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Three-Dimensional Orthodontic Diagnosis and Treatment

A Neuromuscular Approach

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The use of electronically derived measurements and objective, quantitative data to diagnose the functional status of the musculoskeletal system of the head and neck is a significant step forward in the evolution of orthodontics into a major orthopedic specialty.

Musculoskeletal dysfunction of the head and neck is often the primary etiology of a diverse group of symptoms such as TMJ dysfunction, headaches, myalgia, otalgia, cervicalgia, and neuralgias.[1-23] Before beginning treatment, the orthodontist should consider musculoskeletal dysfunction as a possible cause of one or more of these symptoms or as a presymptomatic potential for future dysfunction.[1,4] Today's superior diagnostic capabilities can uncover and intercept presymptomatic musculoskeletal disease that could become acute and symptomatic under the added stress of orthodontic procedures.

Modern instruments that track mandibular movement clearly show the proprioceptive dominance of the occlusion over the musculature. No matter how badly malpositioned the occlusion or how much torquing and twisting are required to occlude the teeth, the muscles will proprioceptively and instantaneously accommodate to pull the mandible to that occlusal position and maintain it there. The fact that the patient can consistently bring the teeth into full intercuspation with seeming ease must no longer lull the orthodontist into treating to an existing occlusal position, because that position will perpetuate, rather than correct, an unrecognized musculoskeletal dysfunction (Fig. 1).

Measurement for the diagnosis of existing musculoskeletal dysfunction in the orthodontic patient provides a needed additional functional diagnosis to complement the conventional use of cephalometric and TMJ x-rays. The electromyograph (EM2)* (Fig. 2) and mandibular kinesiograph (MKG)** (Fig. 3) respectively measure electrical activity of the muscles and the skeletal relation of the mandible to the skull. These data are essential for initial diagnosis, monitoring of treatment progress, and verification that a relaxed neuro-

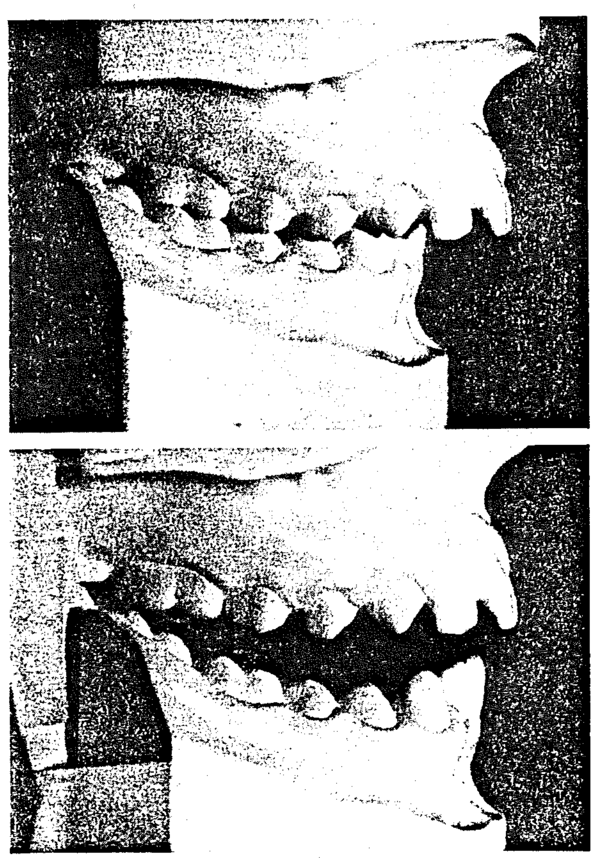

Fig. 1 Existing occlusal relationship (above) and relaxed myocentric relationship (below). (Photographs courtesy of Dr. Yoshitaka Ogata, Seattle)

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*EM2, Myo-tronics Research, Inc.
**Mandibular Kinesiograph (MKG), Myo-tronics Research, Inc.

