SPECIAL ARTICLE

Orthodontics in 3 millennia. Chapter 13: The temporomandibular joint and orthognathic surgery

Norman Wahl
Sequim, Wash

The temporomandibular joint has always been the practitioner's no-man's land. Who's in charge here? The general dentist, the prosthodontist, the oral surgeon, the otolaryngologist, the psychiatrist, or the orthodontist? Theories about the cause of problems are as varied as the specialties involved. Is the cause anatomic, occlusal, neuromuscular, myofascial, psychological, or multifactorial? In another adjunctive domain, the major early advances in orthognathic surgery were the discovery of anesthesia, the experiences of World War I surgeons, and the refinement of maxillary techniques. (Am J Orthod Dentofacial Orthop 2007;131:263-7)

It is estimated that 5% to 30% of people in the United States have temporomandibular dysfunction (TMD), but this condition is not necessarily a product of modern civilization.[1]

The treatment of temporomandibular joint (TMJ) disorders was recorded as early as 3000 BC. However, it was not until the early 1900s that treatment modalities gained attention in the literature.[2] In 1920, Monson[3] was one of the first to propose that malocclusion was responsible for the encroachment of the condyle on the auditory canal and associated nerve structures. The approved treatment for symptoms that included deafness, headaches, burning sensations in the mouth, and crepitus in the joint itself was restoration of the lost vertical dimension.

In the 1930s, Costen[4] reported treating 165 patients by opening the bite in the molar area to increase the vertical dimension and "bring the condyles down from the glenoid fossa." A group of symptoms, which included neuralgia and otic symptoms, became known as "Costen's syndrome." However, Sicher,[5] through anatomical dissection, finally refuted Costen's claims and, consequently, his rationale of treatment.

Neuromuscular theories

During the late 1930s, various treatment methods, other than alteration of the vertical dimension or the patient's bite, were tried, including injection of various materials (eg, HCI) into the joint cavity to allay pain. In 1940, Dingman (1906-69)[6] was convinced that the single most important factor in preventing damage to the TMJ was restoration of proper occlusion. Schultz (1947),[7] after 10 years' experience treating hypermobility of TMJs, suggested that "lax" ligaments could result in subluxation, so he proposed vitamin C therapy for pain and the injection of sclerosing solutions into the joint to develop scar tissue to restrict jaw movement.

In the 1950s, occlusal adjustment continued to be emphasized. Cobin[8] advocated the construction of occlusal acrylic splints. Early in that decade, even though many investigators relied on adjustment of the occlusion, the joint itself was frequently the center of attention. Schwartz[9] proposed intra-articular injection of hydrocortisone.

Myofascial theories

In 1954, Schwartz backed off from his emphasis on the joint to the possibility that muscle spasms were the etiological factor in limited, painful mandibular movement. Accordingly, he advocated ethyl chloride spray, and the medical terms *myofascial pain syndrome* and *trigger zone* entered the dental lexicon. Sicher[10] agreed with treating the musculature. He wrote that overclosure, premature contacts, and mental tension could lead to overexcitation of the mandibular muscles with trismus and bruxism.

In the 1960s, emphasis was placed on the treatment of muscle spasms rather than on the mechanical and structural aspects. For the deeper muscular structures, ultrasound diathermy, voluntarily avoiding clenching the teeth, biteplate or occlusal splints, and phenobarbital or Valium were recommended to relax the skeletal muscles.

Electromyographic research by Moyers, Perry, and others began a new era in the study of TMJ and muscle

Private practice, Glendale, Calif.
Submitted and accepted, November 2006.
0889-5406/$32.00

doi:10.1016/j.ajodo.2006.11.001

dysfunction.[11] Perry et al[12] showed that dental students subjected to answering rigorous academic questions posed by their dean had increased muscle activity and subconscious clenching compared with a control group. Investigators concluded that emotional stress indeed played a part in masticatory muscle response. However, a recent literature review showed that the clinical determination of TMD does not appear to be enhanced by the use of surface electromyography.[13]

Psychological theories

Schwartz[14] was the first to incorporate the diagnostic skills of a psychiatrist. With Ruth Moulton, MD, he concluded: "Predisposition, psychologic as well physiologic, seems to be more important than the particular form of the precipitating factor itself." Moulton[15] pointed out that "a thoughtful, cautious dental approach, based on some knowledge of the tensional factors involved, is much more useful than any effort to make direct psychiatric interpretations." However, Kydd[16] found that 23 of 30 TMD patients he studied were emotionally disturbed.

