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ORIGINAL ARTICLE

Effect of Bionator and Farmand Appliance on the Treatment of Mandibular Deficiency in Prepubertal Stage

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ABSTRACT

Objective: The present study aimed to compare dentoskeletal changes in mandibular-deficient patients treated with Bionator and Farmand appliances.

Methods: This study included 54 subjects treated for class II division I malocclusion. All subjects fulfilled the following criteria: ANB>5°, SNB<77°, and overjet >5 mm. The Bionator group consisted of 27 patients (15 girls, 12 boys) with the mean age of 11 (SD 1) years and the Farmand group consisted of 27 patients (17 girls, 10 boys) with the mean age of 11.1 (SD 1.4) years. Statistical analyses were performed using t-test, paired t-test, Wilcoxon, and Mann–Whitney test.

Results: In the Farmand group, SNB significantly increased from 74.3° (SD 1.7) to 77.6° (SD 2.3) and ANB decreased by 3.2° (SD 1.7) ($p<0.001$). In the Bionator group, SNB significantly increased from 75.5° (SD 0.9) to 79° (SD 0.9), and ANB decreased by 3.3° (SD 1.3) ($p<0.001$). The increase in IMPA showed that the lower incisors were significantly tipped using both appliances. T-test did not show any significant differences between the two groups.

Conclusion: Despite the different designs of the appliances, both were successful in the treatment of class II division 1 malocclusion in mandibular-deficient patients.

Keywords: Bionator, Farmand, mandibular deficiency

INTRODUCTION

Skeletal class II malocclusion may result from mandibular deficiency, maxillary protrusion, or a combination of both (1,2). For more than a century, this deformity has been treated with various functional appliances. Many studies have shown the positive effects of different functional appliances such as the Activator, Bionator, Fränkel-2, Herbst, Twin block, and R-appliance on the treatment of mandibular deficiency (3-11). Functional appliances can be classified into two groups: tooth-borne and tissue-borne.

In general, tissue-borne appliances such as Fränkel produce less dental compensation than tooth-borne ones such as the Activator, Bionator, and Twin block.

The Bionator is a tooth-borne appliance developed in Germany by Wilhelm Balter in the early 1950s. This appliance is one of the most universally used functional appliances for the treatment of class II division 1 malocclusion associated with mandibular deficiency (12,13).

Another functional appliance which has been recently used for the correction of class II division 1 malocclusion with mandibular deficiency is the "Farmand appliance." This appliance has been shown to be effective in the forward movement of the mandible (14) and causes significant changes in the position and anterior displacement of the hyoid bone, resulting in improved airway and respiratory status of patients (15).

Although there are various studies on the treatment effects produced by the Bionator in the literature, there has been no direct comparison between the Bionator (16) and Farmand appliances (14). Therefore, this study

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aimed to compare dentoskeletal effects between the Farmand and Bionator appliances in the treatment of class II division 1 malocclusion with mandibular deficiency in prepubertal patients.

METHODS

In this retrospective study, patient data were handled according to the requirements and recommendations of the Declaration of Helsinki. Informed written consent was obtained from each patient and a parent or guardian.

All patients were selected according to the following inclusion criteria:

1) ANB >5°, SNB <77°, overjet >5 mm at prelateral cephalograms
2) Normal growth
3) No dentofacial syndromes
4) No previous surgical intervention
5) No previous orthodontic intervention
6) No skeletal asymmetry

This study included 54 (32 girls, 22 boys) patients, of whom 27 (17 girls, 10 boys) had been treated with Farmand (Figures 1, 2) and 27 (15 girls, 12 boys) with the Bionator (Figure 3).

All patients were in their prepubertal stage (CS1 and CS2), according to the cervical vertebral maturation method as described by Franchi et al. (17) and Baccetti et al. (18) at treatment initiation.

The mean age of the patients was 11.1 (SD 1.4) years in the Farmand group and they were treated for 16 (SD 1.7) months. The Farmand appliance is a passive tooth-borne device. It contains two extended labial bows in the lower and upper jaws, a tongue bow, four rests or stops, and an acrylic part. The acrylic plate covers the occlusal area to the lingual shields. A thick wire with a diameter of 1 mm, which functions as a tongue bow, connects the right and left acrylic plates on the palatal aspect to reinforce the appliance. The upper and lower labial bows are composed of 0.8-mm stainless steel wire extended from canine to canine with horizontal loops in the canine area. The rests or stops are located on the mesial surface of the upper and lower first permanent molars. Construction bites were taken with 2-3 mm posterior clearance and an edge-to-edge occlusion in the upper and lower incisors.