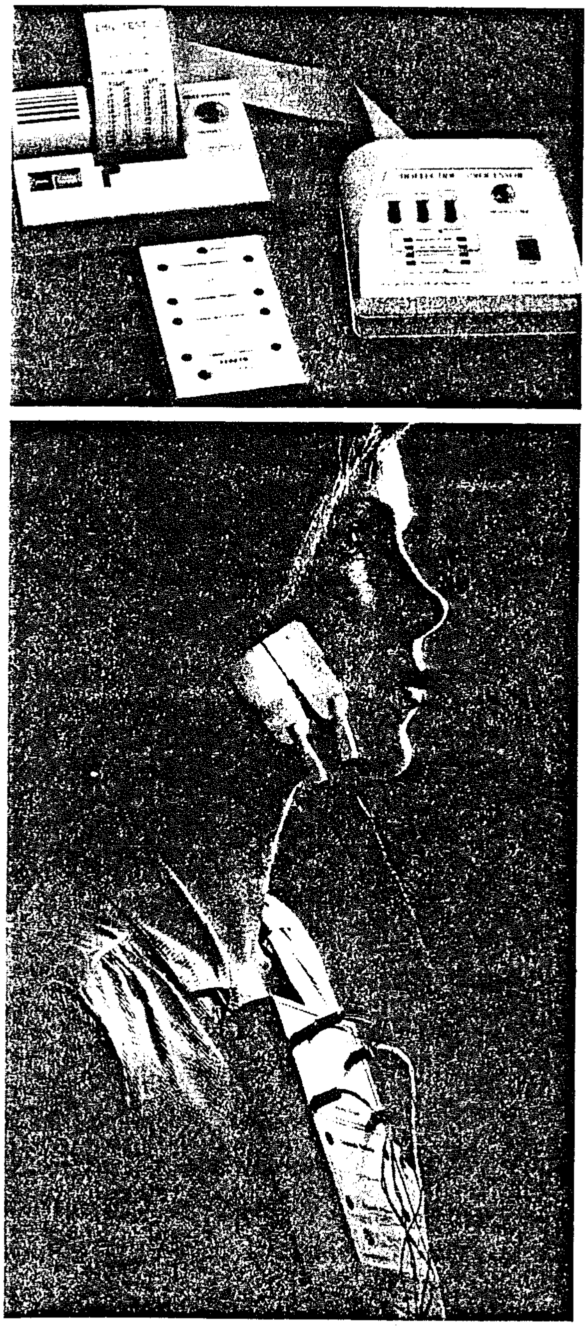

Fig. 2 Electromyograph (EM2).

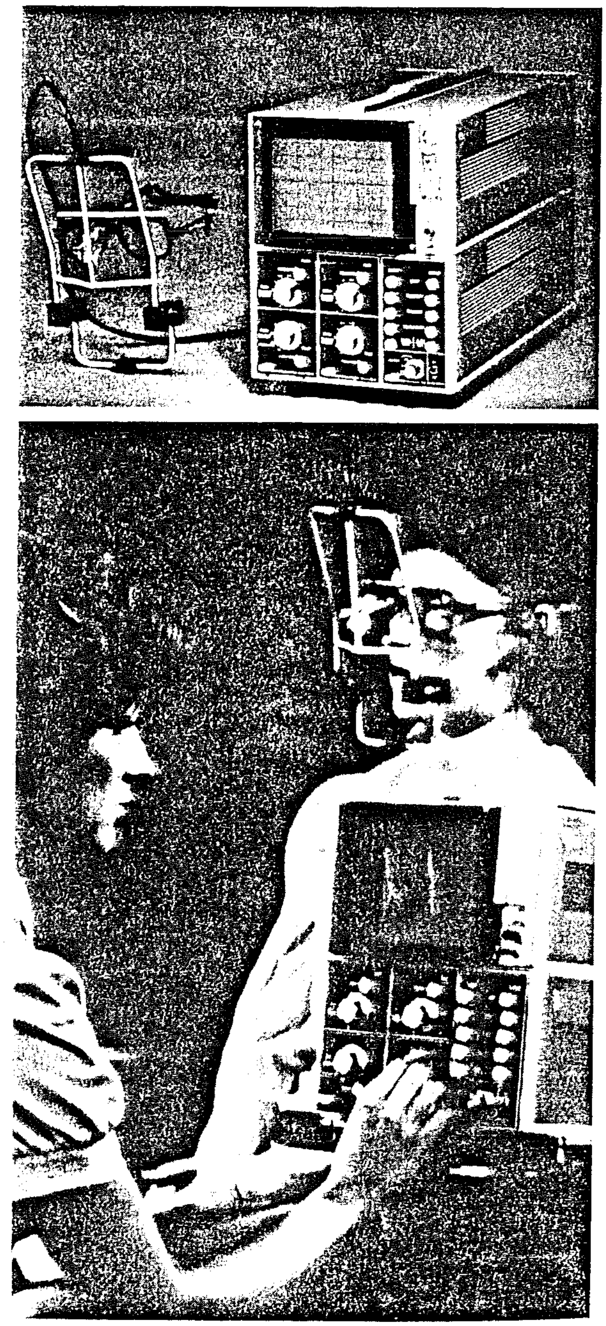

Fig. 3 Mandibular kinesiograph (MKG).

muscular environment—which is the goal of functional orthodontic treatment—has been obtained for the finished case.

