Tutorial

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Robert J. Brown

Suggested Citation

Brown, R. J. (1982). The Frankel Appliance: Indication for use and explanation of function. *International Journal of Orofacial Myology*, 8(3), 4-10.

DOI: <https://doi.org/10.52010/ijom.1982.8.3.2>

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The Frankel Appliance: Indication For Use and Explanation of Function

Robert J. Brown, D.D.S.

Functional jaw orthopedics is not new to orthodontics and the Frankel appliance is only one of many used for this treatment. Before the turn of the century, jumping the bite with a bite plane was proposed. The monoblock was suggested by Pierre Robin in 1902. The more familiar Andresen appliance appeared in 1908. There have since been numerous such appliances used with varying degrees of success.

Histologic studies by Petrovic²⁷, McNamara¹⁸ and many others have demonstrated that cellular activity relating to mandibular growth is stimulated by forward positioning of the mandible.

The intent of this paper is to show some of the etiological factors leading to certain malocclusions and how their correction is imperative to successful treatment with the Frankel Functional Regulator.

Particular attention will be paid to the airway and its effect on the muscles associated with the growth of the oral complex. The importance of proper diagnosis and treatment of airway insufficiencies should also be emphasized in achieving successful Frankel therapy. In the author's opinion, this is also critical to the stability of all other forms of orthodontic treatment.

Before going into the diagnosis and treatment of airway problems, a brief study of how the oral complex develops is in order.

Essentially the maxilla and mandible develop as a response to the developing muscles with the capsular matrix (Moss²²⁻²³, Delaire⁵). This is in combination with the genetically controlled growth (or lack of growth) of the various cartilages, ligaments, bones and teeth (Petrovic et al²⁷). Variations in this normal development can produce congenital deformities such as cleft palate and craniofacial dysostosis. Therefore, to the extent that there is ideal muscle function there is generally ideal growth and development (Murray²⁴).

The carriers of the genetic messages which stimulate the growth of the muscles appear to be the nerves (Washburn⁴⁴). Dr. Frankel⁷ believes that an appliance that changes the position of the mandible by proprioceptive stimulation rather than by positional locking of the teeth or bones would have a more profound effect on the muscle development.

As the face develops, the posture of the tongue provides the inner "framework" for the developing arches and the palate (Proffit³¹, Delaire⁵). A low forward tongue posture can result in the palate dropping at the

posterior (Bushey³). Many times the soft tissue response to this is microrhinodysplasia.

The dental response to this condition is frequently a narrow upper arch with accompanying cross bite either bilateral or unilateral. The unilateral cross bite is frequently associated with a positional midline shift and corresponding asymmetric face (Bushey³).

Ricketts³³ notes that "the nasal cavity happens to be formed by essentially two parts of the maxilla which also happen to be basal structure for upper teeth and most of the upper jaw. The lower limits of the nasal cavity also happen to be the upper limits of the oral cavity".

Normal respiration thus becomes a factor not to be ignored. With the lips sealed, the posterior oral cavity is sealed by the soft palate and a partial vacuum is formed. This results in the adaptation of the lips and cheeks to the exterior of the teeth and alveoli, and the tongue to the palate, alveoli and teeth. The tongue in ideal posture is "stuck" to the palate. A break in this seal allows the tongue to drop. This lack of seal can also result when a seal of the soft palate to the tongue cannot be achieved as in cleft palate. The posture of the resting tongue appears to be of far greater importance than the "tongue thrust" upon swallowing (Proffit³¹). Proffit further suggests that in the short term, function adapts to form more than form to function. For example, the tongue thrust could result from a narrow palate with accompanying lack of seal of tongue to palate.

In the long term the altered function will result in altered form; for example, a drooping mandible can result in excessive eruption of teeth with subsequent permanent change in vertical dimension. Miller²¹ studied the neuromuscular changes following altered respiration. He was able to demonstrate that upon blocking the nasal airway almost all the muscles associated with the oral complex had altered activity. When the nasal airway was blocked, the craniocervical angulation was observed to change (Solow³⁸).

