MYOFUNCTIONAL THERAPY AND ORTHOGNATHIC SURGERY

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This article proposes a standardized method for myofunctional evaluation and treatment for patients undergoing orthognathic surgery. Patients selected for surgery typically exhibit a malocclusion or facial disharmony due to abnormal bone development. Osteotomies may be performed on the mandible and/or maxilla--they are segmental when they alter only part or portions of a determined bone. Surgery to the body or ramus of the mandible is performed to diminish or increase its size. Alloplastic graft material may be used to augment the mandible or the chin. In the maxilla, surgery can also be segmental or total. The maxilla can be superiorily repositioned, advanced, or expanded. Three levels of maxillary advancement procedures are labeled according to Le Fort's classification for fractures: **Le Fort I**--when the osteotomy is horizontal and just over the teeth roots; **Le Fort II** or pyramidal--when the osteotomy is horizontal on the base of the maxillary bone, vertical on the sides of the nasal bones, and then horizontal again over them; **Le Fort III**--is a complete osteotomy of the maxillary bone. The face is completely separated from the skull, including part or all of the orbit. Temporomandibular joint surgery may also be necessary.

Until recently, little attention has been paid to the functional aspects of these skeletal abnormalities. Surgeons and dentists typically consider the bones and their relationship with each other. They focus on aspects of occlusion and facial harmony and tend to disregard the soft tissue. However, soft tissues and bones are profoundly interrelated.

Bones are active entities, responsive to forces exerted upon them. Muscular traction on a specific bone modifies its development (Altmann, 1985). Muscular hypofunction or atrophy on one side of the face can lead to a lack of bone development on that same side. Similarly, in the presence of any bony anomaly there is muscular alteration. Unilateral facial palsy in a newborn typically leads to later facial asymmetry. In the Moebius Syndrome, characteristic mandibular hypodevelopment is thought by some researchers to be a consequence of lack of mobility of the jaw due to an infantile trigeminal paresis (Kirky, 1923; Pitner et al. 1965; Fig. 1). On the other hand, the facial characteristics of Apert's syndrome (Fig. 2) include maxillary hypoplasia, a birdlike nose, and a very high palatal arch leading to muscular alterations that increase with age. These skeletal abnormalities affect respiration, swallowing, and mastication. The facial muscles suffer the consequences. The lips and tongue become hypotonic and swallowing is directly affected.



Figure 1. *Patient with Moebius syndrome*



Figure 2. *Patient with Apert's syndrome*

In normal individuals there is an equilibrium between facial muscles and the tongue. The orbicularis oris muscle, the buccinator muscles, and the superior constrictor of the pharynx act like an elastic band that maintains harmony between the dental arches. The tongue, together with its adjacent muscles, is the only antagonistic force to this mechanism (Fig. 3, page 3). In maxillomandibular deformities this equilibrium is disturbed, often jeopardizing the aesthetic and functional success of orthognathic surgeries.

Characteristics of Prognathic and Retrognathic Patients

Only topics relating to prognathic and retrognathic patients will be addressed here. Prognathic patients usually have the following characteristics: Hypertrophic mandible; maxillary hypodevelopment (giving the patient's face a concave aspect); Class III Angle occlusion with or without an associated openbite; mouth breathing (usually habit-based and not due to nasal obstruction); high palatal

arch (about 40% of the cases); hypertrophic palatal ridges (due to lack of tongue pressure); hypotonic lips and tongue; eversion of lips (mainly of the inferior one); shortening of the superior lip; and, alteration of tongue and lip postures (Fig. 4). The majority of prognathic patients have a lips apart rest posture. This posture is reinforced because the elevators of the jaw are typically hypotonic leaving the mouth open and the lips separated. The tongue rests in the floor of the mouth following the prognathic mandible. The tip of the tongue may contact the lingual surface of the inferior incisors or project between the dental arches. In these cases the tongue has no muscular opposition from the facial muscles. It constantly pushes the mandible forward because the mandible itself finds no opposition from the maxillary bone. Winders (1956) demonstrated that the force of the tongue is greater than that exerted by the buccal tissues. We may infer that altered tongue posture may have a negative influence on occlusion.

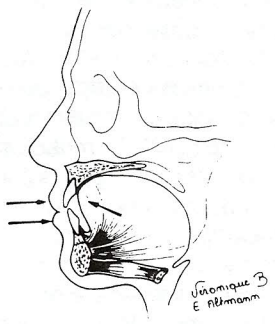


Figure 3. *Equilibrium Between the Tongue and Lips*

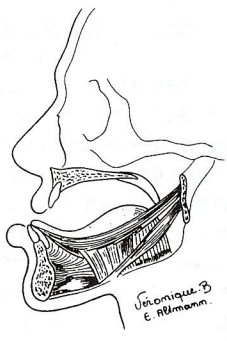


Figure 4. *Prognathic Profile*

Other characteristics of prognathic patients are: Tongue-thrust swallow with contraction of the perioral musculature; and, difficulties in mastication because only the second molars may touch (premature contact). The angle of the jaw is so open that the rest of the teeth do not occlude. Lateral movements of the jaw are often diminished -- which inhibits the rotatory motion necessary for chewing. The mandibular ligaments do not allow a greater range of motion. Often, the tongue is substituted for the jaw when chewing food. The tongue's median portion presses food against the palate in a forward movement; there is difficulty in biting with the incisors because of the faulty occlusion.

Temporomandibular joint (TMJ) dysfunction is a common feature. Sometimes there are anatomical problems of the TMJ as a consequence of an inadequate functional pattern. The condyle, as well as the glenoid fossa, can become flattened because of excessive attrition. This can be caused by a condyle that slides out of the fossa -- going past the articular eminence. Audiological complaints of tinnitus and plugged ears are also typical. However, in the majority of cases the audiogram is normal. These otologic symptoms are sometimes attributed to the Pinto ligament (Pinto, 1962), which extends from the articular disc to the hammer bone in the middle ear. However, this is a subject of controversy.

