts a Stryker autopsy saw equipped with a 1.5-inch diameter mastoid trephine and electric hacksaws were used. The human cadaver material was sectioned no later than 12 hours after death and the anatomical pieces were frozen before the sections were performed. During the process of sectioning, upper and lower teeth were in maximum intercuspidation (CO or CR). It was not possible to obtain the medical and dental histories of all the cases.

Results and Discussion

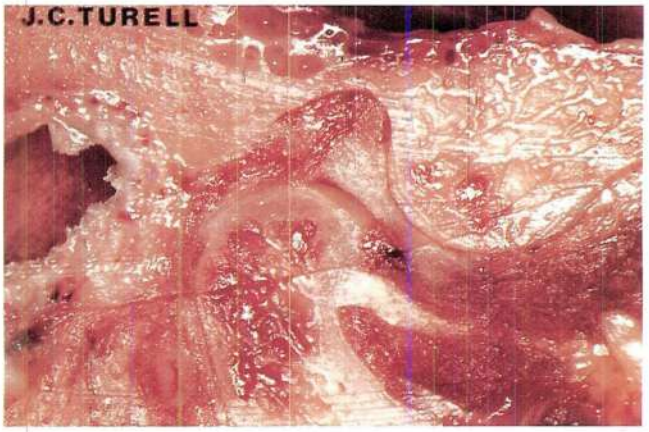
Some of the TMJ section pictures have an orientation drawing or scheme identification, to show placement and explain the anatomic components.

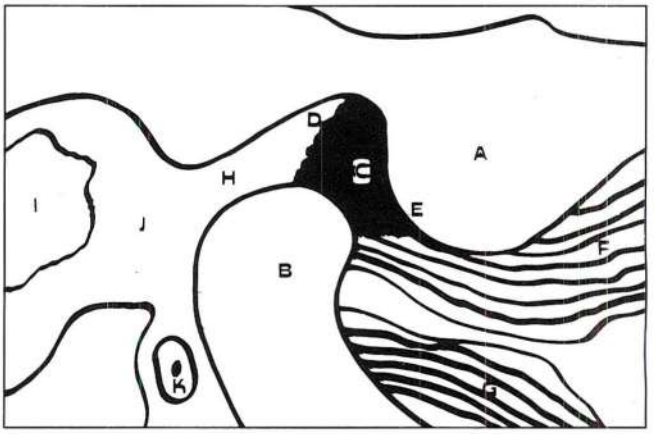
The sagittal section in Figs. 1a and 1b corresponds to a cadaver of a 43-year-old man with complete natural dentures and organic functional occlusion. The osseous surfaces of the lower maxillary condyle, glenoid fossa, and articular eminence of the temporal bone exhibit regularity in their surfaces.

It is possible to observe the normal articular disk, perfectly placed, and the condyle localized in a situation that would coincide with the position of centric relation. Under normal conditions, the disk maintains a close and coordinated relationship with the condyle, mediating between the condyle and the articular eminence of the temporal bone in any of the mandibular displacements. Also observed



Figs. 1a and 1b Sagittal section of a normal TMJ. A, temporal bone; B, condyle; C, articular disk; D, glenoid fossa; E, articular eminence; F, superior belly of the external pterygoid muscle; G, lower belly of the external pterygoid muscle; H, bilaminar zone (retrodiscal attachment).





Figs. 2a and 2b Sagittal section of a normal TMJ. A, temporal bone; B, condyle; C, articular disk; D, glenoid fossa; E, articular eminence; F, superior belly of the external pterygoid muscle; G, lower belly of the external pterygoid muscle; H, bilaminar zone (retrodiscal attachment); I, external auditory canal; J, communication of the TMJ with the auditory conduct; K, vessel.

are the synovial spaces which, through lubrication, facilitate displacements.

The section under consideration shows distinctly the two bellies of the external or lateral pterygoid muscle, the upper one inserted in the disk and the lower one in the neck of the condyle.

McNamara[1] was able to find, through electromyography of monkeys, the counteracting and independent action of both bellies. When the lower belly contracts, it displaces the condyle anteriorly, coincident with mouth opening, while the upper belly remains inactive.[2] By contrast, in closing, the lower belly of the external pterygoid muscle is inactive while the upper belly controls the posterior displacement of the disk strained by the elasticity of the bilaminar zone. This retrodiscal attachment (bilaminar zone) has an active and important role in the position of the disk. It is an elastic tissue connected anteriorly to the disk and posteriorly to the condyle and the temporal bone.

All of these elements as well as the sphenomandibular, stylomandibular, and temporomandibular ligaments take an active part in normal function, and while the muscles move the mandible, the ligaments confine their movements.

The external pterygoid muscle is considered to be part of the joint. One of the reasons justifying this view is that both the upper and the lower belly have a decisive influence upon the normal displacement of the disk and on the normal displacement of the condyle, respectively, depending on whether either belly remains active.[3]

Figures 2a and 2b show a sagittal section of a normal TMJ with both bellies perfectly differentiated as well as a broader view

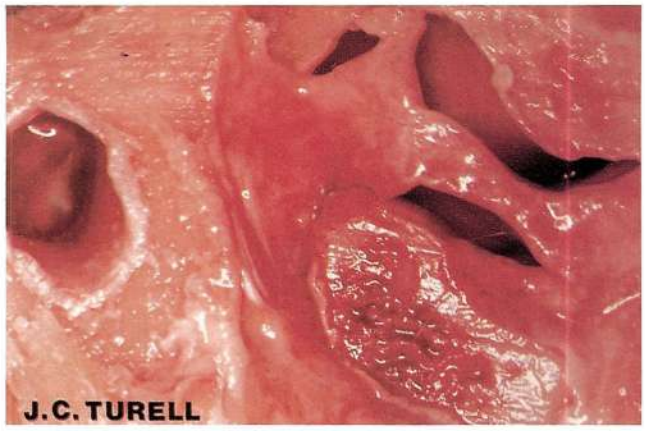


Fig. 3 Sagittal section of a normal TMJ. The condyle was separated from the articular eminence to enable observation of the insertion of the bilaminar zone in the upper and posterior walls of the glenoid fossa.

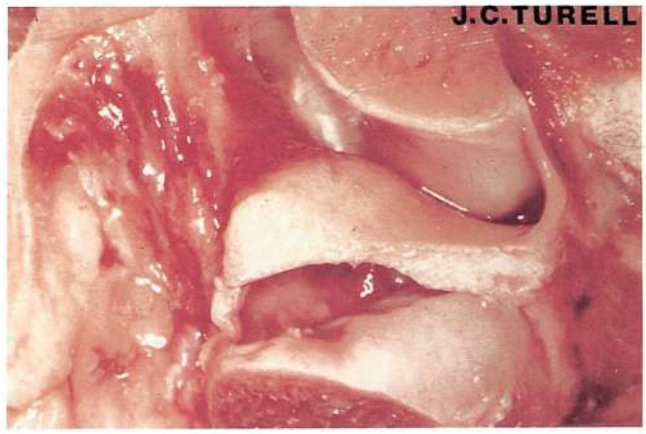


Fig. 4 Sagittal section of a normal TMJ with dissection of the disk illustrating biconcave nature of disk.

of the area corresponding to the bilaminar zone.

When in a normal TMJ the condyle displaces anteriorly, owing to the action of the lower belly of the external pterygoid muscle, the elastic superior stratum of the bilaminar zone strains and retains the disk, that is, it avoids excessive forward displacement of the disk, thus enabling the latter to accommodate the normal sliding of the condyle.[4] Upon closure, the lower belly becomes inactivated, and the regulating action of the bilaminar zone behind the disk and the upper belly in front, enables the disk to maintain its normal position between the condyle and the eminence.

If the bilaminar zone has undergone a degenerative process, the action of the upper belly of the external pterygoid muscle may display the disk anteriorly. In these cases an enlarged space is seen (by x-rays) in the anterior zone of the joint, coinciding with a posterior displacement of the condyle. Transcranial radiographic examination,[5] arthrography,[6,7] and computerized tomography[8,9] are important diagnostic procedures in TMJ dysfunctions.

Figures 2a and 2b show the condyle to be close to the external auditory canal, with no evidence of the existence of an osseous wall to separate the two anatomic entities, there being established communication. Figures 2a and 2b also exhibit the distinct contrast between the disk, which is seen as pearl-grey, and the reddish hue of the upper belly of the external pterygoid muscle. In turn the posterior limit of the disk assumes the shape of a straight line that becomes suddenly more vascularized on changing into a bilaminar zone (retrodiscal attachment).

In the specimen corresponding to Fig. 3 it is possible to see the posterior elastic fibers of the bilaminar zone distinctly inserted on the upper and posterior walls of the glenoid fossa. This specimen represents a sagittal section of a normal TMJ with a separation of components. It accounts for the observation of two wide spaces, above and below the disk; the condyle has been deliberately displaced downward. The disk shows its anterior relationship with the muscle, and a posterior relationship with the stratum of the bilaminar zone.

The disk is contiguous with two convex osseous surfaces: the articular eminence in the upper part and the condyle in the lower. For this reason the disk must be necessarily biconcave, showing in its mid-portion a lower thickness than on its rims. The glenoid fossa is related to the disk to a lesser degree.

Westesson and Rolhin[10] have dealt with the issue thoroughly and specified frequencies of position and configurations of the disks in the various areas under normal and abnormal conditions. They state[10]:

> . . . in the early development of osteoarthrosis there might be an altered position, and this might be followed by an altered configuration.

Malocclusion and TMJ dysfunction may produce thinning and perforation of the disk.

Figure 4 represents a sagittal section of a normal TMJ with disk dissection. Its surfaces are markedly smooth because they contact with completely regular, healthy cortical bone. When pathologic processes arise with concomitant appearance of bone deposition (osteophytes) or resorption, the disk experiences the consequences of osseous alterations.

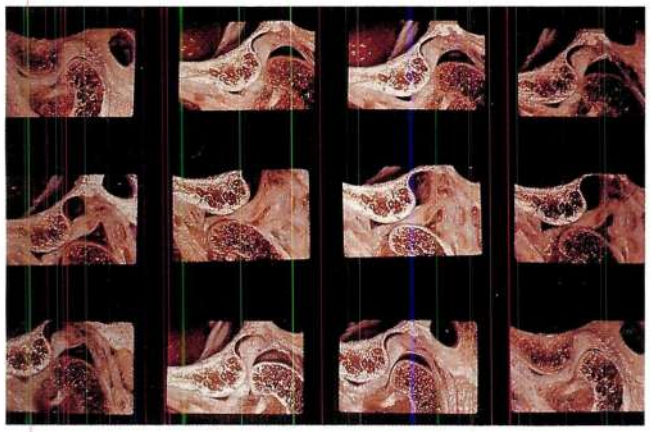


Fig. 5 Representation of a normal functioning activity of a TMJ during opening and closing movements.

