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Comparison of two different types of molar distalization appliance

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ABSTRACT

Aims: The aim of this study was to examine the clinical efficacy of Modified Veltri (MV) and first class (FC) appliances, to investigate the effect on skeletal teeth and soft tissues in the patients and to compare the findings obtained.

Methods: The study included 40 individuals aged between 12 and 16 years with class II malocclusion (ANB <6°), dental crowding not requiring extraction, and no congenital tooth deficiency. MV and FC appliances were applied to 20 and 20 individuals, respectively. At the beginning of the study, at the end of distalization and three months after the reinforcement appliance was applied, cephalometric X-rays and plaster models were taken from the individuals and analyzed. The statistical significance of the changes that occurred during the distalization and reinforcement periods were evaluated by independent student's t test for each group, and the significance between the groups was checked by paired Student's t test.

Results: In the MV and FC groups, molar distalization was achieved in a similar time (4.29±0.97, 4.20±0.86). Skeletal changes were observed only in the MV group in SNB, ANB, SNGoGn, FMA ($p<0.05$) and B-PTV ($p<0.01$) values. In the first molar tooth, the MV group showed -2.16 mm distalization, 1.88 mm intrusion and 5.21° distal tipping, while the FC group showed -2.42 mm distalization and 1.19o distal tipping. During the consolidation period, 1.13 mm recurrence of distalization was observed in the MV group. In the MV group, overjet increased by 2.28 mm and overbite decreased by 1.89 mm. In the FC group, the overjet increased by 1.32 mm and the overbite decreased by 0.94 mm. After soft tissue distalization, Lu-E and Li-E values decreased by 1.45 mm and 1.01 mm in the MV group and by 1.38 mm and 1.30 mm in the FC group.

Conclusion: In this study, although MV and FC appliances provided a similar amount of distalization in a similar amount of time, recurrence was observed in the MV group during the reinforcement period. In addition, loss of anchorage was observed more in the MV group. Anchorage loss should be considered in the clinical application of MV and FC appliances.

Keywords: Distalization, veltri, first class

INTRODUCTION

In the treatment planning of dental class II cases, tooth extraction and molar distalization, which are methods of gaining space for the elimination of protrusion of the upper teeth or dental crowding, have been the subject of debate among researchers[1-3] for many years.

Gianelly and White[4] state that in borderline cases, the decision to extract becomes important because permanent tooth extraction will affect facial aesthetics.

Philip[5] argued that borderline cases can be successfully treated without extraction with the right mechanics at the right time in individuals with normal growth and development who do not have cooperation problems.

Distalization of the maxillary posterior teeth is the most commonly used non-extraction treatment approach. Headgear is the oldest and most common distalization method. However, patient cooperation is required. Intraoral fixed distalization devices have been developed in cases where patient cooperation cannot be achieved. Loss of anchorage during distalization of maxillary molars is the biggest disadvantage of these appliances. In addition, tipping and rotations occurring in distalized molars are also undesirable types of movement.[6-16]

Keleş,[12] reported that they achieved 4.5 mm distalization of the upper first molar tooth without distal tipping and extrusion movement with the Keleş Slider appliance. It was claimed that

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the molars moved distally due to the use of thick wire in the construction of the appliance and the force passing through the level of the center of resistance of the tooth. Fortini et al.[13,17] obtained bodily and rapid molar distalization with the first class (FC) appliance. Küçükkeleş et al.[18] suggested that loss of anchorage was high during molar distalization with the lip bumper supported Veltri appliance, so clinicians should pay attention to case selection when using this appliance.

In this study, it was aimed to investigate the clinical efficacy of the modified veltri (MV) and FC appliances introduced by Baccetti and Franchi,[19] to investigate the effect on skeletal, soft tissues and dentolaveolar structures in the patients and to compare the findings obtained.