Retrognathic and prognathic patients share many characteristics: Mouth breathing; hypertrophy of the papilla ridges; altered tongue and lip postures; deviate swallow; difficulty with biting anteriorly; and, TMJ dysfunction. However, there are some features specific to retrognathic patients, such as: Mandibular hypoplasia; Class II Angle occlusion usually with a significant overjet; diminished transversal palatal diameter and a high palatal arch. Eversion of the inferior lip tends to be greater than in prognathic patients because the superior incisors are pressed against the inferior lip increasing the eversion; the superior lip is shorter than in prognathic patients because of the protruded maxilla; and lip posture is more affected in these patients. Almost no retrognathic patients have good lip posture, whereas in prognathism lip closure may be normal. Tongue posture and movement for deglutition also differ from prognathic patients. The tongue is pushed backwards by the hypoplastic jaw. Its tip is projected upwards towards the lingual surface of the superior incisors or between the dental arches (Fig. 5). During swallowing there is a forward movement of the tongue directed from the bottom of the mouth to the top. In prognathism, on the other hand, the movement is the opposite.

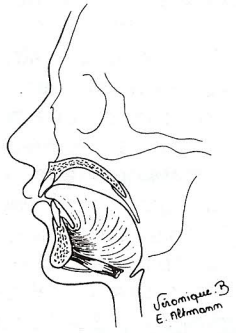


Figure 5. *Retrognathic Profile*

Classification

There are authors who do not agree with the simple classification of prognathic versus retrognathic (Enlow, 1962; Psillakis, 1986), and who suggest that there is never just a single structure involved in a deformity. According to Enlow's bone development theory (1962), if there is an anomaly in a specific bone there will be alterations of the adjacent ones. This concept is important not only in terms of terminology, but also for reviewing surgical procedures. As a result, many Brazilian surgeons

have begun to operate systematically on the mandible and the maxilla.

Maxillomandibular deformities can modify facial aesthetics and the harmony of the dental arches. Deformities can be classified according to relationship between maxilla and mandible, or by facial characteristics. Angle's classification of the dental arches assumes that the first maxillary permanent molars are always in a correct position. However, this classification may disregard problems of facial development and muscular alterations because it takes into consideration only the dental aspect of the relationship. One may use Angle's terminology to classify facial skeletal patterns. An individual could be considered a Class II or a Class III facial type.

Psillakis (1986), a Brazilian plastic surgeon, divides facial deformities as: Cranio-caudal; antero-posterior; transversal; and oblique. The cranio-caudal includes problems of vertical dimension. The face may be excessively long or short in appearance, and also in terms of relationship between the bones and the soft tissues. In the long face the superior incisors appear more than two millimeters (mm.) below the inferior border of the superior lip when the lips are slightly apart. When the individual smiles the gum is visible. In this case, the skeleton is longer than the soft tissues. On the other hand, in the short face, incisors do not show when lips are slightly open, indicating a lack of vertical skeletal development in relation to the soft tissue.

Antero-posterior deformities include maxillary hypoplasia -- also known as pseudo-prognathism. In these cases, the imaginary line that goes from the orbit to the maxillary bone is straight, there is hypoplasia of the inferior orbitary border, and the nasolabial angle is sharper. In the transversal deformities there is a narrowing of the transversal diameter of the palate. This category includes all patients with high palatal arches. Oblique deformities are those in which only one side of the face is affected, as when there is unilateral jaw hypertrophy.

According to Psillakis's classification, a patient can be described as having several coexisting deformities. A patient may have: A long skeletal face, but be short in terms of bones and soft tissues (cranio-caudal); maxillary hypoplasia (antero-posterior category); a narrowing of the palate (transverse category); or, a mandibular asymmetry (oblique category). This classification is very useful in practical terms because it establishes a relationship between bones and soft tissues. It analyzes all planes, allowing a consideration of the patient's face as an anatomic and functional entity.

Evaluation

Before beginning an evaluation it is important to know the surgical and orthodontic treatment plan. A thorough myofunctional evaluation in maxillomandibular deformities not only provides a solid basis for myofunctional therapy but also allows comparison of data pre- and post-surgery, and for future research purposes. Some items from the evaluation form will be considered in detail:

FOOD: It is important to establish the kind of food the patient normally eats. A preference for soft foods may indicate chewing and swallowing dysfunction. Pain and fatigue after chewing hard food and "clicking" sounds in the TMJ may be reported.

PARAFUNCTIONAL ORAL HABITS: Some of the more common habits include: Bruxism, jaw clenching, nail or skin biting, licking or biting of the lips, biting the tongue and cheeks, biting objects, smoking, constantly resting the jaw on the hand, and playing any wind instrument which requires an abnormal jaw posture. Past habits such as finger or pacifier sucking are also to be noted.

FACIAL EVALUATION: Usually, the face has been classified before the evaluation. However, we recommend always measuring the proportion between the three portions of the face: Superior, medial, and inferior third -- using the Boley caliper.

HEAD POSTURE: Problems of head posture are given serious attention, because they can influence muscular function and dentofacial development (Harvold et al, 1973; Solow & Tallgren, 1976; Weber et al, 1981). Winnbearg and Pancherz (1983) demonstrated through electromyographic studies that anterior flexion of the head diminishes masseter muscles activity and its masticatory cycle. According to Schwarz (1928), head posture can also be influenced by mouth breathing due to nasal obstruction.

OCCLUSION: Angle's classification is used to categorize occlusion, and the individual position of each tooth is observed. Most often the dentist or orthodontist provides this information.