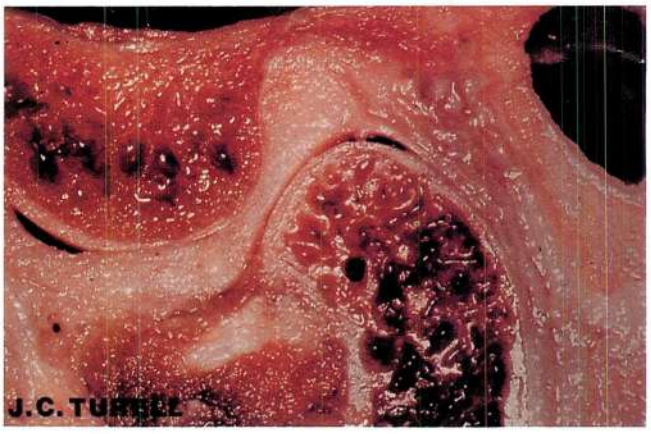


Fig. 6 Sagittal section of a normal TMJ in centric relation position.

Also seen in Fig. 4 (in the upper right-hand angle of the specimen) is the external auditory canal; in the upper portion, the fossa and the articular eminence with its characteristic slope; in the lower part, the condyle head, sectioned and sloped; and the mid-third, occupied by the disk which shows its insertion to the condyle, its smoothness, and its characteristic biconcavity in the areas of relation with the condyle and the eminence. In the portion closest to the auditory canal are observed the elastic fibers corresponding to the posterior insertion of the bilaminar zone.

The above description is regarded as essential for a thorough understanding of the TMJ mechanism.

Normal TMJ Function

Figure 5 shows a composite representation of the normal functioning activity of a TMJ during opening and closing movements. In all the steps of the movement the disk is seen lying between the condyle and the posterior slope of the articular eminence. The anterior and posterior synovial spaces change their configuration when movement is occurring.

During opening, the condyle and the articular disk are displacing to a more anterior position. The disk also has a tight attachment to medial and lateral poles of the condyle.

In the next case, it is possible to see the first and the last steps seen in Fig. 5. The specimen (Fig. 6) shows a normal human TMJ section with its condyles in centric relation. Upon onset of opening, the synovial spaces are rendered evident (Fig. 7), and the disk moves forward as the condyles translate anteriorly. At this moment, the lower belly of the external pterygoid muscle is active.

Two totally convex osseous surfaces are confronted (Figs. 8 and 9), namely, the condyle and the eminence, between which normal sliding with the interposed disk takes place. The biconcavity of the disk is a functional requirement enabling maximum opening. The synovial spaces vary in accordance with the degree of opening, that is, in relation with condylar position. Seeing the position of the condyle (Fig. 8) it is realized that the stratum of the bilaminar zone is demonstrating its elasticity, allowing for the displacement of the disk. The superior belly of the external pterygoid muscle must be, at this time, inactive.

Fig. 9 shows maximum opening, that is, maximum condylar anterior displacement with the disk between the condyle and the eminence. When closing begins (Fig. 10) the situation reverses. Now the active muscle is the superior belly of the external pterygoid and the inferior belly is inactive.

The bilaminar zone with its elasticity displaces the disk posteriorly (Fig. 11) between the condyle and the eminence, while the superior belly contracts, compensating for the action of the posterior attachment. A reduction of the spaces is easily seen to the point where the condyle reaches its centric relation position (Fig. 12). This process of opening and closing is highly complex since the TMJ is a double joint with characteristics differing from all the others in the human organism. A single occlusal reconstruction or an extensive oral rehabilitation may have either a favorable or an unfavorable influence on the joint.

When may a human TMJ studied in a sagittal section be regarded as normal? The answer is intended to provide a criterion enabling determination of the rate of normal and abnormal joint. To evaluate normality of TMJs, two reference points should be taken in connection with the biconcave disk location: the articular eminence and the condyle.[11]

In the normal joint the upper side of the disk is contiguous with

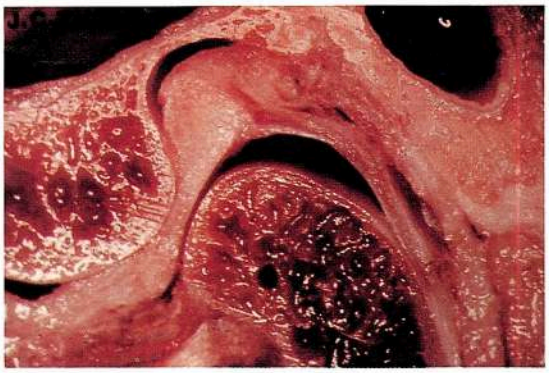


Fig. 7 At opening the condyle displaces anteriorly and the synovial spaces are evident.

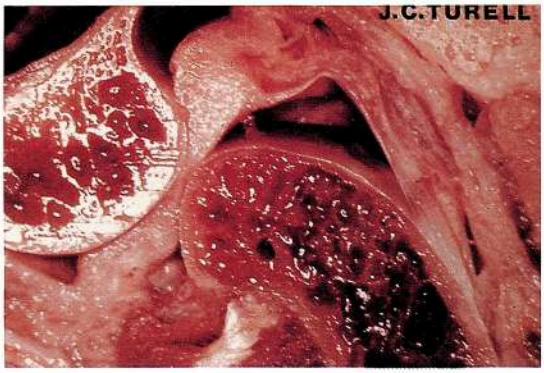


Fig. 8 The two convex osseous surfaces (condyle and eminence) are confronted and the normal articular disk is interposed between them.

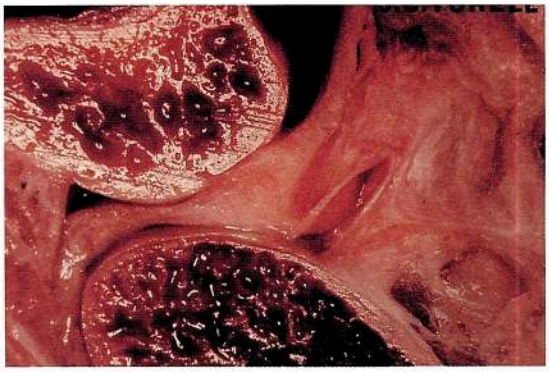


Fig. 9 Maximum condylar anterior displacement. The configuration of the synovial spaces changes at different opening and closing positions.

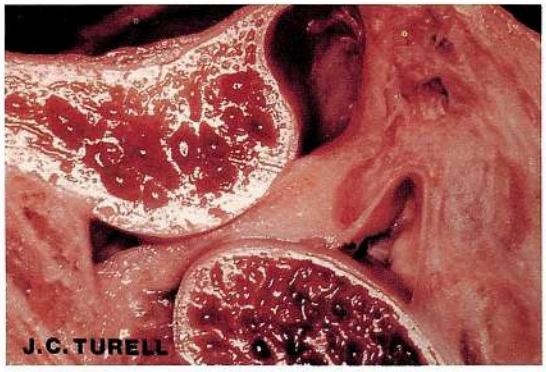


Fig. 10 When closing begins the upper belly of the external pterygoid muscle is active and the normal bilaminar zone shows its elasticity participating in the posterior displacement of the disk.

Fig. 11 The disk is always seen lying between the eminence and the condyle. A reduction of the spaces is easily seen.

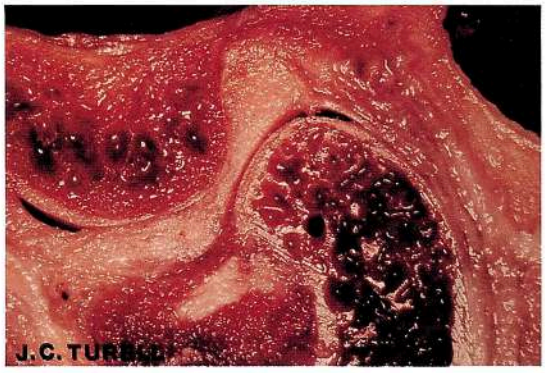
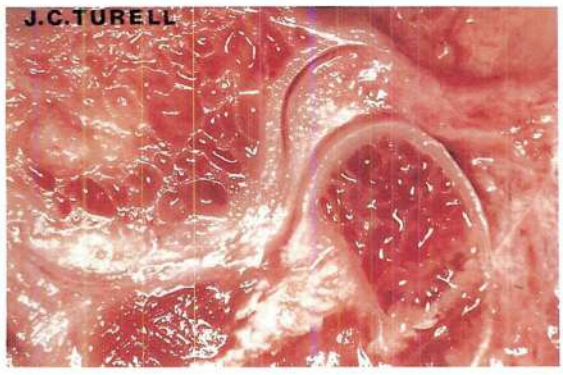
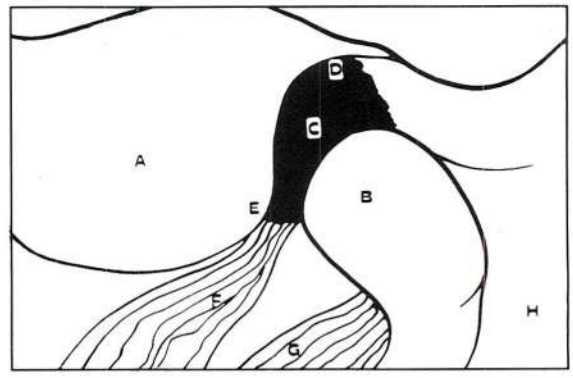


Fig. 12 The condyle reaches its centric relation position.





Figs. 13a and 13b Sagittal section of a normal TMJ. A, temporal bone; B, condyle; C, disk; D, glenoid fossa; E, articular eminence; F, upper belly of the external pterygoid muscle; G, lower belly of the external pterygoid muscle; H, bilaminar zone.

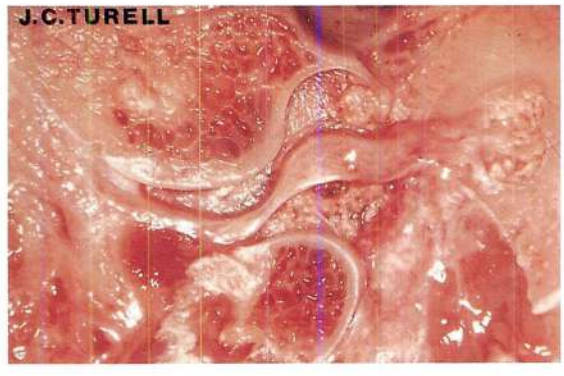
the anterior half of the glenoid fossa and the posterior slope of the articular eminence (Fig. 12). The disk will be extended anteriorly as far as the greatest convexity or curvature of the eminence. With regard to a morphologically normal condyle, the disk is contiguous to it and is extended from the highest curvature of the condyle to its most anterior point. Thus are outlined the author's views on TMJ normality.

