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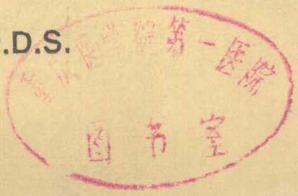

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PREFACE

A CONFUSING IDEA about temporomandibular function permeates the dental literature—the idea that the mandibular condyle, with an interposed meniscus, articulates with the temporal bone. This, of course, is the way it looks when viewed radiographically. For many years, however, it has been evident that this joint is not that simple.

Since 1949,[1] the temporomandibular joint has been described as a true compound joint composed of a lower hinge portion that slides against the articular eminence above. Since 1951,[2] collateral ligaments attaching the articular disc to the condyle have been recognized. Since 1964,[3] it has been known that the articulating parts of this joint, like all other synovial joints, must remain in sharp contact at all times in order to function normally. Why, then, should this joint be so poorly understood?

The purpose of this book is to dispel the mystery that has bred confusion, and some controversy, in the management of masticatory complaints. The objective is to portray as clearly as possible the principles of biomechanics that govern this joint, to refine them in the light of experimental documentation, and to bring them into a clinical setting that can serve as a better foundation for the diagnosis and treatment of complaints in this important area.

One key to understanding masticatory function is that the articular disc is not a passive meniscus separating the articulating bones, as in the knee joint. Rather, it is an active, dynamic part of the joint, serving as a third bone in a true compound joint. Attached to the lateral poles of the mandibular condyle by collateral ligaments, the articular disc is powered to function independently of both condyle and temporal bone—an anatomically unique and functionally distinctive feature of the temporomandibular joint. This structure rotates anteriorly (by the superior head of the lateral pterygoid muscle) when the condyle moves posteriorly during power strokes and maximum intercuspation. It rotates posteriorly (by action of the elastic su-

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[1]Sicher H.: *Oral Anatomy*. St. Louis, C.V. Mosby Co., 1949.

[2]Sicher H.: Functional anatomy of the temporomandibular joint, in Sarnat B.G. (ed.): *The Temporomandibular Joint*. Springfield, Ill., Charles C Thomas, Publisher, 1951, pp. 3–40.

[3]Sicher H.: Functional anatomy of the temporomandibular joint, in Sarnat B.G. (ed.): *The Temporomandibular Joint*, ed. 2. Springfield, Ill., Charles C Thomas, Publisher, 1964, pp. 28–58.

perior retrodiscal lamina) when the condyle moves anteriorly into the forward phase of translatory cycles. The independent movements of this "third bone" are not incidental; they are necessary functions—necessary to maintain sharp contact between the articulating parts of this synovial joint and thus ensure normal joint function. This is significantly different from the conventional concept of articulation of bone against bone with an interposed meniscus. It brings the disc alive in its true functional role in masticatory movements. Surely a more lucid understanding of joint function and dysfunction will evolve as this concept of articular disc action becomes better understood, for in it lies many answers to the peculiar symptoms and antics that this joint displays, to the bewilderment of dentists everywhere.

The method of diagnosis and treatment embodied in this book rests on fundamental biomechanics originally conceived in large part by Harry Sicher. Although some earlier concepts have undergone modification, others have been reinforced by experimental evidence, especially in the field of muscle physiology. This concept of management has evolved during 40 years of clinical practice. Time has refined it to its present form.

It is my earnest wish that these principles and guidelines may help others find a way toward more effective clinical management of temporomandibular disorders.

WELDEN E. BELL

CONTENTS

1 / A Problem for Clinical Dentistry

THROUGHOUT HISTORY, and even today, temporomandibular complaints have been troublesome for doctors to manage well. First medical doctors and subsequently dentists have tried to cope with such problems. On the whole, however, clinical results have been less than satisfying. Frequently the patient is disappointed and the doctor is frustrated. But the accumulation of scientific knowledge about the structures and mechanisms involved has been quite satisfactory. It appears, therefore, that the difficulty lies not so much in lack of basic knowledge as in failure to apply that information at a clinical level.

DEFINING THE PROBLEM

Disorders of the masticatory system are the very substance of dentistry. Clinical management of the dentition proper comprises the major day-to-day duties of the practicing dentist. Management of the masticatory system, however, does not end with the presence, normal structural form, proper alignment, and harmonious occlusion of teeth. The dentition proper represents only the working ends of the apparatus, the tools by which mastication is accomplished, not the system itself.