MEASUREMENT: Boley caliper normative date (in millimeters) are shown in parenthesis. The measures taken are: Distance between the lips at rest (0 mm.); distance between the inferior border of the superior lip and the lower edge of the superior central incisors (to take this measure the patient postures the mouth in a relaxed position, lips slightly apart; Psillakis, 1986, 2-3 mm.); open bite is measured between the teeth of the superior and inferior arches (0 mm.); overjet is measured with the end of the caliper (the antero-posterior distance between the incisors; 0 mm.); diastema (the teeth which present this condition are noted; 0 mm.); the transversal diameter of the hard palate is measured either between the lingual surface of the second premolars according to Bogue (Mayoral et al, 1971, 30 mm.), or between the central fossa of the first and second premolars and the molars (Mayoral, 1971; 35 mm., 41 mm., 47 mm.); interincisal distance which corresponds to the maximal mouth opening (Bell et al, 1983, 50-55 mm.; Gelb, 1977, 40-50 mm.); jaw protrusion (Bell et al, 1983; 8-10 mm.) and lateral motion (Bell et al, 1983, 10 mm.). These measures are important because they furnish quantitative data allowing comparisons and an objective follow-up of the patient's progress.

The next step is the evaluation of the *articulatory organs:* Lips, tongue; chin; cheeks; hard and soft palate;

mandible; and, finally, temporal and masseter muscles. The lips and tongue are examined for their appearance, frenum, posture, mobility, and tonus. To evaluate the tonus of lips, tongue, cheeks, and mentalis muscle we consider postural and functional alterations due to hyper- or hypotonia (for example, the eversion of the lips caused by hypotonia). Another example would be the chin region marked by little cavities, demonstrating an excessive contraction of the mentalis muscle in order to compensate for the lack of lip tonus. A subjective impression of muscle tone can be obtained by applying resistance to the structures to appraise their strength. However, the ideal method to evaluate tonus would be the dynamometer.

VELOPHARYNGEAL SPHINCTER: Detailed evaluation of the soft palate and the function of the velopharyngeal sphincter is reserved for the patients with cleft palate and palatal incompetence or insufficiency due to other causes. The examination would include: Clinical evaluation, X-rays, nasopharyngoscopy, and videofluoroscopy. Surgical advancement of the maxilla in individuals with a slight deficiency in the closure of the velopharyngeal mechanism will produce hypernasality, worsening their speech. However, the majority of authors (e.g., McCarthy et al, 1979; Psillakis, 1986), report no cases of hypernasality following maxillary advancement in noncleft patients.

Continuing the evaluation of the articulatory organs, it will be noted that jaw movements are typically altered in prognathic and retrognathic patients. It is very common to find functional and even anatomical TMJ problems. We usually use a stethoscope to detect clicks or crepitus. We observe mandibular symmetry during opening and closing of the mouth and also during chewing. Muscles are palpated and the patient is asked about any local, cervical, or back pain.

In the evaluation process we also assess the *neurovegetative functions:* Respiration, sucking, chewing, and swallowing. To evaluate *proprioception* we utilize the Ringel Test pre-surgery, after the release of the intermaxillary fixation, and at the end of treatment. We have noticed that stereognosis is almost never altered after fixation release (Altmann, 1987). However, a larger number of patients should be tested to confirm this data.

Myofunctional Therapy for Orthognathic Patients

Although it is increasingly accepted that the success of orthognathic surgery is directly related to function, very little has been written on the subject and no specific method has been developed involving the soft tissues and their equilibrium. In 1983, Bell and associates reported a method of treatment applied post-surgically with the objective of normalizing mouth opening and masticatory function. However, considering the characteristics of these patients, one could conclude that muscular alterations are inherent to all dentofacial deformities and that myofunctional therapy should begin before surgery.

The following standardized method for maxillomandibular deformities was developed based on the author's experience. Patients' contributions were of great importance. Their experiences and feedback have been essential in the development of this program.

Myofunctional treatment should always be coordinated with the orthodontic and surgical treatment plan. The treatment can be divided into three stages: Before surgery, during intermaxillary fixation, and after intermaxillary release.

Treatment Before Surgery

This first stage begins one or two months before surgery. The goals of this stage are: To eliminate parafunctional oral habits, to correct and try to automatize lip and tongue postures, to increase intraoral sensitivity, to normalize tonus, to develop normal deglutition, and finally, to prepare the patient for surgery.

Negative oral habits ideally should be eliminated before starting therapy since habits hinder automatization of correct tongue and lip postures, and interfere with oral physiology. They can even be the cause of pain and TMJ dysfunction. The most common oral habit in these patients is mouth breathing. Before beginning treatment, we refer to an otolaryngologist to screen for any nasal pathology -- although in the majority of cases it is a habit caused by the muscular alterations. The antigravitational muscles of the jaw and the tongue are usually hypotonic further encouraging mouth breathing. When respiration is oral, the nasal physiology is altered. The cilia in the nasal cavity and the sinuses stop moving, and the mucus becomes thickened and dried. After some time, nasal breathing becomes more difficult because the nasal air passage is narrowed.

To resolve mouth-breathing the patient must acquire necessary muscular tonus. The elevators of the jaw and the orbicularis oris muscles are strengthened to facilitate a natural mouth posture without effort. If the condition persists, nasal proprioception may be enhanced through exposure to strong odors. Other exercises to promote nasal breathing include: Holding water in the mouth, holding a spatula or wafer between the lips (Fig. 6), and completing exercises with the oral manometer. When deemed necessary, we also recommend the use of a headgear at night to maintain closed mouth posture.

