MORPHOLOGIC LIMITING FACTORS IN THE TEMPOROMANDIBULAR JOINT

Albert Zola, D.D.S.*
New York University, College of Dentistry, New York, N. Y.

The temporomandibular joint is a provocative challenge to the dental profession. Apart from the fact that this joint is ginglymoarthrodial which permits extreme latitude in its movements, its function as a simple hinge joint has never been satisfactorily explained.

Every joint in the human body has anatomic structures which impart stability during function. These structures are: (1) the osseous conformation of the articulating ends of the bones of the joints consisting of two opposing curved surfaces which are approximately congruent; (2) muscles which activate joints and stabilize the joints for power transmission[1]; (3) ligaments which help stabilize the joint by limiting movement; and (4) capsules and discs which form a part of a joint but which do not materially contribute to its stability. No discs are present in some types of joints.

POSITION OF STABILITY

Stability in a joint is represented by the optimum relationship of the two osseous components during power transmission. Displacement of either of the components under power transmission represents a dislocation.

The position of stability in the temporomandibular joint under power transmission is represented by a specific location of the condyles in the mandibular fossae. This condyle-fossa relationship is representative of the centric relation, hinge, or hinge axis position. When the Gothic arch (needle point) tracing device is used, the position of the condyles in the fossae, when the tracing pin is at the pointed apex of the tracing, is the position of stability during power transmission. All of these defining terms represent the same location of the condyles in the fossae.

Therefore, the temporomandibular joint is in a stable condition when the condyles in the fossae remain in a rigidly supported position during power transmission. If the condyles have no solid buttressing support to resist power transmission, the temporomandibular joint is unstable and is susceptible to dislocation dorsally or cranially.

STRUCTURES THAT RESIST MANDIBULAR DISPLACEMENT

The individual temporomandibular joint has no osseous anatomic structure which can prevent dorsal and cranial displacement under power transmission. The

*Assistant Clinical Professor, Department of Fixed Partial Prosthesis.

function of stabilizing the joint has heretofore been attributed to the muscles and/or the associated ligaments.

The lateral (external) pterygoid muscle is believed to prevent distal and cranial displacement of the condyle from centric relation.[2-4] Other investigators[5] claim to have disproved this theory by their experiments with severed muscles and joints intact using the Gysi tracing apparatus. Tests on live subjects under anesthesia and curare have produced conflicting results.[6,7] Our experience[8] with thesiograph recordings on fully conscious subjects during voluntary muscle relaxation indicated that the external pterygoid muscles were not wholly responsible for the stability of the joint under power closure even on an autonomic level.

The temporomandibular ligaments and accessory capsular ligaments have also been considered either wholly or, at least in conjunction with the external pterygoid muscles, responsible for preventing dorsal and cranial displacement of the condyles. The temporomandibular ligaments do not become stretched until the mandible is swung dorsally as in a hinge opening movement.[9] Therefore, the temporomandibular ligaments could not prevent dorsal or cranial displacement in a closed jaw position under power transmission. The accessory ligaments by themselves could hardly be strong enough to resist the strong pressure of power transmission.

OSSEOUS RELATIONSHIP TO JOINT STABILITY

Muscles and ligaments contribute to the stability of all joints, but in each instance an osseous conformation determines the optimum location of the two or more bones which form the joint. There is always a single position in which the ends of the bones occlude during power transmission. The muscles and ligaments have the function of maintaining this relationship and preventing dislocation from this position under power transmission.

The external pterygoid muscles are subject to a finely integrated autonomic proprioceptive feedback system which prevents dislocation of the condyle in a dorsal or cranial direction. The ligaments also prevent dislocation under certain conditions of strain, especially when one of the condyles is not in the fossa. However, the actual positioning of the two articulating ends of the mandible and the temporal bones must be found in the osseous conformation of these bones.

BILATERAL JOINT STABILITY

Because this necessary osseous formation is lacking in the individual temporomandibular joint, the solution to this problem has remained unaccountably obscure. The single condyle is always described as having one area of contact in the mandibular fossa. The anterior surface of the condyle cushioned by the articular disc is said to bear upon the slope of the articular eminence. This position is untenable since the slope is angled roughly at 30 degrees from the occlusal plane. This unstable position of the condyle would require muscles and ligaments for support during power transmission and plainly shows why the temporomandibular joint has always seemed so unique. Such interpretation of the physiology of the joint would make it the only joint in the human body completely dependent upon the muscles and ligaments for stability.