The almost universal existence of varying degrees of muscle accommodation and sustained tension generated to accomplish an intercuspal occlusion is becoming more and more apparent with the increasing use of electromyography and kinesiometry in clinical practice.[24,25]

Essentials for Functional Diagnosis

Electromyographic (EMG) Data

The EM2 is an eight-channel electromyograph that processes action potential levels derived from electrodes placed over right and left middle masseter, anterior temporalis, posterior temporalis, and anterior digastric muscles. Action potential levels, recorded during both rest and function (clench), are graphically displayed as they sweep across the CRT screen (Fig. 4). The EM2 microprocessor senses, computes, and integrates 256 samples of data every five seconds; it provides a printout documenting the status of the patient's muscles, which then becomes a permanent file record.

Pretreatment EMG data document the direction and degree to which muscles are being forced into sustained contracture as they are proprioceptively directed to pull and hold the mandible in a skeletal malrelation to accomplish intercuspation of a malpositioned occlusion (Fig. 1).

Mandibular Kinesiograph (MKG) Data

The mandibular kinesiograph (MKG) electronically tracks mandibular movement and position. It displays three-dimensional spatial data on the CRT screen at variable magnifications (Fig. 5).[25,28]

In the pretreatment orthodontic examination, the MKG displays the direction and extent to which the mandible deviates from its relaxed trajectory as the muscles close the teeth to a malpositioned occlusion. This skeletal relation information correlates with

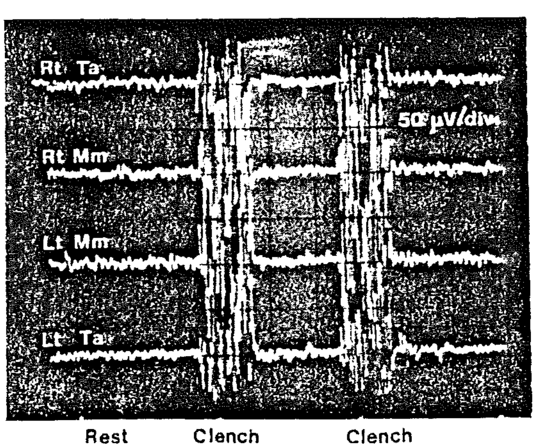

Fig. 4 EMG recording of action potentials during rest and function (clench).

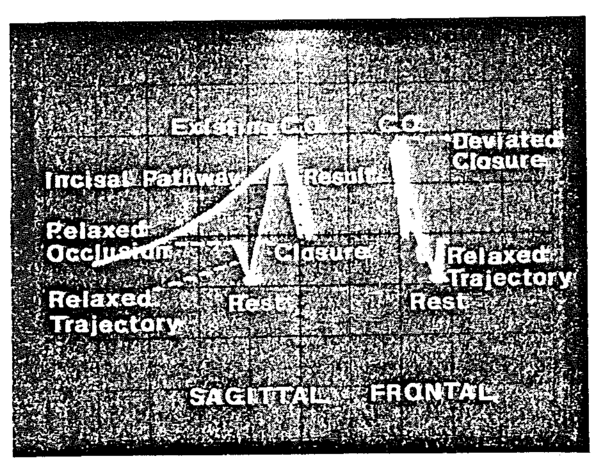

Fig. 5 MKG recording of three-dimensional spatial data on mandibular movement.

Fig. 6 Myo-monitor.

and confirms the electromyographic data, shedding light on the cause of increased electrical activity in various muscles.

Electronically Relaxed Muscles

If EMG and MKG data show existing myostatic contracture and skeletal malrelation, the next step is to use the Myo-monitor*** (Fig. 6) to relax the various craniomandibular muscles simultaneously to their resting lengths by stimulating repetitive muscle contractions (Fig. 7).