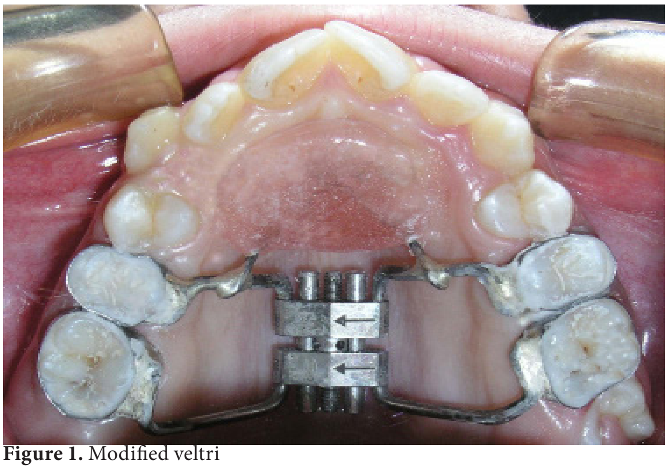

Figure 1. Modified veltri

Figure 2. First class

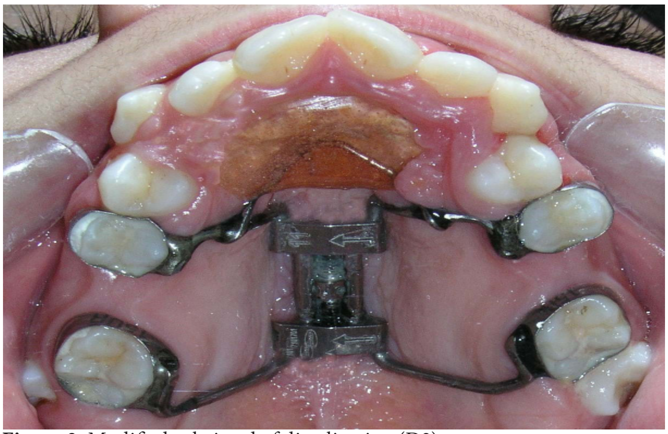

Figure 3. Modified veltri end of distalization (D2)

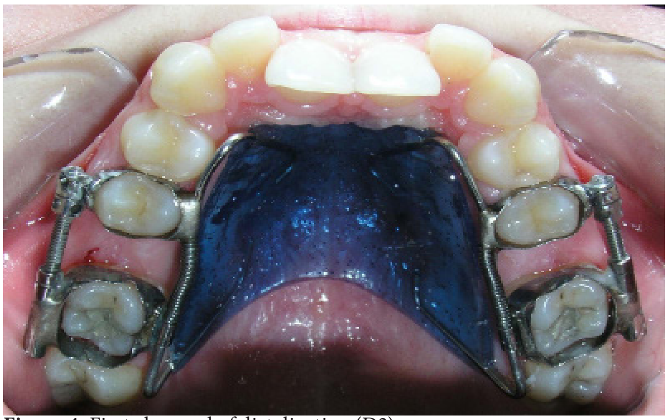

Figure 4. First class end of distalization (D2)

METHODS

This study is a doctoral thesis completed before 2020. Institutional approval was obtained. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The following characteristics were taken into consideration in the selection of the patients:

- ANB <6º
- Tubercle-tubercle class II molar relationship of bilateral upper first molar (U6) and lower first molar (L6),
- Absence of severe space stenosis in the upper and lower jaw that would require extraction,
- Normal or retrusive upper and lower incisors in relation to the basal bone base,
- Normal or deep closure,
- Perpendicular face dimensions are low or within normal limits (SN-Go-Me <37º),
- Having a soft tissue profile that does not require extraction treatment,
- Absence of congenital tooth deficiency,
- Chronological age between 12-16 years.

The MV appliance was applied to 20 individuals (11 girls and 9 boys) and the FC appliance was applied to 20 individuals (12 girls and 8 boys). The mean age of the individuals before distalization (D1) was 13.64±1.46 in the MV group and 13.82±1.43 in the FC group.

Construction and Application of Appliances

The MV appliance was prepared and applied based on the form developed by Bacetti T. and Franchi L.[19] (Figure 1). A schedule was prepared for the parents to perform the screw twice a week, with 90º opening at each activation. Screw activations were continued until a class I molar relationship was achieved. The FC appliance was prepared as developed by Fortini et al.[13] (Figure 2). However, the parents were asked to perform the activation of the screws one half turn (180º) at two-day intervals. Screw activations were performed until a class I molar relationship was achieved (Figure 3, 4). After distalization (D2), the appliance was removed from the mouth and model and lateral cephalometric film records were taken from the patients.