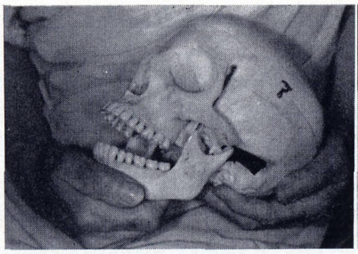

Fig. 1.

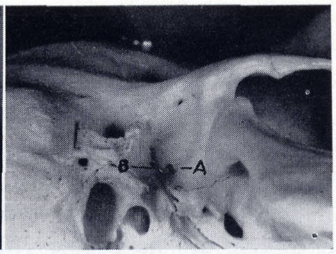

Fig. 2.

Fig. 1.—The cranium is held firmly in the left hand. The mandible is held with the right hand, and the condyles are seated in the mandibular fossae. Gentle force is applied in a craniodorsal direction. The mandible is rotated slightly with the articulating paper between the condyle and the fossa.

Fig. 2.—The marking of the articulating paper, *A*, is observed just anterior to the petrotympanic fissure, *B*.

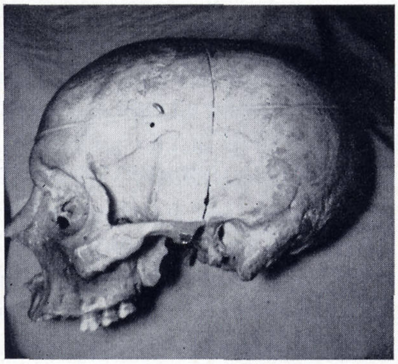

Fig. 3.—The vertical transverse section of the skull has been made on a plane which bisects the mandibular fossa just anterior to the marking seen in Fig. 2.

The single temporomandibular joint does not have the necessary osseous formation for a true joint. However, the problem of stability becomes less obscure when the *whole* mandible is viewed as the bone which articulates with the temporal bones.

When articulating paper is placed between one condyle and the fossa while the mandible is forcibly retruded and rotated (Fig. 1), a mark is made within the fossa (Fig. 2). This mark demonstrates an area of constriction which the mandible encounters and which prevents further dorsal and cranial passage of the condyles. The cause of this constriction can be seen readily in a vertical transverse section of the skull (Fig. 3).

The medial walls of the fossae slope outward in relation to the condyles as viewed anteroposteriorly (Fig. 4). These walls are heavily buttressed (Fig. 5). This outward or distal flare naturally constricts the dorsocranial movement of the condyles since they cannot spread apart to accommodate to the larger dimension. When the fossa is viewed caudocranially, the medial wall flares distally and thus constricts and prevents dorsal movement of the condyles (Figs. 6 and 7).

An osseous prominence or elevation is commonly found at the point of constriction on the medial wall of the fossa (Fig. 8). This prominence forms the dorsocranial border of a craterlike depression or faceting of the medial wall. Normally in the animate subject, approximately 0.4 mm. of disc structure which compresses to 0.2 mm. under power transmission is interposed at this point of articulation with the medial pole of the condyle. In the bare skull, the marking appears slightly dorsocranial to the actual articulation facet because the disc is absent. The raised border in that direction stops the condyles and, consequently, can be marked with the articulating paper.

The interruption provided by both the facet and the raised rim offers a

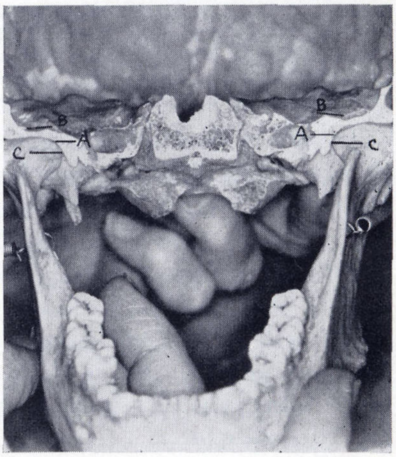

Fig. 4.—The mandible is held so that the condyles articulate with the posterior half of the sectioned skull (Fig. 3). *A*, The outward slope of the medial walls of the fossae. *B*, The roof of the fossa. *C*, The medial pole of condyle.