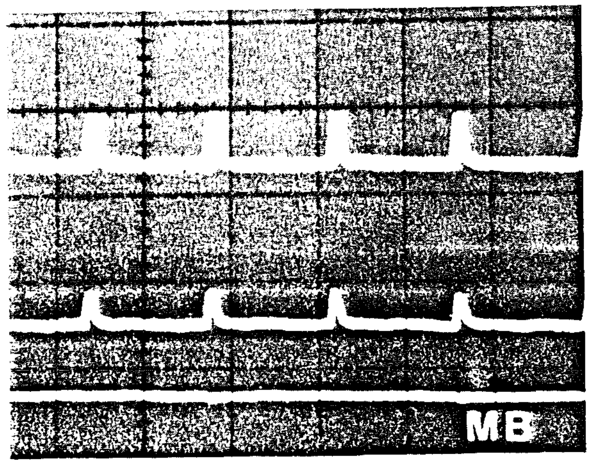

Fig. 7 Repetitive mandibular position after Myo-monitor pulsing.

Reduction of hyperactive electrical firing is most effectively accomplished with neurostimulation by the Myo-monitor through the fifth and seventh cranial nerves.[2,4] In most cases, significant deconditioning occurs within one appointment, but if EMG measurement indicates that the desired resting levels have not been attained at that appointment, subsequent visits and an interim splint may be necessary.

To obtain verifiable resting levels, it is necessary to decondition the muscles down to resting levels of 2-3 microvolts as measured by the electromyograph. The mandible will then be at neuromuscular rest position (NRP). As the muscles relax, an increase in muscle length is reflected in an increase in freeway space, as shown in typical before-and-after MKG measurements (Fig. 8). The difference in the measurements of electrical activity and

***J-3 Myo-monitor, Myo-tronics Research, Inc.

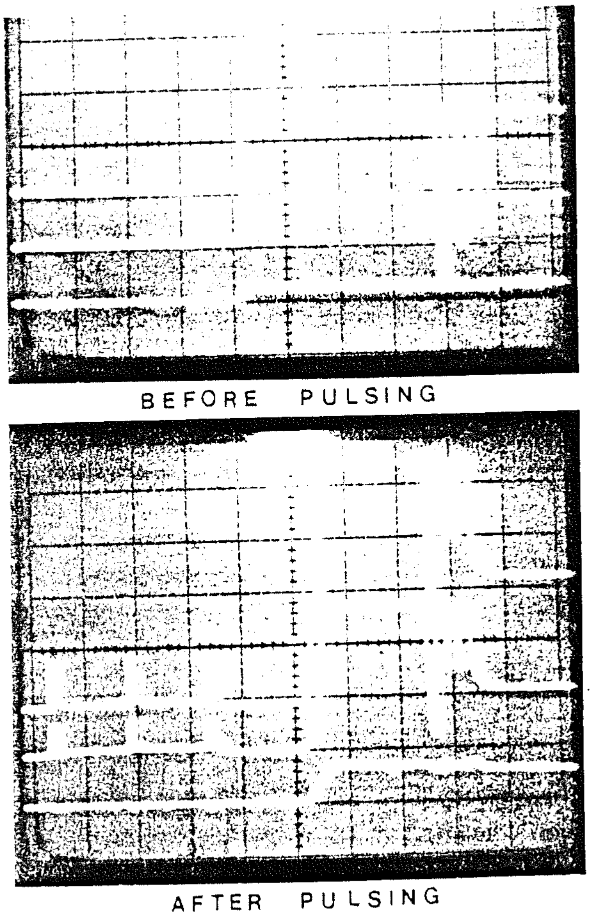

Fig. 8 MKG recording and measurement of increased muscle length after Myo-monitor pulsing.

