



Current Approaches in Myofunctional Orthodontics

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Functional Matrix Theory

Functional matrix theory is the most widely accepted theory of craniofacial growth recently. Moss and Salentijn [1], have suggested that the craniofacial growth is the result of the changes in functional matrix. Accordingly, neither bone nor cartilage is responsible for the growth of the craniofacial skeleton. The growth of the face, is formed by the growth of the soft tissues as a result of functional requirements. The soft tissues grow; and bone and cartilage react.

Myofunctional applications can be used to obtain or alter functional stimulus so that the current bone structure and form can be changed. Trabecular structure change that occurs as a result of forces applied to the bone will cause morphological structure change in bone during craniofacial growth stage [2].

The studies have shown that perioral muscles in children during adolescence affect the posture, breathing, chewing, swallowing, speech and teeth, and the morphology of the jaws [3,4]. Dentists should examine whether there is a dysfunction in muscular activity of each patient, and if any, how this dysfunction affects occlusion. The success and stability of the treatment depends on the pressure equilibrium between the tongue, cheek and lips. Therefore, the treatment plan to correct the malocclusion, should also include a plan to eliminate soft tissue dysfunction [5].

When the evaluation of orofacial muscle dysfunction of the patients is needed, the points to be considered are as follows:

- Whether the patient has chronic headache, open bite, TMJ problems, short frenulum, bruxism, harmful habits, chronic sore throat, chronic irritation of the tongue
- The posture of the head
- Whether the patient can close the mouth in rest position [6]

Design of Myofunctional Appliances

Considering disadvantages of classic functional appliances such as being bulky, limited alignment of the teeth, being made of inflexible materials such as acrylic, and the need for impression and laboratory procedure; pre-orthodontic trainers are designed which work as a myofunctional appliance. These appliances are used in mixed dentition period for myofunctional correction and tooth eruption guidance and they can align the teeth due to their more flexible structure compared to other functional appliances [7].

Trainer systems are fabricated of two different materials and in a single size. The first type is made of silicon and the second type is made of polyurethane and is used in two stages [7].

The soft, blue and silicone types are used in the first 6-8 months of treatment, and the red and polyurethane types are used in the next 6-8 months of treatment. The design of both appliances is the same. The softer first appliance is called Starting Trainer, and the harder second appliance is called Finishing Trainer. First appliance is more flexible in order to increase patient cooperation and to align crowded teeth [7]. The appliance is premoulded to the parabolic shape of the natural arches and adapt to dental arches of any size. The size of appliance can only be reduced by trimming distal portions.

Pre-orthodontic trainer is designed to provide *end-to-end incisor relation* by positioning mandible anteriorly. Therefore, while acting as a functional appliance to correct Class II, it has been reported that the appliance can expand arches due to its elastomeric dental arches [7-10]. Furthermore, it has been indicated that it can create a more balanced face-muscle structure by the tongue tag, the tongue guard and the lip bumper in its structure, training tongue and lip muscles [11,12].

Timing of Myofunctional Therapy

The timing of treatment varies according to the type of malocclusion [13]. Researchers have been stated that early myofunctional treatment during mixed dentition contributes, to a certain extent, to treat malocclusion. It has been indicated that the most ideal time to use pre-orthodontic trainer is when lower-upper incisors erupt. This is the right time to guide newly erupted teeth and for myofunctional training. Pre-orthodontic trainer can be used up to the permanent dentition stage [7].

Frankel [14,15], pointed to the necessity for early elimination of functional problems and incorrect muscle functions in terms of development of dental arches and the surrounding tissues. Baccetti, et al. [16], reported that functional treatment before and during pubertal growth causes skeletal changes, but treatment after pubertal growth remains limited to dentoalveolar effect.

Early phase 1 treatment is believed to reduce the likelihood of trauma by retracting incisors, to shorten the duration of phase 2 treatment, to create a favorable environment for normal function and development depending on the change of face and jaw morphology at an early age [17-20].

In addition, the risk of external apical root resorption during the retraction of upper incisors with double phase treatment is reported to be significantly less than single-phase treatment. Craniofacial structures consisting of skeletal, dental structures and soft tissues, can adapt to changes easier at an early age. Pre-adolescent children often demonstrate greater compliance to treatment than adolescent children [21-23].