Stabilization Period

Reinforcement appliance was applied after the distalization of U6 was completed in the MV and FC patient groups. After the reinforcement appliance was applied, the individuals participating in the study were observed for three months without the application of any appliance (Figure 5). After three months, the appliance was removed from the mouth again and cephalometric films and plaster model records were obtained from both groups in order to monitor spontaneous changes (D3).

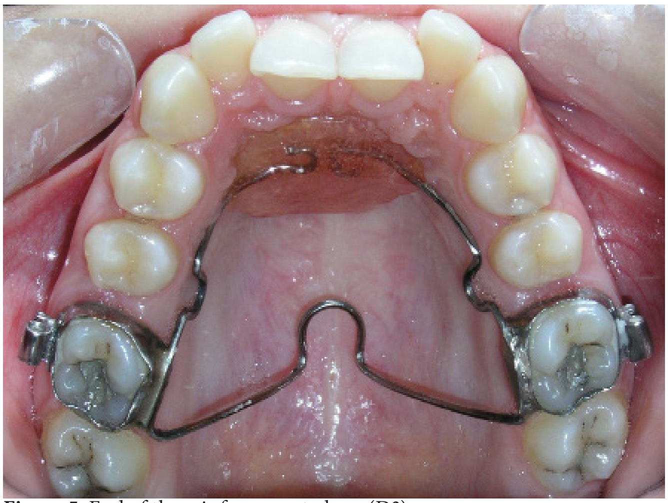

Figure 5. End of the reinforcement phase (D3)

Lateral Cephalometric Filming and Evaluation

All lateral cephalometric films were taken digitally (Vatech, PaX-400C, Korea) in the natural head position at the Oral Diagnosis and Radiology Clinic of Dicle University Faculty of Dentistry. To ensure standardization in the measurements and to monitor the effect of distalization appliances on the posterior teeth in the maxilla, marker wires prepared from 0.5 mm stainless steel wire were fixed in acrylic crowns on the right U6 and second premolar (U5) teeth before distalization (Figure 6).[20] These acrylic marker crowns were temporarily placed on the teeth and the first lateral cephalometric film was taken (Figure 7). The measurements of the maxillary posterior teeth were made on this radiograph (Figure 8). The second lateral cephalometric film was taken when the teeth were in centric occlusion. Skeletal and soft tissue and incisors and lower first molar (L6) values were measured on the second lateral cephalometric film (Figure 9-12).

A total of 28 parameters (13 angular and 15 linear) for cephalometric evaluation were created using measurements from Pancherz,[21] McNamara,[22] Ricketts[23] and Steiner[24] analyses (Table 1). The Frankfurt horizontal plane (FH), the plane passing through the orbital and anatomical porion points, was determined as the horizontal reference plane for the analyses. Pterygo vertical plane (PTV), the line drawn perpendicular to the FH plane from distal to the pterygopalatine fossa, was used as the vertical reference plane in the analyses.

Evaluation of Orthodontic Models

In both groups, plaster models were obtained by taking impressions from the upper jaws of the individuals before distalization (D1), after distalization (D2) and after reinforcement (D3). On these plaster models, the tubercle crests, anterior palatal raphe and posterior palatal raphe points of the U6 teeth were marked with a 0.5 mm pencil. Between these marked points, the midline line (MRL) was determined as the reference plane. Then, the occlusal surface of the models was placed on the glass of the photocopier and photocopies of the models were taken.[25] Angle measurements were made on these photocopies to determine whether there was rotation after distalization of the U6 teeth (Figure 13).