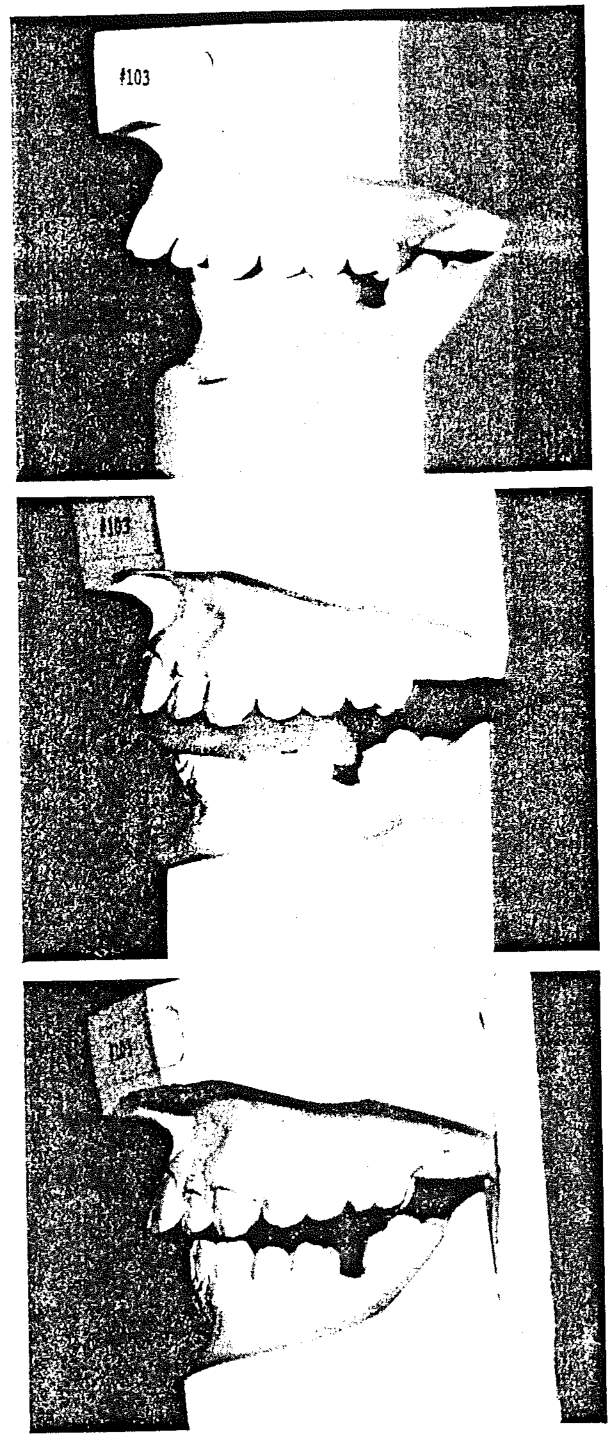

Fig. 9 Maxillomandibular registration for mounting casts to the myocentric position. (Photographs courtesy of Dr. Yoshitaka Ogata, Seattle)

muscle length before and after relaxation represents the extent of muscle accommodation that the patient presents.

Attempting to determine rest position by asking the patient to voluntarily let the mandible relax is ineffective and deceptive. The mandible will still be at an adaptive holding position that is dictated by a proprioceptive response to the occlusion, and EMG data will show that a significant portion of muscle tension still exists, despite the patient's attempt to relax the head and neck muscles voluntarily.

MKG Index

After the EMG data establish that the

various craniomandibular muscles are at their resting lengths and the MKG data establish that the skeletal relation of the mandible to the skull is stable at that position, the orthodontist registers the neuromuscularly coordinated occlusal position (myocentric) with an index, which is an interocclusal maxillomandibular registration at the myocentric occlusal position (Fig. 9).

The resulting myocentric registration is used to mount the casts to this neuromuscularly coordinated skeletal position, to which orthodontic diagnosis and treatment must be directed in order to achieve a relaxed neuromuscular environment for the finished case.

Three-Dimensional Orthodontic Diagnosis and Treatment

A most important finding over the years has been the three-dimensional nature of the skeletal relation of the mandible to the skull, as dictated by occlusal position. Change in vertical dimension inevitably alters the horizontal relations of the mandible to the skull. The prevalence of skeletal distortion in the population becomes apparent once the musculature is deconditioned and the neuromuscularly relaxed occlusal position is compared with the existing centric occlusion.

Data clearly establish that in orthodontic practice we are commonly dealing with muscle-accommodated occlusions that are achieved by muscle stress, involving twisting, torquing, and skewing of the mandible in all directions. Varying degrees of undiagnosed musculoskeletal dysfunction result from sustained muscle contracture and chronic shortening of muscles as they pull the mandible to an existing occlusion that is inharmonious with a relaxed musculature. The findings emphasize the need for precise, objective, quantitative diagnostic data for every orthodontic patient regarding the extent of musculoskeletal dysfunction of the head and neck that stems from an existing malpositioned occlusion.

Because of the hidden subtleties of muscle accommodation, the orthodontist cannot rely on subjective evaluation of muscle relaxation. Diagnosis and treatment based on objective, electronically derived measurements represent a giant step forward in everyday practice.

