DOI: 10.4274/TurkJOrthod.2025.2025.98

TURKISH JOURNAL OF
ORTHODONTICS

Original Article

Face Mask versus Carrière Motion® Class III Appliance: Comparison of Skeletal, Soft Tissue, and Dental Effects in Growing Individuals

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Cite this article as: Polat M, Yılmaz B. Face mask versus Carrière Motion® class III appliance: comparison of skeletal, soft tissue, and dental effects in growing individuals. *Turk J Orthod.* 2025; 38(3): 149-160

Main Points

- Both the face mask and Carrière Motion® III improve sagittal relationships in growing Class III malocclusion patients.
- The face mask produces greater maxillary advancement compared to the Carrière Motion® III.
- The Carrière Motion® III provides more controlled dentoalveolar changes.
- Both appliances have a positive impact on the soft tissue profile.
- Appliance selection should be based on whether skeletal or dental changes are prioritized.

ABSTRACT

Objective: To compare the effects of the face mask and Carrière Motion® III appliance in growing patients with Class III malocclusion associated with maxillary retrognathia. The null hypothesis was that both appliances, applied after rapid maxillary expansion, would have similar effects.

Methods: Skeletal, dental, and soft tissue changes were evaluated using lateral cephalometric radiographs of 26 patients aged 6-9 years, taken before (T0) and after treatment (T1). Cephalometric analyses were performed using Nemoceph® software (NEMOTEC, Madrid, Spain). Statistical analyses were carried out with MedCalc version 12.7.7 (MedCalc Software bvba, Ostend, Belgium) with significance set at $p<0.05$.

Results: SNA°, A-NasionPerp, and Co-A increased significantly in both groups, with no significant intergroup difference. Co-Gn, Wits, ANB°, S-N, and the articular angle also increased significantly in both groups. SNB° decreased significantly only in the Carrière Motion® III group. Greater anterior maxillary rotation occurred with the face mask, while reduced rotation was observed with the Carrière Motion® III. Lower facial height decreased slightly but significantly in the Carrière Motion® III group, and increased in the face mask group. Overjet and molar relationship improved significantly in both groups. The UL-E line distance decreased in the face mask group, while the Carrière Motion® III showed no significant soft tissue changes.

Conclusion: The null hypothesis was rejected. The two appliances had different effects; however, the Carrière Motion® III proved effective for early Class III treatment and may be considered an alternative, particularly for patients with social concerns about extraoral traction.

Keywords: Carrière Motion® appliance, class III malocclusion, face mask, rapid maxillary expansion

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Received: August 14, 2025 **Accepted:** September 03, 2025 **Publication Date:** September 30, 2025

INTRODUCTION

Class III malocclusion might be related to maxillary growth deficiency, mandibular overgrowth, or a combination of these two conditions. The majority of Class III malocclusion patients include maxillary retrognathia as a contributing etiologic factor; it has been previously reported that 60% of the Class III malocclusions are characterized by maxillary deficiency.[1] Meanwhile, vertical and transverse discrepancies may also be present.

Non-surgical treatment of Class III malocclusion remains challenging for orthodontists because of unpredictable growth potential and dependence on patient cooperation. However, early diagnosis and intervention for Class III malocclusion may help reduce the severity of the malocclusion in late adolescence.[2]

The Carrière Motion® appliance was designed by Doctor Luis Carrière to distalize posterior teeth as a segment and to correct the inclination of the occlusal plane.[3] It has been reported that the Carrière Motion® III appliance, when used with Class III intraoral elastics, provides distalization of the mandibular posterior teeth and causes mesialization of the maxillary dentoalveolar complex, thus moving the dentition to a Class I relationship.[4] According to our literature review, there is currently no study available in the literature comparing the effects of the Carrière Motion® III appliance with conventional maxillary protraction achieved with a face mask (FM). Within the scope of this study, we expected that the Carrière Motion® Class III appliance following rapid maxillary expansion, would contribute to correcting Class III malocclusion in growing patients. The aim of the present research was to compare the skeletal, dental and soft tissue effects of the FM and the Carrière Motion® Class III device applied following rapid maxillary expansion in growing individuals aged 6-9 years with skeletal and dental Class III malocclusion. The null hypothesis was that the effects of these two devices applied following rapid maxillary expansion would be the same.

METHODS

The study was performed at the Department of Orthodontics, Bezmialem Vakıf University Faculty of Dentistry between July 1, 2021, and September 1, 2022. The research project was approved and monitored by the Non-Interventional Research Ethics Committee at Bezmialem Vakıf University (date: November 9, 2020, approval no.: 13079). Written informed consent for participation and publication of clinical images was obtained from the patients' legal guardians in accordance with the institutional ethical standards and the Declaration of Helsinki.

Based on a power analysis conducted using data from the study by Keles et al.,[5] which reported a significant 3.11° change in the SNA angle following maxillary expansion and protraction, a minimum of 11 individuals in each group was required to reach a 95% confidence level with a Type I error of 0.05 and a power of 80%. Considering potential participant losses, determined that at least 14 individuals should be included in each group.