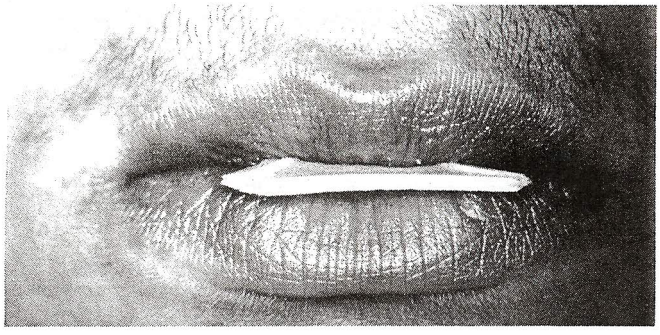


Figure 6. *Holding a Wafer between the Lips*

When nasal respiration is being developed, appropriate tongue and lip posture are introduced. To make this easier, the lips, tongue tip, and papilla ridges are sen-

sitized with a toothpick. To sensitize the tongue tip, the patient is asked to bite it gently with the incisors (if the occlusion allows), and then to put it on the "spot" on the upper alveolus -- just posterior to the incisal papilla. During the first two weeks, patients are asked to keep an orthodontic elastic held by the tongue tip against the papilla for increasing periods of time.

Intraoral sensitivity is approached through taste, touch, and temperature to enhance proprioception, and so as to have a post-surgical parameter. The patient is asked to become more aware of the oral cavity when relaxed and also to be more aware of the taste, temperature, and consistency of food. Sensitivity is also developed unconsciously through the muscular exercises.

Muscular tonus is developed through isometric exercises in which muscle fibers are very tense and the muscle length is not modified. Isometric exercises provide resistance to the musculature or maintain muscle contraction for a few seconds. Several isometric exercises will now be described:

EXERCISES FOR THE LIPS include a circular movement of tongue behind the lips, pushing them outwards, while maintaining lip closure. The jaw is slightly lowered with no lateral deviation. The movement is performed five times to each side followed by a short relaxation period. Other materials and activities include:

Acrylic Plate. A small plate that fits in the vestibule with a chain attached to the center (Fig. 7). The chain is pulled while the patient contracts the lips to stop the plate slipping out of mouth.

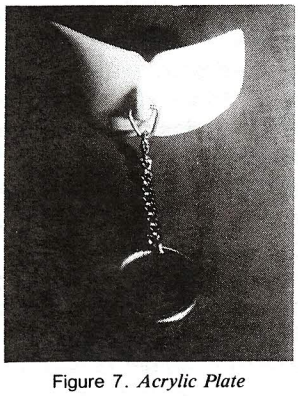


Figure 7. *Acrylic Plate*

Lip Dumbbell. This is a plastic spatula with weights at each end (Fig. 8). These weights can be adjusted according to the patient's lip strength. The spatula is placed between the lips with the teeth occluded lightly. The patient then protrudes the lips and closes them, holding the spatula evenly without any lip eversion. Initially, the patient is asked to hold this position for three or five minutes. As the strength increases, more time is added up to a maximum of 20 minutes. When the bar is easily held for 20 minutes the weight is increased. The patient also raises and lowers the dumbbell.

Rubber Tubes. Two rubber tubes are placed behind the superior and inferior lips, which must be kept closed. The tubes cover the dental arches also forcing the cheeks to be contracted. The patient is asked to maintain the tubes in this position for about 10 minutes -- while concentrating on any other activity such as reading, watching television, or studying. Another exercise with the rubber tube is to pass it from behind the superior lip to the inferior one and back, keeping the lips closed.

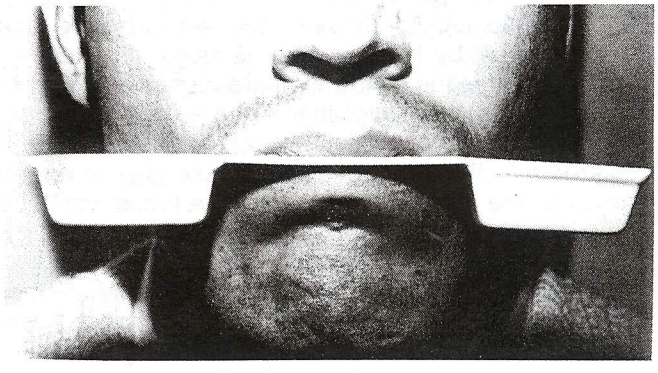


Figure 8. *Lip Dumbbell*

Pacifier. Two types of exercises may be done with a large orthodontic NUK pacifier. Both involve exaggerated sucking while pulling the pacifier outwards. The mandible descends to the lowest possible position with the lips closed. In the first exercise the pacifier is used in its regular position. For the second exercise the pacifier plate is positioned in the vestibule and pulled against the resistance of the lips.

EXERCISES FOR THE TONGUE

Tongue Cone. This involves an acrylic cone with a handle. The tongue fits inside the cone which is pushed towards the inside of the mouth while the patient tries to counteract by protruding the tongue.

Narrowing of the Tongue. The tongue is narrowed for 10 seconds and then relaxed. If this is difficult, a device resembling a ring with a handle is used to induce the narrowing movement. The tongue should not to be introduced into the ring; its tip may only touch it lightly. To induce the narrowing movement a toothbrush can be used to stimulate the tongue. The toothbrush is passed very quickly on the tip of the tongue from one side to the other; along its sides and over its central portion. The toothbrush is always moved from the back of the tongue towards its tip.

Orthodontic Elastics. First, a 5/16 inch elastic is placed around the tongue held by a folded straw. The tongue is then moved inwards on the floor of the mouth without touching the inferior incisors. The mouth must be kept open throughout the exercise. When the patient can easily remove the elastic we do not use the straw and put the elastic directly around the tongue. The number of elastics is then increased up to a maximum of five at the same time according to the patient's skill of removing them. The straw is used to give the patient a sense of security. If the elastic cannot be removed through tongue movement, it can easily be pulled off by grasping the straw. If the exercise is done for the first time without the straw, sometimes the person cannot remove the

elastic either by the movement of the tongue or fingers because the tongue becomes too moist with saliva and the fingers cannot catch the elastic. This may cause the patient to panic.