Conventional orthodontic diagnosis commonly focuses on horizontal tooth-to-tooth relationships with the teeth in existing occlu-

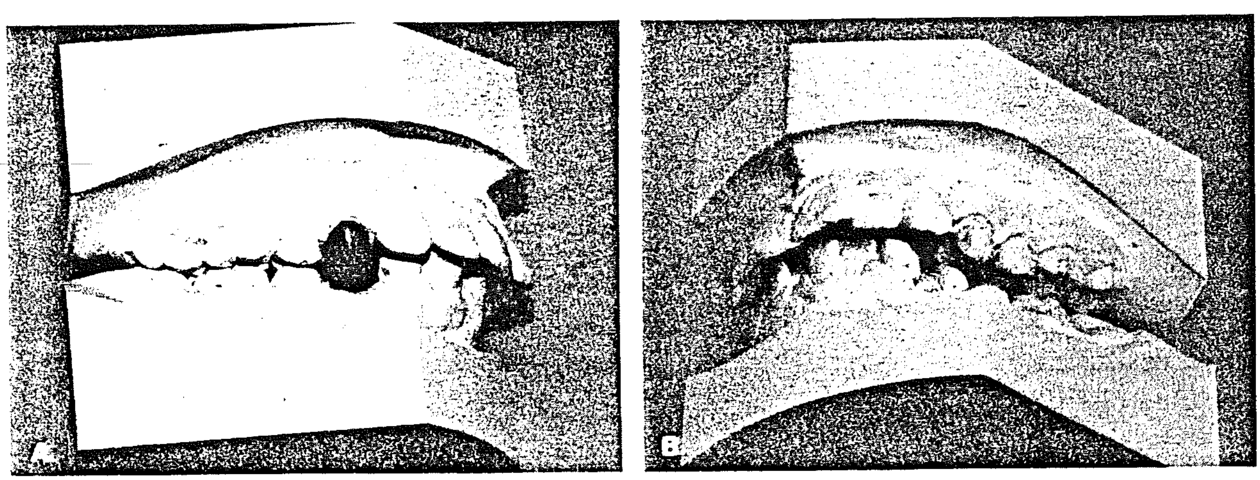

Fig. 10 A. Case scheduled for bicuspid extractions. B. Relaxing muscles increased vertical dimension and repositioned mandible in three dimensions, allowing case to be treated nonextraction.

sion. This "plaster-on-the-bench", two-dimensional approach largely precludes a functional three-dimensional diagnosis that includes vertical dimension.

For teeth to be moved primarily in horizontal directions, there must be space in which to move. If teeth are crowded, the extraction of bicuspids or second molars often becomes necessary. However, moving teeth horizontally into space provided by extraction does not address the functional three-dimensional problem—that of correcting the musculoskeletal dysfunction caused and perpetuated by the existing occlusal position to which we are treating.

The three-dimensional approach expedites orthodontic treatment. The relationship of the mandible to the skull is altered three-dimensionally when the muscles are relaxed to their resting lengths. As the muscles are deconditioned of their tensions and released from the physical restriction of the existing malpositioned occlusion, Angle's classification is often changed. Whenever relaxation results in increased vertical dimension, the neuromuscular occlusal position automatically provides space for tooth movement, reducing the need for extractions.

This phenomenon is illustrated in a case that had been recommended for multiple space-making extractions (Fig. 10). Relaxing the muscles and increasing vertical dimension freed the mandible from the proprioceptive and mechanical restriction of the malposed occlusion. The mandible repositioned three-dimensionally, and the teeth could be moved orthodontically without extractions. The goal of a relaxed neuromuscular environment for the finished case could be achieved.

In Class II cases, which are often overclosed, release from the restriction of the existing occlusion is significant to the diagnosis because it may eliminate the need for extractions and simplify treatment, while correcting any musculoskeletal dysfunction. In Class III cases, identification of muscle tension and consequent overclosure at the existing occlusal level often simplifies the therapeutic approach and improves the prognosis. Moreover, the retention phase of treatment becomes shorter and much less eventful with a quiet, relaxed musculature.

With the realization that eruption of teeth is active throughout life, and with the development of clinical techniques for erupting teeth and increasing vertical dimension, there is a growing demand for functional orthodontic treatment of musculoskeletal dysfunction and its consequences for people of all ages. In cases in which the cuspal anatomy has not yet been unduly defaced by wear, orthodontic eruption alone is the treatment of choice for musculoskeletal dysfunction, rather than adding to tooth height by prosthodontic reconstruction.

In cases in which the occlusal anatomy has been badly worn and must be reconstructed, or in cases with pronounced overclosure and excessive freeway space when the muscles are relaxed, prosthodontists are now recommending orthodontic intervention to avoid an unfavorable crown-root ratio and to erupt the posterior teeth before proceeding with the reconstruction.

Diagnosis Prior to Orthognathic Surgery

The diagnostic significance of the increase in vertical dimension and its accompanying horizontal change in mandibular position confirms the need for quantitative data of existing muscle tension and skeletal malrelation in evaluating the indications for surgical correction of prognathism.