The inclusion criteria for the study were as follows: being aged between 6 and 9 years old, having a negative (up to -4mm) or edge-to-edge incisor relationship, having no severe crowding, having no previous orthodontic treatment history, and having no systemic disease, syndrome etc. that may interfere with orthodontic treatment. Patients who were conveniently allocated to the Carrière Motion® group were required to have at least two-thirds of their lower deciduous canines present. This criterion was assessed using periapical radiographs.

Some data from the individuals included in the FM group (n=6) were collected from the archive of the Bezmialem Vakıf University Department of Orthodontics using the same inclusion criteria.

Rapid maxillary expansion was performed for at least seven days with a McNamara type acrylic cap expander, and the patients were instructed to turn the screw one-quarter-turn twice a day till the desired expansion was achieved. After the expansion, patient treatment was continued with either a FM or a Carrière Motion® III appliance.

The distance from the midpoint of the buccal surface of the mandibular first molar to the mesial one-third of the mandibular primary canine crown was measured with a special ruler to determine the appropriate Carrière Motion® III size. The appliance was bonded according to the recommended bonding procedure. Ormco™ (Glendora, CA, USA) intermaxillary elastics producing 1/4" 6.0 oz force (Ram) were used between the Carrière Motion® appliance and the hook at the posterior of the expansion device. Patients were instructed to use the elastics for 24 hours except while eating (Figures 1 and 2).

The elastics of the FM were positioned at an angle of 30° to the occlusal plane. The force magnitude was adjusted with an extraoral force gauge to provide 450 grams. The patients were instructed to use their appliances for 12-14 hours a day (Figures 3 and 4).

In both groups, the sagittal correction was completed when a Class II canine relationship was achieved, and the appliances were removed. For the retention phase, patients were instructed to wear the Class III Bionator for at least 12 hours per day over a period of 12 months. Follow-up visits were scheduled at 3-month intervals to monitor compliance and ensure treatment stability.

Lateral cephalometric radiographs were taken before treatment (T0) and after the removal of the expansion appliances (T1). Cephalometric analyses were carried out with the Nemoceph® (Nemotec Software, Madrid, Spain) software.

Figure 1. Intraoral records of a patient from Carrière group; a) Pretreatment, b) Before removal of the appliances, c) Posttreatment.

Figure 2. Extraoral records of a patient from Carrière group; a) Pretreatment, b) Posttreatment.

Figure 3. Intraoral records of a patient from FM group; a) Pretreatment, b) Before removal of the appliance, c) Posttreatment.
FM, face mask.

Figure 4. Extraoral records of a patient from FM group; a) Pretreatment, b) Posttreatment.
FM, face mask.

During the study, the lower deciduous canines of two children wearing the Carrière Motion® appliance could not withstand the forces and began to show mobility. These two children were excluded from the study and their treatment continued with a FM.

Statistical Analysis

Descriptive analyses were used to describe continuous variables. Mean and standard deviation values are given for normally distributed data, and median values for non-normally distributed data. The relationship between two dependent, non-normally distributed continuous variables was examined using the Wilcoxon Signed Rank test. The relationship between two independent, non-normally distributed continuous variables was examined using the Mann-Whitney U test. The statistical significance level was set at 0.05. Analyses were performed using MedCalc Statistical Software version 12.7.7 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2013).

RESULTS

There was no statistically significant difference between the groups in which the Carrière Motion® appliance (Carrière) and the FM were used, in terms of gender and age (p>0.05) (Table 1). The total treatment duration was 225±72 days in the facemask group and 256±83 days in the CMIII group.

The comparison between groups according to the cervical vertebral maturation (CVM) stage is presented in Table 2. No statistically significant difference was found in the comparison between groups according to the CVM stage (Table 2).

The comparison of the skeletal parameters within and between groups (Carrière and FM) revealed statistically significant changes (Table 3). Co-A, SNA°, NperpA, Co-Gn, Wits, ANB°, and S-N showed a statistically significant increase between T0 and T1 in both groups. The SNB° decreased significantly from T0 to T1 only in the Carrière Motion® group (Table 3).

Besides those sagittal parameters, some vertical skeletal parameters such as ANS-Me, N-Me, S-Go, and the articular angle also showed a statistically significant increase. N-ANS and FH-MP° showed a statistically significant increase from T0 to T1 only in the Carrière Motion® group, while a significant increase was observed in the FH-PP° only in the FM group. There was no statistically significant difference between the two groups in the FH-PP° value comparison at T0, but there was a statistically significant difference between the two groups at T1.

Table 4 compares dental parameters within and between the Carrière and FM groups. Overjet and molar relationship showed statistically significant differences between T0 and T1 in both groups. There was a significant decrease in L1-A/Pg in both groups. The U1-A/Vert showed a statistically significant increase from T0 to T1 only in the Carrière Motion® group. While there was no statistically significant difference between the groups at T0 in overjet, L1-A/Pg, or the Holdaway ratio, there was a significant difference between the groups at T1. While the amount of overjet increased more in the FM group, the L1-A/Pg distance decreased more in the FM group. In the Carrière Motion® group, the Holdaway ratio increased, whereas in the FM group, it decreased (Table 4).