Prehension, incising, grinding, and swallowing foods are vital body functions. The same is true of respiration and speech, in which the oral structures participate importantly. The mechanisms of oral communication and orofacial expression make social intercourse pleasant and profitable. Chronologically, the oral cavity is the initial organ of sexual expression and throughout life never completely loses this emotional association. The mouth and orofacial structures constitute a region of unusual emotional significance that remains sensitive to threat and responsive to clinical management.

The masticatory system is a complex one indeed. During the many patterns of action required for the preparation of food prior to deglutition, the intricate mechanics involved in the articulation of tooth surfaces (occlusal function) is a study in itself. Mastication calls on an integrated and precisely coordinated biologic system of bones, joints, ligaments, muscles, vessels, nerves, and glands that extends from the lips to the larynx and from the teeth to the esophagus. This system can be affected by disorders and com-

plications without number. It is the purpose of this book to consider in depth one group of disorders of this complex system: the so-called temporomandibular disorders.

More precisely, the objectives of this book are:

1. To consider the anatomical and physiologic factors involved in normal functioning of the masticatory apparatus, other than occlusion per se.
2. To consider departures from normal structural and functional behavior of the masticatory apparatus, other than problems of occlusion per se.
3. The clinical identification of such departures from normal.
4. To establish guidelines for the clinical management of temporomandibular disorders that constitute such departures from normal.

Historical Background

The historical record of the clinical management of temporomandibular disorders is colorful indeed. Many patients with complaints of this type have found themselves in a medical no-man's-land, in that orthopedists have seemed unable to grasp the full significance of masticatory physiology or cope with its impact on disorders of this type, and dentists who undertake management do so without benefit of adequate training and experience in orthopedic medicine. In retrospect, it appears that this clinical dilemma is really a spinoff from the unfortunate separation of the two professions.

In 1934, the otolaryngologist Costen[1] drew attention to the syndrome that bears his name by concluding that lost vertical dimension in the chewing apparatus was chiefly responsible for the complaints. It was a case of astute observation from which an improper conclusion was drawn. Costen correctly observed that disengagement of the occlusion did benefit many of his patients, just as the restriction of traumatic activity in general is known to ameliorate other types of orthopedic complaints. From this observation, however, he improperly assumed that the disengaging material placed between the teeth yielded benefit *because it opened the bite*. He concluded that the chief cause of the complaint was a "closed bite." As a result, the treatment in vogue for many years was the empirical application of various forms of bite-raising dental procedures.

Although the expected results were disappointing, the belief that occlusion is the key to temporomandibular complaints dominated dental practitioners' thinking until the present. Thus, preoccupied as the dental profession has been with occlusion as the dominant etiologic factor and occlusal therapy as the chief form of treatment, the gap between the professions has widened until the problem has come to rest in the lap of dentistry. Unfortunately, most practicing dentists, untrained in orthopedics and un-

schooled in diagnostic techniques, have not been able to manage the problem effectively, nor has the dental educational system met the challenge thus presented.

Temporomandibular therapy since the time of Costen has been largely empirical and oftentimes controversial. Different modalities of treatment have dominated at different times. The profession has witnessed a host of temporarily popular procedures, such as bite-raising, injection of sclerosing solutions into the joints, rehabilitation and reconstruction of the dentition, use of occlusal pivots, surgical removal of the articular disc, occlusal equilibration, use of interocclusal appliances, orthodontics, surgical condylectomy, physiotherapy, injection of cortisone into the joints, muscle relaxant therapy, psychotherapy and tension control, surgical repair of displaced articular discs, and applied kinesiology. Most forms of therapy have concentrated on a particular component of the masticatory apparatus: the dentition, the joints, the musculature. The popularity of any particular treatment modality seemed to bear little relationship to the considerably more orderly accumulation of basic scientific knowledge of the masticatory system. *Important as the dentition is with regard to masticatory function and dysfunction, the passing of time has demonstrated that there is no substitute for a full understanding of the entire masticatory system.* The historical, controversial management of such disorders likely stems from consideration of single components of the masticatory apparatus without regard for the whole system as a functioning unit. History should teach that it is expedient to go back to basics and assimilate on a clinical level the mass of scientific knowledge that has been available for many years, and which should be the basis for the rational diagnosis and effective treatment of temporomandibular disorders.

