EFFECTS OF FARMAND AND FRÄNKEL-2 FUNCTIONAL APPLIANCES ON MANDIBULAR DEFICIENCY IN LATE MIXED DENTITION

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Received: April 03, 2017
Revised: May 05, 2017
Accepted: August 14, 2017
Published: August 16, 2017

Academic Editor: Irina Nicoleta Zetu, DDS, PhD, Professor, „Gr. T. Popa" University of Medicine and Farmacy Jassy, Jassy, Romania

Cite this article:
Pakshir HR, Jamilian A, Mokhtar A, Darnahal A, Kamali Z, Nucci L, Perillo L. Effects of Farmand and Fränkel-2 functional appliances on mandibular deficiency in late mixed dentition. Stoma Edu J. 2017;4(3):176-181.

ABSTRACT

DOI: 10.25241/stomaeduj.2017.4(3).art.3

Introduction: The present study aimed to evaluate the cephalometric changes in Class II Division I mandibular deficient patients treated with the Fränkel 2 and Farmand appliances as a new functional appliance.
Methodology: Fifty-five subjects treated for Class II Division I malocclusion and mandibular deficiency were selected for the study. Twenty-seven of the subjects (17 girls, 10 boys) with the mean age of 11.1 (SD 1.4) years were treated with the Farmand appliance and twenty-eight of them (15 girls, 13 boys) with the mean age of 11 (SD 1.5) years were treated with the FR-2 appliance. T-test, paired t-test, Wilcoxon and Mann-Whitney test were used to evaluate the data.
Results: A skeletal Class I relationship and a marked reduction in overjet were achieved in both treatment groups. ANB decreased significantly by 3.2 (SD 1.7) degrees in the Farmand appliance group and it decreased significantly by 3.5 (SD 1.6) degrees in the Fränkel group.
Conclusion: Both Farmand and Fränkel appliances were successful in the correction of mandibular deficiency in Class II Division 1 patients.
Keywords: malocclusion, Angle Class II Division I, orthodontic appliances, functional appliances.

1. Introduction

A Class II malocclusion may result from a mandibular deficiency, maxillary excess or a combination of both, but the most common finding is mandibular skeletal retrusion.[1,2] Approximately 15% of American children have Class II malocclusion; however, It seems that Class II problems are most prevalent in Caucasians of Northern European descent (for instance, 25% of children in Denmark are reported to be Class II.[3] Different removable functional appliances such as Activator, Bionator, Fränkel-2, Herbst, R-appliance, and Twin Block have been used to treat Class II division 1 malocclusions and mandibular deficiency.[4-13] Fränkel-2 (FR-2) is one of the appliances commonly used in the treatment of Class II division 1 malocclusion. This appliance was developed nearly 50 years ago by Rolf Fränkel as an orthopedic exercise device designed to reprogram the neuromuscular system of the orofacial complex.[14,15] Recently, Perillo et al. performed a meta-analysis of articles studying the changes produced by the FR-2 appliance during the treatment of growing patients with Class II malocclusions and reported that the FR-2 appliance had a statistically significant impact on the size of the mandible in the treated patients.[16]

Another functional appliance used for the correction of mandibular deficiency is the "Farmand Appliance".[17,18] This appliance has been shown to cause significant changes in the position and anterior displacement of the hyoid bone, resulting in the improved airway and respiratory status of the patients.

An electronic search in literature shows that no one

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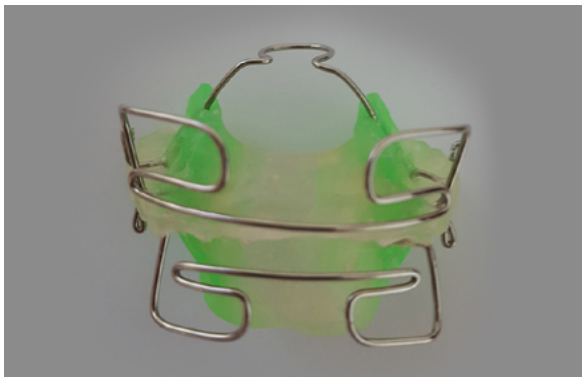

Figure 1. The Farmand appliance from a frontal view.

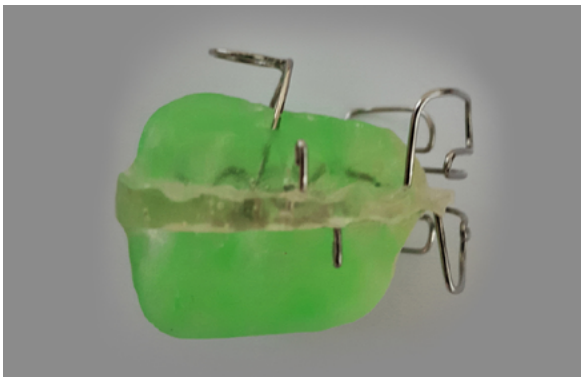

Figure 2. The Farmand appliance from a lateral view.

