Evolution, Epidemiology and Etiology of Temporomandibular Joint Disorders

Sujata M Byahatti

Reader, Department of Oral Medicine and Radiology, Maratha Mandals NG Halgekar College of Dental Sciences and Research Center, Belgaum, Karnataka, India

Correspondence: Sujata M Byahatti, Reader, Department of Oral Medicine and Radiology, Maratha Mandals NG Halgekar College of Dental Sciences and Research Center, Plot No. 49, Sector No. 9, Malamaruthi Extension, Belgaum-590016, Karnataka, India, e-mail: sujatabyahatti@rediffmail.com

ABSTRACT

The temporomandibular joint (TMJ) is unique to mammals, but among different mammalian groups, its morphology and function vary enormously. It is likely that various species show less loading of jaw joints during chewing than humans do. It took approximately 130 million years for the evolutionary process to stabilize this composite, basic vertebrate head skeleton to the jaws. Very little documentations are noted on anthropology of TMJ. When it is concerned with epidemiology, temporomandibular disorders (TMDs) have a number of consistent findings and various causative factors that can contribute to TMDs. The aim of the following article is to provide detailed information regarding its evolution, epidemiology and various causative factors leading to TMDs.

Key Message: The masticatory system is extremely complex.

Keywords: Temporomandibular joint, TMDs, Epidemiology, Biomechanics, Animal, Mastication.

INTRODUCTION

TMJ is a unique joint in which translatory as well as rotational movements are possible, and where both the ends of bone articulate in the same plane with that of other bone. It is also called as ginglymodiarthroidal type of joint wherein it has sliding movement between bony surfaces, in addition to hinge movement, common to diarthroidal joint.1

Jaws and jaw joints hold a particular importance in the history of vertebrates. Comparative studies of many different species have also documented to understand the idea of perpetual change over time. Complicating features of jaws and their joints leading to those of mammals have derived by selective playing with adaptive modifications of several original elements.2 The following article provides detailed information regarding its evolution along with the epidemiology and etiology of TMDs.

DISCUSSION

The masticatory system is extremely complex. It is primarily made of bones, muscles, ligaments and teeth. Movement of mandible needs coordination between them to maximize function and minimize the damage to surrounding structures. This movement occurs as a complex series of interrelated three-dimensional rotational and translational activities, which is determined by combined activities of both TMJs. This complex biomechanics of TMJ makes it difficult to understand the insight of temporomandibular joint.3

Temporomandibular joint (TMJ) is a cardinal feature that separates mammals from other vertebrates. As befits its late evolutionary origin, the TMJ also makes a tardy developmental appearance.4

The TMJ is interesting because of its constituent bones, mandible and squamous temporal, which are intramembranous in origin. Thus, the tissue that covers each articulating surface is a secondary cartilage with a fibrous skin derived from the perioisteum. Another nearly constant feature is the intra-articular disk. The disk, even when incomplete, is associated with the lateral pterygoid muscle,5 which has led some authors to speculate that it arose as a tendon, which later formed the new joint.6

Origin of the Vertebrate Head

A complete vertebrate is a species not only with backbone but also with biting jaws. The first vertebrates had no biting apparatus but the process of cephalization also produced the singular structures called the jaws. Furthermore, complete mammals have long been distinguished from all other vertebrates and from animals very nearly mammalian largely on the basis of their jaw ear structure. However, there is an even greater significance to jaw joints in vertebrate evolution. The true diarthrodial joint was first formed in fishes, and its basic structure remained essentially unchanged when it was appropriated by the limbs of land animals.

Diarthroganathus7 and Probainognathus8 have contact between two bones, squamosal and dentary, which form the jaw joint in mammals.