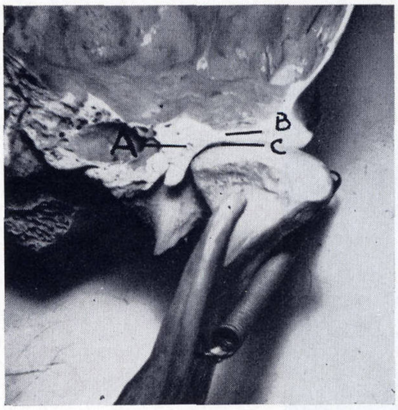

Fig. 5.—A close-up view of the left side of the sectioned skull and the articulated condyle shows: *A*, the medial wall of the mandibular fossa showing strongly buttressed construction. *B*, The relatively thin roof of the fossa. *C*, The space between condyle and roof of fossa.

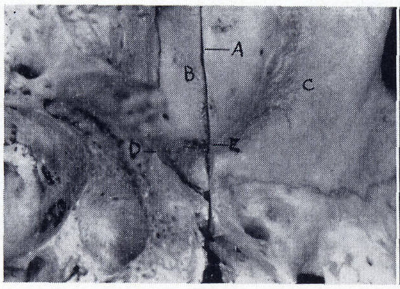

Fig. 6.

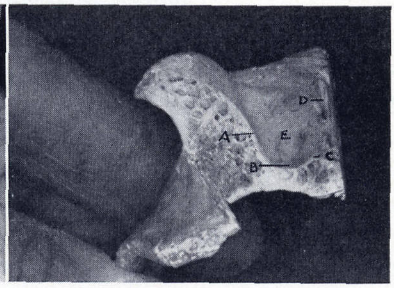

Fig. 7.

Fig. 6.—The mandibular fossa is seen from below. *A*, The section through skull. *B*, The right mandibular fossa. *C*, The articular eminence. *D*, The petrotympanic fissure. *E*, The marked area of restriction of the condyles in the bare skull.

Fig. 7.—A horizontal section through a left mandibular fossa was made at right angles to the section in Fig. 6 through the marked area. *A*, The articular eminence. *B*, The articular facet. *C*, The raised rim of the articular facet which limits dorsal movement. *D*, The petrotympanic fissure. *E*, The roof of the fossa.

definite stop for the condyle. This prevents the wedging and spreading effect that would result from a smooth inclined plane. The presence of these stops provides a constantly uniform seating position for the condyle.

This condylar articulating facet with a raised cranial-dorsal border is located on that portion of the temporal bone which constitutes the anterior part of the medial wall of the mandibular fossa. The facet is anterior to the petrotympanic or Glaserian fissure and is approximately midway from the roof to the medial lip of the fossa. The disc is interposed between the medial pole of the condyle and the articulating facet.

This articular facet provides the necessary anatomic osseous structure, and, together with the posterior slope of the articular eminence, cradles the condyle in a well-buttressed osseous socket. Although there is no typically curved concave surface with which the condyle occludes, the combined form of the medial walls of

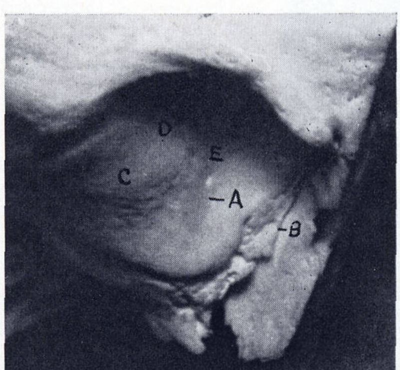

Fig. 8.—*A*, The articular facet is located relative to *B*, the petrotympanic fissure. *C*, The articular eminence. *D*, The roof of the mandibular fossa. *E*, The medial wall of the mandibular fossa.