Figure 3. Before-treatment picture of a patient with mandibular deficiency.

Figure 4. After-treatment picture of the same patient treated with the Farmand appliance.

has ever compared the treatment effects of the Farmand appliance and FR-2; therefore, the aim of this study was to compare the dentoskeletal effects of the Farmand appliance with FR-2 in the treatment of prepubertal Class II division 1 malocclusion patients with mandibular deficiency.

2. Materials and Methods

This retrospective study was reviewed and approved by the Institutional Review Board (IRB) of the School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran and the Tehran Dental Branch, Islamic Azad University, Tehran, Iran and in accordance with the Helsinki Declaration of 1975, as revised in 2000. A pilot study was conducted on 10 patients (5 in each group) and the SNB was chosen as the primary outcome. The sample size of the present study was calculated based on a significance level of 0.05 and a power of 90%, to detect a minimum clinically significant change of 1.6° in SNB. Using a two-tailed paired t-test (PASS 2011, NCSS software, Kaysville, Utah, USA), 26 samples would be required in each group. All subjects met the following inclusion criteria:

1) ANB>5°, SNB<77°, overjet>5 mm at the initial lateral cephalograms;
2) No syndromic or medically compromised patients;
3) No previous surgical intervention;
4) No use of other appliances before or during the period of functional treatment;
5) No skeletal asymmetry;
6) Profile improvement by mandibular advancement in clinical examination.

Twenty-seven subjects (17 girls, 10 boys) were selected from patients treated with the Farmand appliance (Figs. 1-2) and twenty-eight subjects were selected from patients treated with the FR-2 appliance.

At the beginning of the treatment, all patients were in the prepubertal stage (CS1 and CS2), according to the recently improved version of the Cervical Vertebral Maturation (CVM) method as described by Franchi et al.[19] and Baccetti et al.[20]

The mean age of the patients treated with the Farmand appliance in the experimental group was 11.1 (SD 1.4) years and the average treatment time was 16 (SD 1.7) months.

The Farmand appliance is a passive tooth borne appliance. It consists of two extended flexible labial bows, a tongue bow, four rests (stop), and an acrylic plate. The acrylic plate extends from the occlusal surface to the lingual shields. A heavy wire (1 mm diameter), which acts as a tongue bow, is positioned posteriorly to connect the right and left acrylic parts on the palatal aspect in order to reinforce the appliance. The upper and lower labial bows are constructed with 0.8 mm stainless steel wire extended from canine to canine with horizontal loops in the canine region. The rests (stop) are placed on the mesial of the upper and lower first molars. The construction bites of the patients were taken with the upper and lower anterior teeth in an edge-to-edge occlusion with 2 to 3 mm posterior clearance.

The FR-2 group consisted of 28 patients (15 girls, 13 boys) with the mean age of 11 (SD 1.5) years that were treated with the FR-2 appliance. The treatment time was 16.5 (SD 3.5) months.

Table 1. Pre and post cephalometric landmark in the Fränkel and Farmand group.

Variables		Group	Before treatment		After reatment		*p*-value
			Mean	SD	Mean	SD	
Sagittal	SNA (°)	Farmand	81.2	1.5	81.4	1.3	0.124
		FR-2	81	1.3	81.5	1.3	0.001
	SNB (°)	Farmand	74.3	1.7	77.6	2.3	0.001
		FR-2	73.6	3.4	77.6	1.5	0.001
	ANB (°)	Farmand	6.8	1.6	3.6	2.3	0.001
		FR-2	7.3	1.7	3.8	1.5	0.001
	Witts (mm)	Farmand	4.2	1.6	1.9	1.7	0.001
		FR-2	4.7	1.4	2.4	1.5	0.001
	GoGn (mm)	Farmand	66.5	3.5	69.2	3.5	0.001
		FR-2	66.7	2.9	69.8	2.4	0.001
	Co-Gn (mm)	Farmand	103.7	2.9	106.2	2.6	0.001
		FR-2	104	2.3	106.4	2	0.001
	Co-Pog (mm)	Farmand	101.8	1.6	106.3	1.8	0.001
		FR-2	102.6	2.4	105.6	2.3	0.001
	Overjet (mm)	Farmand	7.1	2.1	3.6	1.9	0.001
		FR-2	9.2	3.2	5	1.6	0.001
Vertical	Jarabak (%)	Farmand	64.1	2.2	62	1.4	0.001
		FR-2	64.6	2.7	61.9	1.6	0.001
	GoGn-Sn (°)	Farmand	31.8	4.2	34.1	4	0.001
		FR-2	30.7	4.6	32.5	3.5	0.003
	Palatal-GoGn (°)	Farmand	25.3	2.6	27.5	1.9	0.001
		FR-2	27.4	3.4	28.6	4.5	0.014
	Facial Angle (°)	Farmand	82.9	2.6	85.1	2.5	0.001
		FR-2	83.8	2.3	86.4	1.8	0.001
	Gonial Angle	Farmand	123.7	3	128.7	2.1	0.001
		FR-2	124.8	3.6	128.4	3.3	0.001
Dental	U1-Sn (°)	Farmand	110.1	7	104.4	5.7	0.001
		FR-2	110.3	5.3	104.6	4	0.001
	IMPA (°)	Farmand	95.7	7.3	101.9	6.6	0.001
		FR-2	91.7	8	98.9	6.5	0.001
	Interincisal Angle (°)	Farmand	117.8	5.5	118	6.7	0.777
		FR-2	118.1	4.8	119.1	5.9	0.326