Diarthroses are the most complex joints with a wide single articular cavity surrounded by a specialized sleeve lined with a synovial membrane.2 Schizarthrosis are joints made more mobile by several small separated splits or joint spaces interrupting their bonding tissues. The simplest joints are synarthroses in which the parts are made slightly movable by a binding of cartilage, fibrocartilage or connective tissue between them.2

Evolutionary Stages

The primary jaws were modified gill arches that were connected at their caudal ends by a simple hinge joint. There was an obvious mechanical deficiency in this sort of arrangement because the joint was left hanging-free, protruding slightly on each side like
bowlegged elbows of a primitive reptile within the body wall. The jaws were further strengthened, stiffened and protected by the armor of numerous dermal bony plates plastered to their outer surface. Some of their bones at the edge of the mouth also developed teeth. These outer tooth bearing plates braced by adjacent dermal bones are known as secondary jaws. However, the primary jaws still formed the single joint on each side for the entire jaw complex.

Despite its status as a mammalian identifier, the TMJ shows remarkable morphological and functional variation in different species, reflecting not only the great mammalian adaptive radiation in feeding mechanisms, but also freedom from constraints, such as bearing body weight. The most extreme evolutionary variants include: (1) loss of the synovial cavity in some baleen whales; (2) loss (or possibly primitive absence) of the disk in monotremes, some marsupials, and some edentates (anteaters and sloths); (3) variations in the orientation of the joint cavity from parasagittal (many rodents) to transverse (many carnivores); and (4) reversal of the usual convex/concave relationship so that the mandibular condyle becomes the female element. In addition, the relative size of the joint is exceedingly variable. Soft tissue details, such as capsular ligaments and collagen orientation in the disk are also highly species specific. The striking anatomical differences in TMJs are clearly tied to biomechanics. The features mentioned above are either correlates of loading (e.g., size of articular surfaces) or movement (e.g., orientation of the joint) or both.

Loading of the TMJ is a reaction force arising from the contraction of jaw muscles; its magnitude depends strongly on the position of the bite point relative to the muscle action line. The evolution of the TMJ is thought to have coincided with a period of low reaction loads with higher loading having evolved repeatedly in different lineages, including our own. Rodents fall in the category of minimal TMJ loading, especially during chewing. In contrast, carnivores such as dogs probably sustain TMJ loads that are higher than those in primates. Complex movement in three planes of space is also a primitive characteristic of TMJ, at least if embryology is any indication but there is no uniformity in how movements are accomplished. Opening of the jaw usually involves a combination of forward sliding and rotation around a transverse axis, but some carnivores have lost the ability to slide and some specialized anteaters instead use a rotation around the long axis of the curved mandible. Similarly, transverse movement is usually accomplished by moving one condyle forward and the other one backward, but carnivores use a combination of lateral sliding and rotation around the long axis of the mandible.

Amphibia

The single joint for the double jaws (Figs 1A to C). The jaws of these creatures were used only for protection. The skull became kinetic, new movable joints appeared within the cranium. This ingenious device was a shuttling pterygopalatine component coordinated with joints between the frontal and nasal bones. Proliferation of loose, movable parts imparts the architectural stability of the skull. This kinesis has disappeared in the crania of reptiles, such as turtles and crocodiles those feed in water.

In the carnivorous Pelycosaurs, with which we are more directly concerned since they include the ancestors of all the later mammal-like reptiles and so of the mammals, the teeth are all of a simple blade-like form. They have distal and mesial cutting edges, often serrated like a bread saw. This demonstrates that the sharpening of the teeth by direct tooth-to-tooth contact, which is so important in there in mammals, did not take place in these mammal-like reptiles.

The skull of a primitive amphibia tends to be long, wide and remarkably flat. The first notable change from the amphibian structure was the disappearance of the otic notch that supported the tympanum of the primitive ear. The teeth began to lose their continuity of repetition that is different segments along the dental line developed teeth of different sizes and incipient functions.