Twenty-seven patients in the Bionator group were the control group and the mean age was 11 (SD 1) years and treatment time 16 (SD 1.7) months. The occlusal surfaces of the posterior teeth and mandibular incisors were covered with acryl in both appliances. This acrylic coverage prevents undesirable eruption of the teeth.

All patients were trained to wear the appliances at all times except when eating, contact sports, and brushing. Lateral cephalograms of the samples were taken in centric occlusion at treatment initiation and completion in natural head position when

Figure 2. A lateral view of the Farmand appliance

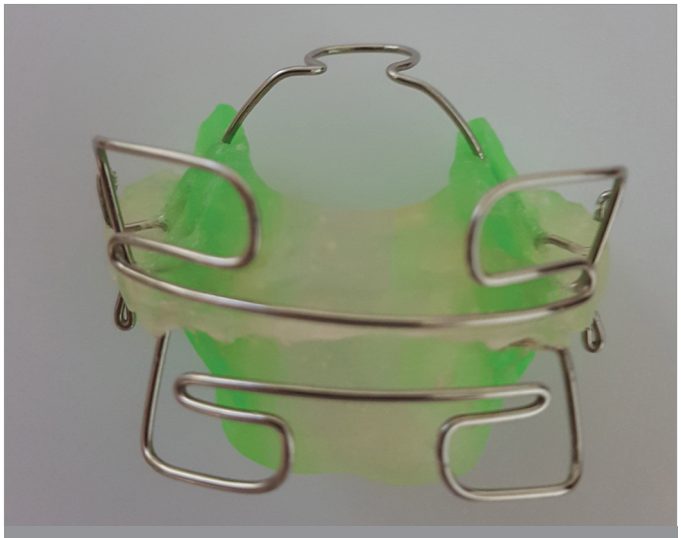

Figure 1. A frontal view of the Farmand appliance

Figure 3. The Bionator appliance

Figure 4. Pre-treatment image of a patient with mandibular deficiency

Figure 5. Post-treatment image of the same patient with Farmand appliance

patients were focusing at a long distant spot at eye level. The linear and angular cephalometric measurements were used for comparison of the treatment effects between the two groups. These measurements were as follows:

SNA, SNB, ANB, Witts (connecting points A and B perpendicular to occlusal plane), GoGn (the distance between gonion and gnathion representing mandibular length), CoGn (the distance between condylion and gnathion), Co–Pog (the distance between condylion and pogonion), overjet, Jarabak index (the ratio between 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 planes), facial depth angle (the angle formed by the intersection of the Frankfort plane with the nasion–pogonion line), U1 to SN (the angle between the long axis of the upper central incisor and anterior cranial base), IMPA (the angle between the long axis of the lower central incisor and mandibular plane), and interincisal angle (the angle between the upper and lower incisors). Measurements were obtained using the pre- and post-treatment radiographs. Each lateral cephalogram was traced by one investigator in two weks intervals on a 0.07 mm frosted acetate using a 0.3-mm lead pencil. Measurements were rounded to the nearest 0.5 mm or degree.

The cephalometric tracings were reevaluated by the same investigator after 1 month. An intraclass correlation coefficient (ICC) test was used to define the repeatability of the data. ICCs extended from 0.67 to 1, indicating acceptable to perfect reliability of the measurements. Table 3 shows the ICCs of all measurements.

The Kolmogorov–Smirnov normality test was used for the cephalometric data. Statistical significance was set at $p<0.05$. The magnification factor of each cephalogram was standardized at 8%. The Statistical Package for Social Sciences, Version 22 (IBM Corp.; Armonk, NY, USA) was used to analyze the data. Paired t-test was used for intra group evaluation if the distribution was normal; otherwise, Wilcoxon test was performed. T-test was used to compare the data between the two appliances if the distribution was normal; otherwise, Mann-Whitney test was applied. Figures 4 and 5 show the pre- and post-treatment images of patients in the Farmand group, respectively.

RESULTS

Tables 1 and 2 show the data of the cephalometric measurements with the two appliances.