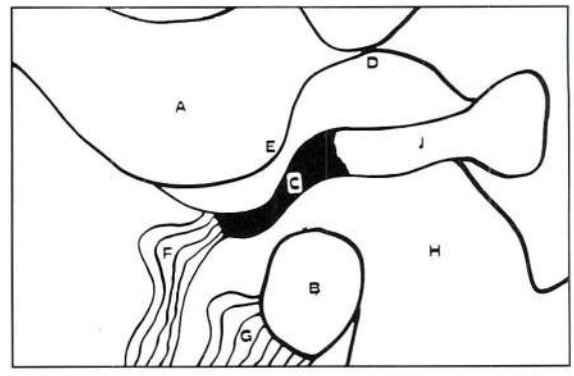
A TMJ is also normal: when the condyle and the disk look and function as a unit[12]; when a condyle does not present radiographically flat surfaces, osteophytes, or resorptions; when a normally thick cortical bone joins an articular eminence of harmonious contour that permits a normal condylar displacement; and when during closing and opening movement, as seen previously, the disk lies between the condyle and the eminence, preserving its biconcave characteristic. By contrast the biconvex disks are associated with osteoarthrosis and often show anterior displacement.[10]

Figures 13a and 13b show a joint with perfectly regular osseous surfaces. The location of the disk, in accordance with the preceding description, is normal in relation to the points of reference, the condyle, and the eminence. It is possible to observe the synovial spaces.

Figures 14a and 14b present the same sagittal section taking up a more extensive field following separation of the disk from two adjoining osseous components: the upper, represented by the temporal bone with its fossa and eminence; and the lower, by the maxillary condyle. It is observed that the disk extends through its posterior insertion, which intrudes into the external auditory canal.

Concern here is with one of the most controversial issues, i.e., that referred to as the communication existing between the TMJ and the auditory apparatus and their possible relationship from the pathologic standpoint. Pinto[13] carried out an investigation of the existing relationship between the TMJ and the middle ear. A ligament, later named the mandibular malleolar, was found, connecting the neck and anterior process of the malleus to





Figs. 14a and 14b Another view of the same saggital section shown in Figs. 13a and 13b after dissecting the articular disk. A, temporal bone; B, condyle; C, disk; J, posterior insertions of the disk intruding into the external auditory canal; I, a communication exists between TMJ and auditory apparatus; D, glenoid fossa; E, articular eminence of the temporal bone A; F and G, bellies of the external pterygoid muscle; H, bilaminar zone.

part of the capsule, the disk, and the sphenomandibular ligament.

By performing the human TMJ sections the author found that in 35% of the cases a communication between the TMJ and the auditory apparatus existed. This communication has led many researchers to think of the possibility of auditory problems in certain cases of TMJ dysfunction. The mechanisms advocated have not been found convincing. In point of fact, the communication does exist. Certainly the problem deserves investigation.

In Figs. 15 and 16 (a sagittal TMJ section from the same specimen), conditions appear completely normal. The disk shows its thickness in its mid-portion (Fig. 16) and upper and lower rims. Between the external auditory canal, in the right side of the specimen, and the posterior surface of the condyle, in the area comprised by the bilaminar zone, there is no osseous tissue. In Figs. 15 and 16 the condyle is deliberately displaced downward for the purpose of examining the disk.

Morpho-Functional Considerations In TMJ Alterations

Direct observation of sections of human cadavers with lesions occurring at the TMJ level enables enhanced understanding and improved interpretation of problems relating to clinical diagnosis. One of the most frequent TMJ alterations is represented by the anterior position and anterior displacement of the disk. The anterior position of the disk (Figs. 17a and 17b) constitutes the stage

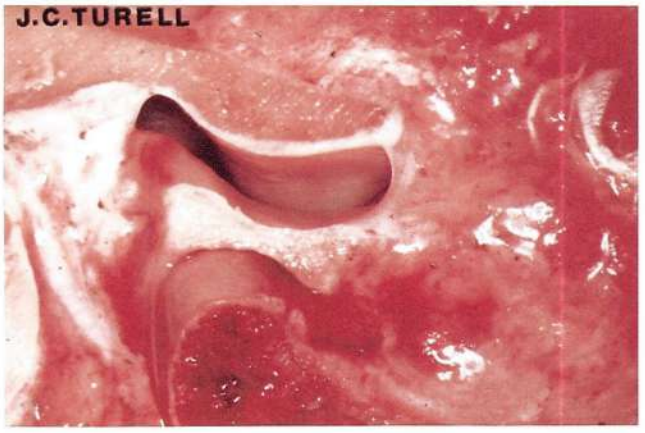


Fig. 15 Sagittal section of a normal TMJ showing the normal biconcavity of the articular disk and the insertions of the retrodiscal attachment in the upper and posterior walls of the glenoid fossa.

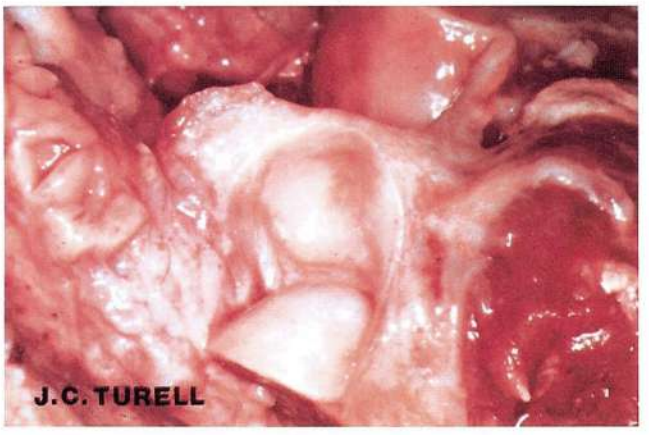
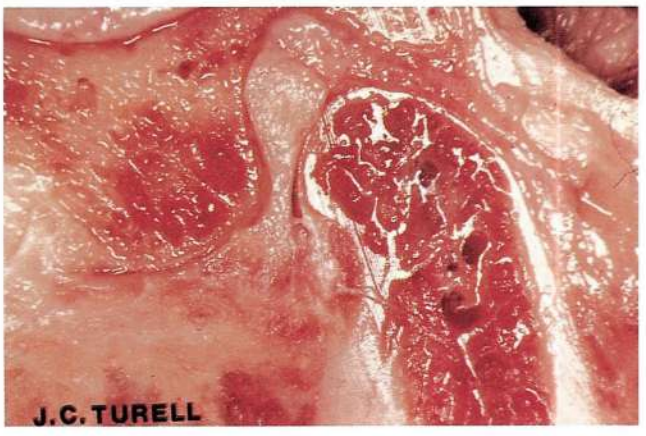
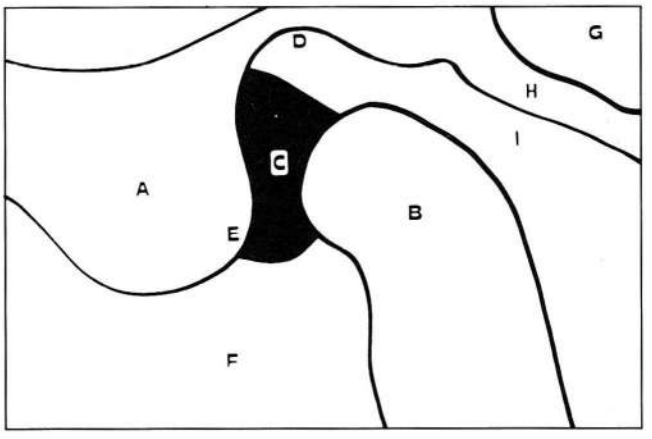
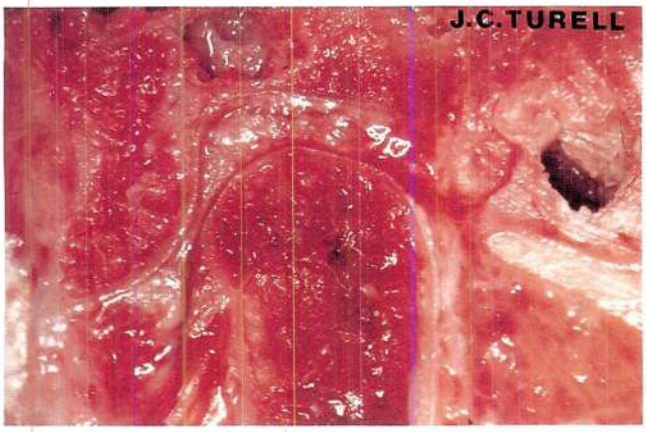


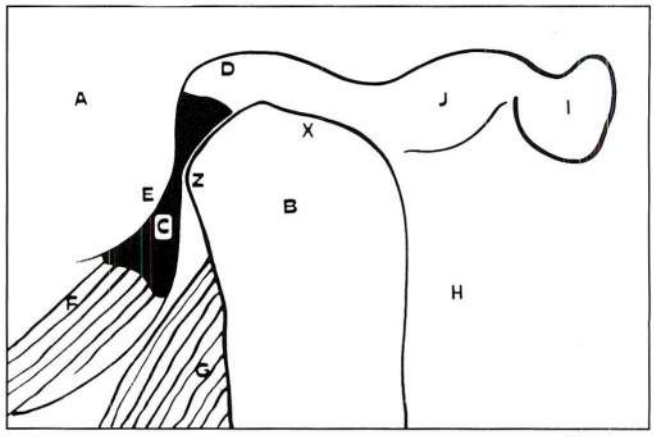
Fig. 16 Another view of the same sagittal section shown in Fig. 15 after separating the condyle from the temporal bone. The condyle was displaced downward to enable examination of the disk. There is a communication between the TMJ and the external auditory canal.





Figs. 17a and 17b Sagittal section of a TMJ showing anterior position of the disk. A, temporal bone; B, condyle; C, disk; D, glenoid fossa; E, eminence; F, area of the pterygoid muscle; G, external auditory canal; H, posterior wall of the fossa; I, bilaminar zone.





Figs. 18a and 18b Sagittal section of an abnormal TMJ. C, Anterior displacement of the disk; A, temporal bone; B, condyle with morphological changes, X and Z; D, glenoid fossa; E, articular eminence; F and G, upper and lower bellies of the external pterygoid muscle; H, bilaminar zone; I, external auditory canal; J, communication between this entity with TMJ.

preceding its anterior displacement (Figs. 18a and 18b).

In Figs. 18a and 18b the posterior rim of the disk does not coincide with the highest portion of the condyle while the anterior rim is seen at a lower position in relation with the most anterior portion of the condyle, thus demonstrating that the location of the disk is not normal according to what has been stated, regarding the criterion adopted to evaluate normal or abnormal TMJ conditions.