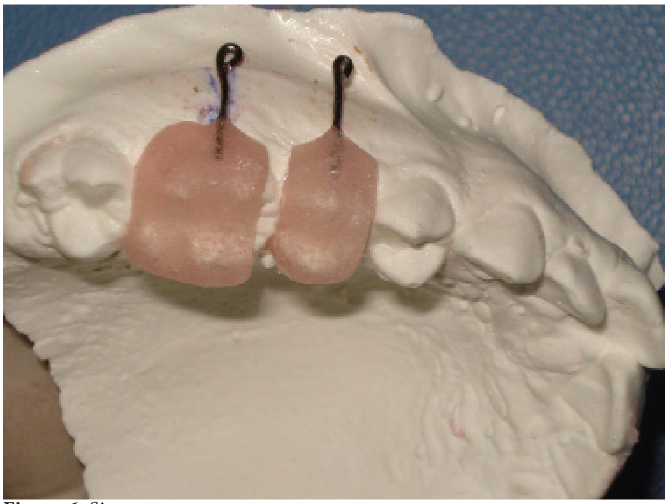

Figure 6. Sign crowns

Figure 7. Cephalometric radiograph with sign crown

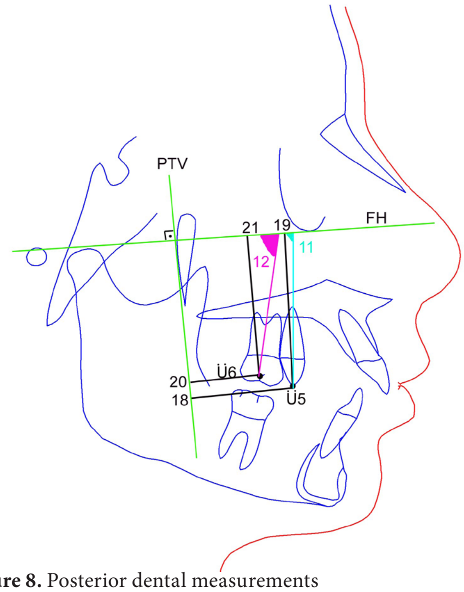

Figure 8. Posterior dental measurements

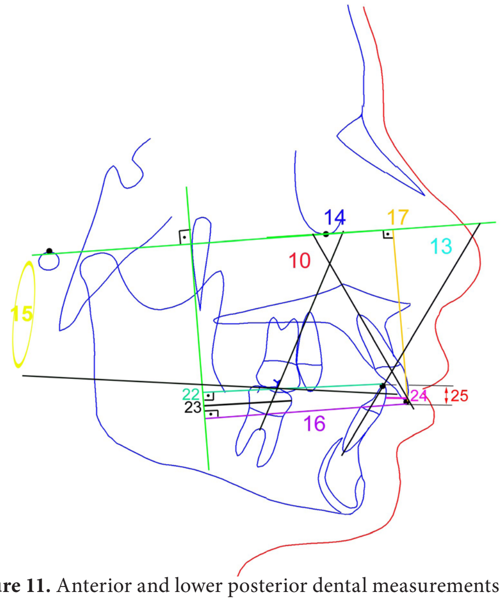

Figure 11. Anterior and lower posterior dental measurements

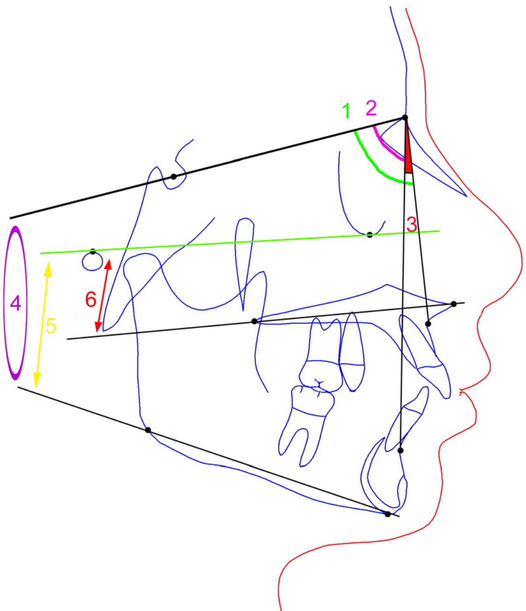

Figure 9. Skeletal angular measurements

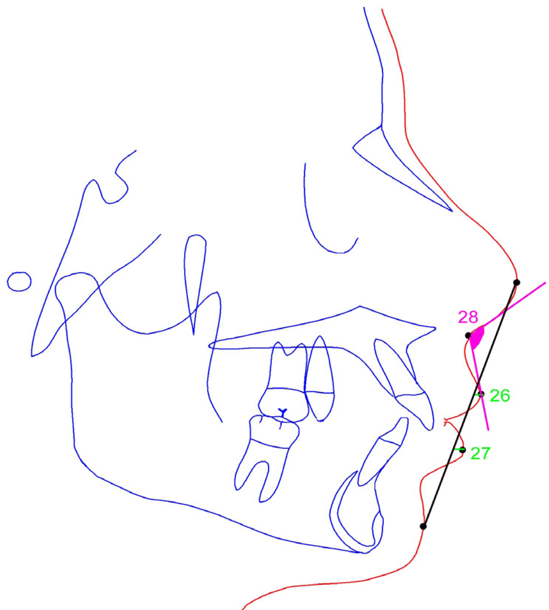

Figure 12. Soft tissue measurements

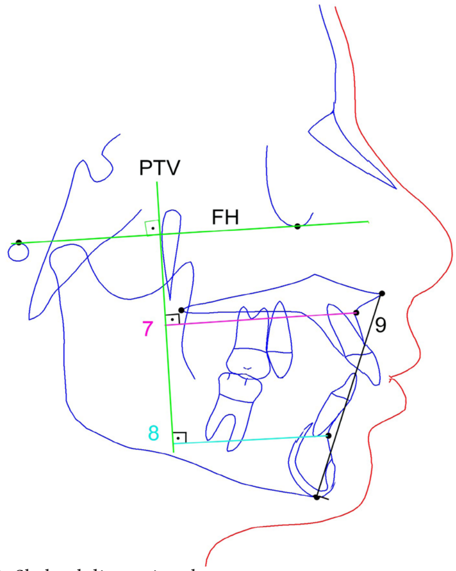

Figure 10. Skeletal dimensional measurements

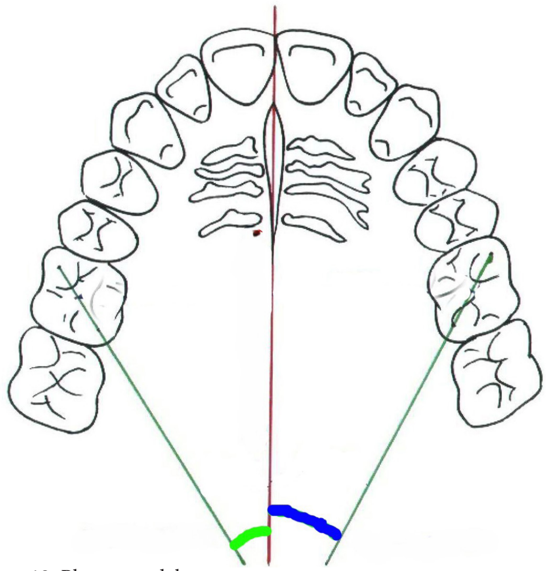

Figure 13. Plaster model measurements

Table 1. Measurements performed for cephalometric evaluation

SKELETEAL	SNA	SNA Angle formed between Sella-Nasion and Nasion-A.
	SNB	SNB Angle formed between Sella-Nasion and Nasion-B.
	ANB	ANB Angle formed between points A-N-B.
	SN-GoMe	SN-GoMe Angle formed between the Sella-Nasion and the mandibular plane.
	FMA	FMA Angle formed between the Frankfurt horizontal plane and the mandibular plane.
	PD-FH	PD-FH Angle between the Frankfurt horizontal plane and the palatal plane.
	OD-FH	OD-FH The angle formed between the FH and the occlusal plane.
	A-PTV	A-PTV Length of the perpendicular drawn from point A to the PTV plane.
	B-PTV	B-PTV The length of the perpendicular drawn from point B to the PTV plane.
	ANS-Me	ANS-Me The distance between the spina nasalis anterior and the Me points.
DENTAL	Overjet	The horizontal distance between the cutting edges of the upper and lower most advanced incisors.
	Overbite	The vertical bite distance between the incisal edges of the upper and lower most advanced incisors.