In a case scheduled for orthognathic surgery to correct prognathism (Fig. 11), freeway space increased 13mm when the Myomonitor was used to relax the tense, proprioceptively shortened muscles to their resting lengths. Since the mandible on average moves posteriorly 1mm for every 2mm of increased vertical opening (1:2 A/V ratio), the mere act of vertically repositioning the mandible 13mm to the more open, relaxed position concomitantly moved the mandible 6.5mm

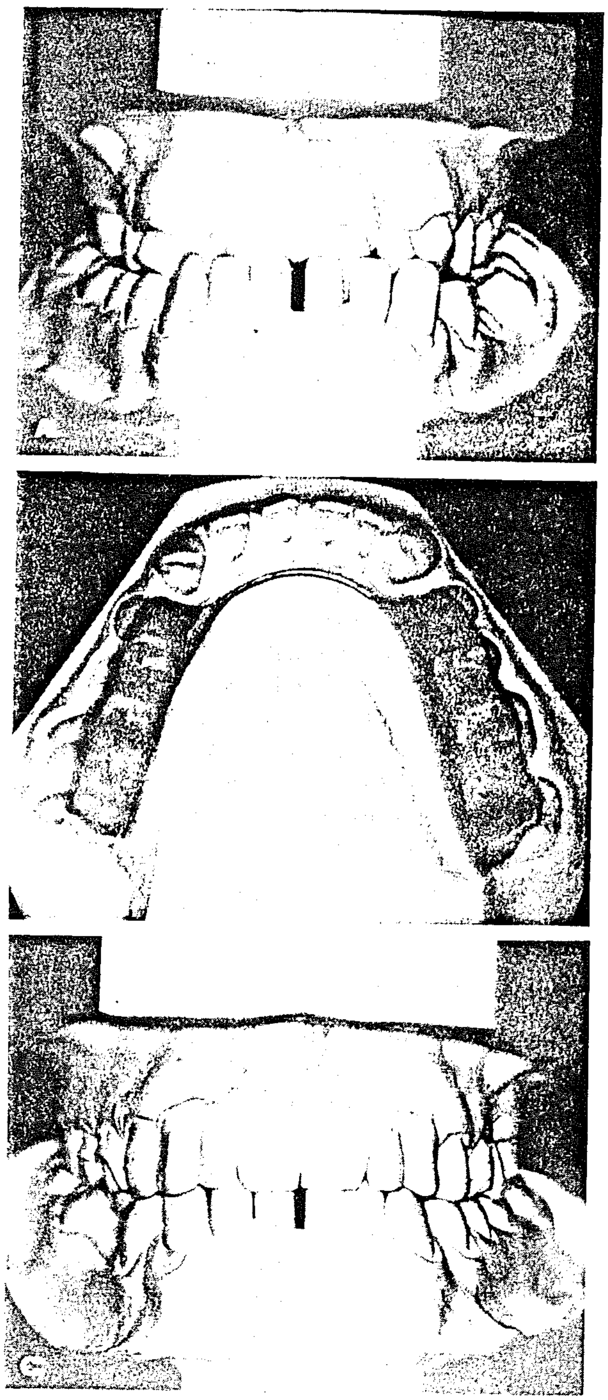

Fig. 11 A.B. Case scheduled for orthognathic surgery. B. MKG index. C. Case seven months later after nonsurgical resolution. (Photographs courtesy of Dr. Richard Philbrick, Seattle)

