Dimensional Changes in Dental Arches After Treatment with a Prefabricated Functional Appliance

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The purpose of this study was to determine the effect of the T4K, a prefabricated functional appliance, on the transverse and anterior-height dimensions of the maxillary and mandibular dental arches. Dimensions before and after treatment were measured on the sample, then, natural growth was subtracted from the treatment effects and compared with twice the error of the method. A clinically significant increase of both dimensions was observed in the maxilla and mandible when Class II malocclusion patients were treated with the T4K. Therefore, this retrospective study demonstrates that T4K is a valid treatment choice at an early age when transverse expansion is part of the treatment goal.

Key words: *Dentofacial orthopedics, transverse expansion, functional appliance*
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INTRODUCTION

Functional appliances have been reported since early in the past century to produce skeletal and dentoalveolar changes.[1-5] Furthermore, treatment of children with increased overjet using functional appliances reduces the probability of needing orthognathic surgery later.[6] The skeletal effect of these appliances appears to result from various phenomena: remodeling and relocation of the glenoid fossa[7,8], accelerated and enhanced condylar growth[9,10] and neuromuscular adaptation.[11-13] Thus, functional appliances have been proposed to treat skeletal deficiencies, such as reduced mandibular growth and transverse development.[9,14] However, their efficiency in this respect is still controversial.[15]

One of the criticisms of studies involving functional appliances is how much of the treatment result is a direct effect of the functional appliance and how much is due to natural growth. Evaluating how much growth or development is directly produced by an appliance can be done by comparison with a control group. However, this is a very complicated task, because it is difficult to randomly allocate patients to control and treatment groups in such a way that both groups are comparable. Furthermore, doing a prospective study might raise the ethical question of not providing treatment when needed or worse, the consequences of no treatment.[16] An alternative is retrospective studies. However, in those studies data have to be compared with a control group built from published normative data precisely matching with the treatment group for age, sex and treatment time.[17,18] Another difficulty with orthodontic appliance studies is that not all statistically significant treatment outcomes really equate to clinically significant changes. To solve the latter problem, the net effect of treatment can be contrasted with twice the method error so treatment effect can be considered clinically significant when it is at least twice the method error.[17,19]

The trainer for kids (T4K™, Myofunctional Research Co, Australia) is a polyurethane prefabricated functional appliance (Figure 1), which is claimed to correct malocclusions at an early age by acting on muscular dysfunction and repositioning the mandible.[20] It is composed of various elements designed to stimulate the facial and masticatory muscles and muscles of the tongue. A previous report has demonstrated that it relocates the mandible in a more forward position in Class II division 1 patients.[21] Therefore, this prefabricated functional appliance appears to produce a sagittal effect similar to that reported for other functional appliances such as the bionator [2,3], twin block[4], Fränkel regulator[1,22], Harvold activator[1] and Herbst.[7,22] On the other hand, an increase of approximately 1.5 mm in maxillary and of 2.9 mm in mandibular interpremolar distances has been reported with other functional appliances such as the Frankel regulator[23]. Some patients treated with the T4K have also shown an increase in dental arch width, but the effect of this appliance on the transverse dimension has not yet been evaluated. Therefore, the purpose of this retrospective study was to determine the effect of the T4K on the transverse and anterior-height dimensions of the maxillary and mandibular dental arches. To determine the clinical significance of the results when comparing the dimensions before and after treatment, the treated group was compared with a control group created from normative data and contrasted with twice the method error.

MATERIAL AND METHODS

Pre- and posttreatment casts from 60 patients treated only with

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the T4K (Figure 1) over 1.3 ± 0.5 years were measured. The study involved preadolescent children (8.3 ± 1.0 years old at the beginning of treatment) of both sexes (32 girls and 28 boys) from 3 different countries, Australia (10 patients), Brazil (26 patients) and Lithuania (24 patients). All patients had Class II, Division 1 malocclusions with crowded teeth. This sample composed the treated group.