The U1-A/Vert increased in both groups, but only the Carrière Motion® group showed a significant difference within group comparisons. For several parameters, there were statistically significant differences between the two groups at T1. Table 5 compares the soft tissue parameters within and between the Carrière and FM groups. The UL-E line value significantly increased only in the FM group. None of the soft tissue parameters seemed to be affected by the Carrière Motion appliance (Table 5).

Twenty lateral cephalograms were randomly retraced after a 2-week interval by the same examiner to assess measurement reliability. Intra-examiner error, calculated using Dahlberg's formula, was within clinically acceptable limits (<0.5 mm for linear and <0.5° for angular measurements). The intraclass correlation coefficient values were ≥0.90, indicating excellent reliability.

Table 1. Demographic comparisons between groups using Carrière and FM

	Carrière n=12	FM n=14	Total n=26	p-value
Gender				
Male	5 (41.6%)	7 (50%)	12 (46.1%)	1.000[1]
Female	7 (58.3%)	7 (50%)	14 (53.8%)	
Treatment age/year				
Mean±SD	7.9±0.8	7.6±1.3	7.7±1.1	0.818[2]
Med (Min.-Max.)	8 (6-8.8)	8 (4.7-9.1)	8 (4.7-9.1)	

[1]Continuity correction; [2]Mann-Whitney U test (p<0.05*) (p<0.01**)
FM, face mask; SD, standard deviation; Min.-Max., minimum-maximum.

Table 2. Comparison between groups according to the CVM stage

	CS1 n=16	CS2 n=10	Total	p-value
Gender n (%)				
Male	9 (56.2)	3 (30)	12 (46.1)	0.212[1]
Female	7 (43.7)	7 (70)	14 (53.8)	
Treatment age/year				
Mean±SD	7.6±1.2	8.0±0.9	7.7±1.1	0.347[2]
Med (Min.-Max.)	8 (4.7-9.1)	8 (6-8.9)	8 (4.7-9.1)	
Carrière/FM n (%)				
Carrière	7 (43.7)	5 (50)		1.00[1]
FM	9 (56.2)	5 (40)		

[1]Continuity correction; [2]Mann-Whitney U test (p<0.05*).
SD, standard deviation; Min.-Max., minimum-maximum.

Table 3. Intra- and inter-groups comparisons of the skeletal parameters

	T0	T1	p-value
Saddle angle (°)			
Carrière	124.9±5.1	124.2±4.9	0.302
	126 (116-133)	124.5 (116-132)	
FM	124±5.3	123.2±4.5	0.263
	124.5 (112-135)	123 (111-130)	
P	0.504	0.678	
Co-A (mm)			
Carrière	70.6±3.5	72.6±4	**0.001*** **
	70.9 (61.2-75.3)	72.9 (62.7-78)	
FM	70.4±3.8	75±4.2	**<0.001*** **
	71 (63.9-75.5)	74.8 (64.4-82)	
P	0.872	0.148	
SNA (°)			
Carrière	78.3±3.5	79.5±3.5	**0.026***
	78 (69-84)	80 (71-85)	
FM	78.9±4.4	81.1±3.7	**0.009****
	79 (70-87)	81.5 (75-88)	
P	0.517	0.310	
A-Nperp (mm)			
Carrière	-3.6±2.8	-2.3±3	**0.021***
	-3.6 (-10.2-1.2)	-2.3 (-9.1-2)	
FM	-2.7±3.8	-1.0±3.3	**0.013***
	-2.6 (-10.2-4.1)	-0.5 (-6-5.2)	
P	0.382	0.408	
Co-Gn (mm)			
Carrière	94±4	96.7±5.1	**0.005****
	94.3 (84.7-101.5)	96 (84.7-105.5)	
FM	96.6±3.8	99.6±4.6	**0.002****
	97.1 (88.9-101.9)	100.3 (88.6-106.7)	
P	0.054	0.108	
SNB (°)			
Carrière	78.2±2.5	77.2±3.1	**0.017***
	79 (72-82)	77.5 (71-82)	
FM	79.2±3.2	78.3±2.6	0.127
	80 (74-84)	78 (73-82)	
P	0.286	0.392	
Pg-Nperp (mm)			
Carrière	-6.5±5.6	-7.4±4.4	0.221
	-6.2 (-17.8-3.1)	-7.8 (-17.7-1.2)	
FM	-5.7±5.7	-5.9±5.7	0.650
	-4.2 (-16.8-3.6)	-6.2 (-16.8-6.1)	
P	0.646	0.535	