All patients were instructed to wear the appliances full-time except for eating, contact sports, and tooth brushing. Lateral cephalograms of the samples were taken in centric occlusion at the beginning and at the end of the treatment.

The angular and linear cephalometric measurements used for comparison of the treatment results of the two groups were as following: SNA, SNB, ANB, Witts (connecting points A and B perpendicular to occlusal plane), GoGn (the distance between the gonion and the gnathion representing the mandibular length), CoGn (the distance from the con-

Table 2. Comparison of changes during treatment with Fränkel and Farmand.

Variables		Farmand		FR-2		*p*-value
		Mean	SD	Mean	SD	
Sagittal	SNA (°)	0.2	0.7	0.5	0.6	0.115
	SNB (°)	3.3	1.9	3.9	1.6	0.166
	ANB (°)	-3.2	1.7	-3.5	1.6	0.617
	Witts (mm)	-2.3	1.5	-2.4	1.0	0.431
	GoGn (mm)	2.7	1.5	3.0	2.3	0.544
	Co-Gn (mm)	2.6	1.2	2.4	1.9	0.645
	Co-Pog (mm)	4.5	1.9	3.0	2.3	0.012
	Overjet (mm)	-3.5	2.3	-4.2	3.3	0.407
Vertical	Jarabak (%)	-2.1	1.8	-2.6	2.2	0.384
	GoGn-Sn (°)	2.3	1.8	1.9	3.0	0.549
	Palatal-GoGn (°)	2.2	2.1	1.2	1.9	0.378
	Facial Angle (°)	2.2	1.2	2.6	1.8	0.706
	Gonial Angle	4.9	3	3.6	2.6	0.097
Dental	U1-Sn (°)	-5.7	4.2	-5.6	3.6	0.954
	IMPA (°)	6.2	3.8	7.2	5.2	0.424
	Interincisal Angle (°)	0.3	4.7	1	5.5	0.645

dyle to the gnathion), Co-Pog (the distance from the condyle to the pogonion), overjet, Jarabak index (the ratio between the posterior and anterior face heights; S-Go/N-Me), GoGn-Sn (the angle between SN and the mandibular plane), Palatal-GoGn (the angle between the palatal and mandibular plane), facial angle (the angle formed by the intersection of the Frankfort plane with the nasion-pogonion line), 1 to SN (angle between the long axis of the upper central incisor and the anterior cranial base), IMPA (the angle between the long axis of the lower central incisor and the mandibular plane), and the interincisal angle (the angle between the upper and lower incisors). The measurements were performed before and after the treatment radiographs. Each film was traced by one investigator on 0.003-inch frosted acetate with a 0.3 mm lead pencil. Measurements were taken to the nearest 0.5 mm or degrees. Four weeks after the first measurements, the tracings and measurements were repeated by the same investigator. The intraclass correlation coefficient (ICC) was used to measure the reliability of the results. ICC indicated acceptable to excellent (0.72 to 0.92) reliability for the measurements.

The Kolmogorov-Smirnov normality test was applied to the cephalometric data. The statistical significance was set at $p<0.05$. The magnification factor of the cephalograms was standardized at 8%. The Statistical Package for Social Sciences, Version 22 (SPSS Inc. Chicago, Illinois, USA) was used to analyze the data. The paired t-test was used for the intra group evaluation if the distribution was normal; otherwise, the Wilcoxon test was used. The T-test was used to compare the data between the two groups if the distribution was normal; otherwise, the Mann-Whitney test was used.