Current Myofunctional Applications

Trainer System

Non-thermoformable trainer system

- Infant Trainer
- T4K (trainer for kids)
- Lingua
- T4B (trainer for braces)
- T4CII (trainer for class II correction)
- T4A (trainer for alignment)

Thermoformable trainer system

- T4F (the functional trainer)
- T4U (the multifunctional trainer)

Myobrace System

- MBS (myobrace starter)
- MB (myobrace)
- MBN (myobrace no core)
- Myobrace for Juniors
- Myobrace for Kids
- Myobrace for Teens

TMJ System

- TMJ (temporomandibular joint appliance)
- TMJ-MBV (temporomandibular joint appliance-mouth breathers version)
- TMD (temporomandibular daytime appliance)
- Bruxogard

Trainer System

Non-thermoformable trainer system

Infant trainer: It is a single size, prefabricated exerciser designed for children between the ages of 2 and 5 years, to contribute to the children's jaw and tooth development. It helps to change mouth breathing into nasal breathing and ensures correct positioning of the tongue tip. It may prevent the need for orthodontic treatment in the future in children with habits like thumb sucking or mouth breathing. The philosophy of infant trainer is to transmit the impulses from chewing to the muscles of mastication while the appliance is in mouth and to support the development of the jaw in this manner. The appliance must be worn 2 times a day, each 20 minutes. It can be sterilized by boiling water [7].

T4K (trainer for kids): It is a prefabricated appliance, produced for preparation to orthodontic treatment in children between 6-11 years of age. This appliance is used for myofunctional habits correction and for eruption guidance [24]. It aims to eliminate muscular factors in the etiology of malocclusion. It increases the stability of later treatment, supports the development of the face, reduces the severity of malocclusion, and minimizes the need for extraction treatment [25].

It can be used in class II cases with mild anterior crowding, cases with anterior open bite, mild class III cases, in the presence of habits such as tongue thrusting, thumb sucking, and atypical swallowing (Figure 1, Figure 2, Figure 3, Figure 4 and Figure 5). It should not be used in cases with posterior cross bite, cases with severe class II and



Figure 3: The sagittal intraoral view of the patient before (T0) and after (T1) treatment with trainer system.



Figure 4: The lateral cephalometric radiograph of the patient before (T0) and after (T1) treatment with trainer system.

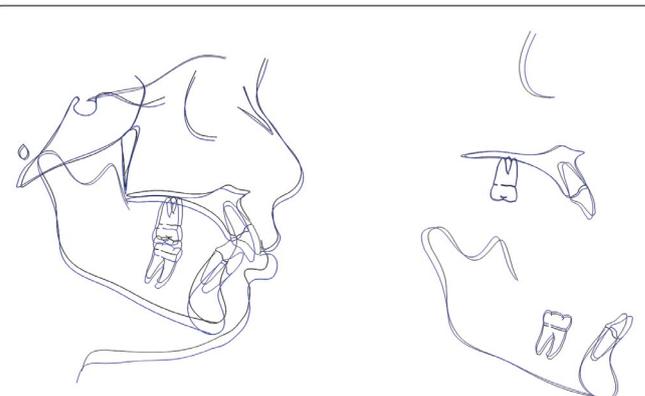


Figure 5: The superimpositions of lateral cephalometric radiographs of the patient taken before (T0) and after (T1) treatment with trainer system. The black lines represent T0 and the blue lines represent T1.



Figure 1: The frontal extraoral view of the patient before (T0) and after (T1) treatment with trainer system.

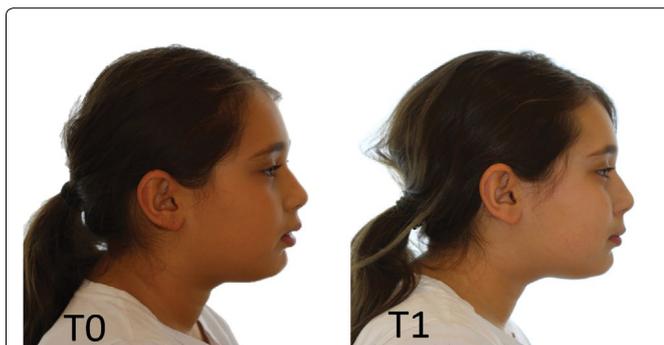


Figure 2: The lateral extraoral view of the patient before (T0) and after (T1) treatment with trainer system.

III, cases with a physical barrier for nasal breathing. Myofunctional treatment is effective in correcting Class II, by a tongue tag which guides the tongue to the correct position while swallowing, a tongue guard which stops *tongue* thrusting, a lip bumper which prevents mentalis muscle hyperactivity, and buccal shields which direct to class I bite [10,24,26].