In 1969, Laskin[17] proposed a psychophysiologic theory based on myofascial pain spasms. His studies supported muscle fatigue as a primary factor in the pain, being primarily psychologically motivated by continuous tension-relieving oral habits. "Thus," he said, "we have come to consider the pain dysfunction syndrome as essentially a functional psychophysiological disease, with organic changes that later may be noted in the teeth and joint as secondary rather than primary phenomena."

Recent theories

In the 1980s, new imaging techniques such as computed tomography, arthrography, and magnetic resonance imaging opened new windows to the intracapsular elements. Using arthrography, surgical findings, and occlusal splint therapy, Farrar and McCarty[18] emphasized the disc/intercapsular interference phenomenon. The comment of Storey[19] that the etiology was multifactorial emphasized the consensus of therapists dealing with TMD patients. Thus, in the 1990s, according to Perry,[20] "from the first efforts of Costen to relate the problem to a single factor of jaw or 'bite' relation, the evolution of scientific research and clinical practice has developed a multifactorial etiologic concept."

In 1990, sample studies indicated that orthodontic treatment is not responsible for creating TMDs, regardless of the orthodontic technique, and that orthodontic treatment is not specific or necessary to cure signs and symptoms of TMD.[21]

Current studies include one funded by the National Institute of Dental and Craniofacial Research at the University of Maryland Dental School to evaluate whether a combination of pharmacologic and psychologic treatments is better than either 1 alone in reducing pain and disability associated with TMD, and another, funded by the National Institute of Neurological Disorders and Stroke to determine whether there is any connection between sleep and TMJ pain.[22]

Articulators and centric relation

In the early 1970s, Roth admonished orthodontists to mount their cases because he believed that pretreatment, articulated, centric-relation (CR) mounted models are the best to identify the so-called "Sunday bite" and any occlusal or condylar disharmonies. At this time, CR was considered a posterior-superior (retruded) condyle position. However, in a recent review, Rinchuse and Kandasamy[23] found sufficient evidence to argue against mounting. They also found that the benefit of using gnathologic CR records and articulators in orthodontics was not substantiated by scientific evidence.

A recent survey of randomly selected subscribers of the *Journal of Clinical Orthodontics*[24] showed that about 21% of the respondents routinely mounted models, 44% mounted models occasionally, and 35% never mounted models.

Over the past half century, the definition of CR has changed from a retruded, posterior and, for the most part, a superior condyle position to an anterior-superior one. With the introduction of more sophisticated TMJ imaging to demonstrate internal derangement, the positions of the condyles in the glenoid fossa and the CR position were not found to be diagnostic of TMDs. Other myths included the notions that orthodontic treatment causes TMD and that there is only 1 acceptable position of the condyles in the glenoid fossa (there is a range of "normal" positions).[25]

TMJ prostheses

The first surgeon to place an alloplastic material between the human skull and the mandible was Eggers (1946). He placed tantalum foil over the base of the skull and over the mandibular stump in a 4-year-old girl with extensive ankylosis to prevent recurrence. Smith and Robinson (1957) solved the problem of recurrence of bony ankylosis by placing a stainless steel plate between the skull and the mandible.

It was not until the 1960s that total TMJ prostheses were used. In 1965, Christensen added a TMJ condylar prosthesis to his TMJ fossa-eminence prosthesis to create a total joint replacement. The prosthesis con-

sisted of an acrylic head fixed to a vitallium plate that could be screwed to the ramus. In 1972, Kent et al[26] published a pilot study of a Proplast-coated, chrome-cobalt condylar prosthesis.