In the Bionator group, ANB decreased by 3.3° (SD 1.3) ($p<0.001$), and SNB increased from 75.5° (SD 0.9) to 79° (SD 0.9) ($p<0.001$). Witts decreased from 4.2 (SD 1.6) to 1.9 (SD 1.7). Overjet also showed a significant decrease from 7.6 (SD 1.9) to 4.2 (SD 1.7) mm. IMPA increased from 91.3° (SD 4.2) to 98.8° (SD 5.3) ($p<0.001$). GoGn, CoGn, Co-Pog, Jarabak index, GoGn-Sn, palatal-GoGn, facial angle, gonial angle, the angle formed by the junction of the posterior and lower borders of lower jaw, and U1–SN showed significant changes (Table 1, 2).

In the Farmand group, paired t-tests showed that ANB decreased by 3.2° (SD 1.7) ($p<0.001$) and SNB increased to 3.3° (SD 1.9) ($p<0.001$). Witts decreased from 3.5 (SD 1.5) to 1.5 (SD 1.1). Overjet significantly decreased from 7.1 (SD 2.1) to 3.6 (SD 1.9) mm. IMPA significantly increased by 6.2° (SD 3.8) ($p<0.001$). GoGn, CoGn, Co-Pog, Jarabak index, GoGn-Sn, palatal-GoGn, facial angle, gonial angle, and U1 to SN also showed significant changes (Table 1, 2).

T-test showed that there were no significant differences between the two groups at treatment initiation. The anteroposterior position of the maxilla (SNA) was unaffected by treatment with both appliances; whereas the sagittal position of the mandible (SNB) improved with both functional appliances.

Both appliances showed significantly increased GoGn, Co-Gn, and Co–Pog. T-test did not show any significant differences between the two groups.

DISCUSSION

Both the Farmand and Bionator improved the intermaxillary discrepancy in Class II division 1 malocclusion patients with mandibular deficiency. Favorable mandibular growth was also achieved with both functional appliances.

The Farmand is a passive tooth-born device, consisting of a labial bow on each dental arch, two rests or stops on the first

Table 1. Pre- and post-treatment measurements in the Bionator and Farmand groups

			Before treatment			After treatment			
Variables		**Group**	**Mean**	**SD**	**Min-Max**	**Mean**	**SD**	**Min-Max**	**p**
Sagittal	SNA (°)	Farmand	81.2	1.5	79–84	81.4	1.3	80–84	0.110
		Bionator	81.3	0.9	80–82	81.4	0.8	80–82	0.212
	SNB (°)	Farmand	74.3	1.7	72–77	77.6	2.3	72–80	0.001
		Bionator	75.5	0.9	72–77	79	0.9	77–80	0.001
	ANB (°)	Farmand	6.8	1.6	5–10	3.6	2.3	1–8	0.001
		Bionator	5.6	1	5–10	2.4	1.3	0–5	0.001
	Witts (mm)	Farmand	4.2	1.6	1–7	1.9	1.7	0–5	0.001
		Bionator	3.5	1.5	1–6	1.5	1.1	0–4	0.001
	GoGn (mm)	Farmand	66.5	3.5	60–71	69.2	3.5	62–75	0.001
		Bionator	68.1	2	63–73	70.2	2.1	64–76	0.001
	Co-Gn (mm)	Farmand	103.7	2.9	98–123	106.2	2.6	100–127	0.001
		Bionator	103.3	3.3	100–110	105.6	3.2	102–113	0.001
	Co–Pog (mm)	Farmand	101.8	1.6	100–106	106.3	1.8	102–110	0.001
		Bionator	102	1.8	100–109	105.8	1.6	97.4–113	0.001
	Overjet (mm)	Farmand	7.1	2.1	5–12	3.6	1.9	0.5–10	0.001
		Bionator	7.6	1.9	5–12	4.2	1.7	0.5–10	0.001
Vertical	Jarabak (%)	Farmand	64.1	2.2	60–64	62	1.4	60–67	0.001
		Bionator	65.1	2.5	60–64	62	1.6	61–70	0.001
	GoGn–Sn (°)	Farmand	31.8	4.2	24–41	34.1	4	26–41	0.001
		Bionator	29.1	3.6	24–38	31.3	3.6	26–41	0.001
	Palatal–GoGn (°)	Farmand	25.3	2.6	20–30	27.5	1.9	24–32	0.001
		Bionator	26.7	1.1	25–29.8	28.4	1	26–34.8	0.001
	Facial Angle (°)	Farmand	82.9	2.6	80–88	85.1	2.5	80–90	0.001
		Bionator	86.3	1.7	81–89	88.5	2	84–93	0.001
	Gonial Angle	Farmand	123.7	3	116–128	128.7	2.1	123–133	0.001
		Bionator	123.7	4.1	113.4–133	127.4	3.1	119.5–141	0.001
Dental	U1–Sn (°)	Farmand	110.1	7	96–128	104.4	5.7	94–114	0.001
		Bionator	111.3	5.8	100–123	104.2	4.1	94–111	0.001
	IMPA (°)	Farmand	95.7	7.3	86–110	101.9	6.6	91–117	0.001
		Bionator	91.3	4.2	84–99	98.8	5.3	90–113	0.001
	Interincisal Angle (°)	Farmand	117.8	5.5	100–129	118	6.7	105–130	0.777
		Bionator	117	7	104–130	119.3	5.7	110–130	0.05