The condyle is also placed in a situation that is higher and more posterior than normal, with concomitant backward pressure on the bilaminar zone. The anterior position of the disk (Figs. 17a and 17b) does not cause an opening click because the anterior and thicker portion of the disk has not totally been placed underneath the most anterior portion of the condyle.

This anterior position of the disk is frequently caused by occlusal disharmony. The anterior position attained by the disk is the result of the pressure exerted by the condyle on the superoposterior area of the TMJ. There are excessive loads exerted over the TMJ. It may remain asymptomatic for a long period of time until apparent pathological changes are taking place as muscular disorders, opening mouth deviation, or morphologic changes are brought out by radiographic examination.

The pathologic condition consequent to the anterior position of the disk is the anterior displacement of the disk, an example of which is seen in Figs. 18a and 18b. The differences are clear-cut. In this case the disk appears divided into two sectors, above and below the point where the condyle assumes a relationship with the articular eminence of the temporal bone. This interarticular disk was examined following section and was found to present a small perforation.

An area of marked thickness of the anterior rim of the disk is seen underneath the most anterior and most prominent portion of the condyle. When the condyle begins to translate anteriorly, it exerts pressure on the disk, and at a certain moment its anterior rim displaces abruptly and backwards, causing click and enabling the patient to open his or her mouth without difficulties.

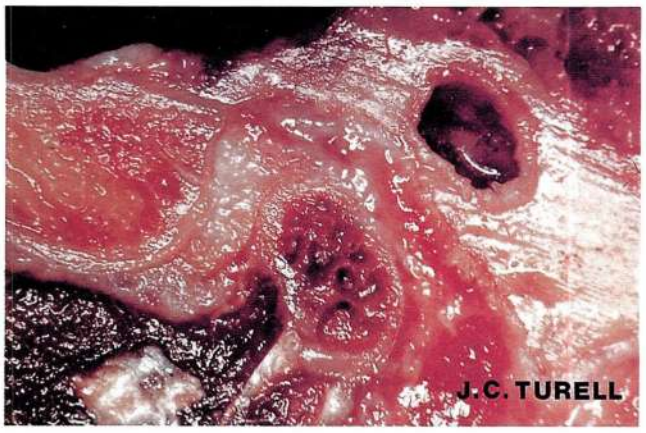
However, the most characteristic and obvious noise occurs when the whole disk and not only part of it, is located in front of the condyle. In this case, it is a mass of a larger volume that is seen to displace, as observed in the specimen in Figs. 19a and 19b.

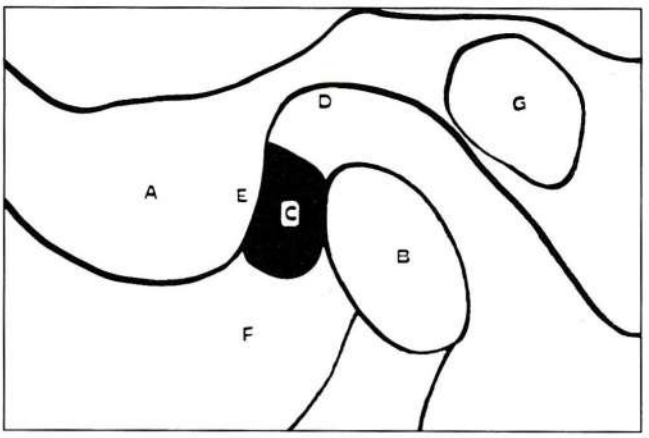
The specimens in Figs. 19a and 19b and 27a and 27b correspond to the right and left TMJ, respectively (of the same cadaver) and account for two different abnormal situations.

Opening click frequently occurs in patients with occlusal disharmony where the disk is anteriorly placed with respect to its normal position and is compressed and deformed by the action of the condyle in an attempt by the latter to translate anteriorly at opening. The disk has lost its normal biconcavity. The abrupt sliding of the disk between the condyle and the eminence gives rise to clicking, enabling the anterior displacement of the condyle with consequent maximum mouth opening. After closing, the condyle is displaced posteriorly and the disk occupies its defective anterior displacement. In this case the TMJ dysfunction is characterized by an opening click.

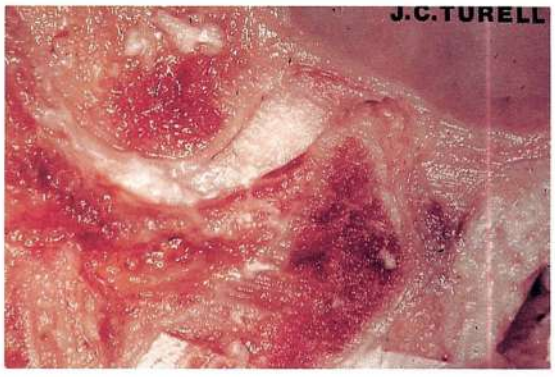
Frequently the patient pays little attention to these clicks occurring at the TMJ level, the antecedent of severe lesions. Oral rehabilitation should not be advised until this problem is properly treated.

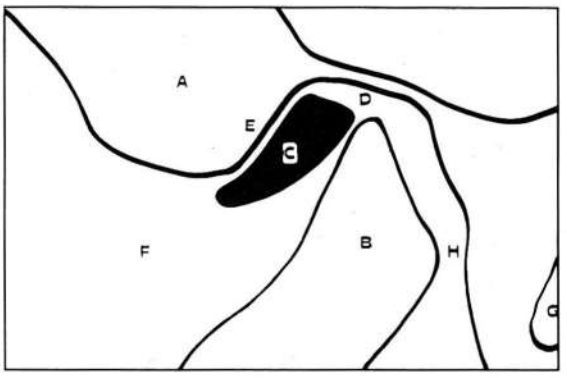
The click may occur at the onset of opening, or at an intermediate or late stage.[14-15] The earlier the elimination of noise the





Figs. 19a and 19b Sagittal section of an abnormal TMJ showing the anterior displacement of a rounded disk, C. A, temporal bone; B, condyle; D, glenoid fossa; E, articular eminence; F, external pterygoid muscle; G, auditory canal; I, bilaminar zone.





Figs. 20a and 20b Sagittal section of an abnormal TMJ showing osteoarthrosis. A, temporal bone; B, condyle with extensive morphological changes; C, abnormal biconvex disk; D, flattening of the glenoid fossa; E, eminence; F, area of the external pterygoid muscle; G, external auditory canal; H, degenerated bilaminar zone.

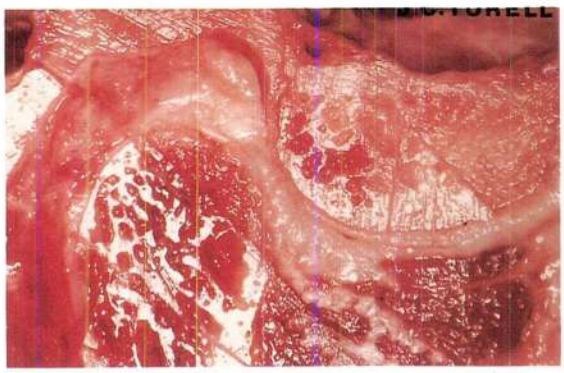
greater the chances of success. The later the stage, the greater the anterior displacement of the disk and the greater the damage.

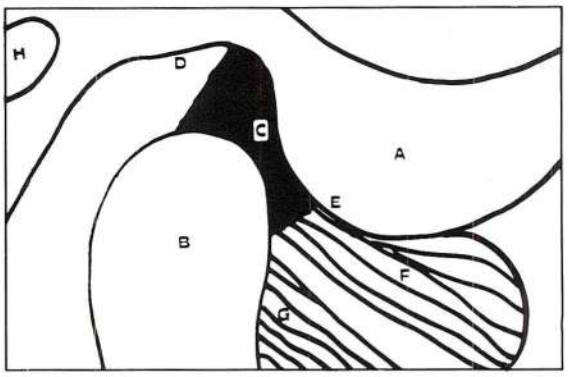
In the early development of osteoarthrosis the altered position of the disk (characterized by an anterior displacement) will be followed by a morphological change of the disk. In advanced stages the altered configuration can show thickening, biconvexity, a bilobed, rounded, or triangular shape and may also be folded around a thin central portion or separated in two parts.

The more advanced is the stage of osteoarthrosis, the greater is the deformation and the lesser the possibilities of successful treatment. In subjects who demonstrate an early opening click there is minimal damage and the disk will be recaptured readily. On other occasions there occurs one click upon opening and another at closure, namely, reciprocal clicking. This condition might be represented by the human TMJ section seen in Figs. 20a and 20b that show an advanced pathologic state. Therein are observed important structural and functional changes.

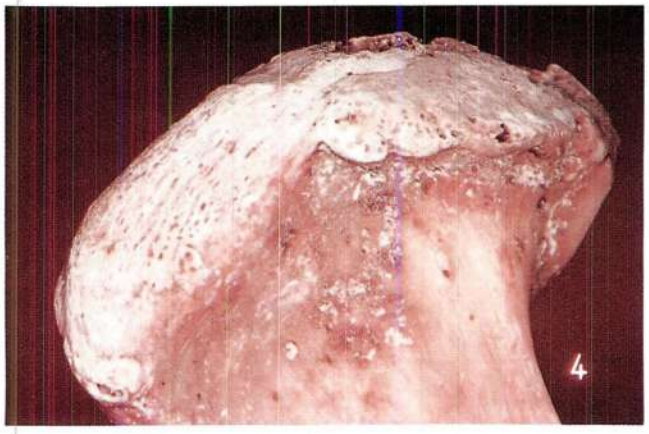
In Figs. 20a and 20b the condyle has lost its normal anatomic characteristic to take up an angular or rectangular shape, of straight and irregular surfaces, leaning on the posterior wall of the fossa with alteration of the bilaminar zone, wherein its elastic condition has surely disappeared or else presents a degenerative state. Flattening in the fossa is apparent. The biconvex disk shows marked thickness and does not coincide with its normal shape. The deformation of a disk represents a more advanced stage than an early anterior displacement of the disk. The external pterygoid muscle does not exhibit the characteristics of the previous sections; there is a loss of morphology and, most likely of functionality.

In this case reciprocal clicking may take place, that is: first, on opening, when the disk displaces abruptly backward and the condyle translates forward; and second, on closure when the disk





Figs. 21a and 21b Sagittal section of a normal TMJ. A, temporal bone; B, condyle; C, disk; D, glenoid fossa; E, eminence; F and G, bellies of the external pterygoid muscle; H, external auditory canal; I, bilaminar zone.



Figs. 22 and 23 Condyles with morphological changes corresponding to skulls with extensive attrition of the teeth.

Fig. 24 Anteroposterior section of the condyle shown in Fig. 22.

Fig. 25 Anteroposterior section of the condyle shown in Fig. 23.

turns forward and the condyle recovers its initial position. There will never be a closing click without an opening click, although there may be an opening click without a closing click.