	U1-FH angle	The angle formed between the long axis of the upper most advanced incisor and the FH plane.
	U1-FH mm	The perpendicular distance of the incisal edge of the upper most advanced incisor to the FH plane.
	U1-PTV	The perpendicular distance from the incisor edge of the upper most incisor to the PTV plane.
	U5-FH angle	The angle formed between the line through the index wire in acrylic crowns placed on the upper second premolar and the FH plane.
	U5-FH mm	The perpendicular distance from the upper second premolar marker point to the FH plane.
	U5-PTV	The perpendicular distance from the upper second premolar marker point to the PTV plane.
	U6-FH angle	The angle formed between the line through the index wire in acrylic crowns placed on the upper first premolar and the FH plane.
	U6-FH mm	It is the perpendicular distance from the upper first molar marker point to the FH plane.
	U6-PTV	The perpendicular distance from the upper first molar landmark to the PTV plane.
	L6-FH angle	The angle formed between the FH and the line connecting the center of the crown and the furcation point of the lower first molar.
	L6-PTV	The perpendicular distance of the mesial contact point of the lower first molar from the plane of the PTV.
	L1-FH angle	The angle formed between the long axis of the lower most advanced incisor and the FH.
	L1-PTV	The perpendicular distance of the incisal edge of the lower most advanced incisor from the plane of the PTV.
SOFT TISSUEU	NLA	The angle formed by the line extending from the vermilion border of the upper lip to the subnasal and the tangent drawn from the subnasal to the lower border of the nose.
	Lu-E	Distance between line E and point Ls.
	Li-E	The distance between the E line and the Li point.