Tongue Weight. This is a triangular weight held by a string that is placed on the tongue. Five types of exercises can be done with it. To begin, a lighter weight is used for all exercises. The weights range from 20 to 50 grams. The device is positioned on the middle of the tongue with its apex aligned with the tip of the tongue. Five exercises are as follows: Raise and lower the weight very slowly keeping the tongue inside the mouth; narrow and relax the tongue (keeping it inside the mouth); laterally move the tongue with a slight raising to avoid touching the teeth; protrude and retract the tongue with a slight raising (again avoiding touching the teeth); and, maintain the tongue raised in the middle of the oral cavity with the mouth wide open. The tongue may not touch either the palate or the inferior incisors. This activity and those for the lip dumbbell were developed by the author and the results have been very encouraging.

Clothspin. The spring of a clothespin is modified to reduce its closing pressure. It is affixed to the median portion of the tongue. The tongue is moved inwards and outwards without touching the teeth until the pin falls. The inward movement is vigorous to work the styloglossus and the hyoglossus muscles more effectively. Through this exercise, tongue muscles are strengthened and the pressure exerted by the pin on the tongue tip increases the sensitivity of this region. While working with muscular tonus, one has to be aware of the cases in which there are no changes in the tongue's mass. This may indicate macroglossia. True macroglossia is a rare condition. Forward tongue posture and low tone can make a tongue appear to be overlarge for the oral cavity. Incorrect diagnosis can lead to unnecessary glossectomy procedures. However, when the tongue is truly macroglossic, a partial glossectomy is indicated followed by myofunctional therapy and then, orthognathic surgery.

EXERCISES FOR THE CHEEKS

A useful exercise for the cheeks is to contract them against intraoral air pressure. The lips are tightly closed and the cheeks contract slowly, letting out air gradually so as to give the feeling of actually pushing it out of the mouth. Another exercise involves a spatula or handle with a small ball on its end. The ball is placed on the inside of the cheek exerting an outward pressure while the patient counteracts by contracting the same cheek.

EXERCISES FOR THE MASTICATORY MUSCLES

One activity involves a piece of *rubber tube with an attached string.* The patient chews on the tube with exaggerated jaw movements. The rubber tube is chewed on one side of the mouth, then passed to the other side without opening the mouth. This exercise works all muscles of mastication and the orbicularis oris muscle. We also stimulate the correct tongue movements required for chewing, avoiding the muscular imbalance caused by unilateral chewing.

Teething Ring. The preferred rubber teething ring consists of a large ring attached to a small one by a short stem. The ring is placed on the second molars and the patient clenches for up to 10 seconds -- to avoid spasm. Then, the ring is moved to the first molars and the exercise is repeated. Gradually, it is moved to more anterior teeth until reaching the incisors. Another type of exercise involves chewing the middle stem portion leaving the small ring over the tongue. This also stimulates the lateral movements of the tongue.

APPLICATION OF MANUAL RESISTANCE EITHER TO THE OPENING OR TO THE CLOSING OF THE MOUTH

Opening. The patient opens the mouth slightly, with a fist under the chin to supply gently resistance. The pressure is maintained for three to five seconds followed by relaxation.

Closing. The patient places four fingers covered with cushioned material (to protect the skin) over the inferior teeth to gently oppose the closure of the jaw.

The *velum* is exercised through voluntary contraction and relaxation to increase its proprioception and strength. This is particularly important when the patient has a cleft palate or when maxillary advancement is planned.

In the individual with a severe midface hypodevelopment the velar physiology can be altered. The depth of the pharynx is diminished causing the velum to be in a vertical position. The posterior nasal spine is too near the posterior pharyngeal wall, and with a minimum contraction the whole velum touches the posterior pharyngeal wall. These factors, especially in the more severe cases, can cause a hyponasal voice, a condition that is solved only after the surgical maxillary advancement (McCarthy, 1979). Depending on the patient's pathology, other muscles may be exercised. In case of existing mentalis muscle tension, exercises to its antagonist (the quadratus muscle) are performed.

Before surgery the patient is taught a normal swallow pattern even if the maxillomandibular relationship is unfavorable. This conditioning will enable the patient to change the deglutition pattern and control swallowing after surgery (during the period of intermaxillary fixation). It is important to learn a correct swallow before surgery, because this prevents the tongue from forcing itself against the teeth threatening the fixation's stability. It also offers more security during the period immediately after the fixation release, when bone relapses are still likely to occur.

When correcting presurgical swallowing, it is necessary to remember that we swallow twice each minute while awake, and almost nine times per minute when eating (Harden & Rydell, 1984). After the fixation release, any strong and constant atypical pressures of the tongue added to lip incompetence can provoke relapses in a short period of time. Barrett and Hanson (1978) report on a patient who had normal occlusion

after the release of the intermaxillary fixation, and only two weeks later presented an open bite. This situation reverted six weeks later, and stayed stable, as a result of myofunctional therapy.

Deglutition is taught through established myofunctional therapy procedures. The following are some preparatory exercises: Suck the tongue hard against the palate for 20 seconds; suck the tongue and then open and close the teeth without letting it fall; bite hard for five seconds; and, swallow with teeth apart and the tip of the tongue behind the inferior incisors, just moving the back of the tongue. Before swallowing we ask patients to put saliva on the back of the tongue to elicit the reflex of swallowing; swallow water (then yogurt, and later wafers) with teeth apart and tongue sucked; swallow with teeth together but lips apart; and, finally establish a continuous (sequential) swallow. When the patient is able to swallow continuously, we observe the patient eating a complete meal. The last step for this stage is to prepare the patient for surgery. Instructions are given regarding diet, oral hygiene, and also about typical post-surgery emotional reactions.