Table 3. Continued

	T0	T1	p-value
Gonial angle (°)			
Carrière	125.8±9.0	125.9±8.1	0.964
	126 (111-142)	126.5 (111-140)	
FM	126.1±8.1	125.9±8.9	0.719
	125 (114-143)	125 (113-146)	
P	0.908	0.963	
Wits (mm)			
Carrière	-4.0±3.1	-2.2±2.2	**0.021***
	-5.2 (-8.5-0.9)	-2.0 (-5.1-1.5)	
FM	-5.9±2.3	-2.6±2.1	**0.001*** **
	-5.6 [-11-(-2.1)]	-2.8 (-6.3-1.2)	
P	0.215	0.662	
ANB (°)			
Carrière	-0.1±2.2	2.3±2.4	**0.001*** **
	-0.5 (-4-4)	3 (-4-5)	
FM	-0.4±2.3	2.8±1.8	**<0.001*** **
	-0.5 (-5-3)	3 (0-6)	
P	0.870	0.798	
FH-occlusal plane (°)			
Carrière	10.9±4.1	10.5±3.1	0.782
	10.5 (5-18)	11.0 (3-15)	
FM	12.3±3.8	10.9±4	0.128
	12.5 (5-18)	11 (2-18)	
P	0.433	0.625	
FH-palatal plane (°)			
Carrière	1.6±2.6	0.8±2.5	0.225
	2 (-3-6)	0.5 (-3-5)	
FM	0±2.9	-1.7±3.2	**0.020***
	-0.5 (-5-5)	-2 (-7-4)	
P	0.165	**0.023***	
Mandibular plane angle (MPA) (°)			
Carrière	25.7±6.2	26.6±5.3	0.098
	26 (15-38)	28 (17-33)	
FM	25.5±6.5	26.4±6.7	0.237
	24.5 (13-39)	24.5 (16-39)	
P	0.982	0.963	
N-ANS (mm)			
Carrière	44.2±2.6	45.6±2.6	**0.005****
	43.7 (40.4-48.9)	45.1 (41.9-50.4)	
FM	43.1±2.6	44.1±3	0.084
	43.3 (37.1-47)	44.4 (38.8-48)	
P	0.395	0.358	

Table 3. Continued

	T0	T1	p-value
ANS-Me (mm)			
Carrière	58.9±21.2	58.6±11.4	**0.019***
	53(40.4-130)	55(40-90)	
FM	64±30.6	67.9±32.4	**<0.001*****
	55.9 (51-170)	59 (54.1-180)	
P	0.241	0.118	
SN-occlusal plane (°)			
Carrière	19.4±4.2	17.8±5	0.167
	21 (12-26)	19 (8-23)	
FM	19.8 ±3.7	18.4±4.3	0.106
	20.5 (13-25)	18.5 (8-26)	
P	0.853	0.871	
FH-MP (°)			
Carrière	26.6±5.4	27.9±4.4	**0.049***
	25.5 (18-38)	29 (19-33)	
FM	26.8±6.2	27.7±6	0.242
	26.5 (15-39)	27 (18-39)	
P	0.836	0.872	
Maxillary height (°)			
Carrière	56.9±3.5	57.9±3.6	0.146
	57.5 (51-63)	57.5 (52-67)	
FM	55.5±2.4	55.3±3.4	1.000
	56 (51-59)	57 (50-60)	
P	0.340	0.131	
Maxillary depth angle (°)			
Carrière	86±3.8	87.6±3.4	0.052
	86 (77-93)	88 (80-92)	
FM	86.3±4.6	89.1±3.8	**0.005****
	86.5 (78-95)	90 (83-96)	
P	0.799	0.267	
N-Me (mm)			
Carrière	94.1±9.5	98.4±10.3	**<0.001*****
	94.9 (65.2-106.5)	99.3 (67.1-110.8)	
FM	97.5±5.2	101.7±5.9	**0.002****
	98.9 (88.6-108)	101.3 (93.1-115)	
P	0.270	0.476	
S-Go (mm)			
Carrière	66.8±10.8	69.5±12	**0.002****
	65.4 (57.7-101.7)	67.2 (58.7-108.3)	
FM	65.2±5.1	67.5±5	**0.010****
	64.4 (57.7-73.9)	66.9 (59.1-77.2)	
P	0.927	0.909	

Table 3. Continued

	T0	T1	p-value
SN-FH (°)			
Carrière	7.9±1.6	8±1.9	0.951
	7.5 (7-13)	7.5 (6-14)	
FM	7.4±0.5	7.6±0.5	0.317
	7 (7-8)	8 (7-8)	
P	0.600	0.920	
S-N (mm)			
Carrière	60.3±2.7	61.5±2.6	**0.018***
	59.7 (55.9-65.5)	60.9 (57-67.2)	
FM	60.3±2.3	61.8±2	**0.005****
	60.3 (55.9-65.3)	62.3 (57-64.5)	
P	0.696	0.490	
Articular angle (°)			
Carrière	141.6±6.6	144.2±6.4	**0.013***
	141.5 (130-154)	145 (132-153)	
FM	143.2±8.8	145.6±8.3	**0.018***
	143 (130-161)	146 (129-160)	
P	0.645	0.730	

[1]Wilcoxon signed-rank test; [2]Mann-Whitney U test (p<0.05*) (p<0.01**) (p<0.001***)

DISCUSSION

When selecting patients to be included in the present study, care was taken to ensure that both groups' participants had Class III malocclusions with maxillary retrognathia but no significant mandibular prognathia. The sagittal position of the maxilla and mandible was verified by evaluating the related parameters on the lateral cephalometric radiographs (SNA°, SNB°, A-NasionPerp).