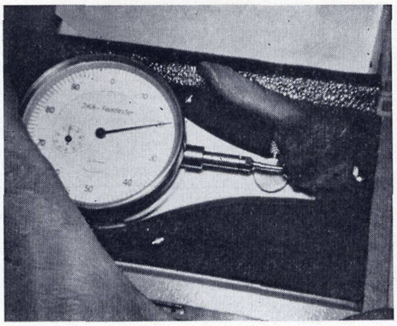

Fig. 9.—A dial gauge with a 3 ounce pressure is used to measure the discs. The pressure can be increased by applying force to a rod on the left of the dial. The terminals are on the right. A disc between the terminals is being displaced by the pressure applied. The instrument is registering 0.2 mm.

both fossae and the posterior slopes of the eminence actually form a counterpart of a concave opponent. Under power transmission, the condyle is prevented from moving ventrally by the eminence and dorsally and cranially by the raised border of the articular facet.

RELATION OF ARTICULAR DISC TO JOINT STABILITY

The morphology of the articular disc justifies the hypothesis that this osseous conformation functions as a true joint. Whenever an articular disc is present in a joint, the thinnest part of the disc represents the place through which the articulating bone makes most intimate approximation. Consequently, the thinnest part of the disc identifies the relative locations of the articulating bones in their most stable position.

Articular discs were measured with an accurate dial gauge in two ways (Fig. 9). One measurement was made under the normal 3 ounce spring pressure of the instrument. The second measurement was made with considerable pressure

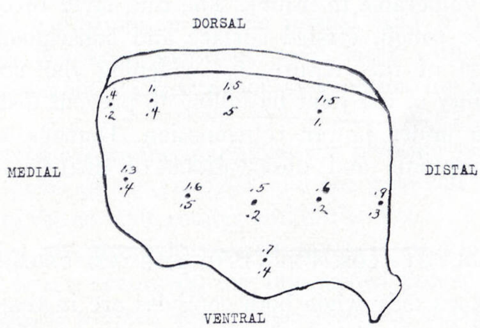

Fig. 10.—The numbers in the outlined disc represent areas and thickness in millimeters of the measurements. The upper figures represent the thickness of the disc under 3 ounces and the lower figures the thickness under pressure in excess of 10 pounds.

to assimilate the force applied under power transmission (Fig. 10). The terminals of the instrument were designed to correspond to the diameters of the osseous occluding surfaces.

The disc contains two areas of relatively greatly reduced thickness (Fig. 11): (1) the area between the anterior surface of the condyle and the posterior slope of the eminence, and (2) the area between the medial pole of the condyle and the medial wall of the fossa. The thickness of the disc could be reduced approximately 50 per cent at the thinnest points measured when under pressure.

A photograph made of the disc with light coming through its body shows the thin parts (Fig. 12). The two thin parts of the disc correspond to the two articulating surfaces of the condyle.

TRANSVERSE ROTATION

Rotational movement of the mandible evidently takes place about the medial pole contacts. The condyles maintain contact while their anterior surfaces slide within the curvature of the disc. This interpretation of the hinge movement of the condyles accounts for the regularity with which the axis of rotation can be ascertained. If the condyle made only the anterior contact during hinge arc rotation and that contact was maintained by muscles, then the irregularity of the osseous form of the condyle and the intermittency of muscular contraction would hardly permit relatively consistent success in hinge axis determination.

PERFORATIONS OF ARTICULAR DISCS

The greatest evidence of wear, deterioration, or traumatic injury in approximately 100 skulls* that I examined was at the medial pole of the condyle. The other three bearing areas were generally smooth and unaffected. Dr. deVere† states that he has seen very few perforated discs. Those that were seen were perforated close to the contact of the medial pole of the condyle with the medial wall of the mandibular fossa. Since this point had thus far been overlooked as a bearing surface, these perforations were often interpreted as dehiscences or the result of pathologic conditions within the joint cavity.

It is conceivable that the medial pole of the condyle, because of its small diameter, is especially vulnerable to injury. The thin layer of cortical bone once injured could present a rough, eroded surface and subsequently cause damage to the disc. A condition of this nature, by widening the intercondylar distance, would affect the stability of the joint by failing to prevent distal and cranial movement of the condyle under power transmission. Damage of this nature could well explain the symptoms and observations of disturbed temporomandibular joints.

ARTHRODIAL AND GINGLYMUS COMPONENTS OF THE TEMPOROMANDIBULAR JOINT

Joint stability exists only when both condyles are in the well-buttressed position as described. When either or both condyles are out of position, the force of

*Skulls obtained from C. A. deVere.
†deVere, C. A.: Personal communication.