We can therefore demonstrate that a properly functioning airway is imperative to the ideal posture of the head and associated structures (McNamara¹³). It now becomes quite apparent that the achievement of stable results, whether orthodontic or myofunctional, depends greatly on the achievement of an adequate airway. In addition, the oral capsule which includes the nasal cavity must not contain structures that prevent proper posture, such as adenoids and tonsils, or bulky retainers (Ricketts^{33, 34}, Linder-Aronson¹¹).

The diagnosis and treatment of the above mentioned problems is, to say the least, complicated and, in many cases, controversial. The author has found

Presented at the annual convention of the International Association of Orofacial Myology, San Diego, CA, July, 1982.

Dr. Brown is in private practice in Danville, CA. He studied under the personal instruction of Dr. Rolf Frankel in both 1977 and 1980.

it necessary to search out his professional community for practitioners who are knowledgeable in these areas. Many of the articles referred to herein have been purchased and given to those who aid in the correction of airway problems.

Nasorespiratory malfunction can be congenital, environmental, or both. Congenital problems may include cleft palate, insufficient soft palate, submucous clefts, and excessive nasopharyngeal depth. Many of these cases are best treated surgically and will not be discussed further.

We can, in most cases, do a lot for the environmentally-caused blockage. Some of the conditions leading to respiratory problems are hypertrophy of tonsils, adenoids and turbinates, chronic infection, allergies, and deviated nasal septums. The deviated nasal septum is believed in many cases to be a result of chronic allergies and infection.

The controversy over tonsils and adenoids as a cause of malocclusion still exists. Diamond⁶ claims no relation, while Bushey³, Pruzansky³², Subtelny⁴⁰, Ricketts³⁴, Linder-aronsen¹², and others conclude a definite relationship.

The author has experienced dramatic improvement in the development of the oral complex after tonsilectomy, adenoidectomy or both, as have Solow³⁸ and Ricketts³³. In all cases a thorough diagnosis should be made and all positives and negatives weighed before proceeding. Sometimes nutritional therapy can be quite successful in bringing these lymphoid tissues under control (Smith³⁷).

A complete medical history is always recommended in the diagnosis of airway problems. Histories of otitis media, recurrent sore throats, hearing problems, chapped lips or nose, headaches, or frequent colds all point toward allergies.

Hyperactive children, depressed natures, aggressive and schizoid personalities and chronically tired children also may be suffering from the many manifestations of allergies, particularly food allergies (Hoffer⁹).

Bushey² recommends a "six point" clinical examination designed to alert the practitioner to the mouth breather:

1. Look for the "adenoid face", typical "mouth-gaping" or lip incompetency when relaxed. In those cases where either the upper lip is short or the lower face-height long, the prognosis of a spontaneous stable result following airway correction is poor (Pogen²⁹).
2. Evaluation of the nares and nasofacial angle. The typical "pinched together" nares are often tipped up with the nares directly visible.
3. Mode of respiration evaluation is used to determine the severity of the mouth breathing. In lieu of the sophisticated devices used by the ENT, one may merely have the patient seal his lips for one or two minutes, watching for difficulty in respiration. Next close one nostril, then the other. This will help determine if the obstruction is nasal or pharyngeal in nature. Having the patient "hum" through each nostril will aid in determining if air is flowing.