In the Carrière group, careful consideration was given to the root resorption status of the lower deciduous canines to ensure adequate resistance to Class III elastic forces. Nevertheless, our findings indicated that the absence of teeth between the canines and molars compromised direct force transmission, increasing the risk of appliance debonding. This problem may also be explained by the short crown length of the anchoring teeth and the challenges of maintaining adequate isolation in pediatric patients.

Although the appliance was initially assumed to function as a space maintainer in cases with missing posterior teeth, these patients demonstrated increased mobility and extrusion of the deciduous canines, most likely due to uneven force distribution. As a result, two patients had to be excluded from the study and were subsequently managed with facemask therapy.

In Class III cases, the Carrière system recommends Force 1 elastics (1/4" 6.0 oz-340 grams), avoiding the use of higher-force Force 2 elastics.[6] This is due to the shorter and smaller

Table 4. Intra- and inter-groups comparisons of the dental parameters

Overbite (mm)	T0	T1	p-value
Carrière	1.1±2.5	0.7±1.9	0.553
	1.2 (-3.2-3.7)	0.9 (-3.2-3.9)	
FM	1.5±1.9	2±1.3	0.183
	1.7 (-1.8-4)	1.9 (-0.3-4.3)	
P	0.908	0.068	
Overjet (mm)			
Carrière	-1.9±1.1	2.3±1.3	**0.018***
	-1.9 [-4-(-0.7)]	2.5 (-0.3-5.2)	
FM	-0.7±1.8	3.5±1.2	**0.012***
	-1 (-2.6-2.9)	3.6 (1.1-5.7)	
P	0.353	**0.022***	
Interincisal angle (°)			
Carrière	134±13.3	134.6±7.2	0.610
	135 (108-153)	135 (121-147)	
FM	138±9.1	138.6±6.2	0.933
	136.5 (124-154)	137.5 (129-148)	
P	0.601	0.200	
Molar relationship (mm)			
Carrière	-1.7±1.6	-0.3±1.8	**0.020***
	-1.5 (-4.8-0.6)	-0.7 (-2.6-3.3)	
FM	-2.6±2.9	0.1±2.1	**0.001****
	-1.9 (-8.3-0.8)	0.3 (-3.9-3)	
P	0.679	0.890	
U1-A/Vert (mm)			
Carrière	17.2±3.3	19.5±1.8	**0.018***
	17.4 (10.6-20.7)	18.8 (17-22.9)	
FM	20.2±2.1	21.1±1.5	0.161
	20.3 (17.4-23.4)	21.3 (17.8-23.7)	
P	**0.037***	**0.047***	
U1-FH (°)			
Carrière	108.9±9.9	109.8±6.5	0.351
	108 (97-127)	109 (97-120)	
FM	108.3±9.9	109.6±5.5	0.140
	105.5 (96-122)	109 (103-122)	
P	0.908	0.848	
L1-A/Pg (mm)			
Carrière	3.2±1.5	2±1.3	**0.009****
	3 (0.8-5.8)	2.4 (-0.1-3.6)	
FM	3.2±1.8	0.9±1.6	**0.001*****
	3.3 (0.3-6.6)	0.9 (-1.5-4.2)	
P	0.927	**0.036***	
L1-MPA (°)			
Carrière	87.6±8.8	87.3±7.8	0.833
	87 (73-104)	86 (74-100)	
FM	86.5±6.8	84.2±7.7	0.058
	84 (79-101)	85 (74-100)	
P	0.712	0.333	

Table 4. Continued

Overbite (mm)	T0	T1	p-value
Holdaway ratio (/)			
Carrière	2.4±12.1	6.1±14.6	0.650
	0.2 (-15.6-28)	4.1 (-20-44)	
FM	4.7±19.7	-3.5±12.7	0.245
	-0.5 (-24-63)	0.6 (-43-10)	
P	0.963	**0.022***	
U1/SN (°)			
Carrière	100.9±10.2	101.8±7.5	0.310
	100 (89-121)	101 (89-113)	
FM	100.5±9.7	101.9±5.9	0.141
	98 (89-114)	101 (96-116)	
P	0.954	0.827	
U1/Palatal plane (°)			
Carrière	110.1±10.2	110.8±7.6	0.173
	110 (96-129)	108 (97-123)	
FM	108.1±8.7	107.7±4.9	0.610
	107 (97-120)	108 (97-115)	
P	0.908	0.478	
U1/Occlusal plane (°)			
Carrière	60.4±7.1	59±4.8	0.248
	61 (47-70)	58 (50-67)	
FM	59.5±6.7	60.5±3.3	0.888
	61.5 (49-67)	61 (55-65)	
P	0.954	0.367	
L1/Occlusal plane (°)			
Carrière	75.9±7.5	76.5±5.9	0.549
	74.5 (61-90)	75.5 (67-88)	
FM	78.9±6.2	79.1±4.5	0.861
	77.5 (69-89)	78.5 (73-88)	
P	0.268	0.181	