Prior to Costen's work, anatomists described the structures of the joint in general terms, with little reference to masticatory function. With the publication of his *Oral Anatomy* in 1949,[11] Sicher emerged as the dominant figure. His book provided accurate descriptions of the components of the masticatory apparatus, correlating the anatomical structures with the requirements of function. In 1954, Rees, the British anatomist, added to Sicher's brilliant work.[10] Had Rees lived to note the later work of Krogh-Poulsen and Moelhave in 1957,[5] perhaps some of the confusion of recent years might not have taken place at all. Du Brul[3] has added significantly to Sicher's monumental work.

During this same period, giant strides were made in the understanding of the evolution, embryology, growth and development, functional remodeling, and histopathology of the masticatory apparatus. For this, the profession is indebted to many dedicated researchers from a variety of disciplines.

A better understanding of pain mechanisms and muscle physiology has contributed significantly to the knowledge of masticatory dysfunctions and disorders. The muscular genesis of pain, the secondary effects of deep pain, the modulation of pain impulses, and the discovery of an endogenous antinociceptive system have opened new avenues of thought on masticatory pains. Electromyographic studies have done much to elucidate muscle function, to isolate and identify the action of specific masticatory muscles with the different jaw movements, and to augment the comprehension of what takes place in the process of incising and grinding foods.

More uniform terminology, improved classification of orofacial pain syndromes, more accurate categorization of temporomandibular disorders, and enlightened examining techniques have streamlined the clinical task of identifying disorders of the temporomandibular joints and masticatory musculature. The accumulation of clinical data on etiologic factors, particularly those relevant to abusive habits, bruxism, emotional stress, trauma, and occlusal discrepancies, has given better insight into cause and prevention. Interdisciplinary cooperation in management is doing much to develop guidelines for a rational approach to the whole problem.

There is now a sizable mass of reliable, factual, scientific information available to researchers and clinicians alike. Using this information, unified concepts of normal masticatory function can be formed, criteria for the recognition of masticatory dysfunctions can be established, and effective measures to alleviate temporomandibular complaints can be developed. There is no longer any valid reason for divisive, conflicting, and mutually exclusive concepts of what constitutes normal masticatory function. Purely empirical and trial-and-error therapy are no longer justifiable. Precise differential diagnosis and rational, predictable treatment methods can bring management of most temporomandibular disorders within the grasp of knowledgeable practitioners of dentistry.

Responsibility for Management

Ordinarily, complaints involving the masticatory system are presented to the dentist directly by the patient or by the referring physician on the assumption that they relate to the dentition. Some complaints are not attended by pain or discomfort, the disorder being wholly that of dysfunction. Such complaints include (1) restriction of jaw movement that interferes with opening the mouth or making usual chewing movements, (2) abnormal noises or strange sensations during jaw movements, and (3) a sudden alteration in the bite. Some complaints consist of pain only—discomfort with chewing and jaw movements. Most complaints, however, have components of dysfunction and pain in myriad combinations. The management of all such complaints involves diagnosis and treatment.

DIAGNOSIS.—It is a serious mistake to assume that the presenting symptoms automatically indicate the proper category into which the particular complaint should fall. Nor do they signify the seriousness of the problem or responsiveness to treatment. It is the responsibility of the examining dentist to make a diagnosis prior to undertaking definitive treatment. An accurate diagnosis is the first step in the treatment of any disorder, and the process cannot be abridged.

The diagnosis of disorders of the masticatory system requires the services of a dentist knowledgeable in pain and oriented toward masticatory function. Only he has the training and expertise to trace pain sources and judge masticatory function. It is the professional obligation of every dentist who undertakes the management of such disorders to make himself proficient in these areas.

A diagnosis should (1) identify and classify the disorder properly, (2) establish the reason for dysfunction and the source of pain, (3) determine the etiology, if at all possible, and (4) provide a basis for prognosis in the light of effective therapy.