4. Determine the swallowing pattern. Is it tooth-together or tooth-apart? The tooth-apart swallow is usually accompanied by a pursing of the lips with accompanying tongue thrust. In severe tongue thrust cases the patient will have great difficulty when asked to swallow with his lips apart and his teeth together. When the extent of lip competence, overbite or open bite is weighed, an assessment of the complexity of the tongue problem begins to be possible.
5. Assessment of frontal facial morphology. Does the patient demonstrate a dolichofacial form (long and narrow) associated with skeletal open bite or a brachyfacial form associated with deep bite? Is the face symmetric or does the lower face have a functional shift to accommodate a crossbite?
6. Assessment of the clinical characteristics of the oral cavity.
 - a) Dental midline—is the deviation dental or due to a mandibular shift?
 - b) Anterior crossbite—can be an indication of a potential skeletal open bite.
 - c) Posterior crossbite—when maxillary in nature, is a key to adenoid obstruction. Evaluation of which arch is to "blame" can be critical in determining the treatment and its ultimate stability. A collapsed lower arch (buccal cross bite) can be evidence of glossoptosis or low tongue. An excessively wide lower arch can be associated with a developing Class III. Frontal and lateral cephalometric x-rays are in order to verify your findings.
 - d) The height and contour of the palatal vault. Deep palatal vaults are usually associated with a narrow upper arch and low tongue (mouth breathing, tonsilitis).
 - e) Palatine tonsils—have the patient protrude his tongue, curling just the tip up. In many cases this will drop the posterior allowing clear view without uncomfortable tongue depressing. Large tonsils that meet at the midline can result in forward tongue displacement (Bushey^{2, 3}).
 - f) The gag reflex elicited by tongue depression can indicate inflamed tonsils even though they are not enlarged significantly.
 - g) Assessment of adenoid tissue can be accomplished best with a lateral cephalogram.
 - h) Investigation of the soft palate. With the presence of a bifid uvula or a deep oropharynx, the palate should be palpated. The presence of a notch (submucous cleft) contraindicates tonsil or adenoidectomies, due to the resultant speech difficulties when a posterior seal cannot be achieved.

Cephalometric evaluation is quite valuable in verifying your clinical findings. Through the measurement of these films, accurate assessment of the deformities can be made. One of the key indicators of oral respiration is the angulation of the palate. The palatal plane is normally parallel to the Frankfort plane. The low

tongue posture associated with mouth breathing will result in a forward, upward tipping of this plane (Bushey¹). The lateral head films will also show the characteristic low tongue posture of a mouth breather as well as the forward or downward displacement of the tongue by the tonsils (Ricketts³⁴).

The lateral cephalogram can also be used to demonstrate hypertrophy of the distal portion of the inferior or medial turbinate. In several cases, unsuspected chronic allergies causing nocturnal oral respiration have been first suspected due to this condition. This hypertrophy usually consists of goblet cells which form thick mucous as a postnasal drip. Surgical removal and cauterization can easily be performed as an in-office procedure by the ENT.

The proposals of Bushey² regarding treatment of these problems are quite complex. Before one proposes a surgical approach, an attempt at nutritional correction is worth a trial period (Smith³⁷).

The author has had varying degrees of success with this approach. In the case of those who adhere strictly to the program, correction has been sufficient to discontinue medical treatment and allow nasal respiration. Application of Smith's "stress formula" followed by the allergy program appears to subdue allergies and, in many cases, decreases lymphoid hypertrophy.

Price³⁰ began his work in the 1930s studying the health of people all over the world with respect to their diets. Being a dentist, he made much reference to the lack of dental crowding and arch collapse associated with cultures who had no access to "foods of commerce".

Pottenger²⁹, by accident, discovered that cats developed numerous diseases, most related to improper bone development due to processing milk and cooking meat.

Although this research was and is extremely eye-opening, there appears to be a resistance in the field of medicine to admit that our bodies are capable of curing or avoiding most diseases, including the problems discussed in this paper, without the help of "modern medicine".

In the personal experience of the author, three cases of severe allergies were cured nutritionally. Myself, my daughters Kim (17), and Michelle (6) all suffered from asthma. After one year of nutritional therapy, including elimination of processed foods (90%), and addition of vitamins and minerals similar to Smith³⁷, only occasional "hay fever" is experienced. The younger daughter experiences no symptoms whatsoever.

One very important factor to consider in the nutritional (holistic) approach toward airway obstruction is the secondary benefits. Dr. Melvin Page²⁶ states that many of the same requirements for treating allergies are those for preventing degenerative diseases. Empty calories such as alcohol, sugar, white flour, and many processed foods actually deplete the body of its nutritional building blocks (Hoffer⁹ & Page²⁶).

The production of cortisol (an adrenal hormone) can

only be accomplished by healthy adrenal glands. Cortisol is not only able to counteract histamine, but also aids in the prevention of obesity and aids in triglyceride metabolism (Guyton¹⁰). It may just be possible that adrenal health through ideal nutrition is one of the factors that resulted in the findings of Dr. Price - absence of allergies, well-developed dental arches, lack of obesity, no coronary heart disease.