[1]Wilcoxon signed-rank test; [2]Mann-Whitney U test; (p<0.05*) (p<0.01**) (p<0.001***)

roots of the lower canines and the more cortical structure of the mandible. In a small subset of our patients, increased mobility and extrusion of deciduous canines were observed with Force 1 elastics, necessitating the use of Ram elastics (6 Oz, 1/4" diameter) 24 hours a day, except during meals. These findings underscore the importance of adapting elastic protocols to individual dental anatomy and patient characteristics.

Co-A, SNA° and A-Nasionperp, which determine the sagittal position of point A, showed a significant increase in both groups. This might be explained by the forward movement of point A with the combined effects of treatment and growth. These results are consistent with previous studies evaluating protraction using a FM.[7-13]

An et al.[14] applied the Carrière Motion® and Tandem appliances to two 8-year-old patients and reported that SNA° and

Table 5. Intra- and inter-groups comparisons of the soft tissue parameters

UL-E line (mm)	T0	T1	p-value
Carrière	-1.5±1.8	-1±1.5	0.099
	-1.4 (-5.1-3.1)	-1.1 (-4.6-2.1)	
FM	-1.8±1.7	-0.5±1.3	**0.005****
	-1.8 (-5-1.2)	-0.4 (-2.6-1.6)	
P	0.836	0.357	
LL-E line (mm)			
Carrière	1.6±1.4	1.2±1.9	0.593
	1.4 (-1.3-4.1)	1.3 (-2.3-4.4)	
FM	0.9±1.6	0.3±1.7	0.402
	0.8 (-1.4-3.7)	-0.1 (-2.3-4.3)	
P	0.198	0.154	
Nasolabial angle (°)			
Carrière	111.1±14.3	111.7±12	0.753
	108 (79-133)	110.5 (87-136)	
FM	110.3±12.7	110.4±13.9	0.420
	113 (87-131)	109.5 (94-135)	
P	0.747	0.679	

[1]Wilcoxon signed-rank test; [2]Mann-Whitney U test (p<0.05*) (p<0.01**)

A-Nasionperp values increased more with the Carrière Motion® appliance. On the other hand, in a study that used the Carrière Motion® appliance to treat patients with Class III malocclusion in the permanent dentition, there was no statistically significant difference observed in the parameters describing the sagittal change of the point A during the 6.3 month of the sagittal correction phase of the treatment.[15] However, there was a significant increase in Wits and ANB° and these changes were thought to be caused by the change in point B.

In the present study, Co-Gn increased statistically significantly in both groups. This result is consistent with those of Cozza et al.[8] and Chong et al.[16] An increase in Co-Gn was also observed in McNamara et al.'s[18] study, which examined the effects of the Carrière Motion® appliance in patients with Class III malocclusions in individuals with at least the 4th CVM stage. Similar findings were found in our investigation, and we may speculate that growth was the cause of the increase in Co-Gn.

SNB° decreased significantly in the Carrière group, but the decrease in the FM group was not statistically significant. The decrease in SNB° recorded in the Carrière group coincides with studies reporting that point B was moved backward with the use of a FM and the mandible was rotated posteriorly, reducing the mandibular projection.[8,9,17] While no significant difference was found in the MPA° value in the comparison between and within the groups, a significant difference was found within the group in the Carrière group in the FH-MP° value. This can be explained by the fact that the cGo point referenced when creating the mandibular plane is different from the Go point in MPA value, but the significant difference recorded in this value is quite small (1.3°). Contrary to our findings, in An et al.'s[17] report comparing the effects of Carrière Motion® and Tandem appliances, a higher SNB° value was reported with the Carrière Motion® appliance. McNamara et al[15] determined that the SNB° decreased as in our study, and reported that the mandibular plane inclination (FH-MP°) did not show a statistically significant difference. In this context, the change in the SNB angle in our study is consistent with the significant increase in the FH-Mandibular plane angle.

In studies evaluating the effects of the Carrière Motion® II appliance, which works with biomechanics opposite to Class III correction, significant reductions in ANB° and Wits were observed.[3,18-20] On the other hand, ANB° and Wits showed a significant increase in studies on the Class III appliance.[14,15] In the present study, the increase in ANB° and Wits in both groups can be explained by the increase in SNA°; additionally, in the Carrière group, the decrease in SNB° also contributed to this increase.