Reptilia

Reptiles cannot chew. In general, they use their teeth only to seize their prey, and if this cannot be swallowed whole, it is torn apart by a number of animals or by a single animal ‘worrying’ it. The
A group of reptiles which later gave rise to mammals - the ‘mammal-like reptiles diverged at an early stage from the main reptilian stem, and by the Permian, some 250 million years ago, were widespread and might reasonably be regarded as the ‘Lords of Creation’. Later their place has been taken by the dinosaurs, which remained the dominant group until the latest Cretaceous. The mammal-like reptiles did not, however, quite disappear. Small members of the group survived, perhaps in areas where there was insufficient food for the large dinosaurs, or by eating items of food too trivial for their notice. In this group of tiny mammal-like reptiles, a number of changes took place, all probably associated with the acquisition of the ability to maintain a body temperature above that of their surroundings. This increased their activity and their ability to avoid their enemies, but it carried the penalty that it vastly increased the food requirement.17

Reptilia have loss of bony parts (Figs 2A to D). In the Pelycosauria, the lower jaw is of an essentially reptilian form. The tooth bearing bone or dentary has a strictly limited extension distal to the tooth row; the other bones of the jaw are well-developed and comprise the posterior third of the jaw. The quadrate—the skull bone which forms with the articular in the lower jaw, the jaw hinge, is a large bone with a considerable dorsoventral extension.17

Mammalian Architectural Theme
The viscerocranium provides roofs and walls to the upper food way, the neurocranium houses the brain whereas the mandible is a long, straight, level bar with its fulcrum, the jaw joint at the backend. The mandible walls the upper food way, which is roofed above by the palate and floored below by a muscular hammock hung between the bony bodies of both sides. This is the basic characteristic of mammalian skull, from it, two adaptive feeding modifications labeled carnivores as opposed to herbivores exist.2

The early American forms are grouped as the Pelycosauria, comprising carnivorous, piscivorous and herbivorous forms. The herbivores are of interest as they were the first group of vertebrates to exploit plant life directly as food. The specialization of the teeth and masticatory apparatus is such in herbivorous forms that their capacity for further evolution is limited, so that major evolutionary changes are always initiated by carnivorous or insectivorous forms.17

Austrolopithecus africanus skull (Fig. 3) is the least differentiated. The jaws protrude sharply housing a short cheek teeth. The upper jaw has outstanding canine buttresses whereas the lower jaw is fairly shallow. The zygomatic arches are quite slender. The teeth are broad, spatulate, bulky and long rooted as they project from their sturdy buttresses.2 Austrolopithecus boisei skull (Fig. 4) is considerably differentiated. The skull dorsum is deeply vaulted in a short asymmetrical arch, the supraorbital ridges are bulky, jaws are severely retracted, no canine buttresses, and massive zygomatic buttresses give the face a “dished” in frontal plane. The teeth are smaller and occlusal surfaces are more than three times greater than in modern man.2

Masticatory Action in Primitive Man
Animals, such as pig, bear, and humans can masticate a variety of foods to a satisfactory degree. It is readily accepted that muscle
attachments in the humans depend upon the functional activity of the individual for their development and that muscle development can reflect the exercise and activity that each muscle experiences.

Modifications of the muscular elements (Figs 5A to C) of the apparatus were evident in the specialization of lateral pterygoid muscle and a decrease in the bulk of temporalis muscle. Bilateral contraction of the lateral pterygoid muscles permitted a modification of condylar movement within the glenoid fossa to include a protrusive excursion. It has been suggested that primitive man’s protrusive movement has merely been a bilateral sequel to the individual forward movement of each blanching condyle during lateral excursions of the mandible.

It must, of course, be remembered that nature has evolved satisfactory modifications over countless periods of time and that adequate adaptation may not be possible in a single lifetime. Indeed, with observation of a wide range of functional activities that have been satisfactorily accommodated by modification of this joint in the animal kingdom, one is drawn to the belief that the lack of time to respond is responsible for masticatory dysfunction in the most cases.

Changes in the masticatory apparatus of primitive man were not only the result of his omnivorous diet, but also of the adaptation of the upright posture that necessitated a change in the position of the head relative to the spine. The inclusion of a protrusive mandibular movement and modification of the associated musculature are characteristics of the hominoid masticatory apparatus.