The major difficulty in the nutritional approach to correction of nasorespiratory problems is medical cooperation. Most popular sources of information, including major medical schools and their graduates, do not support this approach. Television, radio, and many physicians support the proliferation of processed foods. Just ask your physician if you need vitamins. The answer is, in most cases, "Not if you eat a well-balanced diet." A well-balanced diet is at best difficult to achieve due to our methods of farming, preserving and processing. The study of the nutritional approach toward allergy correction will require another presentation. The purpose of this discussion was to open some eyes to alternatives to drugs and/or surgery.

The conclusion that Dr. Frankel makes is: do not attempt Functional Regulator therapy without achieving a lip seal. Once lip seal is accomplished, in the majority of cases, correction of the deformity can be accomplished.

THE FRANKEL APPLIANCE

The Frankel Functional Regulator was originated by Dr. Rolf Frankel of Zwickau, East Germany. The appliance is designed to intercept abnormal muscle function and stimulate hypertonic function of under-developed muscles. The appliance can only stimulate growing tissues, thus is used only during the growing years. It is best used between the ages of 7 and 10, preferably only for two years. As previously discussed, if muscle tonicity can be increased, more growth of the muscle and subsequent growth of the supporting structures will be accomplished.

This appliance does not make contact with teeth except in special circumstances where springs are used to align teeth that were previously displaced by improper muscle activity and under-developed arches.

The functional regulator is not meant as a universal orthodontic appliance, and is definitely limited by rate of growth and cooperation. It is not meant to be used on cases requiring extraction, although there are certain exceptions.

The main thrust is the proprioceptive stimulation of muscles, ligaments and periosteum. Dr. Frankel feels strongly that the mandible must be brought forward (in Class II malocclusion) by a proprioceptive response to the appliance, never locked forward. This is accomplished by a lingual shield (Figure 1,a). To accomplish a proprioceptive response, the mandible is only advanced 3mm and the appliance is "broken in" over a two-month period.

It is important to recognize that the functional regulator is not a tooth-moving appliance, neither is it like most other activator-type appliances. Except for

Fig. 1 Frankel I or II, showing lingual pad (a), lip shield (b), mentalis muscle (c).

occlusal rests and stops, it has no tooth or alveolar contact once the patient has achieved the desired posture. The Frankel Functional Regulator is designed to do the following:

1. Increase intraoral space – both sagittal and transverse.
2. Alter vertical proportions of intraoral space.
3. Position the mandible properly.
4. Enhance proper muscle function toward a relaxed oral seal.

1. The increase in intraoral space sagittally and transversely is accomplished by the buccal and lip shields (Figure 1,b and Figure 2,d). The pressure of the soft tissue on the teeth and alveoli create crowding and inhibit basal bone development. The shields force these tissues away allowing the tongue to be their only acting tissue force. The tension created, according to Frankel, results in a "pull" or stretch on the basal bones. While the physical expansion is going on, the muscles react with increased tonicity. As previously discussed, this can result in increased growth in muscle length (Figure 1,c). The result is, once the arches have been expanded, the muscles will be much less likely to relapse them inward.
2. The vertical increase of intraoral space is accomplished by the forward positioning of the mandible and posterior bite opening. With the cheeks held away from the posterior teeth by the buccal shields, the posterior teeth are allowed to erupt or elongate.
3. Forward positioning of the mandible by proprioceptive muscle activity, according to Frankel, will stimulate growth. Unlike activators, the Frankel Functional Regulator does not lock the mandible forward. It is critical that the mandible

be advanced only 2 to 3mm to achieve a proprioceptive response. Excessive advancement creates a distal force on the maxilla as would an activator and can lead to tissue irritation. Therefore the mandible is advanced slowly in steps by adjusting the appliance.