TREATMENT.—Although the dentist is responsible for the diagnosis, subsequent treatment may or may not rest in his hands. If etiologic factors in the case are exclusively related to conditions amenable to dental treatment, then the responsibility for therapy should remain the dentist's. Interdisciplinary dental cooperative effort, however, may be needed to ensure a successful outcome. Some temporomandibular disorders are associated with conditions that are not responsive to dental treatment measures. Management of these conditions should be done by an appropriate medical practitioner or by a cooperative interdisciplinary team.

Preliminary consultations prior to definitive therapy may do much to smooth the clinical course and ensure the outcome of complex masticatory conditions.

SYNOVIAL JOINTS

The word *articulation*, meaning the place of junction between two discrete objects, is used in orthopedic nomenclature to designate the place of union or junction between two or more bones of the skeleton. Such articulations are commonly called *joints*. Joints are classified as *synarthrodial* or *diarthrodial*.

In *synarthrodial or fibrous joints*, the parts are united by fibrous tissue. When the intervening fibrous tissue is continuous, the joint is referred to as a *suture*. Some common sutures are those of the cranial bones and the pubic symphysis. When the bones are connected by ligaments only, the joint is referred to as *syndesmosis;* an example is the tibiofibular articula-

tion. When the fibrous joint is composed of a conical process inserted into a socket-like portion, it is referred to as *gomphosis*. The teeth in the alveolar process form such a joint.

Diarthrodial joints are discontinuous articulations that permit greater freedom of movement between the united parts. The articulating surfaces are composed of a tissue able to sustain compression and movement simultaneously, a condition that precludes the presence of blood vessels and nerve receptors in the pressure-bearing areas. Metabolic and nutritional requirements of such nonvascularized tissue are provided by surface contact of joint fluid, called *synovial fluid*. The presence of synovial fluid requires that the articular surfaces be encapsulated to confine it. The inner surface of the capsule is composed of a specialized connective tissue that secretes the synovial fluid, the *synovial membrane*. Because of this structural arrangement imposed on movable joints by the demands of simultaneous compression and movement, diarthrodial joints are referred to as *synovial joints*. These joints facilitate locomotion in the musculoskeletal system. Synovial joints may be classified as *simple* or *compound*.

Simple synovial joints involve only two bones. They may be structured for flexion and extension only—hinge movement. Hinge joints *(ginglymoid)* have articular surfaces contoured to permit movement in a single plane and are supported by closely placed collateral ligaments that resist movement in other planes. The phalangeal joints are of this type. More flexible condyloid joints *(condyloarthrosis)* permit movement in more than a single plane—flexion, extension, abduction (turning outward or laterally), and adduction (turning inward or medially). Such joints present a contouring and ligamentous arrangement compatible with movement in different planes. The metacarpophalangeal articulation of the index finger is of this type. A still more flexible simple joint is the carpometacarpal joint of the thumb. Some synovial joints are structured to permit sliding movement between the united parts *(arthrodial)*, the surfaces being flat or slightly curved and unrestrained by closely placed ligaments. Some joints have a ball and socket arrangement *(enarthrosis)*, such as the hip joint.

Compound synovial joints involve three or more bones. When the sliding movement is quite limited, the term *amphiarthrosis* applies. This movement is seen in intercarpal, carpometacarpal, and intermetacarpal joints. Pivotal movement is termed *trochoid* and is seen in the elbow during pronation and supination of the forearm. Compound joints may be structured chiefly for hinge movement, such as the knee joint. Others have complete freedom of movement, such as the elbow joint, in which flexion, extension, abduction, adduction, and trochoid movement are possible.

Structural Characteristics of Synovial Joints

ENCAPSULATION.—The fibrous capsule is attached near the periphery of the articular surfaces. One can usually identify this attachment area on the dry bone, the surface thus enclosed being the nonvascularized pressure-bearing portion and indicative of the articular surface.

The capsule is well vascularized and innervated. The vessels supply the tissue fluid, which has free metabolic interchange with the synovial fluid within the joint cavity. The synovial membrane that secretes the synovial fluid lines the inner surface of the fibrous capsule and may overlie slightly the articular surfaces peripherally, especially if the articular body is convex. The synovial fluid supplies the nutritional and metabolic requirements of the nonvascularized tissues within the capsule. It also serves as joint lubricant and furnishes phagocytic capability. It fills the joint cavity. The capsule is innervated by sensory receptors for proprioceptive monitoring and conscious sensibility.