The FH-PP° of the FM group decreased from T0 to T1 statistically significantly, this decrease was not significant for the Carrière group. The application of higher forces and the shorter duration of daily usage in the FM group. In other words, the orthopedic effects, can explain why the anterior rotation of the maxilla with the use of a FM might be related to this difference between groups. The elastics used in the Carrière group may have caused less anterior rotation of the palatal plane due to the weaker forces, and the 24-hour usage might have led to more dental effects.[21]

The lower anterior facial height showed a statistically significant decrease in the Carrière group. On the other hand, a significant increase was found in the FM group. The reason for the decrease in the Carrière group might be the counterclockwise rotation of the occlusal plane. Studies evaluating the Carrière Motion® Class II appliance have shown a significant increase in lower anterior facial height.[3,18-20] With reverse biomechanics, counterclockwise rotation in the occlusal plane could be expected with a Class III appliance. In contrast, McNamara et al,.[15] observed an increase in lower anterior facial height when using the Carrière Motion® appliance for Class III malocclusion, which is not in harmony with our findings. However, these authors also reported significant counterclockwise rotation in the occlusal plane. Based on these findings, it might be reasonable to assume that counterclockwise rotation of the occlusal plane was not statistically significant, and counterclockwise rotation in the mandibular plane was not detectable due to early contacts present in the majority of the x-rays in our study, since T1 radiographs were taken just after the removal of the expansion devices, following the completion of the sagittal correction. Furthermore, the decrease in ANS-Me in both groups may help explain this finding, which was possibly induced by the posterior intrusion caused by the acrylic cap splint expansion device followed by mandibular anterior rotation.

The N-ANS value in our study increased in both groups, but the increase was statistically significant only in the Carrière group.

This change can be explained by the fact that the individuals in both groups showed anterior and downward growth of the maxilla during the treatment process. In addition, a significant counterclockwise rotation was observed in the FH-PP° in the FM group. This rotation was not significant in the Carrière group. Consistent with the rotation observed in the palatal plane, in the FM group, the increase in the N-ANS distance was not significant, possibly related to the anterior rotation of the maxilla. Similar to the N-ANS parameter, the FH-MP° increased in both groups, but the change was statistically significant only in the Carrière group. This can be explained by the posterior vertical control that occurs with the use of an acrylic cap-splint device. This result is similar to the results of McNamara et al.[15]

The maxillary depth angle, which is an important parameter to evaluate the sagittal position of the maxilla, increased in both groups, but the amount of increase was statistically significant only in the FM group. In our study, an increase in SNA° was also observed in both groups. Although there was no statistically significant difference in the increase in SNA° between the two groups, the increase in the FM group (2.2°) was greater than that in the Carrière group (1.2°), which may have affected the maxillary depth parameter.

In our study, anterior and posterior facial heights (N-Me and S-Go) showed a statistically significant increase in both groups. The distance between Sella and Nasion (S-N) increased significantly in both groups, as did the articular angle. All these changes might be related to the growth of the individuals included in the study sample. It can be assumed that there may be deviations in vertical values due to early contacts in the patients' occlusion, and parameters related to the position and rotation of the lower jaw may be affected since T1 lateral cephalometric radiographs were taken immediately after removal of the acrylic cap type expansion appliances. This issue may be considered a limitation of the study. After the occlusion has settled, lateral cephalometric X-rays may be repeated to assess changes at this stage.

The overjet showed a significant increase in both groups. This finding is supported by the findings of many authors who reported anterior movement of point A, an increase in overjet, and amelioration of the sagittal relationship of the upper and lower jaws.[8,17,22,23] There are also studies reporting retroclination of the lower incisors as well as the anterior movement of the upper incisors contributing to the overjet correction in Class III individuals.[24,25] In the paper by An et al.,[14] an increase in the overjet was found in both Tandem and Carrière appliances. A significant increase in overjet was observed by McNamara et al.[15] in an older group of Class III individuals. All these findings are in harmony with our results. The significant increase in the overjet in both groups in our study indicates that the increase in the parameters determining the sagittal position of the maxilla causes the upper incisors to move forward. In addition, a decrease was observed in L1-A/Pg in both groups, while the decrease in this distance was statistically greater in the FM group. In addition, while the L1-MPA° value was almost unchanged in the Carrière group, it showed a greater change, close to the significance level, in the FM group. This indicates that the lower incisors inclination was preserved in the Carrière group since there is no pressure-causing-chin pad in the design of the Carrière appliance.

Another dental parameter, the molar relationship, increased statistically significantly in both groups in our study. In studies by Yin et al.[3] and Kim-Berman et al.,[18] in which Class II malocclusion corrections were achieved with the Carrière Motion® appliance, significant improvements were observed in the molar relationship, similar to the findings of our study.

The change in the U1-A/Vert parameter increased significantly in the Carrière group, but the increase in the FM group was not statistically significant. Although the inclination of the upper incisors did not change significantly in both groups, the movement of the true vertical line, which moves forward with growth, was accompanied by proclined upper incisors in the FM group. The less proclination observed in the Carrière group may help to explain this difference. Another explanation might be that the change in SNA° was greater in the FM group, and the incisors in the FM group were able to move more forward to maintain the U1-A/Vert distance.