Use of appliance during the day is divided into morning, noon and evening sessions, some simple exercises should be recommended while appliance is in the mouth. For this purpose, patients are asked to swallow keeping the appliance in the mouth, while lips are closed and the tongue tip is on the tongue tag [24].

Ramirez-Yanez and Farrell [5], have proposed that T4K increases the transversal development of the dental arches up to 4 mm a year. Treatment can be terminated when the lips are brought into contact in resting position, and when no perioral muscle activity occurs while swallowing [24].

Lingua: It is a modified exerciser, made in standard size just for upper arch to be used with fixed treatment in cases between the ages of 12 and 15 years. *It aims stable expansion of upper arch and resolving the lack of space which may result in extraction treatment, by ensuring correct positioning of the tongue tip.* It has a bracket channel which prevents irritation of the soft tissues with the brackets. It is used throughout the day, except eating time, and since it does not impair speech patient cooperation is not a problem [27].

T4B (trainer for braces): It is an appliance made in standard size for upper and lower arches to be used in conjunction with fixed treatment in cases between 12 and 15 years. They are designed to be adapted with brackets of all sizes. It is used to correct class II relation by preventing tongue thrusting swallowing and changing mouth breathing to nasal breathing. It provides passive expansion of upper arch with tongue. Appliance can also be used in combination with class II elastics or headgear by trimming vertical sides. It also prevents the formation of acute TMJ disorder symptoms which can be caused by premature contacts during orthodontic treatment. It prevents bruxism, and allows the teeth to move more rapidly by reducing the effects of myofunctional forces on the dental arches [28].

T4CII (trainer for class II correction): It is a prefabricated appliance, having thicker and higher sides than T4B appliance, which is produced to be used before or during fixed treatment in class II cases between the ages of 12 and 15 years. It is more retentive than T4K and T4B due to extended height of upper bracket channels. It must be preferred instead of T4B and T4K in severe class II cases. For the best result, it is suggested to apply fixed mechanics to upper arch immediately after completion of the permanent dentition, and to delay the lower fixed for a while. This will allow the lower anteriors to align spontaneously due to the reduction of mental muscle activity. The appliance should be used 1 to 4 hours a day and overnight while sleeping [29].

T4A (trainer for alignment): It is a prefabricated appliance made in standard size, designed for alignment of permanent dentition in 15 years and older cases. This appliance is indicated in correction of class II div 1 cases with lack of space up to 2-3 mm and over jet up to 5 mm. It provides the best expansion in V-shaped arches applying a slight force. Phase 1 appliance should be used 3-4 hours a day and overnight while sleeping for 6-8 months alone or in combination with lingual applications. Changes created by the phase 1 appliance can be observed in two months. Phase 2 appliance can be phased into use starting with 3-4 hours during the day while continuing with the phase 1 appliance at night for the prevention of mucosal irritation. After obtaining desired dental relations, phase 1 appliance should be used only at night for retention. T4A, can also be used for retention after conventional fixed orthodontic treatment [30].

Thermoformable trainer system

T4F (the functional trainer): It is a double layer prefabricated trainer with upper and lower arch channels. The outer layer is coated with thermoformable EVA (ethylene vinyl acetate) and the inner

layer is a semi-rigid polyurethane skeleton. The appliance can be customised by fitting indirectly using upper and lower models in mixed dentition. During adjustment; the appliance is first adapted to the upper dentition and then the mandible is guided forward to the desired position and the bite is recorded. While taking the bite registration, the patient should bite firmly, so the lower and front part of appliance will be shaped. At the same time, a vacuum is created by sucking in strongly with the lips closed and the tongue pushed up into the palate with the tip on the Tongue Tag. After holding this position for at least 20 seconds, the appliance is removed and placed in cold water. The advantages of T4F are the reduction of patient chair time and the elimination of the need for laboratory construction. During mixed dentition the appliance can be remoulded by heating to accommodate erupting teeth. More bulky than the other trainers, it is used for retention after arch expansion and class II treatment, as a temporary retainer when functional appliances are renewed, and for retention between phase I and II treatment [31].

T4U (the multifunctional trainer): It is an appliance with the outer layer coated with EVA and the inner layer of polyurethane skeleton. While in boiling water, semi-rigid polyurethane frame maintains shape and supports the softer outer layer during the adaptation to oral structures. It can be used as temporary retainer, mouth guard, and upper occlusal splint. The adjustment process is the same as T4F [32].