ARTICULAR SURFACES.—The articular surfaces of synovial joints are composed of a thin layer of hyaline cartilage which, except in the peripheral areas, is nonvascularized and noninnervated. This is referred to as *articular cartilage*.

LIMITATION OF JOINT MOVEMENTS.—The type, direction, and extent of movement of a joint during normal functioning is restricted by several factors:

1. Shape and structural relationship of the moving parts.
2. Size and location of the articular surfaces or facets.
3. Location and structure of the fibrous capsule.
4. Location, length, and structure of collateral ligaments.
5. Location and structure of other supporting articular ligaments.
6. Location and structure of check ligaments.
7. The stretching length of muscles that power the joint.
8. The presence of other structural restraints, such as surrounding tissues.

JOINT STABILITY AND MOVEMENT.—Normally, the articular surfaces of a synovial joint remain in sharp contact at all times. Separation of such articular surfaces constitutes luxation or dislocation. Sharp contact of the articular surfaces in the resting condition of the joint results from muscle tonus as modified by the effect of gravity. Positive gravitational force, as in weight-bearing joints, increases such contact. Negative gravitational effect, as for example in shoulder joints, stimulates the muscle spindles and re-

flexly increases muscle contraction, thus maintaining continuous sharp contact of the articular surfaces. Stability and movement are the product of muscle action, the type and range of useful movement being determined by integrated muscle activity, as limited by the structural factors that restrain joint movement (mentioned above). *All synovial joints are pressure-bearing joints*. It is the combination of simultaneous compression and movement that determines diarthrodial joint structure. The degree of pressure varies according to the demands of function.

MENISCUS.—A meniscus (from the Greek *meniskos*, meaning "crescent") is a wedge-shaped crescent of fibrocartilage or dense fibrous tissue, one side of which forms a marginal attachment at the articular capsule and the other two sides extend into the joint cavity and end in a free edge. The structure does not divide the joint cavity into separate compartments, nor does it restrict or confine the synovial fluid. It facilitates movements of the bony parts but does not act as a true articular surface, in that it is not a determinant of that movement. Two such structures are found in the knee joint, the medial meniscus attaching to the medial margin of the superior articular surface of the tibia and the lateral meniscus attaching to the lateral margin of the superior articular surface of the tibia.

SPECIAL FEATURES OF CRANIOMANDIBULAR ARTICULATION

The craniomandibular articulation consists of two synovial (true diarthrodial) joints, the right and left temporomandibular joints. These joints have characteristics that are not shared by all other synovial joints. It is essential that these special features be recognized and appreciated.

Phylogenic Heritage

Costen's syndrome included several symptoms, some clearly auricular, some temporomandibular. His therapy, which was unmistakably masticatory, seemed also to alleviate the auricular component of the complaint. Anatomists, however, insisted that the joint and ear symptoms be delineated, thus dividing the syndrome into two parts. Treatment of the ear portion remained to otolaryngologists, while treatment of the masticatory portion was allotted to dentists. It is interesting to note, however, that in due time researchers established an intimate structural relationship between the ear and the joint.

The mandibular joint of lower animal life has undergone considerable change, especially from the amphibia through the mammal-like reptiles (Fig 1–1).[2] In the mammal, the primitive jaw articulation of the lower ver-