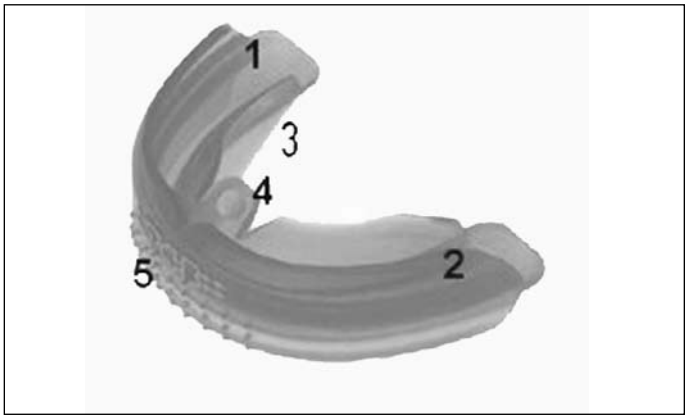

Figure 1: The T4K showing the various parts composing the prefabricated functional appliance: (1) dental channels with predetermined bite position; (2) facial bowls to separate buccinators and orbicularis oris muscles from dental arches; (3) lingual bowls to help guide mandibular repositioning; (4) lingual tag to stimulate tongue repositioning; (5) device to reduce activity of the menton musculature.

A control group composed of 32 girls and 28 boys was built from data published by Moorees.[24] Briefly, data from clinical histories of the patients in the treated group were used to determine age at the beginning and at the end of treatment, as well as the duration of treatment. Thus, each patient in the treated group had a matched control from normative data with respect to age, sex and observation period.

Distances measured

Four measurements were made on maxillary and mandibular casts of each patient in both treated and control groups: intercanine (IC) distance, interpremolar (IP) distance, intermolar (IM) distance and height of anterior arch (AAH). IC was determined as the distance between the tips of the canines. IP in the maxillary arch was the distance between the mesial fossae of the deciduous first molars or the first premolars, and in the mandibular arch, the distance between the tips of the mesial cusps of the deciduous first molars or the first premolars. IM was the distance between the central fossae of the permanent first molars in the maxillary arch, and the distance between the central cusp tips of the lower permanent first molars of the mandibular arch (Figure 2).

In the maxillary arch, AAH was determined by the distance between the middle point of a line drawn between the fossae of the deciduous first molars or first premolars, and the incisal border of the central incisors at the midline. In the mandibular arch, AAH was similarly measured, but the line was drawn between the mesial cusps of the deciduous first molars or first premolars (Figure 2). If any of the central incisors was positioned more labially than the other, AAH was measured to the incisor more labially positioned.

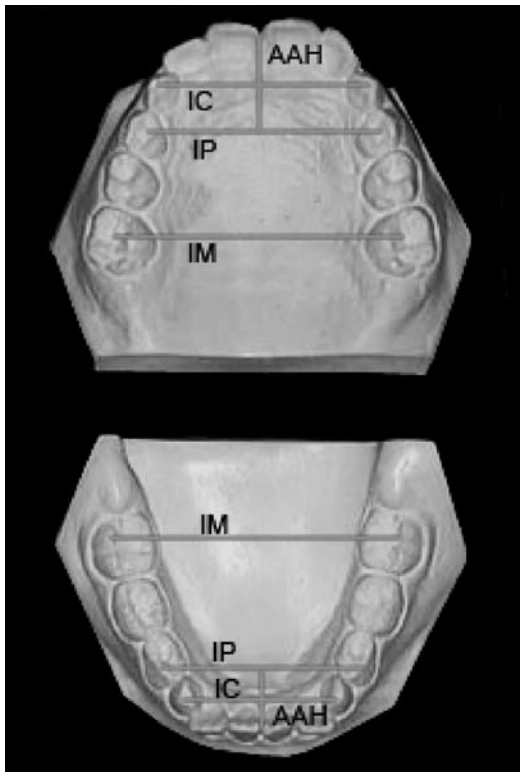

Figure 2: Diagram showing various measurements performed on casts in this study.

Inclusion criteria for the treated group were those patients treated only with the T4K and having measurement reference points present at the beginning and end of treatment. Therefore, when the primary first molars were exfoliated during the treatment period, the first premolars must have been erupted by the end of the observation period to measure the IP distance.

Data analysis

Statistical analysis was performed following the methods described by Trenouth[17] and Valant.[18] Data obtained from each measurement (pre- and posttreatment) within and between both treatment and control groups were analyzed using Mann Whitney test. This nonparametric statistical test was chosen because the data was nonhomogeneous and might not have been normally distributed. The statistical test was performed using Prism 4 (GraphPad Software Inc, San Diego, Calif). A P-value lower than .05 was considered significant.

Error of the method was determined by the formula:

$$ME = \sqrt{\frac{\sum d^2}{2\,(n-1)}}$$

where d is the difference between measurement pairs and n is the number of pairs.