4. The development of good muscle tone and function is created by the lip and buccal shields. Once the patient adapts to the appliance, all movements such as swallowing and speaking become exercises to stimulate proper muscle function. For this reason, it is imperative that the patient be comfortable, not over-stretched; that the bite is not over-advanced; and that the break-in period is slow. Most of all, the appliance will not work without lip seal.

In the case of excessive protrusions, correction must be achieved with conventional appliances to the extent that a comfortable lip seal can be held. It may also be necessary to have several months of pre-treatment exercises. In some cases, where cooperation is poor or the airway cannot be cleared, Frankel therapy should not be attempted. In Class III cases, myofunctional tongue therapy is imperative during treatment. This is due to the extremely low tongue posture associated with mandibular prognathism. Unlike other functional appliances, the Frankel does not take up palatal space, allowing the patient to perform the necessary tongue exercises.

The optimum time for Frankel therapy is during the most active growing periods. Usually treatment should begin around age 7½ years. Earlier treatment can only be performed on very mature children. It is most effective to begin after eruption of the first permanent molars and lateral incisors.

Fig. 2 Frankel I or II. Occlusal rest (a) prevents posterior teeth from closing. Stops (b) which fit into grooves cut into deciduous teeth, along with adjustable labial wire (c), create a distal force on the maxilla when lip pressure is exerted on labial pad (d). Low position of this pad also forces the upper lip to elongate (exercise) in order to close.

If one waits until the permanent canines erupt, the stimulation of transverse development is limited. This is partially due to the fact that the erupting teeth are responsible for the development of the alveolar process. If the Frankel is in place during this eruption, the alveolar bone will be encouraged to form with a wider transverse dimension.

The active treatment stage with the functional regulator should be two years or less. Once goals are achieved, the regulator may be used during sleeping hours as a retainer.

An important reason for early treatment is to interrupt the development of the extreme vertical dimension associated with some mouth breathers. The Frankel appliance is far less effective on the very vertical or dolichofacial pattern. These cases usually experience severe mentalis strain on lip closure. With the lip shields in place, the strain is excessive for proper therapy. In mild dolichofacial open bite cases, the Frankel IV can overcome the problem to a great extent when treatment is begun by 7 years.

In the case of Class III treatment, prolonged treatment may be necessary. These cases have a tendency to have mandibular growth at a much later age, but the nighttime use of this appliance will usually control this. Once the lower incisors have been brought inside the uppers, the occlusal rests (Figure 3, OR) are cut off allowing the bite to close, thus aiding in retention.

As we mentioned earlier, the development of the dental arches in the associated bones occurs primarily as a response to the developing muscles. Figure 4 illustrates the continuous ring of muscles that control the horizontal plane of development. Ideally, the circumference of this "oval" would be dictated by the genes.

Figure 5 demonstrates the muscles controlling the anterior vertical development and how they relate to the structures in Figure 4.

Fig. 3 Frankel III. Lip shield (a) is in the depth of the vestibule of the upper lip holding the muscle away from the alveolus. The force of this muscle distally is transmitted to the mandible due to the adaptation of plastic to the lower posterior and the pressure of this labial wire (b) against the lower anteriors. The upper stops (s) allow the distal displacement (pressure) but prevent the appliance from moving forward.

Fig. 4 A continuous "ring" of muscles is formed by the superior constrictor of the pharynx, the buccinator and the orbicularis oris. This is a primary limiting factor in arch development.

It now becomes apparent that if one could alter the growth of the different segments of these groups of muscles, the development of the bony structures could be altered, hopefully controlled.

Any environmental phenomenon that would increase the tonicity of one set of muscles and not another would alter the genetically directed growth. For example, chronic mouth breathing will result in the lengthening of the vertical muscles. The tongue would drop, taking away internal support from the upper arch. The muscle pressure from the cheeks would then dominate and the classic narrow upper arch occurs. Due to the stretch on the buccinator ring (Figure 4) crowding also can occur in the lower arch depending on the anterior-posterior placement of the tongue.

Frankel treatment for this case would be to: 1) correct the airway obstruction and achieve lip seal; 2) expand the palate with a palate-spreading appliance; 3) apply either a Frankel I if a Class II, or Frankel IV if a Class I malocclusion.