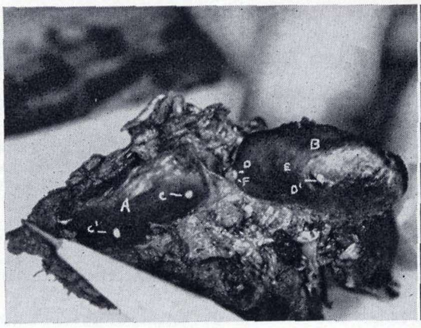

Fig. 11.

Fig. 12.

Fig. 11.—The left articular disc, *A*, is peeled away from the condyle, *B*. *C* and *C'*, Represent the thinnest parts of the disc. *D* and *D'*, Indicate the corresponding surface on the condyle when the disc is in its proper position. *E*, The anterior surface. *F*, The medial pole on the condyle.

Fig. 12.—A transilluminated articular disc shows an elongated thin region. This is the same disc as seen in Fig. 11. The narrow end with its very thin center is the part of the disc that is interposed between the medial pole of the condyle and the articular facet. The wide end is interposed between the anterior superior surface of the condyle and the articular eminence.

or balancing side bracing.

power transmission must be opposed by muscles and ligaments. Therein lies the arthrodial component of the temporomandibular joint which constitutes a part of the masticatory function.

The minute by minute unimpeded closures that take place during swallowing constitute the most demanding activity of the temporomandibular joint. This activity normally occurs with the condyles in the position of stability and represents the ginglymus element of temporomandibular function.

CONCLUSIONS

1. The temporomandibular joints possess the necessary osseous conformation to position the mandible in a stable location during power transmission.

2. The muscles and ligaments which activate and limit movements of the temporomandibular joints have the same functions as their counterparts in other joints of the body.

3. An anatomic conformation of the medial wall of the mandibular fossa, hitherto undescribed, has been identified as a facet with a raised craniodorsal border. This facet is a point of bearing or articulation for the medial pole of the condyle.

4. In hinge movement of the mandible, the pivoting point is the articulation between the medial poles of the condyles and the condylar articular facets, while the anterior surface of the condyle rotates within the disc.

5. The condyles are normally seated in their positions of stability under power transmission which occurs during unimpeded power closure. The anterior surface of the condyles is pressed against the posterior slopes of the articular eminence, and the medial poles are pressed against the condylar articular facets on the medial walls of the mandibular fossae. In this bone-directed position, the muscles are always alert to prevent dislocation by intolerable forces of intensity or direction.

REFERENCES

1. Dempster, W. T.: Anthropometry of Body Action, Ann. N.Y. Acad. Sc. **63**:557-585, 1957.
2. Steinhardt, G.: Untersuchungen über die Beanspruchung der Kiefergelenke und ihre bewelglichen Folgen, Deutsch Zahn **88**:91, 1934.
3. Sicher, H.: Oral Anatomy, St. Louis, 1949, The C. V. Mosby Company.
4. Sicher, H.: Functional Anatomy of the Temporomandibular Joint, *in* Sarnat, B., editor: The Temporomandibular Joint, Springfield, Ill., 1951, Charles C Thomas, Publisher, chap. 1, pp. 3-40.
5. Aprile, H., and Saizar, P.: Gothic Arch Tracing and Temporomandibular Anatomy, J.A.D.A. **35**:256-261, 1947.
6. Posselt, U.: Studies in the Mobility of the Human Mandible, Acta odont. Scandinav. **10**:19-160, suppl. 10, 1952.
7. Boucher, L. J., and Jacoby, J.: Posterior Border Movements of the Human Mandible, J. Pros. Den. **11**:836-841, 1961.
8. Zola, A., and Rothschild, E. A.: Condyle Positions in Unimpeded Jaw Movements, J. Pros. Den. **11**:873-881, 1961.
9. Ärstadt, T.: The Capsular Ligaments of the Temporomandibular Joint and Retrusion Facets of the Dentition in Relationship to Mandibular Movements, Oslo, 1954, Akademisk Forlag, p. 59.

120 Central Park South
New York 19, N. Y.