DIET

The patient should eat every two hours to avoid excessive weight loss. Food should be liquid (because of the intermaxillary fixation); sieved (so that no fibers attach to the fixation); at room temperature (hot food tends to cause edema); administered with a spoon, straw, or syringe (but preferably with a straw to encourage the patient to pucker); finally, the meals should be rich in protein, iron, and Vitamin C to promote healing.

ORAL HYGIENE

Oral hygiene is performed after feeding to avoid the accumulation of food on the fixation wires. The patient rinses the mouth with antiseptic. Brushing is also recommended three times daily, but only with a very light vertical motion. A syringe can also be used to throw jets of water on the cheek region. The use of the waterpick is not recommended because the waterjet is too focused and strong. Oral hygiene activities indirectly help intraoral proprioception and encourage some mobility of the lips and cheeks.

EMOTIONAL PREPARATION

The patient is prepared for the postsurgical exerience with the following information: Intermaxillary fixation will last up to 60 days dependent on the type of surgery; expect some swelling; after surgery the face will be bandaged; and some areas of the face may show bruising. We also explain to the patient there may be a sensation that the surgery was not performed. At first the jaw may be sensed to be in the same position. The tongue may also feel overlarge. Our experience is that with motor and sensory exercises done pre-surgery complaints such as these are minimized.

GENERAL ORIENTATION

We ask the patient to move the head gently in all directions after surgery because the natural tendency is to avoid movement for fear of causing a setback in the post-surgical recovery. The therapist reminds the patient that it is very important to keep lips closed, the tongue in the correct posture, and to try to swallow correctly. Even if unable to correctly swallow, the patient should attempt to swallow without pushing the tongue against the teeth.

Physical activities (e.g., jogging) are avoided for two to three months. Sun, saunas, and very hot showers should also be avoided to prevent edema. Sometimes patients complain of swelling on hot days even six months post-surgery. Patients should always be able to contact the therapist for reassurance and information.

Treatment During Intermaxillary Fixation

During this stage of the treatment (Fig. 9), activities are focused at improving mobility and sensation. Although, the patient only comes for therapy every fifteen days, the exercises are performed daily at home.

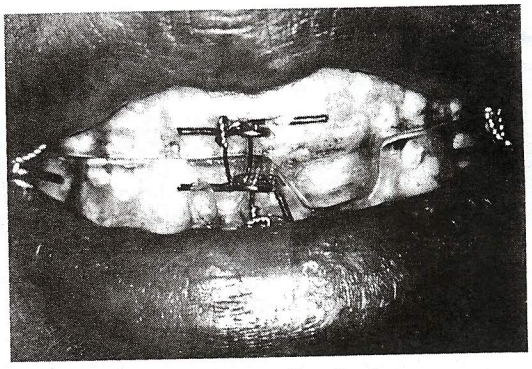


Figure 9. *Intermaxillary Fixation*

Sensitivity: These activities can begin immediately post-surgery. After surgery there is, typically, a total or partial reduction of sensation due to edema and microlesions to the nerves. Consequently, the patient has less awareness of articulatory organs, making correct oral posture and movements even more difficult. Additionally, the facial area has suffered a great change in a short period of time, without allowing the patient to build a new body image. The previous body image stays in the mind and the patient has the sensation that the surgery was not performed -- similar to someone with a phatom limb sensation following amputation. Sensitivity exercises are divided into: Proprioception, and Exteroception.

Proprioception. The patient is asked to: Look into a mirror every day to become accustomed to the new appearance; explore the oral cavity with the tongue, touching it on the palate and counting each tooth; and develop awareness of tongue posture and movement during swallowing.

Exteroception. This involves exercises to develop tactile and thermic sensitivity. To recover tactile sensitivity we ask the patient to take advantage of everyday life activities: When drying the face, feel the towel texture (or when shaving feel the blade on the skin). There is also a specific exercise done to stimulate touch sensitivity --

the patient uses brushes of five different thicknesses on the face several times a day. Later, during the office visit, the brushes are passed over the patient's face with eyes closed, and the task is to identify each of them. We use brushes that can be easily identified. The patient does not have to become an expert in sensitivity but only to feel touch as before.

For thermic sensitivity we ask the patient to pass an ice cube covered with a thin piece of cloth with circular movements over the entire face until the ice is melted. We only use cold stimuli because there are more exteroceptors for cold than for hot stimuli. Additionally, there are some regions of the face (e.g., the forehead) which have very low sensitivity to heat stimuli (Bradley, 1985). After the cold stimulus is removed, the cold sensation lasts for some seconds. When the temperature in the cold receptors is below a determined level, the cold afferent nerve endings continue discharging at the same level of the initial stimulus (Mountcastle, 1978). The use of cold stimulus not only helps in terms of sensitivity but also helps reduce edema. Most patients who undergo mandibular osteotomy complain of lack of sensation in the chin region. This is often the last area to recover.

Mobility: Mobility exercises can be started 12 to 15 days after surgery, allowing the patient some time to recover from the surgical trauma. Also, 12 to 15 days after surgery the unattached muscles have had time to, once again, to become affixed. According to an histological study on Rhesus monkeys, two weeks after maxillary osteotomy, the mucoperiosteum is completely revascularized and reinserted on the subjacent bones (Bell et al, 1975).

We allow the patient to begin light isotonic exercises. Isotonic exercises are those in which there is no alteration of tonus but only of mass. The muscular fibers become shorter and thicker responding to the various kinds of movement. The prescribed exercises involve the mobility of the cheeks, lips, and tongue. Initially, the exercises must be light to avoid any attempted mouth opening. Nothing should offset the balance of the intermaxillary fixation.

EXERCISES FOR CHEEKS

Air under pressure inside the oral cavity can be passed from one cheek to the other alternately and if possible, from the superior to the inferior lip, and vice-versa. The same procedure is done with the antiseptic used for the oral hygiene.

EXERCISES FOR LIPS

Using a straw in eating is an indirect manner of exercising the lips. Additional lip exercises include: Alternately pucker and spread the lips; push the lips to one side and the other alternately; and, firmly compress the lips and relax.