The specimen of Figs. 20a and 20b represents a case of osteoarthrosis or degenerative arthritis, a final pathologic condition of an anterior displacement of the disk, corresponding to a cadaver of a 68-year-old edentulous man who had probably never used a complete prosthesis. This cadaver is of the same age as that of the TMJ section seen in Figs. 21a and 21b, which exhibited functional occlusion with full natural dentition, a marked difference being observed between them.

No direct relationship can be established between age and degenerative arthritis or osteoarthrosis. (Advanced age is no reason for TMJ dysfunction.) The most important factor related to osteoarthrosis is the occlusion.

Internal derangement of the TMJ will be more frequent in elderly people, primarily if they derive from an economically poorer social background, because occlusal dysfunctions as caused by extractions, interferences, abrasion, loss of teeth, or noncorrected malpositions of teeth, will be more frequent. These unfavorable occlusal conditions have probably been acting for a period of up to 60 or 70 years. For this reason, TMJ dysfunctions are more frequent in this age group than in young people.

However, older healthy individuals with natural upper and lower teeth and natural organic occlusion will have normal TMJs. It is what we see in cadaver TMJ sections and it constitutes a general clinical observation. Thus, it should be stated that osteoarthrosis is related to occlusal conditions. Aging will aggravate the problem if there is an occlusal dysfunction.

Cases of osteoarthrosis usually affect one of the TMJs. Conversely, rheumatic arthritis often affects both TMJs.

Impact loading could cause the alterations or changes in TMJs that are seen in osteoarthrosis. They must be regarded as pathological changes rather than adaptive changes.

These are the result of abnormal conditions such as severe abrasion, bruxism, clenching, occlusal interferences, loss of posterior teeth, etc.

Rehabilitation, performed at the right time using the concepts of organic occlusion, is the answer to a great many TMJ problems.

Richards and Brown[16] studied the extent and rate of occlusal attrition in relation to degenerative arthritis of the TMJ in 101 skulls of early aboriginal men in Australia. According to this research, joint degenerations affected 40% of the specimens and were associated with attrition. The authors observed that degenerations affected the temporal joint more frequently than the condyle; and the age, unaccompanied by tooth wear, was not significant in the progress of the disease.

In the course of my research I have examined and sectioned mandibular condyles corresponding to skulls with extensive attrition or abrasion of the teeth.

Twenty condyles were selected from skulls that showed a reduction of the crown length to one third of normal.

All the condyles showed a visible deformation that was more evident after sectioning. Figures 22 and 24 correspond to one of the specimens before and after sectioning; Figs. 23 and 25 to another one. At these stages regression to normality is rather difficult.

The percentage of joint degeneration is higher when the study is made in both hard and soft tissues of the TMJ, because alteration occurs earlier in soft tissues (disk, capsule, bilaminar zone, etc.) than in bone.

Osteoarthrosis of the TMJ can be the result of an increase of the occlusal stress caused by progressive attrition. Occlusal and TMJ examination of cadavers substantiate the view that degenerative arthritis or osteoarthrosis are directly related to occlusal problems rather than age alone. Nevertheless, while ruling out a contradiction, TMJ alterations are most commonly seen in advanced age.[17]

Symptoms of osteoarthrosis may vary from one patient to another as does the course of the disease in one subject. Observations performed in human TMJs may demonstrate varied characteristics of lesions, although not so different as to prevent identification and diagnosis. Osteoarthrosis can also develop without symptoms.

If, under any of these situations, an iatrogenic prosthesis is placed, it may provoke distinct symptomatology involving pain at opening, noise, or pressure upon the ear; the diagnosis often being completed and confirmed through clinical examination and useful transcranial radiographic findings.

Histologically it is found that osteoarthrosis involves loss of the fibrous tissue, which covers the articular surface as well as osseous resorptions in some areas and bone deposits in others. The disk may calcify, perforate, or sclerose. Moreover, the condyle with its flattenings, osteophytes, and alteration of varying degrees may cause marked compression of the vascularized, innervated tissues of the retrodiscal attachment of the disk and provoke its perforation resulting in a painful condition that was not present earlier. Morphological changes are often seen at the articular eminence.

Reciprocal clicking may have occurred as in the case of the specimen in Figs. 20a and 20b as well as that seen in Figs. 26a and 26b, which exhibits a TMJ affected by osteoarthrosis.

In this sagittal section of the TMJ (Figs. 26a and 26b) the condyle, whose morphology has been deeply affected, presents an angle with an osteophyte in its upper

portion and absence of cortical bone in the midportion of the anterior and posterior surfaces. The condyle is seen as displaced posteriorly which causes compression and degeneration of the bilaminar zone. The fossa exhibits marked irregularities as does the upper area of the condyle, owing to the process of osseous resorption.

The thickened disk, far removed from the condyle, has lost its normal shape. However, it is interesting to note that unlike the case in Figs. 20a and 20b, the two bellies of the external pterygoid muscle are perfectly differentiated and their aspect differs somewhat, but not greatly, from those seen in normal cases.

No two cases are alike, and consequently, the symptomatology may vary.

The section of Figs. 26a and 26b also corresponds to an edentulous subject. It may be assumed that these TMJs have probably supported, for decades, functional loads far greater than those exerted on TMJs of healthy persons with complete natural dentition and good occlusion, in whom are seen conditions such as those corresponding to the specimens described in Figs. 1a and 1b, 2a and 2b, 6, 21a and 21b, etc.

Different problems may be posed by persons with occlusal disturbances, muscular disorders, and TMJ dysfunctions requiring oral rehabilitation to be preceded by thorough clinical and radiographic examination to ensure accurate diagnosis and treatment.

The cases presented to TMJ specimens seen in Figs. 18a and 18b, 20a and 20b, and 26a and 26b may be grouped, despite differences in dysfunction, under the heading of disk displacements with reduction. That is, the disk is displaced anteriorly and translates posteriorly when the condyle shifts forward, to return to its abnormal position. The presence or absence of a single or reciprocal clicking depends on each individual case.

The other type of anterior displacement of the disk is characterized by the absence of posterior displacement of the disk and may, therefore, be regarded as an anterior displacement of the disk without reduction. In this case the disk causes limited opening by preventing anterior sliding of the condyle (closed lock) (Figs. 27a and 27b). The disk is displaced anteriorly with respect to the condyle, occupying a defective position. As the condyle tends to translate forward, the disk bears its pressure, but owing to its volume or to the scarce space between the condyle and the eminence, it cannot slide posteriorly while preventing the condyle from sliding anteriorly with consequent limitation of opening. In this case there is no noise either at opening or at closure, because the position of the disk with respect to the condyle does not vary.

In this case, the anterior displacement of the disk, without reduction or without posterior sliding provokes, simultaneously, a posterior displacement of the condyle, which exerts pressure on the bilaminar zone or elastic posterior insertion of the disk. TMJ functioning is found compromised and the patient, normally presenting a 40-mm opening between the upper and lower incisal rims, sometimes finds it difficult to open his mouth more than 25 mm. If the strain is repeated, opening eventually becomes painful. Frequently it is asymptomatic. It is possible that the main and common cause of this situation is provoked by a balancing interference capable of displacing the mandible laterally.

Alterations caused by interferences may be of varying types. The lesion may appear in the tooth which provokes them, in the antagonist, in more distant teeth, in the muscles, in one or both TMJs, on the enamel (attrition), or in periodontal tissues.

If this condition is diagnosed at an early stage treatment is simpler and more effective. However, as these lesions are often asymptomatic and even when noticeable, they are not ascribed due importance, frequently the condition is diagnosed only when considerable pain develops or after an ORL examination.

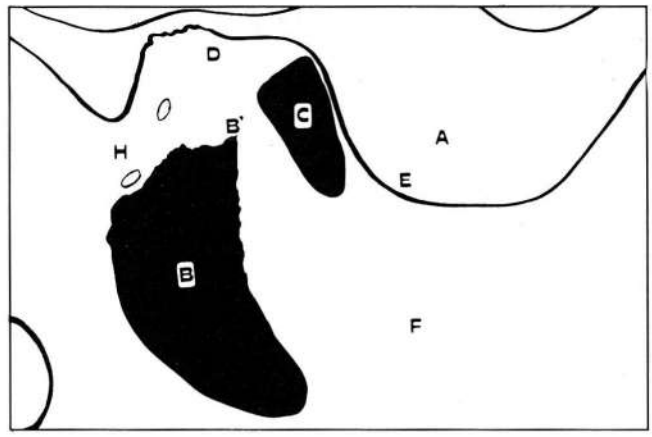
The extracapsular pain is in most cases muscular, provoked by interferences. The intracapsular pain may be related to rheumatic arthritis, osteoarthrosis, traumatic arthritis, etc., or to changes of an organic nature, which render it more difficult than in the case of a strictly functional problem.

A severe lesion is seen in Figs. 28a and 28b, showing a TMJ sagittal section with anterior displacement of the disk. In order to facilitate placement of the section it may be stated that the auditory canal is outside the photograph, in its right upper angle; the disk appears completely deformed, lying between the condyle and the eminence with total alteration of its normal shape, most of it rolled up and divided in front of the condyle. In similar cases an arthrography procedure did show, quite distinctly, the existing deformation.

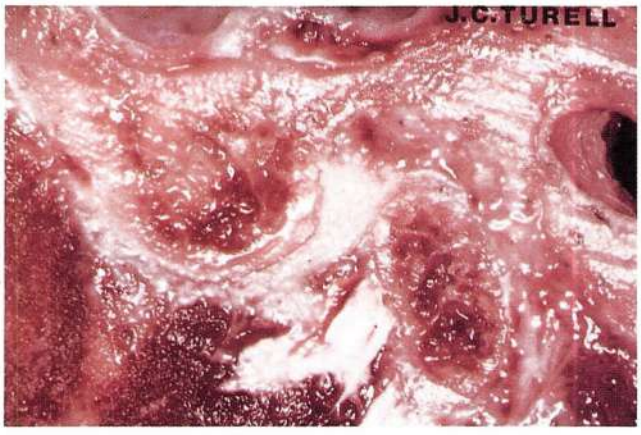
In the specimen in Figs. 28a and 28b, careful examination will show irregularities on all the osseous surfaces, both of the condyle and of the fossa and eminence. The condyle presents a distinct morphologic discrepancy and is displaced anteriorly. The posterior insertion of the disk or bilaminar zone shows a marked thickening, while the external pterygoid muscle exhibits its relationship with the disk and the condyle.