3. Results

In the Farmand appliance group, paired t-tests showed a significant ANB decrease of 3.2 (SD 1.7) degrees ($p<0.001$) and an SNB increase of 3.3 (SD 1.9) degrees ($p<0.001$). Overjet significantly decreased from 7.1 (SD 2.1) mm to 3.6 (SD 1.9) mm. IMPA significantly increased by 6.2 (SD 3.8) degrees ($p<0.001$) (Table 1).

In the FR-2 group, ANB significantly decreased by 3.5 (SD 1.6) degrees ($p<0.001$), and SNB significantly increased from 73.6 (SD 3.4) to 77.6 (SD 1.5) degrees ($p<0.001$). Overjet also showed a significant decrease from 9.2 (SD 3.2) to 5 (1.6) mm ($P<0.001$). IMPA significantly increased from 91.7 (SD 8) to 98.9 (SD 6.5) degrees ($p<0.001$) (Table 1). Both appliances significantly increased GoGn, Co-Gn, and Co-Pog. T-test did not show any significant differences between the two groups (Table 2). Figures 3 and 4 show before and after treatment pictures of a patient treated with the Farmand appliance.

4. Discussion

The findings of this study showed that, both the Farmand and FR-2 appliances could successfully improve the intermaxillary discrepancy in Class II growing patients with mandibular deficiency.

After treatment, SNB and ANB showed significant changes. The Increase of SNB and decrease of ANB are indicative of favorable changes in the mandibular growth. The increase of GoGn, Co-Gn, and Co-Pog also indicates favorable mandibular growth.

The Farmand appliance is a passive tooth-born appliance composed of one extended labial bow on each jaw, two rests (stop) on each dental arch, a tongue bow and an acrylic plate. The labial bows with a distance of 1 mm from the labial surfaces of the upper and lower anterior teeth, act as an eruptive guidance for the incisors as well as eliminating the perioral muscles' forces, especially in case of severe mentalis muscle contraction. The tongue bow, with its loop in a distal direction, helps the patient to redirect his/her tongue to a distal position, thus removing the tongue pressure from the anterior part of the upper jaw. In addition, the patient is instructed to open and close his/her mandible while stabilizing the appliance on the maxillary arch by the tongue tip. This kind of exercise will improved the patient's adaptation in the new advanced mandibular position. The rests (stop), which are placed in the mesial surfaces of the first molars, restrict the first molars mesial movement and assist in achieving Class I molar relationship by forward movement of mandible.

In two recent studies, Yassaei and Soroush[17] and Yassaei et al.[21] studied the effects of the Farmand functional appliance on the hyoid bone position in Class II division 1 malocclusion patients. They found that the hyoid bone shifted significantly forward in the horizontal dimension.

The results of our study are consistent with the findings of the study conducted by Perillo et al.[6] in which the Fränkel-2 treatment produced a significant decrease in the ANB angle that improved the skeletal intermaxillary and occlusal relationship in Class II growing patients with mandibular retrusion. According to Fränkel,[15,22] the FR-2 acts by changing the biomechanical environment of the developing dentition. In agreement with many previous studies,[6,10,14,23-27] FR-2 proclines lower incisors slightly, probably because the lower labial pads of FR-2 change the lip posture and reduce the soft tissue pressure on the lower incisors. In this study, IMPA also increased significantly, which is similar to the finding of other functional appliances.[8,16,28]

The Farmand functional appliance, similar to the Bionator functional appliance is not as bulky as the FR-2 appliance and shows better patient tolerance and does not interfere as much with their speech.

The treatment in this study was for skeletal correction and further treatment in all patients was continued with fixed orthodontics.

5. Conclusion

Farmand functional appliances and Fränkel appliance were successful in the correction of mandibular deficiency in Class II division 1 patients and can be used as an alternative functional appliance.

Author Contributions

Concept - HP, AJ; Design - HP, AJ; Supervision - AJ; Resources - AM, AD; Materials - AM, AD; Data Collection and/or Processing – AM; Analysis and/or Interpretation - AD, ZK; Literature Search - LP, LN; Writing Manuscript - LP, AJ; Critical Review - LP, AJ.

Conflicts of Interest

None declared.

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Questions

This study was:

❑a. Prospective;
❑b. Retrospective;
❑c. Descriptive;
❑d. A case series.

What was the mean age of the patients in Farmand group in this study?

❑a. 11.1 years;
❑b. 13 years;
❑c. 9 years;
❑d. 10 years.

All the patients in study had the following malocclusion?

❑a. Class 2 division 2;
❑b. Class 2 division 1;
❑c. Class 2 division 1 and division2;
❑d. Class 1 with deep bite.

SNB significantly increased from 74.3° to... in Farmand group?

❑a. 76.8°;
❑b. 76.7°;
❑c. 75°;
❑d. 77.6°.