The function of this appliance would be to increase the tonicity of those muscle groups that are underdeveloped. The lower lip shields (Figure 2,d) would force the upper lip to stretch down in lip closure by holding the mentalis muscle down. The buccinator is held laterally increasing its length. The tongue is allowed room to assume a better position due to the lack of structures in the palatal vault. Because of this, tongue therapy can be applied during treatment.

In the case of the Frankel I, II, and III, the pressure of the muscles of the underdeveloped arch are transferred to the overdeveloped arch. The Frankel II upper lip shields (Figure 3,a) create a distal force by holding the lip forward. This force is transferred to the lower arch by the labial wire (Figure 3,b) and the adaptation of the plastic to the lower posterior teeth.

In the Frankel I and II, the force of the lower lip shields (Figure 2,d) is transmitted to the upper arch by

Fig. 5 Demonstrates the muscles controlling the vertical development of the anterior oral complex: (b) buccinator, (z) zygomaticus, (d) depressor labii inferioris, (o) orbicularis oris, (i) incisus inferioris, (n) naso labialis, (c) caninus, (t) triangularis.

the labial wire (c) and the upper stops (b). The buccal shields hold the buccinator ring of muscles away from the developing arches resulting in the expansion of those arches and the lengthening of those muscles (Figure 1,c). The extent of arch expansion can be controlled by the fabrication and adjustment of the appliance. For example, by extending the lip shields in the Frankel I, II, or III, further than the recommended 2 or 3mm you can create a distal force on the opposite arch of many hundreds of grams. This force is not usually desirable, but when it is called for it can be achieved.

When delivering a Frankel appliance or adjusting it, care should be taken to assure the patient is comfortable and that there is no undue muscle strain or lip strain apparent in the face of the patient. A patient that is not comfortable not only is unable to cooperate as much as you need, but the Frankel appliance may be accomplishing the opposite of the desired goal. Figure 6 demonstrates an overexpanded buccal shield with the

Fig. 6 Frankel III, transverse section. Tension created by buccal shield (s) creating a widening force (a) on soft and hard tissue. Tongue (t). Fold of tissue (b) created by excessively wide appliance, which also causes narrowing force (c) due to improper adjustment.

resultant fold of tissue (b) and the reverse inward force (c).

In the case of the severe Class II protrusions, the Frankel appliance has the capability of immediately creating a more attractive face because the patient is stimulated to bite forward. When this is pointed out to the patient, the patient is very likely to cooperate even to the point where they break into the appliance too quickly. Once the patient has adapted to the appliance over the month or two-month break-in period, this enthusiasm created by the more attractive face is much to our advantage. A twenty-four hour use of this appliance, taken out only to eat and brush, will lead to correction in as little as four months of a severe Class II, depending on the patient's rate of growth. Class III's take much longer and can take up to several years to get into a Class I relationship, depending on the growth rate of the patient.

SUMMARY

In spite of the seemingly never-ending controversy over tonsils, adenoids, turbinates and airway, there is no denying that for the Frankel appliance to be used effectively, lip seal must be achieved. It therefore is absolutely fundamental that adequate airway be established so that adequate habits can be achieved that are conducive to ideal occlusion. From a purely mechanical standpoint, if adenoids or tonsils or turbinates are obstructing the airway for the use of the Frankel appliance, it is absolutely necessary to open the airway, which may mean the removal of one, two or three of these structures.

In the opinion of the author, when adequate airway can be achieved the results of the use of the Frankel Functional Therapy during a period of growth, particularly ages 7 to 10, will produce routinely excellent results.

There is growing evidence to the effect that tonsils, adenoids, and turbinates have a dramatic effect on the development of the oral complex.

Some methods of diagnosing and correcting the blocked airway were suggested. The importance of this in achieving lip seal was emphasized in preparation for the use of the Frankel Functional Regulator.

The Frankel Functional Regulator was discussed. Dr. Frankel's theories on how it works were presented. With application of the appliance during prime growing years, correction of Class I open bite, Class II mandibular insufficiency, open and closed bite, and Class III malocclusion can be achieved.

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