In our study, the L1-A/Pg parameter showed a significant decrease in both groups. We can assume that the distalization of the posterior segment caused traction of the transseptal fibers that also distalized the lower incisors in the Carrière group. A greater amount of decrease in the L1-A/Pg distance was recorded in comparison between groups. This finding might be related to the fact that the lower incisors retroclined more in the FM group, causing a greater decrease in the L1-A/Pg distance, because of the pressure applied by the chin pad of the FM.[21]

In our study, some individuals had deciduous incisor teeth at the beginning of the treatment. In some patients, deciduous incisor teeth were lost during the treatment. These patients' data were excluded from the comparison since the parameters determined for permanent and deciduous teeth are different. Hence, the number of samples (Carrière: n=7; FM: n=8) should be taken into consideration when evaluating the overbite, overjet, interincisal angle, U1-A/Vert, U1-FH°, U1/SN°, and U1/Palatal Plane° parameters.

The UL-E-line distance decreased in both groups, but the decrease was statistically significant only in the FM group. The larger forces applied by the orthopedic appliance and the fact that these larger forces were more effective on the basal portion of the alveolar process suggest that the change in the perioral tissues was more pronounced in the FM group.

The 6-9 year age group was chosen because this stage corresponds to the early mixed dentition period, during which orthopedic modification of maxillary growth is considered most effective. Previous studies have shown that facemask therapy produces the most favorable skeletal effects when initiated at an early age.[9,10,22] Likewise, the Carrière Motion® III appliance has been reported to be more effective in growing patients due to the responsiveness of craniofacial structures during active growth.[15,21]

Study Limitations

This study has some limitations that should be considered. The relatively small sample size, which was further reduced due to the early loss of deciduous teeth, limits the generalizability of the results. Furthermore, the combined use of prospective and retrospective data may be a source of methodological bias, and the relatively short follow-up period prevents definitive conclusions about long-term treatment stability. Although FM has long been used in the early treatment of Class III malocclusions due to its strong skeletal effects and predictable clinical outcomes, and CMIII produced similar results, the limited sample size in the present study prevented the true differences between the two appliances from being fully revealed. Moreover, the absence of patient-specific and distance-based elastic selection in the CM group can be considered a limitation, as it prevents standardization of force application.

In the present study, the mean treatment duration was approximately 225±72 days in the FM group and 256±83 days in the CMIII group. These findings are consistent with previously reported treatment durations for orthopedic correction of skeletal Class III malocclusion. The relatively comparable values suggest that both approaches require a similar clinical timeframe, which should be taken into account when considering their efficiency and applicability in daily practice. Another clinically important factor is patient compliance, particularly with regard to elastic wear and appliance maintenance. Although compliance was monitored during routine follow-up visits, no objective compliance measurement tool was implemented in this study. This limitation should be acknowledged, as compliance directly affects treatment outcomes. Future studies incorporating standardized compliance assessment methods (e.g., wear-time sensors or patient-reported diaries) could provide more accurate insights into the impact of compliance on treatment effectiveness.

Future studies with larger sample groups, randomized designs, and long-term follow-ups are needed to validate and expand these findings. In addition, incorporating factors such as patient compliance, appliance wear time, treatment stability, and retention protocols into future investigations is strongly recommended.

CONCLUSION

The dental, skeletal, and soft tissue effects of the FM and the Carrière Motion® Class III appliance used following rapid maxillary expansion were compared in children aged 6 to 9 years with Class III malocclusion.

Within the limitations of this study, both appliances were effective in improving skeletal and dental relationships in growing Class III patients. While the FM produced more pronounced maxillary rotation and dentoalveolar effects, the Carrière Motion® Class III appliance corrected sagittal discrepancies with better preservation of lower incisor inclination and reduced dependence on an extraoral device. These findings suggest that the Carrière Motion® Class III may serve as a practical treatment alternative, particularly in patients who refuse extraoral appliances or when maintaining lower incisor position is a clinical priority. Future long-term studies are required to evaluate the stability of these outcomes and to further clarify the comparative skeletal and soft tissue effects of the two approaches.

Ethics

Ethics Committee Approval: The research project was approved and monitored by the Non-Interventional Research Ethics Committee at Bezmialem Vakıf University (date: November 9, 2020, approval no.: 13079).

Informed Consent: Written informed consent for participation and publication of clinical images was obtained from the patients' legal guardians.

Footnotes

Author Contributions: Surgical and Medical Practices - M.P., B.Y.; Concept - M.P., B.Y.; Design - M.P., B.Y.; Data Collection and/or Processing - M.P., B.Y.; Analysis and/or Interpretation - M.P., B.Y.; Literature Search - M.P.; Writing - M.P.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: Financial support was provided by the Scientific Research Projects Coordination Unit of Bezmialem Vakıf University (Project no: 20210205) for the procurement of materials necessary for the study.

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