SNA, SNB, ANB, Witts: connecting points A and B perpendicular to occlusal plane; GoGn: the distance between gonion and gnathion representing the mandibular length; CoGn: the distance between condylion and gnathion; Co-Pog: the distance between condylion and pogonion; overjet, Jarabak index (the ratio between posterior and anterior face heights; S–Go/N–Me), GoGn–Sn (the angle between SN and the mandibular plane), palatal–GoGn (the angle between palatal and mandibular planes), facial angle (the angle formed by the intersection of the Frankfort plane with the nasion–pogonion line), gonial angle (the angle between the ramal plane and mandibular plane), U1 to SN (the angle between the long axis of the upper central incisor and anterior cranial base), IMPA (the angle between the long axis of the lower central incisor and mandibular plane), and interincisal angle (the angle between the upper and lower incisors)

permanent molars, as well as tongue bow and an acrylic plate. Two labial bows are placed 1 mm away from the labial surfaces of the lower and upper anterior teeth. It performs as a barrier for eliminating the force of the perioral muscles, particularly in case of severe mentalis muscle contraction, and as well as an eruptive guidance for the incisors. Each Farmand has a tongue bow with a loop located in a distal direction. Tongue bows help the patient to redirect their tongue to a distal position, thus the pressure of tongue is removed from the anterior part of the upper jaw. The patient is trained to push the tongue tip on the tongue bow. This type of function will improve the mandible into a more advanced position. The rests or stops, which are positioned in the mesial aspect of the first permanent molars, control the first permanent molars from mesial movement and assist in achieving class I molar relationship while the mandible moves in a forward position. The effects of Twin Block and Farmand were evaluated by Yassaei et al. (14), and they showed that both the Twin Block and Farmand were effective in the treatment of class II division I with mandibular deficiency. It has also been proven that Farmand significantly shifted the hyoid bone forward and nonsignificantly upward (15).

The Bionator is a tooth-borne apparatus that has been reported to produce considerable changes in dentoskeletal structures

Table 2. Comparison of changes during treatment between the Bionator and Farmand

		Farmand		Bionator		
Variables		**Mean**	**SD**	**Mean**	**SD**	**p**
Sagittal	SNA (°)	0.2	0.7	0.1	0.6	0.678
	SNB (°)	3.3	1.9	3.4	1.2	0.732
	ANB (°)	–3.2	1.7	–3.3	1.3	0.610
	Witts (mm)	–2.3	1.5	–2	0.9	0.371
	GoGn (mm)	2.7	1.5	2.1	1.1	0.117
	Co-Gn (mm)	2.6	1.2	2.3	1.6	0.331
	Co–Pog (mm)	4.5	1.9	3.7	1.5	0.117
	Overjet (mm)	–3.5	2.3	–3.4	2.1	0.851
Vertical	Jarabak (%)	–2.1	1.8	–3.1	2.4	0.095
	GoGn–Sn (°)	2.3	1.8	2.1	2.6	0.859
	Palatal–GoGn (°)	2.2	2.1	1.7	0.6	0.157
	Facial Angle (°)	2.2	1.2	2.2	1.3	0.926
	Gonial Angle	4.9	3	3.7	2.4	0.109
Dental	U1–Sn (°)	–5.7	4.2	–7.1	4.2	0.227
	IMPA (°)	6.2	3.8	7.5	3.6	0.205
	Interincisal Angle (°)	0.3	4.7	2.3	5.8	0.163