EXERCISES FOR THE TONGUE

These exercises include: Press the tongue against the papilla; alternately touch the tip of the tongue on the papilla and on the mouth's floor; pull the tongue back over the palate; pop the tongue slowly and with no force and tension. The therapist must observe very carefully during this exercise. If the patient cannot pop the tongue without trying to open the mouth, it must be stopped immediately.

Treatment After Intermaxillary Fixation Release

Approximately 50 days after surgery the intermaxillary fixation is released; directly after this the maximal interincisal distance is remeasured. At this final stage, the patient attends for therapy once weekly. All previously established goals must first be achieved, namely the ability to: Achieve the patient's previous range of mouth opening; increase jaw mobility; acquire an adequate chewing pattern; normalize sensitivity; achieve normal muscular tonus and mobility; automatize tongue and lip postures; automatize the correct swallow; and correct any speech problems that might be present.

After release of prolonged fixation, there is a limitation of the mouth opening. Specific jaw exercises are required to mobilize the joint. When the surgery is done only in the maxillary bone, jaw exercises can be started from two to four weeks post-surgery (when the osteotomy is performed on the mandible or combined, five to eight weeks are recommended; Bell et al, 1983).

Exercises should always be preceded by a warm-up period of opening and closing the mouth repeatedly without effort. Then, forced opening of the mouth can be started. The patient opens the mouth and keeps it open for 20 seconds -- trying to open it more and more. Following these exercises, we suggest the use of some kind of material that will ensure the opening of the mouth -- such as stacked wooden tongue depressors. They are inserted between the incisors -- being careful not to scratch the teeth when placing and removing them. The patient forces mouth opening, always taking into account the pain level. Gradually, the number of spatulas is increased until the mouth opening reaches 40 to 50 mm. Each week the therapist prescribes the number of spatulas to be used by the patient. The additional spatulas are inserted in the *middle* of the pile and not on the top to avoid pressing the incisors lingually. The final number of spatulas is based on the presurgical interincisal distance, and also on the distance measured immediately following intermaxillary release.

In 1985 the author investigated 30 orthognathic surgery cases; 27 reached normal mouth opening in a period from two to five weeks, while three took six to eight weeks due of post-surgical problems (Altmann, 1985). Some authors have reported, however, that their patients needed from four to ten weeks of exercises to achieve their presurgical interincisal distance (Bell et al, 1983). This difference may be attributable to the different therapeutic exercise regimens, or to psychological factors since these patients are often afraid to fully open their mouths. When the patient is afraid of opening the mouth or when there is real difficulty we apply ice to the masseter region. The short term therapeutic use of a cold stimulus over the region of the jaw muscles is recom-

mended in the presence of pain or any other discomfort caused by muscular hyperactivity (Christensen & Mohamed, 1984).

The majority of exercises for mouth opening are isometric, and the continued contraction of the muscles that lower the mandible can produce pain and fatigue, inhibiting the patient's cooperation. With the application of ice before the exercises, this problem is partially resolved because the threshold of pain is raised (Lehmann & De Lateur, 1982). The anesthetic effect of the cold stimulus generally allows the individual to maintain mouth opening for longer periods of time.

We can also use indirect methods so that the patient is unaware of the mouth opening and is, therefore, less fearful. One method is to pretend exaggerated masticatory movements, as though chewing sticky candy. Another way to indirectly open the mouth is to engage in exaggerated sucking exercises. For this purpose we use the oral manometer or the #2 orthodontic pacifier and we ask the patient to lower the jaw as much as possible with lips closed so that the cheeks will collapse towards the inside of the mouth.

Mouth opening exercises indirectly increase jaw mobility. However, we also advocate specific exercises for mobility; for example: Gently open and close the mouth; slightly open the mouth and then protrude the jaw keeping the position for two seconds; slightly open the mouth and move the jaw sideways keeping the position for two seconds, performing the exercise each time to a different side. All these exercises are to be done very slowly and within the patient's pain limits. Through these exercises masticatory muscles are activated, allowing the patient to acquire a normal chewing pattern.

After intermaxillary release, the patient's diet is changed from liquid to creamy. Typically, the patient lacks sufficient strength to chew. The maxillomandibular relationship is altered and the individual has to become accustomed to this new situation. The masticatory muscles play an important role in the movement and positioning of the jaw because the muscular afferent nervous endings are the main sensors of jaw position (Broekhuijsen & van Willigen, 1982). At this point there is a muscular adaptation through the exercises, and simultaneously there are slight changes in the position of the teeth. There is also bone remodeling of the osteotomized segments (Bell et al, 1983). Sometimes the patient reports a total inability to chew and swallow. However, we have noticed that complaints such as "I don't know what to do with my tongue. It seems so big" have stopped since we started partially re-educating the swallowing before surgery. When this is done, the proprioception of the appropriate swallowing movement appears ingrained -- which seems to help adaptation after surgery. Food consistency is gradually changed from creamy to fork mashed, then food is cut in small pieces and finally, normal size bites of food are introduced. Usually, in two or three weeks, the patient can eat everything except hard food requiring biting with incisors -- which is delayed for a least one month. In addition to their regular diet, we ask the patient to chew a sticky jelly twice a day to further encourage jaw mobility.

Sensitivity and muscular exercises are continued at this stage. Sensitivity activities now focus on oral stereognosis to help the acquisition of the new body image. Besides asking the patient to be aware of the mouth during day-to-day activities, we utilize an exercise with pairs of acrylic shapes. One set of shapes is left on the table and the other set is kept by the therapist who introduces them one by one into the patient's mouth for identification with eyes closed. In the majority of cases this is done just once or twice because usually the patient has minimal stereognosis problems.