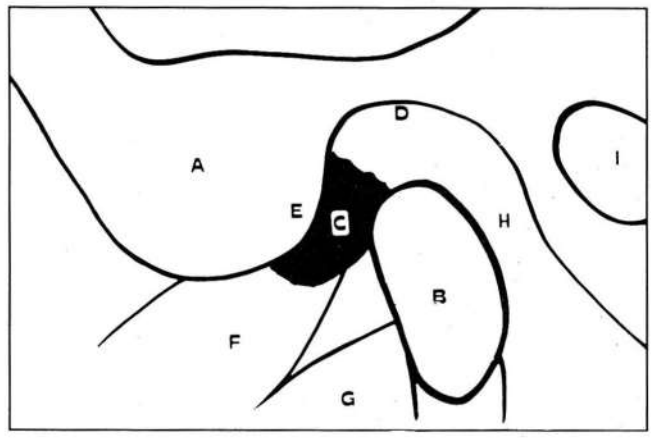
Specimens in Figs. 27a and 27b and 28a and 28b correspond to what is clinically named as limitation of mouth opening from anterior displacement of the disk without reduction (closed lock).

The preceding specimens (Figs. 17a and 17b, 18a and 18b, 27a and 27b, and 28a and 28b) and the following to be described (Figs. 29a to 35b) were taken

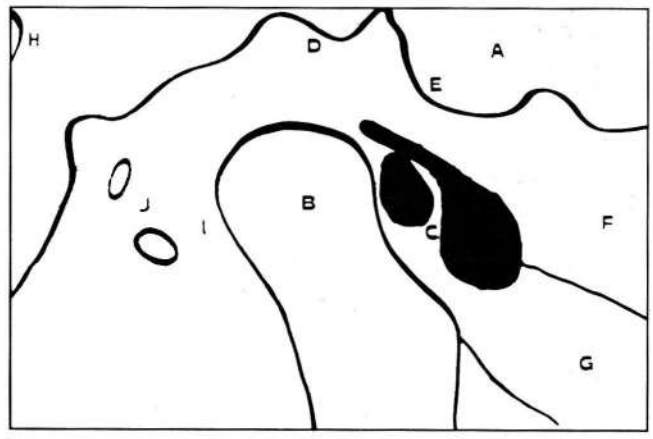


Figs. 26a and 26b Sagittal section of an abnormal TMJ affected by osteoarthrosis. A, temporal bone; B, condyle with morphological changes showing an osteophyte B'; C, altered configuration of the disk; D, flattened glenoid fossa; E, eminence; F, area of the external pterygoid muscle; H, bilaminar zone and vessels.

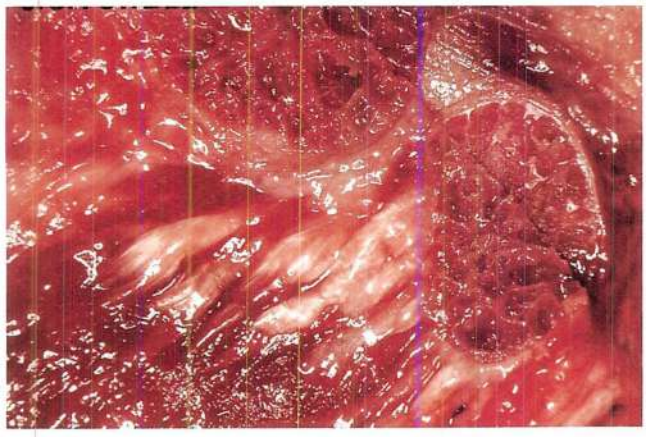


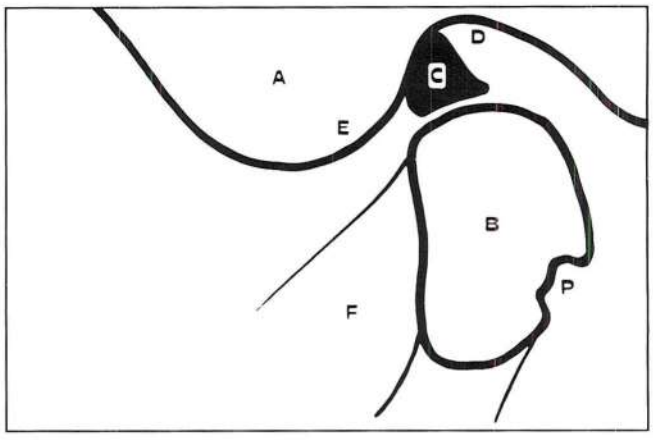


Figs. 27a and 27b Sagittal section of an abnormal TMJ with anterior displacement of disk, C. A, temporal bone; B, condyle; D, glenoid fossa; E, eminence; F and G, bellies of the external pterygoid muscle; H, bilaminar zone; I, external auditory canal.

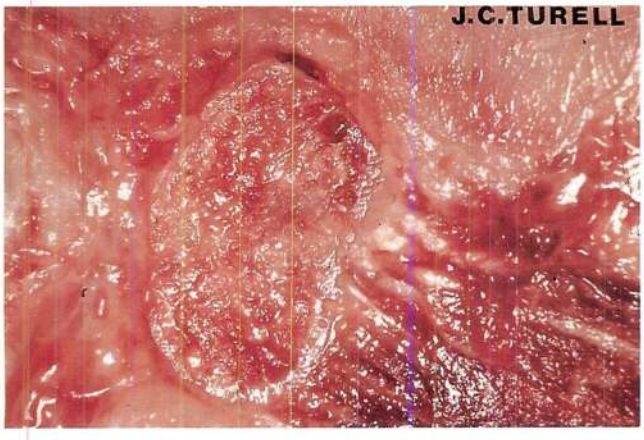


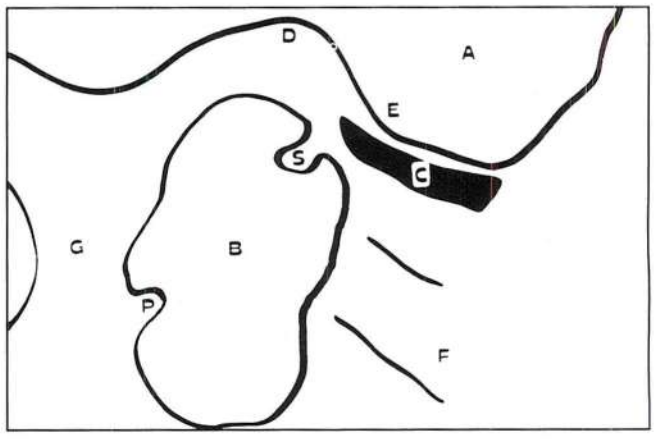
Figs. 28a and 28b Sagittal section of an abnormal TMJ. A, temporal bone; B, condyle; C, deformed disk displaced anteriorly; D, glenoid fossa; E, eminence; F and G, external pterygoid muscle; H, external auditory canal; J, bilaminar zone and vessels.



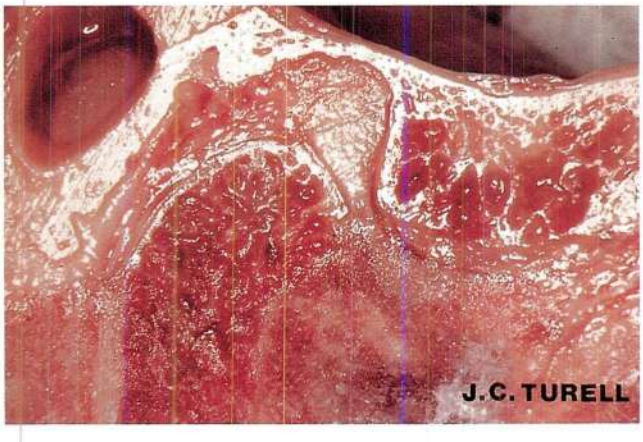


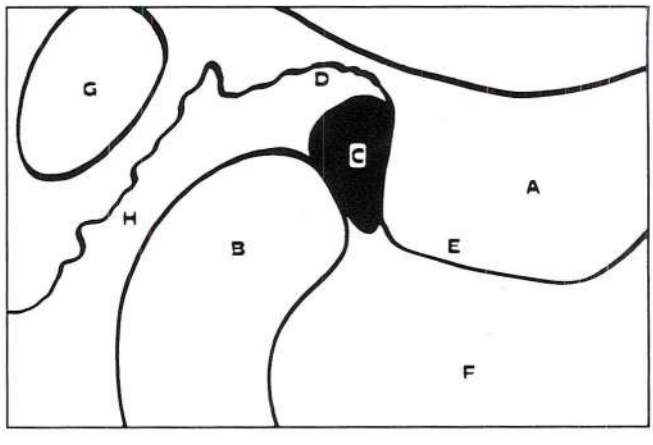
Figs. 29a and 29b Sagittal section of an abnormal TMJ. A, temporal bone; B, condyle with an arthritic lesion on the posterior area P; C, anteroposterior shortening of the disk; D, glenoid fossa; E, eminence; F, external pterygoid muscle.





Figs. 30a and 30b Sagittal section of an abnormal TMJ. A, temporal bone; B, condyle with arthritic lesion in S and P; C, disk displaced anteriorly with morphological changes; D, glenoid fossa; E, eminence; F, external pterygoid muscle; G, bilaminar zone.





Figs 31a and 31b Sagittal section of an abnormal TMJ. A, temporal bone; B,condyle; C, pathological disk with anteroposterior shortening and loss of its biconcavity; D, glenoid fossa; E, articular eminence; F, area of the external pterygoid muscle; G, external auditory canal; H, bilaminar zone.

from fresh cadavers whose partially or scarcely dentulous mouths were characterized by malocclusions due to lack of occlusal relations, and lateral displacement of the mandible owing to interfering contacts. The specimen in Figs. 29a and 29b, also partially dentulous, exhibits another variant, i.e., a rounded disk concomitant with distinct anteroposterior shortening. There is also loss of substance in the posterior surface of the condyle with broad medullar spaces.

The posterior irregularity of the condyle is seen as an arthritic lesion, in which case it might be diagnosed radiologically. The articular eminence does not exhibit abnormal irregularities. This specimen corresponds to a 36-year-old woman with natural decayed lower teeth and only four upper teeth. She presented marked loss of vertical dimension, which accounts for TMJ dysfunction, in this case causing anterior displacement of the condyle.

The specimen in Figs. 30a and 30b is that of a 45-year-old man with occlusal dysfunction from marked attrition or abrasion of teeth and loss of vertical dimension. It is possible to observe arthritic lesions in the anterosuperior and posterior zone of the condyle represented by a cortical resorption. The osseous structures, condyle, fossa, and eminence all show irregularities; the disk is seen displaced, markedly reduced in thickness, with loss of its characteristic biconcavity. TMJ arthritic lesions often coincide with displacements of the condyle.

Figs. 31a and 31b exhibit, as major lesions, anteroposterior shortening of the disk, flattening of the articular eminence, and irregularities in the osseous surfaces. Concern here is for a verified case of occlusal dysfunction from numerous successive extractions of long standing, which had caused extrusion of several upper teeth and malocclusion.