SNA, SNB, ANB, Witts (connecting points A and B perpendicular to occlusal plane), GoGn (the distance between gonion and gnathion representing mandibular length), CoGn (the distance between condylion and Gnathion), Co–Pog (the distance between condylion and pogonion), overjet, Jarabak index (the ratio between 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 planes), facial angle (the angle formed by the intersection of the Frankfort plane with the nasion–pogonion line), gonial angle (the angle between the ramal plane and mandibular plane), U1–SN (the angle between the long axis of the upper central incisor and anterior cranial base), IMPA (the angle between the long axis of the lower central incisor and mandibular plane), and interincisal angle (the angle between the upper and lower incisors)

Table 3. Intraclass correlation coefficients test of all measurements

Variables	**ICC**	
Sagittal	SNA (°)	0.898
	SNB (°)	0.950
	ANB (°)	0.958
	Witts (mm)	0.956
	GoGn (mm)	0.917
	Co-Gn (mm)	0.670
	Co–Pog (mm)	0.670
	Overjet (mm)	0.851
Vertical	Jarabak (%)	0.998
	GoGn–Sn (°)	0.859
	Palatal–GoGn (°)	0.893
	Facial Angle (°)	0.943
	Gonial Angle	0.909
Dental	U1–Sn (°)	0.997
	IMPA (°)	0.831
	Interincisal Angle (°)	0.991

ICC: intraclass correlation coefficients

through a repositioning of the lower jaw in a more forward position, establish normal overjet and overbite, control dental eruption, and improve facial structures (19).

The difference between the two appliances is that two rests or stops are located on the mesial surface of the upper and lower first permanent molars in the Farmand appliance. These rests are used to prevent the forward movement of dentition and serve as stabilizing elements. There are two labial bows in Farmand appliance while there is only one labial bow in the Bionator. Two labial bows are used to stabilize the appliance. In the Bionator, the lingual flange has deep extensions beneath the mandibular molars and behind the lower incisors, whereas in Farmand, the lingual flange is not extended as much. The small size of the Farmand makes this appliance more convenient for patients.

Almeida et al. (20) evaluated the dentoskeletal effects of the Bionator on class II division I malocclusion with mandibular deficiency and reported favorable movement of the mandible.

GoGn–Sn increased in the Bionator and Farmand. This causes a clockwise rotation of the mandible, which is favorable in horizontal growers. Similar findings for Bionator have been reported in the literature, which confirm the results of the current study (19,21).

In the current study, the Bionator and Farmand caused flaring of the lower incisors and retrusion of the upper incisors. This protrusion of lower incisors, which can be observed in most functional appliances, is not favorable in class II division I malocclusion with mandibular deficiency. In the current study, no significant differences between the lower and upper anteriors were observed in both groups. These findings are concomitant with those of Almeida et al. (20). To date, only the R-appliance has been reported to move the mandible forward without any proclination of the lower anteriors (3,6).

Both Farmand and Bionator are used for skeletal problems and further correction is continued with fixed orthodontics.

CONCLUSION

There were no changes in the forward growth of the maxilla with either of the appliances.

Both Farmand and Bionator appliances

- Moved the mandible forward
- Caused tipping of the lower incisors
- Caused retrusion of the upper incisors

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Orthodontic Research Center, Shiraz University School of Dentistry.

Informed Consent: Written informed consent was obtained from who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - H.P., A.J.; Design - H.P., A.J.; Supervision - A.J.; Resources - A.M., A.D.; Materials - A.M., A.D.; Data Collection and/or Processing - A.M., M.H.B.; Analysis and/or Interpretation - A.D., Z.K.; Literature Search - M.H.B.; Writing Manuscript - M.H.B., A.J.; Critical Review - Z.K., A.J.