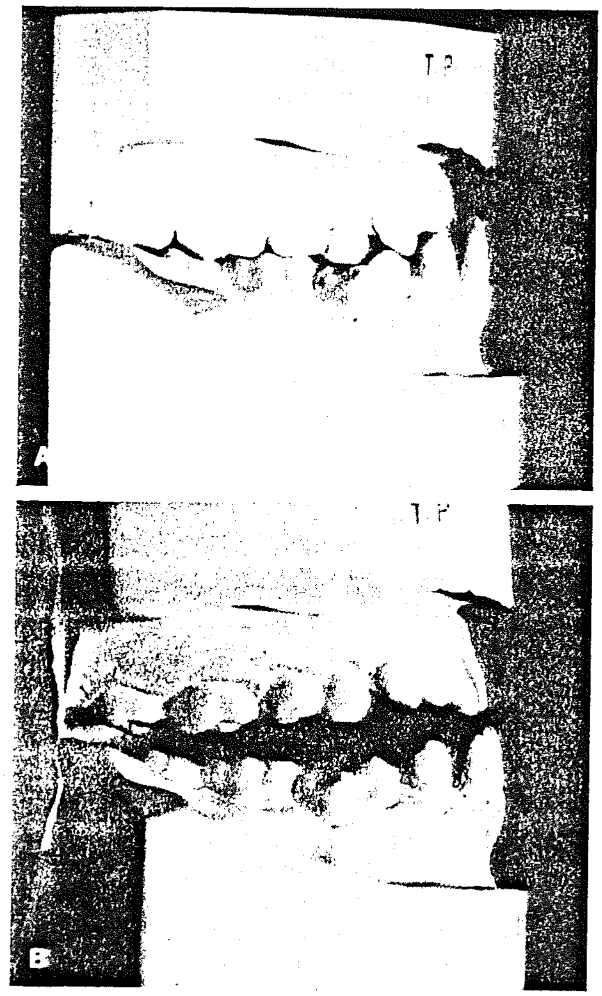

Fig. 12 A. Case similar to that in Figure 10. B. MKG indexed position. (Photographs courtesy of Dr. Yoshitaka Ogata, Seattle)

posteriorly, altering the Angle classification.

A similar Class III case and its conservative nonsurgical resolution is shown (Fig. 12).

MKG and Tongue Thrust

The MKG also clearly identifies the occurrence and nature of a deviate swallow (Fig. 13). It displays the thickness of tongue between the teeth during that swallow and the direction and extent of mandibular thrusts that result during deglutition. As treatment proceeds, the

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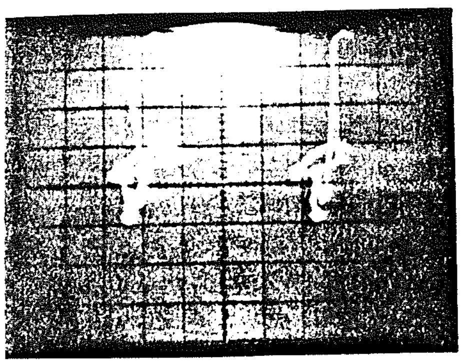

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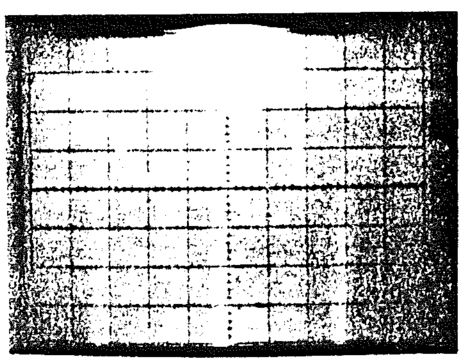

Fig. 13 MKG recording of deviate swallow before and after correction.

orthodontist can monitor on the the MKG screen whether treatment—as usually occurs—has automatically corrected the problem. If myofunctional therapy is instituted, the MKG display serves as an effective biofeedback adjunct that the patient can follow visually during myofunctional training sessions.

Summary

Improvement of appearance is a primary motivation for patients seeking orthodontic treatment. However, every orthodontic patient is also a neuromuscular patient. Alleviation of the head and neck pain of musculoskeletal dysfunction must become an equally strong motivation for orthodontic care, as health-care professionals and the public become increasingly aware of its effectiveness and availability.

It is essential in the diagnosis of every patient, before instituting therapy, to derive precise, quantitative data that reveal whether the skeletal relation of the mandible to the skull is distorted or not, and document the extent of musculoskeletal dysfunction of the head and neck stemming from an existing malpositioned occlusion. With today's state-of-the-art diagnostic tools, orthodontics has progressed beyond the two-dimensional diagnostic approach to a more comprehensive and realistic three-dimensional diagnosis, and to treatment targeted to the neuromuscularly relaxed (myocentric) position of occlusion.

Structural diagnosis based on cephalometric and other x-rays gains in significance when supported by functional data of musculoskeletal status. The increasing emphasis on the orthopedic correction of skeletal malrelation of the mandible to the skull inevitably expands the scope and changes the image of orthodontic practice. As EMG and MKG data show, the significance of the orthopedic capability of orthodontics extends beyond the jaws alone to the entire musculoskeletal system of the head and neck; and, as functional considerations become paramount, the orthodontist becomes the primary orthopedic specialist in treatment of head and neck pain.

The influx of adult dysfunction patients into orthodontic practices greatly enlarges the scope of orthodontics and the demand for orthodontic services. It brings new opportunity, responsibility, and gratification to the orthodontist as a primary therapist in alleviating human suffering.

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