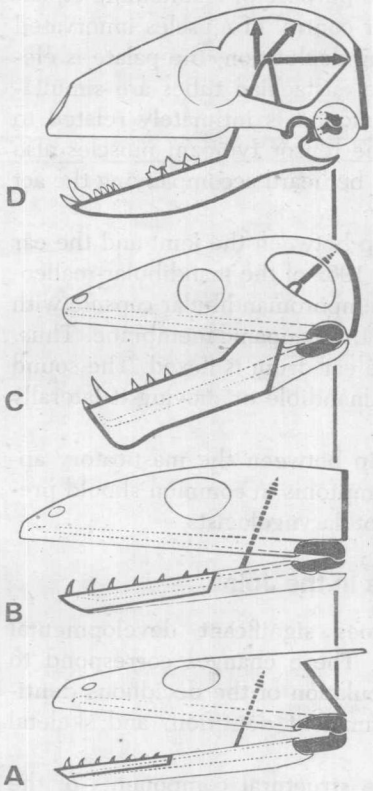

Fig 1–1.—Evolution of mammalian jaw joint. Back of skull and dentary bone in *heavy outline. Arrows* indicate muscle vectors. *A,* amphibian. Note notch on rear skull margin and muscle attached on undersurface of skull roof. *B,* reptile. Note increase in dentary bone and straight rear skull margin. *C,* mammal-like reptile. Note great increase in dentary bone with coronoid process and opening in skull roof (temporal fossa). *D,* mammal. Note dentary bone new contacts skull, forming the dentary-squamosal (temporomandibular) joint—an entirely new jaw joint. The primitive jaw articulation now forms the malleolar-incus joint of the ear ossicles. (From Du Brul E.L., in Sarnat B.G., Laskin D.M. (eds.): *The Temporomandibular Joint,* ed. 3, 1979. Courtesy of Charles C Thomas, Publisher, Springfield, Ill.)

tebrates is located in the middle ear as the articulation between the malleus and incus bones. The temporomandibular joint is phylogenically recent and peculiar to mammals.

In the important development of the craniomandibular articulation over eons of time, certain structures of the ear and temporomandibular joint became intimately related. The tensor tympani muscle, which flexes the tympanic membrane (arising from the cartilaginous portion of the eustachian tube and inserting into the malleus bone), is innervated by the mandibular division of the trigeminal nerve, which also innervates the masticatory muscles. Likewise, the tensor palati muscle, which elevates the palate and opens the eustachian tube by straightening it (arising from the sphenoid bone and wall of the eustachian tube and, after passing around the hamular process of the pterygoid bone, inserting into the aponeurosis of the soft palate), also is innervated by the mandibular division of the trigeminal nerve. Thus, the eustachian tube, which connects the cavity of

the middle ear with the nasopharynx for the purpose of maintaining equalized air pressure on the ear drum, is under control of muscles innervated by nerves that subserve mastication. During deglutition, the palate is elevated to valve off the nasopharynx and the eustachian tubes are simultaneously opened. Thus, normal auditory function is intimately related to masticatory function. At the same time, the tensor tympani muscles also flex the ear drums, the sound of which may be heard accompanying the act of swallowing.

Another interesting structural relationship between the joint and the ear was brought to light by Pinto's discovery in 1962 of the mandibular-malleolar ligament.[9] This structure connects the temporomandibular capsule with the malleus bone, which in turn attaches to the tympanic membrane. Thus, when the condyle is translated forward, the ear drum is flexed. The sound of flexion can be heard by protruding the mandible or moving it laterally from side to side.

The structural and functional relationship between the masticatory apparatus and ears is intimate indeed, and symptoms in common should present no surprise or problem to dentists or otolaryngologists.

Chronological Changes in the Joint

The temporomandibular joint undergoes significant developmental change from infancy to skeletal maturity. These changes correspond to edentulousness at birth, eruption and articulation of the deciduous dentition, eruption and articulation of the permanent dentition, and skeletal maturation of the maxillary bones.

Although the joint at birth displays the structural components of the adult joint (Fig 1–2), it lies in line with the occlusal plane rather than an inch or more superior to it, as in the adult jaw (Fig 1–3). The articular eminence is low, the fossa is relatively flat, and hinge movement is the normal type of action. These features at birth are quite similar to the joints of carnivores. Throughout fetal life, the fibrous articular surfaces and interposing disc are vascularized and innervated. This state disappears as function induces compression of the disc between the condyle and temporal bone.[7] The growth changes that take place from birth to maturity are great.

The growth process is complex indeed and not completely understood. As the mandible moves forward and downward, its size increases in the opposite superior and posterior directions. This involves not only condylar growth, but also widespread remodeling of the entire bone, as resorptive and depository activity takes place. As the ramus grows posteriorly, the condyle simultaneously grows posteriorly and superiorly by active endochondral osseous proliferation. Intramembranous growth processes likewise take place throughout the osseous structures.