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REFERENCES

1. McNamara JA, Jr., Ellis E 3rd. Cephalometric analysis of untreated adults with ideal facial and occlusal relationships. Int J Adult Orthodon Orthognath Surg 1988; 3: 221-31.
2. Perillo L, Padricelli G, Isola G, Femiano F, Chiodini P, Matarese G. Class II malocclusion division 1: a new classification method by cephalometric analysis Eur J Paediatr Dent 2012; 13: 192-6.
3. Showkatbakhsh R, Castaldo MI, Jamilian A, Padricelli G, Fahimi Hanzayi M, Cappabianca S, et al. Treatment effects of R-appliance and Frankel-2 in Class II division 1 malocclusions. Eur J Paediatr Dent 2013; 14: 17-22.
4. O'Brien K, Wright J, Conboy F, Appelbe P, Davies L, Connolly I, et al. Early treatment for Class II Division 1 malocclusion with the Twin-block appliance: a multi-center, randomized, controlled trial. Am J Orthod Dentofacial Orthop 2009; 135: 573-9. [CrossRef]
5. Perillo L, Castaldo MI, Cannavale R, Longobardi A, Grassia V, Rullo R, et al. Evaluation of long-term effects in patients treated with Frankel-2 appliance. Eur J Paediatr Dent 2011; 12: 261-6.
6. Jamilian A, Showkatbakhsh R, Amiri SS. Treatment effects of the R-appliance and twin block in Class II division 1 malocclusion. Eur J Orthod 2011; 33: 354-8. [CrossRef]
7. Pancherz H. The Herbst appliance: a paradigm change in Class II treatment. World J Orthod 2005; 6 Suppl: 8-10.
8. Franchi L, Pavoni C, Faltin K Jr, McNamara JA Jr, Cozza P. Long-term skeletal and dental effects and treatment timing for functional appliances in Class II malocclusion. Angle Orthod 2013; 83: 334-40. [CrossRef]
9. Perillo L, Johnston LE Jr, Ferro A. Permanence of skeletal changes after function regulator (FR-2) treatment of patients with retrusive Class II malocclusions. Am J Orthod Dentofacial Orthop 1996; 109: 132-9. [CrossRef]
10. Showkatbakhsh R, Meybodi SE, Jamilian A, Meybodi SA, Meybodi EM. Treatment effects of R-appliance and anterior inclined bite plate in class II, division I malocclusion. J Appl Oral Sci 2011; 19: 634-8. [CrossRef]
11. Jamilian A, Showkatbakhsh R, Kamali Z. R-appliance: a different design in functional therapy in Class II Division I malocclusion. Int J Orthod Milwaukee 2009; 20: 11-4.
12. Jacobs T, Sawaengkit P. National Institute of Dental and Craniofacial Research efficacy trials of bionator class II treatment: a review. Angle Orthod 2002; 72: 571-5.
13. Martins RP, da Rosa Martins JC, Martins LP, Buschang PH. Skeletal and dental components of Class II correction with the bionator and removable headgear splint appliances. Am J Orthod Dentofacial Orthop 2008; 134: 732-41. [CrossRef]
14. Yassaei S, Jamilian A, Joshan N. Effects of Twin-Block and Faramand-LL appliances on soft tissue profile in the treatment of Class II division 1 malocclusion. International journal of orthodontics. 2014; 25: 57-62.
15. Yassaei S, Sorush M. Changes in hyoid position following treatment of Class II division1 malocclusions with a functional appliance. J Clin Pediatr Dent 2008; 33: 81-4. [CrossRef]
16. Siara-Olds NJ, Pangrazio-Kulbersh V, Berger J, Bayirli B. Long-term dentoskeletal changes with the Bionator, Herbst, Twin Block, and MARA functional appliances. Angle Orthod 2010; 80: 18-29. [CrossRef]
17. Franchi L, Baccetti T, De Toffol L, Polimeni A, Cozza P. Phases of the dentition for the assessment of skeletal maturity: a diagnostic performance study. Am J Orthod Dentofacial Orthop 2008; 133: 395-400; quiz 76 e1-2.
18. Baccetti T, Franchi L, McNamara JA Jr. The cervical vertebral maturation (CVM) method for assessment of optimal treatment timing in dentofacial orthopedics. Semin Orthod 2005; 11: 119-29. [CrossRef]
19. Malta LA, Baccetti T, Franchi L, Faltin K Jr., McNamara JA Jr. Long-term dentoskeletal effects and facial profile changes induced by bionator therapy. Angle Orthod 2010; 80: 10-7. [CrossRef]
20. Almeida MR, Henriques JF, Almeida RR, Almeida-Pedrin RR, Ursi W. Treatment effects produced by the Bionator appliance. Comparison with an untreated Class II sample. Eur J Orthod 2004; 260: 65-72. [CrossRef]
21. Illing HM, Morris DO, Lee RT. A prospective evaluation of Bass, Bionator and Twin Block appliances. Part I--The hard tissues. Eur J Orthod 1998; 20: 501-16. [CrossRef]