Total TMJ replacement results in the loss of influence of the lateral pterygoid muscle in protrusive movements. All reviewed designs resulted in loss of translational movements of the mandible, especially in an anterior direction. Fitting to the skull is still a major problem, as is the combination of the required motions and low wear rates.[27]

ORTHOGNATHIC SURGERY TO MIDCENTURY

Early orthognathic surgery was limited to the mandible because of the difficulty in maintaining the blood supply. Even so, virtually nothing effectively could be done before the middle of the 19th century because of the lack of satisfactory anesthesia.[28]

The first operation for the correction of malocclusion was performed in the United States in 1849 by Simon P. Hullihen, MD, DDS (Hon) (1810-57), in a patient with an open-bite deformity secondary to scar contractures of the neck and chest. He removed a wedge-shaped section from the anterior portion of the mandible, repositioned it, and fixed it with wire ligatures. Although the operation was performed primarily to correct the grotesque facial deformity, Hullihen, without formal dental training, had enough vision to reduce the Class III malocclusion with bilateral subapical osteotomies. All this without anesthesia, antibiotics, and sophisticated instruments![29]

Crawford Long, a physician, claimed that he used ether as an anesthetic in an operation as early as 1842 but did not publish his work. In 1844, Horace Wells, a Connecticut dentist, discovered that nitrous oxide could be used as an anesthetic and successfully used it to conduct several extractions in his private practice (Fig 1). In 1846, another dentist (and a student of Wells), William Morton, took credit for the discovery when he conducted the first successful public demonstration of the use of ether as anesthesia for surgery.[30]

Popularization of orthognathic surgery was aided by the use of the Gigli saw, first described in 1890 by Leonardo Gigli (1863-1908), an Italian gynecologist who developed his wire saw for symphysiotomy of the pelvis.[27]

The terminology for maxillary orthognathic surgical procedures was based on how the maxilla fractures. In 1901, René LeFort of the University of Lille in France published the results of cadaver experiments in which he struck cadaver heads with a piano leg and then dissected the heads to see the location and extent of the fractures. His work resulted in the classification of 3 types: LeFort I, LeFort II, and LeFort III.[31]

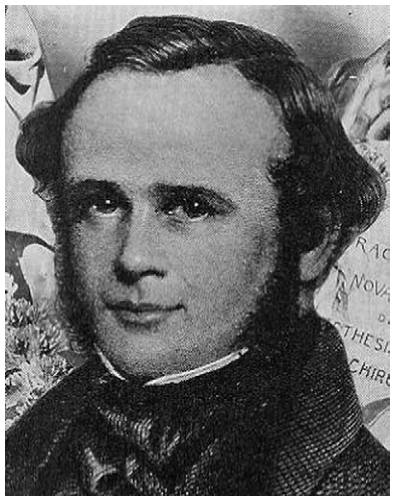

Fig 1. Although others claimed credit, Horace Wells is now recognized as the dentist who gave health professions general anesthesia.

Edward H. Angle recognized that not all dentofacial deformities could be corrected orthodontically, so he suggested that Vilray Blair, a general surgeon, perform a double mandibular resection on a prognathic medical student in 1906. Although there were problems with fixation and infection, an acceptable result was finally attained. This was the first described ostectomy of the horizontal ramus to correct mandibular prognathism. It later became known as the "St. Louis operation."[32] At that time, orthodontic appliances were removed before surgery.

Blair was the dominant figure in early orthognathic surgery. He was also the first to realize the benefits of cooperation between orthodontists and surgeons. During World War I, Blair was senior maxillofacial consultant to the American military forces. Despite complications caused by contamination of extraoral wounds, the experiences of war surgery proved to be invaluable training for surgeons managing elective surgery for deformities. After the war, Blair established, with Robert Ivy—the first professor of plastic surgery at an American university—a number of military hospital centers for the treatment of face and jaw injuries.[33]

Varaztad H. Kazanjian (1879-1974) was an Armenian-American who received his DMD degree (1905) at Harvard Dental School. He drew on his early experience at a wire factory in devising prostheses for the shattered jaws and gaping skull wounds of Allied soldiers. It was not until after his accomplishments as a

Fig 2. Physician Robert Ivy and dentist-physician Vilray Kazanjian helped elevate plastic surgery to a distinct specialty.