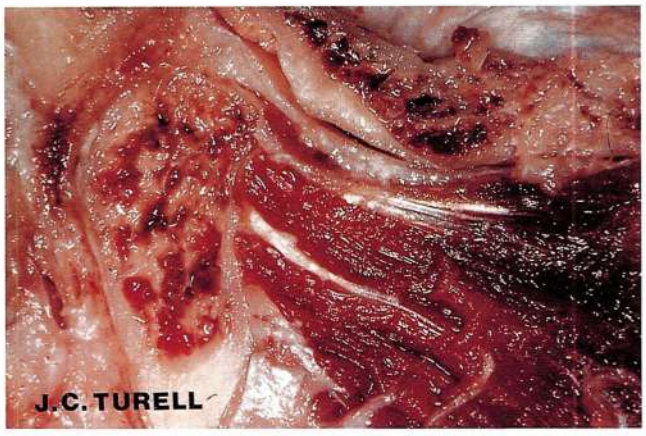
These different situations, present in cases of TMJ dysfunction, call for close examination before planning oral rehabilitation in an attempt to verify the influence of occlusion in the TMJ mechanism.

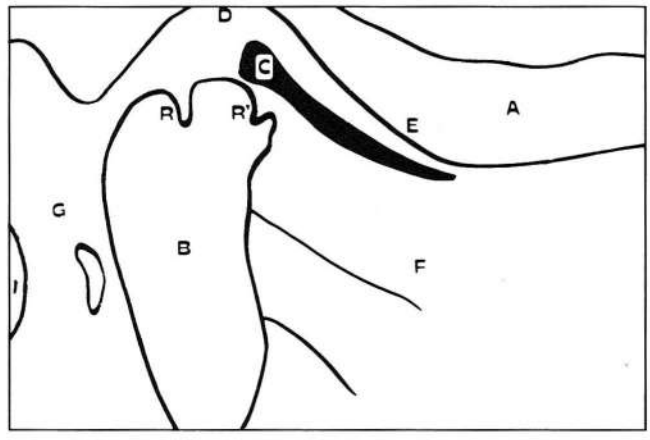
Figs. 32a and 32b and 33a and 33b correspond to sagittal sections of right and left TMJs of the same cadaver, a 69-year-old man, showing advanced articular lesions. There is an absence of posterior teeth and abrasion of anterior teeth, resulting in TMJ pathologic changes. The loss of posterior teeth and abrasion of anterior ones enables the condyle to penetrate deeply into the fossa causing an excessive load on the bilaminar zone giving rise to degenerative states or on the disk with resulting anterior displacement.

In cases similar to those in Figs. 32a and 32b and 33a and 33b it is possible to observe articular symptoms and, more frequently, muscular ones, detected through careful palpation. The condition may involve a state whose symptomatology is overlooked by the patient, but which is rendered apparent by clinical and radiographic examination; detection is important because if at that stage adequate occlusal conditions are restored by oral rehabilitation, more advanced stages of the alteration might be precluded.

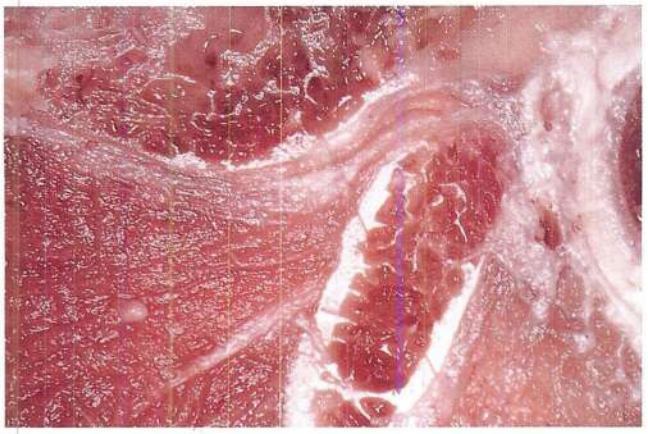
By contrast, when fundamental occlusion principles are not respected or when inappropriate techniques are used, there will be aggravation of the condition. The resulting effect in this case, is an impairment of the situation, making the solution and the relief of symptoms more difficult.

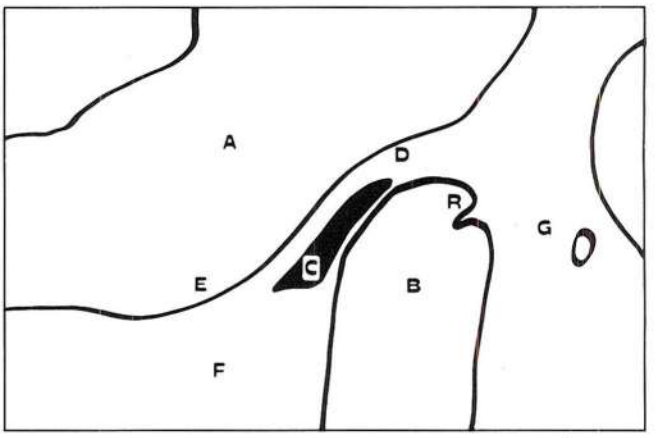
In both specimens in Figs. 32a to 33b it is possible to observe extremely thin disks whose upper surfaces show small irregularities coinciding with those in the articular eminence. In the disks, a degenerative process has taken place. In both specimens the right





Figs. 32a and 32b Sagittal section of an abnormal TMJ. A, temporal bone; B, condyle with arthritic lesions R and R'; C, abnormal disk; D, glenoid fossa; E, articular eminence; F, external pterygoid muscle; G, bilaminar zone with vesssels; I, external auditory canal.





Figs. 33a and 33b Sagittal section of an abnormal TMJ. A, temporal bone; B, condyle with arthritic lesion R; C, abnormal disk; D, glenoid fossa; E, articular eminence; F, external pterygoid muscle; G, bilaminar zone with vessels.

and left external pterygoid muscles are seen, with aspects or conditions similar to the normal. Nevertheless the condyles show important arthritic lesions, which could be diagnosed radiographically. The one on p. 271 (Figs. 32a and 32b) presents a marked resorption process in the anterosuperior zone, and the one on p. 272 (Figs. 33a and 33b) shows a similar lesion in the posterosuperior area. At the aforesaid points the cortical bone has disappeared while medullar spaces are seen exposed.

Both TMJs communicate with the corresponding external auditory canal and show alterations in the bilaminar zone that are undergoing degenerative processes. In accordance with observations in the sections, these joints do not produce clicking upon opening and closure although it might have been evident at earlier stages.

TMJ lesions may present other characteristics.

The specimen in Figs. 34a and 34b represents a human TMJ sagittal section corresponding to a 47-year-old who exhibits marked posterior displacement of the condyle. It shows a distinct concavity on the anterior surface, flattening of the eminence, a glenoid fossa, and irregular boundaries, a wide disk far removed from normal, and perforation of the retrodiscal attachment. This condylar position causes inflammation in the early stages when the condyle intrudes on the bilaminar zone, and later its degeneration and perforation.

Occlusal examination of the cadaver showed loss of 18 teeth in addition to the third molars. The four upper incisors, the four lower incisors, and two lower premolars were preserved.

In this case, there is excessive functional load on the TMJ with consequent posterior displacement of the condyle.

When radiology discloses a distal displacement of the mandible and the condyles are seen in the posterior zone of the joint, patients frequently experience chronic headaches and pain in the neck and face. Transcranial radiographs must be taken whenever the TMJ is symptomatic. This examination should be made even in asymptomatic patients if there is an indication of abnormality.

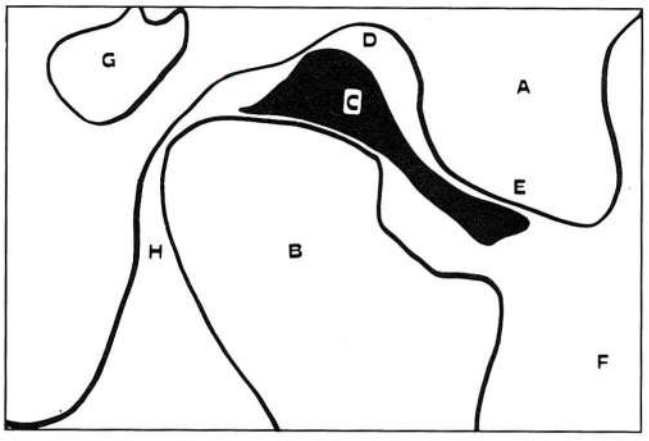
Occlusal dysfunction may result in the anterosuperior displacement of the condyle (as shown in Figs. 35a and 35b) where it is seen compressing the disk against the eminence. There is a wide space behind the condyle in the area of the bilaminar zone.

The anterior displacement of the mandible because of interferences or loss of posterior teeth causes marked abrasion in anterior teeth. Such abnormal conditions result in changes in TMJ hard and soft tissues, which may not be regarded as adaptation or remodeling effects.

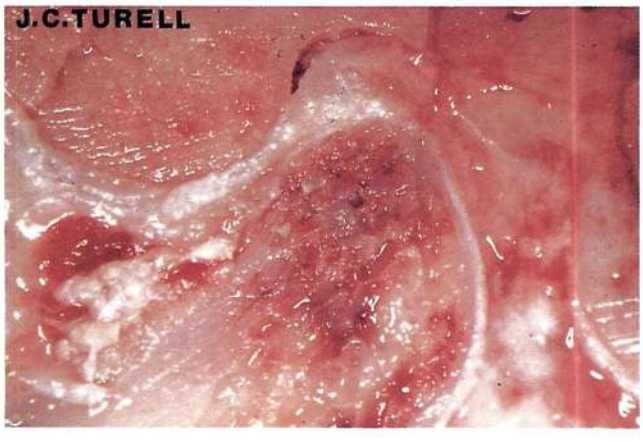
We should take into account that the TMJ is capable of supporting functional stresses, pressures, and loads only to a limited extent; when exceeded, structural and/or functional changes occur in it.

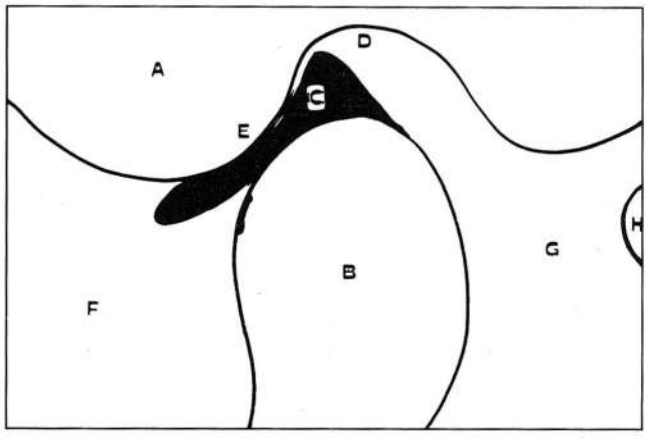
Finally, the specimen in Figs. 36a and 36b is the TMJ of the cadaver of a 30-year-old woman who suffered from rheumatoid arthritis. Background data indicate generalized alterations from the disease. Figures 36a and 36b show upper and posterior erosion of the condyle resulting in shortening of the mandibular rami with flattened articular eminence and reduced interarticular space. The disk has been displaced anteriorly with loss of normal morphology.