Statistical Analysis

Statistical evaluations were performed with the SPSS 10.0.0 program (Chicago, Illinois, USA). Comparisons were made both within and between groups to determine the statistical significance of the changes in cephalometric and plaster models in the MV and FC groups. For each group, the evaluation of the statistical significance of the changes in the distalization (D2-D1) and three-month reinforcement period (D3-D2) was performed by independent student's t-test, and the significance of the changes in the D2-D1 and D3-D2 periods of the groups was checked between the groups by paired student's t-test.

RESULTS

Distalization time (D2-D1) lasted an average of 4.29±0.97 months in the MV group and 4.20±0.86 months in the FC group. When the ages and distalization times of the individuals with MV and FC appliances were compared by independent student's t-test, no statistical difference was found ($p>0.05$).

To test the similarity of the groups before distalization (D1), skeletal, dental and soft tissue measurements made on lateral cephalometric radiographs were compared. In the comparison, only the mean OD-FH angle of 3.31° ($p<0.05$) and the mean U5-FH angle of 4.01° ($p<0.01$) were statistically significantly higher in the MV group (Table 2).

Findings of the MV Group

The cephalometric and model measurements of the MV group in the D1, D2 and D3 periods and the statistical comparison of the changes after distalization (D2-D1) and after reinforcement (D3-D2) are shown in Table 3 and Table 4.

Accordingly, in the evaluation of cephalometric measurements;

After distalization (D2-D1), there was a statistically significant increase ($p<0.05$, $p<0.01$) in the mean value of SNB, B-PTV (0.64°, 1.73 mm) and a statistically significant decrease ($p<0.05$) in the mean value of ANB, SN-GoMe and FMA (0.8).

After distalization, the mean overjet increased by 2.28 mm and the mean overbite decreased by 1.89 mm ($p<0.001$). After consolidation, overjet and overbite decreased by 0.45 mm and increased by 0.63 mm, respectively, at a statistically significant level ($p<0.01$).

After distalization, the upper incisors (U1) protruded a statistically significant average of 11.71° angular (U1-FH angle) and 4.39 mm dimensional (U1-PTV mm) ($p<0.001$, $p<0.01$). After reinforcement, U1 moved statistically significantly mean, angular 4.75° (U1-FH angle) and dimensional (U1-PTV) 1.49 mm distally ($p<0.001$, $p<0.05$).

After distalization, the upper second premolar (U5) moved statistically significantly mean, angular 9.68° (U5-FH angle) and dimensionally 4.94 mm (U5-PTV) mesially ($p<0.001$). After consolidation, U5 moved in a statistically significant mean, angular 12.12° (U5-FH angle) and dimensional 3.27 mm distally ($p<0.001$). After distalization, the U6-FH angle decreased by a statistically significant mean of 5.21° and U6

Table 2. Comparison of cephalometric measurements between MV and FC groups before distalization