British army surgeon during World War I had led to his reputation as the "miracle man of the western front" that he got his medical degree (1921). He and Robert H. Ivy (1881-1974) helped elevate plastic surgery to a distinct specialty (Fig 2). Further fame came to the Kazanjian family when Varaztad's niece became actress and TV personality Arlene Francis.[34,35]

Günther Cohn-Stock, who also had dental and medical degrees, was in many ways considered the father of maxillary orthognathic surgery. He, too, treated soldiers with lower facial injuries during World War I. To escape persecution in Germany, he fled to England in 1939 with the help of Prince Bernhard of the Netherlands, who had been his patient. Cohn-Stock was mentor to Martin Wassmund, also a Berliner, who further developed the techniques of mandibular and maxillary surgery and started the "German School." In 1927, Wassmund performed a LeFort I osteotomy to close an open-bite malocclusion. He also developed the anterior maxillary osteotomy, which is still used today.[31]

In 1928, at the Austrian school he had founded, Hans Pichler suggested alternative methods for mandibular corrective surgery. From his unit, some of the most famous 20th-century surgeons obtained their training, including Richard Trauner, who developed procedures for the correction of micrognathia. Trauner started another center in Graz, where Heinz Köle and Hugo Obwegeser were trained. Köle was the first to describe bimaxillary alveolar surgery for the correction of protrusion and also for deep or short-face deformities. He also produced new techniques for open-bite closure and genioplasty.[28]

Back in the United States, mandibular ostectomy was further refined with preservation of the inferior dental nerve by Reed O. Dingman in 1944, a maxillofacial and plastic surgeon at the University of Michigan; he improved techniques, fixation, and the final occlusion, and reduced the risk of complications.

After World War II, orthognathic surgeons realized that the lateral skull radiograph provided a means for assessing the amount of surgery needed to bring the patient within the mean for the population group. They also realized that orthodontists could provide excellent occlusions if the teeth were uprighted over basal bone before surgery.

The specialty of orthognathic surgery did not fully develop until 1965, when Obwegeser[35] demonstrated the possibility of repositioning the maxilla in a stable consistent manner and reported simultaneous repositioning of the maxilla and mandible in 1970 (more on Obwegeser later).

Firsts in orthognathic surgery to mid-20th century

- 1842, Inhalant for surgical purposes—Crawford W. Long, MD
- 1844, Nitrous oxide for dental surgury (extractions)—Horace Wells
- 1846, Ether in dental surgery—William T. G. Morton
- 1849, Operation for correction of malocclusion—Hullihen
- 1864, Maxillary down-fracture osteotomy (now called LeFort I)—David W. Cheever
- 1890, Gigli saw—Leonardo Gigli
- ca 1900, Chloroform—James Simpson (United Kingdom)
- 1907, Horizontal osteotomy of ramus, external approach
- 1909, Treatment of open bite with ramus surgery—Wayne Babcock
- 1912, Textbook description of corrections for maxillofacial deformities
- 1921, Anterior maxillary osteotomy—Günther Cohn-Stock
- 1927, Total maxilllary osteotomy and inverted "L" ramal osteotomy, external approach—Wassmund
- 1928, First use of Gigli saw in mandibular surgery—F. Kostecka [Moos]
- 1934, Full-blown maxillary osteotomy—Axhausen
- 1939, Beveled horizontal osteotomy of the ramus, extraoral approach—Kazanjian

- 1942, Postmaxillary ostectomy for correction of anterior open bite and step horizontal osteotomy of the ramus, intraoral approach—Schuchardt
- 1955, Intraoral sagittal split osteotomy—Obwegeser and Trauner