Myobrace system

It is a prefabricated double core system of various sizes, which is developed mostly as an alternative to conventional fixed treatment for cases between the ages of 5 and 15 years. The aim of the system is to eliminate the etiologic factors that cause malocclusion, and to prevent dental arch constriction by directing the alignment of teeth from the late mixed dentition. This appliance is indicated in correction of mild class II cases with crowding up to 4-6 mm and overjet up to 5 mm. The main idea of Myobrace is to correct dental alignment without bonding. The aim is to correct anterior crowding and to bring mandible into class I relation [33].

The outer layer is made of flexible and soft silicone and it has separate slots for each tooth in dental arch. The inner layer is the hard part made of medical nylon-based material called 'DynamCore'. The pre-moulded arch form of inner layer produces arch lengthening by correcting the anterior arch form. In order to determine the appropriate size of the Myobrace for the patient, a sum of the widths of the upper left-right centrals and laterals is calculated using a scale. After selecting the appropriate size of Myobrace, it is placed in the mouth, and the upper canine position corresponding to the Myobrace tooth slots is checked. Wearing the Myobrace for a minimum of two hours each day and overnight, provides adequate arch expansion and positive forces to align the anterior dentition. It may be better to use conventional fixed brackets instead of the Myobrace in reluctant patients [33].

MBS (myobrace starter): It is produced in prefabricated standard size to be applied to cases with a not well-developed dental arch and with severe crowding. MBS does not have separate slots for each tooth. After 6-12 months, patient can switch to use 'Regular Myobrace', after evaluating the development of arch form and changes in myofunctional habits [33].

MB (regular myobrace): It is produced in 6 different sizes, with separate tooth slots and DynamCore inner layer in order to ensure optimum dental alignment and arch development in late mixed and early permanent dentition [33].

MBN (myobrace no core): It has the most flexibility among Myobrace appliances. It is preferred in severe cases in terms of both providing comfort to the patient and correcting the arch form. The appliance is available in 6 different sizes, without the inner DynamCore. Although the MBN loses some of the Myobrace's effectiveness on dental arch, it gains a large amount of flexibility to fit more mouths, and requires less patient cooperation. The MBN

features the myofunctional effects to re-train the oral musculature which assists in correcting arch development and dental alignment [33].

Myobrace for juniors: It is a three-stage appliance system designed specifically to correct poor oral habits while treating upper and lower jaw development problems. It is most effective in the primary dentition between 3-5 years of age. The J1 provides habit correction, the J2 provides arch development as well as habit correction, and the J3 provides continued jaw development and occlusal correction [33].

Myobrace for Kids: It is a three-stage appliance system designed specifically to correct oral habits while treating upper and lower jaw development problems. It is most effective after a child's permanent teeth have erupted (ages 5-8). The K1 provides habit correction, the K2 provides arch development in addition to habit correction, and the K3 provides final retention [33].

Myobrace for teens: It is a four-stage appliance system designed for habit correction and arch development. It is most effective when the permanent teeth have erupted and is designed to guide the erupting teeth into their natural position. The T1 provides habit correction and initial dental alignment, the T2 provides arch development in addition to habit correction, the T3 provides individual tooth alignment, and the T4 provides final alignment of the teeth and jaws [33].

TMJ system

It is developed specifically for reducing joint pain in TMJ dysfunctions caused by parafunctional habits such as bruxism, tongue thrusting swallowing, etc. [34].

TMJ (temporomandibular joint appliance): It is prefabricated from medical silicone, made in a single size which shows the soft and flexible features. Use is generally one hour daily plus night time while sleeping. It is easy to wear due to the soft and flexible features. It shows a good adaptation to the patient's mouth with its aerofoil shaped base. TMJ relieves the load on the joint. It allows physician to intervene quickly [34].

The TMJ uses the principles that advocate the treatment for any inflamed joint should be to decrease joint inflammation and muscle pain by joint decompression and limitation of function. The resting length of the muscles that close the lower jaw is increased when the appliance is in place. This results in a decrease in tension of the muscles and provides relief. Its aerofoil shaped base decompresses the joint and its mouthguard effect restricts parafunctional movements. The base is 3.5 mm thick in posterior area, and to 2mm in anterior. This offers an effective pivotal splint to the majority of patients with complete posterior dentition. TMJ cannot be applied to open bite cases because it does not have an active retention to keep it in the mouth at night [34].