Table 1: Changes in Transverse Dimension. Treatment (T) and Control (C) Groups Before (1) and After (2) Observation Period in mm.

	Treatment Group					Control Group				
Distance	T 1	*SD*	T 2	*SD*	*P*-value	C 1	*SD*	C 2	*SD*	*P*-value
Maxillary arch										
IC	32.0	± 1.1	33.2	± 1.0	>.01	30.6	± 0.8	31.2	± 0.9	>.01
IP	35.1	± 1.8	36.8	± 2.2	>.01	30.3	± 0.8	30.6	± 0.8	>.01
IM	46.2	± 1.9	47.6	± 1.9	>.05	38.9	± 0.6	39.4	± 0.7	>.05
AAH	17.9	± 2.2	17.1	± 2.5	<.05	29.3	± 0.6	29.5	± 0.6	<.05
Mandibular arch										
IC	27.6	± 2.0	27.8	± 1.9	<.05	24.9	± 0.8	25.2	± 0.7	<.05
IP	33.9	± 1.8	35.7	± 1.8	>.01	26.5	± 0.6	26.9	± 0.7	>.01
IM	47.5	± 2.0	48.5	± 2.1	>.05	33.7	± 0.2	33.8	± 0.3	<.05
AAH	12.7	± 2.1	12.7	± 2.6	<.05	25.0	± 0.6	24.9	± 0.6	<.05

Table 2: Clinical Significance of Net Treatment Effect* Caused by the T4K.

Distance	T	*SD*	C	*SD*	T net effect	2 ME	Clinical Significance
Maxillary arch							
IC	1.2	± 0.3	0.6	± 0.5	0.60	0.77	No
IP	1.7	± 0.8	0.3	± 0.2	1.40	1.09	Yes
IM	1.4	± 0.5	0.5	± 0.3	0.90	0.87	Yes
AAH	-0.8	± 0.6	0.2	± 0.3	1.00	0.79	Yes
Mandibular arch							
IC	0.2	± 0.6	0.3	± 0.4	-0.10	0.83	No
IP	1.8	± 0.8	0.4	± 0.3	1.40	1.09	Yes
IM	1.0	± 0.6	0.1	± 0.2	0.90	0.76	Yes
AAH	0	± 0.7	-0.1	± 0.3	0.10	0.76	No

*Determined by subtracting natural growth occurring in control group over the observational period from the effect produced by the T4K on dental arch dimensions (T net effect) and comparing with twice the method error (2ME).

T = T2 – T1; T net effect = T – C.

Clinical significance of treatment with the T4K on maxillary and mandibular arch dimensions was determined by subtracting natural growth from the treatment change, then, the difference compared with twice the method error.[18] A difference higher than the value of twice the method error was considered a clinically significant effect produced by the functional appliance.

RESULTS

Changes in transverse dimensions and AAH for both maxillary and mandibular arches within and between both treatment and control groups were statistically analyzed and results are shown in Table 1. Patients treated with the T4K showed a significant increase in IP and IM distances at the end of the observation period in both maxillary and mandibular dental arches. Significant increase was also observed in the maxillary arch for IC distance, but not in the mandibular (Table 1). No significant differences were found within the treated group in the maxillary and mandibular AAHs at the end of the observation period when compared with the initial measurement. The control group showed a significantly increased IC, IP and IM in the maxillary arch during a growth period similar to that of the treatment group, whereas IP was the only transverse distance significantly increased in the mandibular arch over the observation period (Table 1). No significant change was observed in the AAH distances either in the maxillary or mandibular dental arch over the observation period for the control group. Although it was not the purpose of this study, improved tooth alignment was observed in most of the treated cases.

To differentiate the effect of treatment with T4K over natural growth, the clinical significance was determined as explained above by subtracting the value of natural growth from the value of the treatment effect, then compared with twice the method error. These results are shown in Table 2. Clinical significance for T4K treatment was observed in the IP and IM distances for both maxillary and mandibular arches. The IC distance showed no clinical significance in either the maxillary or mandibular arches, although in the maxillary arch the increase in IC distance for the treatment group was twice that occurring in the control group (Table 2). T4K caused a clinically significant increase in AAH in the maxillary arch, but not in the mandibular.