Often, in cases of rheumatic arthritis, upon closure, occlusal contacts of molars are taking place on the side of the erosion causing an anterior open bite. While treatment of this disease is the domain of the specialist, the gnathologist should identify it on the basis of its symptomatology, and through correct interpretation of transcranial radiogra-

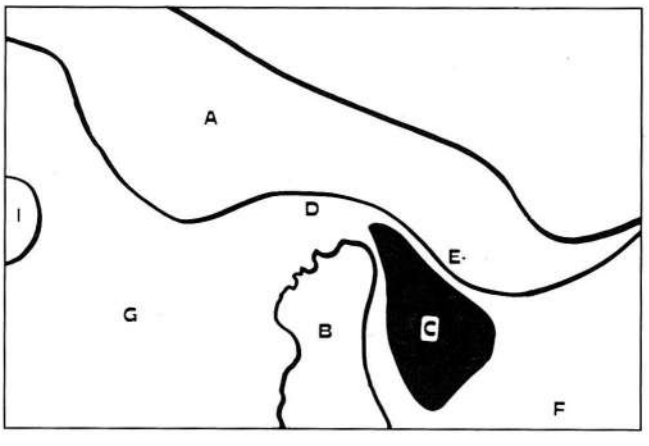


Figs. 34a and 34b Sagittal section of an abnormal TMJ with posterior displacement of the condyle. A, temporal bone; B, condyle; C, disk; D, glenoid fossa; E, flattened eminence; F, area of the external pterygoid muscle; G, external auditory canal; H, bilaminar zone compressed by the posterior condylar displacement.





Figs. 35a and 35b Sagittal section of an abnormal TMJ with an anterior displacement of the condyle. A, temporal bone; B, condyle with irregularities in the anterior area; C, abnormal disk; D, glenoid fossa; E, eminence; F, area of the external pterygoid muscle; G, bilaminar zone; H, external auditory canal.



Figs. 36a and 36b Sagittal section of an abnormal TMJ affected by rheumatic arthritis. A, temporal bone; B, condyle with erosions in the upper and posterior areas; C, abnormal disk displaced anteriorly; D, glenoid cavity; E, articular eminence; F, area of the external pterygoid muscle; G, bilaminar zone; I, external auditory canal.

phies, arthrographies, and computerized tomographies.

This disease is incompletely understood. The predisposing causes are varied. It is not provoked by a specific organism but infection, even of a low degree, is an important factor to be taken into account.

Summary and Conclusions

1. Both normal and abnormal findings in the TMJ have been made through autopsy specimens.
2. Criteria were established for the rate determination of normal and abnormal joints.
3. When studying normality one may readily observe the antagonism and independence between the upper and lower belly of the external pterygoid muscle; the functional unit involved by the condyle and the disk; the importance of the biconcavity of the disk, as a sine qua non condition of normality; the significance of the articular eminence in the normal condylar displacement; and the need for a bilaminar zone or retrodiscal attachment under normal elastic conditions. Anatomic conditions closely and significantly interrelated with clinical situations have been described.
4. In 100 human TMJ sections taken from cadavers, the number of abnormal cases was 80.

The numerous cases of abnormal TMJs detected (80%) were characterized by the following various conditions:

–anterior position of the disk (Figs. 17a and 17b)
–anterior displacement of the disk (Figs. 18a to 20b, and 26a to 28b)
–anteroposterior shortening of the disk (Figs. 29a and 29b)
–perforation of the disk (Figs. 18a and 18b)
–degeneration of the disk (Figs. 32a to 33b)
–degeneration of the bilaminar zone (retrodiscal attachment) (Figs. 20a and 20b and 26a and 26b)
–resorption and flattening of the articular eminence (Figs. 28a and 28b)
–resorption and flattening of the condyle (Figs. 20a and 20b and 26a and 26b)
–resorption and flattening of the fossa (Figs. 20a and 20b)
–formation of osteophytes (Figs. 26a and 26b)
–degenerative arthritis or osteoarthrosis (Figs. 20a and 20b and 26a and 26b)
–rheumatic arthritis (Figs. 36a and 36b)
–posterior displacement of the condyle (Figs. 34a and 34b)
–anterior displacement of the condyle (Figs. 35a and 35b)
–arthritic lesions of the condyle (Figs. 29a to 30b and 32a to 33b)
–biconcavex disks (Figs. 27a and 27b and 29a and 29b)

5. Totally edentulous subjects exhibited the most severe TMJ disorders in both soft and hard tissues.
6. Alterations in soft tissues are seen earlier than morphological changes in bone.
7. Advanced age per se is not a sufficient cause of TMJ dysfunction in healthy individuals who preserve their natural teeth without occlusal disharmony. This was borne out by the observations described.

TMJ dysfunction is seen in both young and elderly subjects and although age is not decisive, dysfunction is more frequent in the latter because they undergo occlusal functional incoordination over the years.

8. Attrition, loss of posterior teeth, parafunction, and malocclusion should be identified as the most important etiologic causes of either degenerative arthritis or osteoarthrosis.
9. Clicking and locking disorders caused by disk displacement show a close relation to malocclusion.
10. The impact upon the TMJ by loads or excessive stress transmitted to it by these or other occlusal conditions are responsible factors in TMJ dysfunction.
11. A thorough clinical examination may diagnose initial pathologic conditions enabling the undertaking of a conservative treatment thus preventing subsequent successive alterations leading to osteoarthrosis, a state at which regression to absolute normality is hardly attainable. Even at this stage restorative dentistry may improve prevalent conditions.

Human TMJ sections contribute significant knowledge enabling better evaluation of clinical problems as well as reliable interpretation of TMJ radiographic examinations.

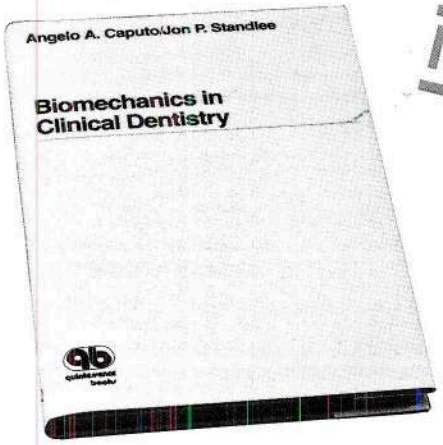
12. In some specimens it is possible to observe direct communication between the TMJ and the external auditory canal. Reports relate auditory problems with occlusal and joint dysfunctions on the basis of the frequent presence of concomitant alterations.

Further research is bound to contribute concrete data of obvious significance on this correlation. □

References

1. McNamara JA Jr: The independent functions of the two heads of the lateral pterygoid muscle. *Am J Anat* 1973;138:197-205.
2. Williamson EH, Steinke RM, Morse PK, et al: Centric relation: a comparison of muscle-determined position and operator guidance. *Am J Orthod* 1980;77:133-145.
3. Mahan PE: The temporomandibular joint in function and pathofunction, in Solberg WK, Clark GT (eds): *Temporomandibular Joint Problems*. Chicago, Quintessence Publ Co, 1980.
4. Solberg WK, Clark GT: *Temporomandibular Joint Problems: Biologic Diagnosis and Treatment*. Berlin, Quintessence Publ Co, 1980, p 44.
5. Updegrave WJ: An evaluation of temporomandibular joint roentgenography. *J Am Dent Assoc* 1953;46:408-419.

6. Blaschke DD, Solberg WK, Sanders B: Arthrography of the temporomandibular joint: review of current status. *J Am Dent Assoc* 1980;100:388-395.
7. Farrar WB, McCarty WL Jr: Inferior joint space arthrography and characteristics of condylar paths in internal derangements of the TMJ. *J Prosthet Dent* 1979;41:540-555.
8. Gibilisco JA (ed): *Stafne's Oral Radiographic Diagnosis*, ed 5, Philadelphia, W.B. Saunders Co, 1985.
9. Turell JC: Computerized tomography in the diagnosis and prognosis of TMJ dysfunctions. *J Gnathol* 1982;1:59-69.
10. Westesson PL, Rohlin M: Internal derangement related to osteoarthrosis in temporomandibular joint autopsy specimens. *Oral Surg Oral Med Oral Pathol* 1984;57:17-22.
11. Dolwick MF, Lipton JS, Warner MK, et al: Sagittal anatomy of the human temporomandibular joint spaces: normal and abnormal findings. *J Oral Maxillofac Surg* 1983;41:86-88.
12. McHorris WH: The condyle-disc dilemma. *J Gnathol* 1984;3:3-16.
13. Pinto OF: A new structure related to the temporomandibular joint and middle ear. *J Prosthet Dent* 1962;12:95-103.
14. Friedman MH, Weisberg J: *Temporomandibular Joint Disorders: Diagnosis and Treatment*. Chicago, Quintessence Publ Co, 1985.
15. Guichet NF: *Clinical Management of Orofacial Pain TMJ Dysfunction: Etiology, Diagnosis, Protocol for Treatment*. Anaheim, Ca, N.F. Guichet, 1982.
16. Richards LC, Brown T: Dental attrition and degenerative arthritis of the temporomandibular joint. *J Oral Rehabil* 1981;8: 293-307.
17. Turell JC: Observations on 100 TMJ human sections. *The Quintessence* (in Japanese) 1986;5:19-36.



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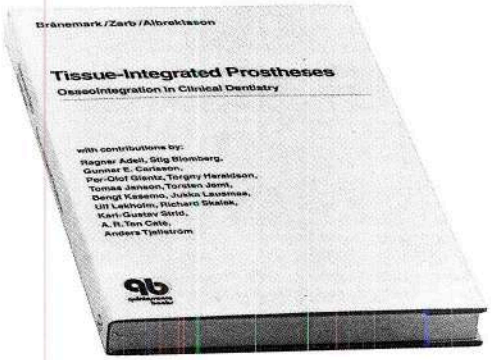

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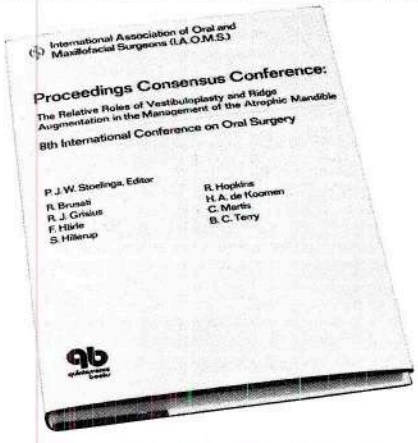

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