The musculature needs exercise post-surgery. After prolonged intermaxillary fixation there can be a reduction in the length of muscle fibers which directly affects their stretch and elasticity (Witzmann et al, 1982). Lack of use also diminishes muscle mass (Maier et al, 1976). In a recent study it was demonstrated that the masseter muscles suffer a focal denervation as a result of the orthognathic surgery (Boyd et al, 1982) and this can lead to degenerative alterations (Jolez & Sreter, 1981).

We utilize exercises for mobility and tonus, that is, both isotonic and isometric exercises. We cannot only apply isometric exercises since this would cause chronic muscular tension with loss of elasticity. Skeletal stability would be threatened because of excessive muscle contraction. After surgery, myofunctional exercises are easier to perform because there is harmony between the bone structures and the soft tissues. The exercise regimen facilitates adaptation of the soft tissues to the bony changes. Usually lips that were short gain length, allowing the patient to close the lips with less or no chin tension. Gallagher et al (1984) demonstrated great improvement in the soft tissues of those patients who underwent Le Fort I procedures associated with advancement genioplasty. According to these authors there was dento-skeletal improvement, increase of muscular tonus, and lip changes which allowed the lips to be kept closed without any eversion. To increase mobility we select appropriate exercises such as: Puckering and stretching the lips alternately; lateralizing the tongue touching its tip to the lip margins; and, passing air from one cheek to the other.

The final step of this phase is the automatization of the new swallow pattern. Achieving this goal is directly related to resting tongue and lip postures. Barrett and Hanson (1978) state that "posture is the basis for function: Every muscular movement is influenced by the posture from which it was started and to which it returns" (p. 169). To develop automaticity of the swallowing movements the patient has to be able to swallow quickly, without awareness of the individual movements. To develop this ability we squirt water in the patient's mouth very quickly while counting numbers. Each number corresponds to a swallow. This exercise is done with four types of swallow: With the tongue sucked to the palate and the mouth open (we call that "sucked swallow"); with teeth closed and lips apart (which we call "smiling swallow"); with lips and teeth closed; and continuous swallow.

We also ask the patient to bring one complete meal to the clinic and to signal each swallow by raising a hand.

Another activity consists of reading a sentence or a few words silently with lips closed and tongue in correct position. Then, the patient repeats the memorized sentence aloud. This is done with a whole text, one sentence at a time. When the patient needs to swallow saliva it must be done while reading silently and not while talking. Besides these exercises, we follow all the classic myofunctional therapy procedures.

The establishment of nasal respiration has a positive influence on the automatization of normal deglutition and tongue and lip posture. Gotzfried and Masing (1984) demonstrated that the majority of patients submitted to ventral advancement or caudal dislocation of the maxilla presented a post-surgical improvement in nasal respiration. These same investigators also analyzed 17 patients, 14 of whom showed improvement in nasal respiration after middle third advancement. In this study they demonstrated that the nasal tube had increased 5 mm. in its vertical extension, and that the naso-labial angle had been augmented. These small structural changes reduce respiratory resistance, allowing the air to enter the nasal cavity more easily. These observations were supported by rhinometric airflow testing.

When speech is affected, usually the phonemes are modified in terms of the place of articulation. The position of the tongue is altered, and it touches the wrong place in the oral cavity. Usually, the phonemes affected in Portuguese are: The alveolars /t/, /d/, /n/, /l/; and, fricatives /s/, /ʃ/, /z/, /ʒ/. In the first case, the tongue touches either the lingual surface of the superior incisors or is projected between the dental arches. For the fricatives, the tongue may be placed between the incisors or laterally between the premolars, with the airstream being directed to the cheeks. The majority of speech alterations are inaudible; they are simply postural. Speech alterations vary according to each patient's pathology and from one individual to the other; sometimes speech is entirely normal.

The active phase of therapy is completed once the patient has achieved the following goals: Automatized tongue and lip postures; automatized correct swallowing; normalized mouth opening; normal chewing, and normalized speech movement patterns. After these targets have been reached, the patient attends once a month for follow-up sessions. This is done in order to assure automatization and to prevent any functional skeletal or dental relapses.

Conclusion

Orthognathic surgery, together with orthodontic treatment to align the teeth, provide a harmonious maxillomandibular relationship. Surgery and orthodontics also improve the relationship between the bones and soft tissues. There is an anatomical and aesthetic improvement. However, function in itself is not modified. If the individual has hypotonic lips and tongue thrust, these conditions will persist after surgery. The anatomic harmony of the face will improve function, but it will not solve the problem completely.

Myofunctional therapy adds a new dimension to orthognathic surgery. The functional aspects have begun to receive their due value. Some surgical techniques have also become revised in view of a new understanding of physiology, and the once common relapses due to muscle imbalances can now be avoided.

The main goal of myofunctional therapy for patients undergoing orthognathic surgery is to restore normal function and to obtain muscular static and dynamic equilibrium. A successful stable outcome from the surgical, orthodontic, and myofunctional treatments has a great impact on the patient's psychological well-being. Myofunctional therapy's relationship to orthognathic surgery is a field ripe for future research.

Editor's Comment: *Ms. Altmann's approach was described in a presentation to the International Association of Orofacial Myology, Fifteenth Annual Convention, Chicago, 1987. Her program was developed cooperatively with a team of oral surgeons in Sao Paulo, Brazil. Therapists will find that patients' rehabilitation needs vary according to the type of surgery performed. Surgical methods of rigid fixation (permanent screws and plates rather than temporary wires to hold the bones in their corrected position) seem to be gaining popularity. Such techniques can reduce to as little as two weeks the time that the jaws are immobilized. This should reduce those muscle and joint problems, caused by prolonged jaw immobility, that Ms. Altmann describes. However, with less time in fixation for the muscles to adapt, there will be an increased need for myofunctional therapy prior to and following surgery so as to help create a favorable muscle environment for the new position of the bones and teeth.*

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