Epidemiology of TMDs

It is evident from the numerous epidemiologic studies on the occurrence of TMDs in the general population where there are a number of consistent findings. Firstly, signs of TMD appear in about 60 to 70% of the general population and yet only about one in four people with signs are actually aware of or report any symptoms. Furthermore, only about 5% of the population will have symptoms severe enough for them to seek treatment.

Another consistent finding is that of those who seek treatment for TMD, by far the greatest majority is females outnumbering males by at least four to one. It is suspected that TMD affects both males and females in almost equal numbers in general population although females are possibly more likely to seek treatment.

Although, TMD may occur at any age, the most common time of presentation is early adulthood.

The prevalence of TMD signs and symptoms in a large elderly sample was composed of medicare recipients, where the sample size was 429 subjects derived from an eligible sample of 866 subjects. The mean age of the sample was 74.4 years and 42% were males overall, 12% of the subjects reported a history of TMD and 6.5% reported pain with jaw function. Joint noise was documented in 35.2% of the sample, joint tenderness in 8.4%, muscle tenderness in 12.8% and limitation of jaw motion in 22.4%.

In pediatric populations, it has been reported that on a sample of 11 and 15 years subjects, who had been examined for signs and symptoms, the sample was composed of 119 subjects where the point prevalence of subjects reporting one or more symptoms of...
TMD increased with age (35% at age 7, 61% at age 11, and 66% at age 15), 60% of the sample reported one or more TMD symptoms, 66% reported one or more symptoms at age 15.

Etiology

The causes of TMD range from traumatic injury to immune-mediated systemic disease to neoplastic growths to incompletely understood neurobiologic mechanisms. Less common but better recognized causes of TMD are (1) a wide range of direct injuries, such as fractures of the mandibular condyle (2) systemic diseases, such as immune-mediated arthritis (3) growth disturbances and (4) tumors. Some nonfunctional movements of the mandible (bruxing) and tooth clenching habits are clinically associated with a variety of jaw muscle symptoms and associated less clearly with internal joint disk derangements. Chronic parafunctional clenching is suspected of association with chronic TMD and has been shown experimentally to cause acute TMD in human beings. However, these behaviors are not established as causes of TMD and may be propagating factors only. Malocclusion is not established as an important factor in TMD. There is no compelling evidence that orthodontic treatment increases or decreases the chances of developing TMD nor is there any evidence of increased risk for TMD related to any particular type of orthodontic mechanics or to orthodontic treatments with tooth extractions. TMD is also caused by health care manipulations, e.g. holding mouth open wide, prolonging wide opening of mouth, stretching or forcing the mouth open, forcing the jaws shut, relate to routine dental examination, oral endotracheal intubation for general anesthesia, and the entire range of dental services from restorative and orthodontic treatments to tooth extraction to orthognathic surgery. There is no scientific evidence that common or routine dental or medical procedures cause TMD. Orthognathic surgery, orthodontic treatment, prosthodontic rehabilitation and mandibular fracture repairs have been associated with morphologic TMJ changes and worsening of pre-existing TMD.

Diagnosis of TMDs

The gold standard of diagnosis in TMDs consists of (1) patient history (2) physical evaluation, and in the most chronic cases, (3) behavioral or psychologic assessment. This evaluation should include a detailed pain and jaw function history as well as objective measurements of such jaw functions as interincisal opening, opening pattern, and a range of eccentric jaw motions. TMJ sounds should be described and related to symptoms.

CONCLUSION

The different evolutionary stages have made this TMJ as complex structure. Clinical manifestation may not be completely contributory in the diagnosis of TMDs. They need to correlate with standard diagnostic modalities for the confirmation of origin of particular problem. Various etiological factors have made the management of TMDs challenging. Treatments of TMDs are behavioral, psychologic and psychosocial factors rather than physical or structural factors. Poor outcome could be related to depression, somatization, anxiety, and low self esteem. Combination therapy (education, pharmacotherapy, trigger point therapy, physiotherapy and intraoral appliances and relaxation therapy) may be helpful in providing a better outcome.

REFERENCES