TMJ-MBV (temporomandibular joint appliance-mouth breathers version): The appliance is modified to be used in mouth breathers. It features 4 large breathing holes, and an 11 mm base for increased bite opening. The sides are higher for improved retention while sleeping. The TMJ-MBV is effective in preventing snoring by opening of the airway by opening of the vertical dimension and advancing the mandible. The advantage compared to other snoring devices is to be flexible and to allow some movement of the lower jaw. This situation is also preventing joint pain which can be observed in other rigid appliances. Appliance can also be used for diagnostic purposes in ascertaining the effectiveness of more complex appliances. If the case is found to benefit from this appliance, then the patient can switch to more complex appliances. The lack of use of any application of this appliance in sleep apnea, is its deficiency [35].

TMD (temporomandibular daytime appliance): It is a harder semi-flexible, customizable, double layer day-time splint. It is effective in reduction of clicking and acute TM Joint pain. Once heated in boiled water for 2 minutes, it is fitted to the mouth and the patient is asked to close up into the correct mandibular position and bite up

hard as possible. Then the appliance is removed, cooled under cool tap water, left for about 1 minute to allow the EVA cool down. It is indicated that the use of the TMJ for the night time instead of TMD, is the ideal combination for treatment [36].

BRUXOGARD: Bruxism, is a bad habit difficult to cure. BRUXOGARD serves as a protective barrier between the teeth, reduces tension in the muscles and prevents tooth damages. It is designed as a unique flat base to protect teeth and jaws from the effects of bruxism. It is available in soft and hard forms [37].

Current Applications with Myofunctional Appliances

Ramirez-Yanez, et al. [10], have studied the effect of treatment with T4K on transverse dimensions of maxillary and mandibular arches, and observed more improvement in dimensions of dental arches in patients treated with T4K, compared to the control group. It is reported that the use of T4K appliances would be appropriate if transverse expansion is needed especially in treatment of the children at an early age.

Ramirez-Yanez and Farrell [5], have indicated that chewing, cheek and lip muscles activity, the position of the tongue and parafunctional habits must be assessed as the main factors of the etiology of existing or future malocclusion. The researchers suggest that pre-orthodontic myofunctional treatment will eliminate the soft tissue dysfunctions. As a result, it is advocated that in cases with eliminated muscle dysfunctions more stable treatment results can be obtained.

IÜşümez, et al. [8] have studied the dentoskeletal treatment effects caused by the pre-orthodontic trainer appliance in class II div 1 cases. Lateral cephalometric radiographs were taken at the beginning and the end of the treatment. (Figure 4) 20 class II div 1 patients (10 girls, 10 boys, mean age: 9.6 ± 1.3 years) were treated with orthodontic trainer. Control group consisting of 20 untreated cases with class II div 1 malocclusion (mean age: 10.2 ± 0.8 years) was evaluated in order to eliminate the effects of growth. Consequently, the SNB angle and facial height increased, the ANB angle decreased, proclination of lower incisors and retroclination of upper incisors increased, and the overjet decreased in the treatment group. Researchers reported that pre-orthodontic trainer application results in dentoalveolar changes leading to a significant decrease in overjet, but it should be used for appropriate patient.

Quadrelli, et al. [11] have studied the changes resulting from early application of T4K appliance used for 1 year and 16 hours a day in skeletal class 2 cases. A total of 6 cases (4 girls and 2 boys) between 4 years and 9 month to 9 years and 1month were evaluated in the study. These cases were divided equally into A and B groups according to their characteristics. While individuals in group A had skeletal class 2 relation, dentoalveolar open bite, atypical swallowing, mouth breathing and tongue position disorder; cases in group B had skeletal class 2 relation, dentoalveolar deep bite, mouth breathing habits and bruxism. As a result; atypical swallowing was prevented by normalizing the activity of the muscles of mastication and a progress was provided in the control of bruxism in both groups. A 1.5° reduction in the ANB angle was determined. While dentoalveolar open bite in group a decreased; a very slight decrease in deep bite was observed in group B. An increase in nasal breathing was observed. An increase in intermolar width was also detected depending on the correct tongue positioning.

Uysal, et al. [38] have examined the effects of pre-orthodontic trainer appliance on anterior temporal, mental, orbicularis oris and masseter muscles through electromyography (EMG) in patients with class II div 1 malocclusion and insufficient lip thickness. 20 patients (mean age: 9.8 ± 2.2 years) with a class II division 1 malocclusion were treated with pre-orthodontic trainer appliances. Group A, consisting of 15 untreated patients with class II div 1 malocclusion (mean age: 9.2 ± 0.9 years) was used as a control group. EMG recordings were taken during different functions such as sucking, swallowing and while teeth were closed tightly. As a result; the effect of anterior temporal, masseter and mental muscles decreased during pre-

orthodontic trainer treatment. In the control group, it was observed that statistically significant changes occurred in the anterior temporal and masseter muscles while teeth were closed.