DISCUSSION

Functional appliances have been extensively reported in the literature as a valid alternative for treating malocclusions, as they may stimulate jaw growth and development in preadolescent patients.[1-3,5,7-12,22,25] However, evaluating which portion of the result is produced directly by the appliance and which by natural growth is difficult.[16] In this retrospective study, the clinical effect produced by the prefabricated functional appliance used to stimulate development of the dental arches in preadolescent patients was determined, first, by building a control group from normative data; second, by subtracting the treatment effect from natural growth; and third, by contrasting the difference with twice the method error.[17-19] Thus, it was observed that patients treated with the T4K had significantly increased transverse dimensions at the first premolars and first molars having statistical significance. Therefore, T4K can be recommended as a useful tool for stimulating transverse development in young patients.

An increase in IP and IM distances has been reported to be associated with an increase in arch perimeter.[26,27] Current results

have demonstrated that both maxillary and mandibular IP and IM distances are significantly increased by the T4K, thus, the perimeter of the arches may have increased, providing more room for tooth alignment, which was frequently noticed in the treated group at the end of the observation period. Furthermore, the highest effect is produced at the first premolars, and a lower but still significant effect at the first molars. It thus appears the prefabricated functional appliance stimulates further transverse development overlapping that produced by natural growth, which may be an asset when treating patients with crowding caused by decreased maxillary or mandibular transverse development.

This study has demonstrated that T4K stimulates transverse development, but it also appears that it tends to round the maxillary dental arch. This is inferred because there was an increase in IP and IM distances associated with a clinically significant reduction in maxillary AAH, which may be due to an effect on the inclination of the maxillary incisors reported in a previous study.[21] This dentoalveolar effect appears not to occur in the mandibular arch as there was no clinically significant effect in that group treated with the T4K. Although the current study did not include x-ray measurement, these results seem to agree partly with those reported by Usumez and coworkers.[21] They reported that the T4K has a dentoalveolar effect, in that it significantly reduces the inclination of the maxillary incisors while significantly increasing the inclination of the mandibular incisors. The current study showed no significant effect on the mandibular AAH, suggesting that there were no significant variations in mandibular incisors inclination. Further studies may be required to clarify how this functional appliance affects the position and inclination of the mandibular incisors. In short, the T4K stimulates dimensional development of the maxillary arch, tending to round it, whereas on the mandibular arch it stimulates transverse development without significantly affecting the anterior arch.

The significant transverse development observed in the current study appears to be produced mainly by the buccal shields of the prefabricated functional appliance used for treatment in this study. The facial bowls included in the structure of T4K may stimulate transverse development in a way similar to Fränkel regulators[28,29], in separating the buccinator and orbicularis oris muscles from the teeth and reducing the forces produced by those muscles on the buccal aspects of the teeth. These forces are reported to normally be 2.7 g on the maxillary dental arch and 2 g on the mandibular dental arch in normal occlusion[30], but they may increase up to 21 g in the molar region and up to 80 g in the canine region in thumb-sucking patients.[30,31] Through the facial bowls, the T4K releases the teeth from those forces applied by the facial muscles directly on the tooth crowns[30,32], but at the same time, tensional forces are delivered to the alveolar and basal bone at the insertion sites of the buccinators and orbicularis oris muscles.[33] These tensional forces stimulate bone formation on the external surfaces of the maxilla and mandible[33], and thereby may produce that clinically significant increase in transverse dimensions observed in this study. We postulate that the increase in transverse dimensions reported in this study occurs in a way similar to that observed in the Fränkel Regulator[23], wherein there is bodily movement of the dentoalveolar unit and not tipping of the teeth. However, radiographic studies are required to evaluate those changes in the basal and the alveolar bone, as well as in the long axes of the teeth.

It has been reported that most arch dimensions are established at 7 years of age.[34,35] Therefore, the results of this study, added to those from a previous study concluding that T4K relocates the mandible to a more forward position in Class II Division 1 patients[21], confirm that this prefabricated functional appliance can be recommended for treating Class II Division 1 malocclusions in preadolescent patients. Furthermore, this appliance might be used to treat malocclusions wherein a lack of transverse development is causing tooth crowding. However, further studies are required to demonstrate the effect of the T4K on other malocclusions.

CONCLUSIONS

This retrospective study has shown that the T4K, a prefabricated functional appliance, is a valid alternative to treat malocclusions at an early age, as it clinically significantly stimulates transverse development of the dental arches. Therefore, this appliance is a valuable tool in improving dental arch development when a lack of transverse development is diagnosed at an early age.

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