REFERENCES

1. Ackerman M. Evidence-based orthodontics for the 21st century. J Am Dent Assoc 2004;135:162-7.
2. Walker JA. A historical review of treatment modalities for temporomandibular dysfunction. J Western Soc Periodontol 1977;25:27-33.
3. Monson GS. Occlusion as applied to crown and bridge work. J Am Dent Assoc 1920;7:399-413.
4. Costen JB. Neuralgia and ear symptoms associated with disturbed function of the temporomandibular joint. JAMA 1936; 107:252-8.
5. Sicher H. Temporomandibular articulation in mandibular overclosure. J Am Dent Assoc 1948;36:131-9.
6. Dingman RO. Diagnosis and treatment of lesions of the TMJ. Am J Orthod Oral Surg 1940;26:374-90.
7. Schultz LW. Report of ten years experience in treating hypermobility of the temporomandibular joints. J Oral Surg 1947;5:202-7.
8. Cobin HP. The temporomandibular syndrome and centric relation. N Y Dent J 1952;18:393-406.
9. Schwartz LL. Ethyl chloride treatment of limited painful mandibular movement. J Am Dent Assoc 1954;48:497-507.
10. Sicher H. Structural and functional basis for disorders of the temporomandibular joint articulation. J Oral Surg 1955;13: 275-9.
11. Graber TM. Orthodontics: principals and practice. 3rd ed. Philadelphia: Saunders; 1972.
12. Perry HT, Lammie GA, Main J, Teuscher GW. Occlusion in a stress situation. J Am Dent Assoc 1960;60:626-33.
13. Klasser GD, Okeson JP. The clinical usefulness of surface electromyography in the diagnosis and treatment of temporomandibular disorders. J Am Dent Assoc 2006;137:763-71.
14. Schwartz LL. A TMJ pain-dysfunction syndrome. J Chron Dis 1956;3:284-93.
15. Moulton RE. Psychiatric considerations in maxillofacial pain. J Am Dent Assoc 1955;51:408.
16. Kydd WL. Psychosomatic aspects of temporomandibular joint dysfunction. J Am Dent Assoc 1959;59:31-44.
17. Laskin DM. Etiology of the pain-dysfunction syndrome. J Am Dent Assoc 1969;79:147-53.
18. Farrar WB, McCarty WL, editors. A clinical outline of temporomandibular diagnosis and treatment. 7th ed. Montgomery, Ala: Normandie Publications; 1983. p. 115-42.
19. Storey AT. Controversies related to temporomandibular joint function and dysfunction. In: Zarb GA, Carlsson GE, editors. Temporomandibular joint: function and dysfunction. Copenhagen: Munksgaard; 1979. p. 447.
20. Perry HT. Temporomandibular joint dysfunction: from Costen to the present. Ann Acad Med Singapore 1995;24:163-7.
21. Reynders RM. Orthodontics and temporomandibular disorders: a review of the literature (1966-1988). Am J Orthod Dentofacial Orthop 1990;97:463-71.
22. Blum K. An open and shut case. Seattle Times 2005 Dec 11; section M4. p. 1-2.
23. Rinchuse DJ, Kandasamy S. Articulators in orthodontics: an evidence-based perspective. Am J Orthod Dentofacial Orthop 2006;129:299-308.
24. Sheridan JJ. The reader's corner. J Clin Orthod 2001;35:423-6.
25. Rinchuse DJ, Kandasamy S. Centric relation: a historical and contemporary orthodontic perspective. J Am Dent Assoc 2006; 137:494-501.
26. Kent JN, Homsy CA, Gross BD, et al. Pilot studies of a porous implant in dentistry and oral surgery. J Oral Surg 1972;30:608-15.
27. van Loon JP, de Bont GM, Boering G. Evaluation of temporomandibular joint prostheses: review of the literature from 1946 to 1994 and implications for future prosthesis designs. J Oral Maxillofac Surg 1995;53:984-96.
28. Moos KF. The origins of orthognathic surgery. Dent Hist 2000;37:5-18.
29. Aziz SR, Simon P. Hullihen and the origin of orthognathic surgery. Oral Maxillofac Surg 2004;62:1303-7.
30. History of dentistry. Available at: http://www.ada.org/public/resources/history/timeline_19cent.asp. Accessed August 24, 2005.
31. McKinstry RE. Cleft palate dental care. Arlington, Va: ABI Professional Publications; 2000. p. 40-3.
32. Blair VP. Report of a case of double resection for the correction of protrusion of the mandible. Dent Cosmos 1906;48:817-20.
33. The legacy of Vilray Blair. Available at: http://www.plasticsurgery.wustl.edu/overview/vilrayblair.asp. Accessed July 3, 2006.
34. Deranian HM. The miracle man of the western front. Bull Hist Dent 1984;32:85-95.
35. Pioneers of plastic surgery. Available at: http://www.countway.med.harvard.edu/archives. Accessed November 21, 2005.