De Felicio, et al. [39] have examined the effects of orofacial myofunctional therapy (OMT) on temporomandibular disorders. In this study of 30 patients, patients were divided into three groups; 10 patients were treated with OMT, 10 with occlusal splint and 10 were determined as control group. 10 cases were separated as asymptomatic group. As a result, positive effects such as decrease in tenderness and pain in palpation, increase in mandibular mobility distance, decrease in the frequency and severity of symptoms were observed in patients treated with OMT. Positive effects in patients treated with occlusal splint were also inspected.

Smithpeter and Covell [40] have investigated the effects of orofacial myofunctional treatment (OMT) on the closure of open bite. They have investigated the relapse before, during and after treatment in 76 cases with dental anterior open bite. In the experimental group consisting of 27 cases orthodontic treatment was applied along with OMT; while in the control group of 49 cases fixed orthodontic treatment was applied only. As a result, the mean overbite relapse was found to be 0.5 mm in the experimental group and 3.4 mm in the control group. This study showed that OMT combined with fixed orthodontic treatment is more effective in closing the anterior open bite than just orthodontic treatment.

Veske SP [41], have evaluated the effects of Frankel II and pre-orthodontic trainer appliances, used in treatment of class II div 1 malocclusion, on skeletal and dental structures and muscles of mastication comparatively. Frankel II was applied to 13 individuals, and pre orthodontic trainer was applied to 13 individuals; 11 individuals were followed up without any treatment. The mean ages were, 8 years and 5 months, 8 years and 8 months, and 9 years and 1 month respectively. Lateral and posteroanterior cephalometric radiographs and EMG recordings were taken and dental casts were obtained at the beginning and end of treatment. As a result of cephalometric assessment, an increase in mandibular length, a reduction in overjet and overbite, uprighting of maxillary incisors, protrusion of mandibular incisors, and mezialization of mandibular molars were observed in both groups. As a result of posteroanterior radiographic and dental model measurements; an increase was observed in maxillary intermolar, mandibular intermolar and intercanine width in individuals in the Frankel II group; and an increase in maxillary and mandibular intercanine width was observed in the pre-orthodontic trainer appliance group. EMG measurements at the beginning and end of treatment, showed no significant effect of both treatment appliances on the activity of muscles of mastication. At the end of the study, both treatment appliances were shown to be highly effective in correcting malocclusion with mainly dentoskeletal effect, but the skeletal effects of Frankel II were found to be more than pre-orthodontic trainer appliance.

Das and Reddy [42], have investigated the effects of pre-orthodontics trainers in their study on 50 class II div 1 patients between 8-12 years of age (20 treatment, 30 control). Patients in the treatment group were treated with pre-orthodontic trainers for 15 months. Lateral cephalometric radiographs of all patients were taken at the beginning and end of treatment. When the results were analyzed; decrease in the ANB angle, increase in anterior and posterior face height, increase in mandibular incisor angle and decrease in overjet was observed in the treatment group.

Tulunoglu Ö, et al. [43], applied trainer to a girl with anterior open bite and class 1 malocclusion due to infantile swallowing. The patient was taught swallowing exercises and trainer appliance was used 1 hour during the day and all night. After 1 year, a retention appliance was used. After 2-year treatment, improvement of swallowing habits, elimination of open bite, and eruption of permanent central incisors as desired, was observed.

In a case report Germeç, et al. [44] published, lip closure was found to be insufficient and lower lip was found to be behind upper incisors

due to asymmetric and increased overjet in a 7.5 year-old patient having thumb sucking habit. The patient was asked to wear trainer appliance during night time and after 2 months of treatment, it was shown that the patient abandoned finger sucking habit, the overjet decreased and maxillary dental arch form improved.

Result

Dentists should examine whether there is a dysfunction in muscular activity in each patient, and if any, how this dysfunction affects occlusion. The success and stability of the treatment can only be achieved by eliminating any dysfunction at the formation phase.

While the importance of myofunctional treatment applied before orthodontic treatment and during mixed dentition is known, it should be kept in mind that long-term follow-up studies of early myofunctional treatment are not adequate. Therefore, myofunctional appliances can be seen as an exerciser for elimination of habits that may cause malocclusion or as appliances helping orthodontic treatments.

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