Comparison of Baseline Measurements Between Groups	Veltri n=20	First Class n=20	Significance	
SKELETEAL	SNA	80.62±3.17	80.94±4.97	-
	SNB	76.84±2.65	76.63±3.32	-
	ANB	4.05±1.47	4.30±2.08	-
	SN-GoMe	30.47±4.16	30.90±4.08	-
	FMA	25.77±5.14	23.55±5.52	-
	PD-FH	2.93±4.25	0.63±3.85	-
	OD- FH	10.42±3.69	7.16±4.81	*
	A PTV	49.85±4.65	49.18±4.97	-
	B PTV	40.39±5.01	41.15±4.99	-
	ANS Me	65.58±5.27	62.16±6.22	-
DENTAL	Overjet	4.86±1.56	4.11±1.24	-
	Overbite	4.16±1.90	3.56±1.09	-
	U1-FH angle	100.96±7.66	103.11±7.57	-
	U1-FH mm	52.33±4.64	48.99±6.66	-
	U1-PTV	50.43±4.51	50.37±5.43	-
	U5-FH angle	80.99±5.24	85.79±4.64	**
	U5-FH mm	47.44±4.32	45.83±6.28	-
	U5-PTV	23.49±3.68	24.68±4.51	-
	U6-FH angle	91.88±5.42	88.64±7.30	-
	U6-FH mm	45.94±4.39	44.21±5.76	-
	U6-PTV	23.76±3.56	23.88±4.80	-
	L6-FH angle	67.86±5.34	69.53±3.44	-
	A6-PTV	21.14±3.46	23.03±4.77	-
	L1-FH angle	57.16±7.09	59.47±6.43	-
	L1-PTV	46.56±4.48	46.47±5.51	-
SOFT TISSUE	NLA	116.68±11.76	112.33±7.76	-
	Lu-E	-4.69±2.90	-5.16±2.28	-
	Li-E	-3.61±2.58	-3.95±2.61	-

- $p>0.05$, * $p<0.05$, ** $p<0.01$

tilted distally (p<0.01). U6-PTV decreased by a statistically significant mean of 2.16 mm, i.e. U6 moved in the distal direction (p<0.01). U6-FH mm decreased by a statistically significant mean of 1.88 mm, i.e. U6 was intruded (p<0.01). After consolidation, U6-PTV increased by a statistically significant mean of 1.13 mm, i.e. U6 moved mesially (p<0.05). After distalization, the lower incisor (L1) moved forward in the sagittal direction by a statistically significant mean of 1.93 mm (L1-PTV) (p<0.01). After distalization, the upper lip (Lu) and lower lip (Li) moved forward in the sagittal direction by a statistically significant mean of 1.45 mm (Lu-E) and 1.01 mm (Li-E), respectively (p<0.001). After reinforcement, Li-E increased by a statistically significant mean of 0.40 mm (p<0.05).

According to the evaluation of model measurements;

After distalization, only the left U6-OHD decreased by a statistically significant mean of 3.25° (p<0.05) (Table 4).

Findings for the FC Group

The statistical comparison of cephalometric measurements of D1, D2 and D3 periods, changes after distalization (D2-D1) and changes after reinforcement (D3-D2) in the FC group are shown in Table 5. Accordingly;

After distalization (D2-D1), there was no statistically significant difference (p>0.05) in skeletal values in the measurements.

After distalization, the mean overjet increased by 1.32 mm and the mean overbite decreased by 1.89 mm (p<0.001). After consolidation, overjet decreased by a statistically significant mean of 0.67 mm (p<0.01).

After distalization, the upper incisors (U1) protruded a statistically significant average of 3.49° angular (U1-FH angle) and 1.59 mm dimensional (U1-PTV mm) (p<0.05).

Table 3. Measurements of D1, D2 and D3 periods of the MV group; statistical evaluation of changes after distalization (D2-D1) and reinforcement (D3-D2)

Modified Veltri n=20	D1 Mean±SD	D2 Mean±SD		D3 Mean±SD	D2-D1 Mean±SD	p	D3-D2 Mean±SD	p
SKELETEAL	SNA	80.62±3.17	80.53±3.15	80.86±3.23	-0.09±3.34		0.27±1.38	
	SNB	76.84±2.65	77.49±3.19	76.69±2.70	0.64±1.27	*	-0.80±0.90	**
	ANB	4.05±1.47	3.35±1.96	3.81±1.88	-0.70±1.30	*	0.46±0.96	*
	SN-GoMe	30.47±4.16	29.71±4.47	29.66±4.62	-0.73±1.39	*	-0.05±1.06	
	FMA	25.77±5.14	24.42±5.00	24.27±5.05	-1.35±2.30	*	-0.15±1.45	
	PD-FH	2.93±4.25	2.64±3.62	2.53±3.64	-0.25±1.93		-0.11±1.61	
	OD-FH	10.42±3.69	9.29±3.87	9.88±3.71	-1.13±3.37		0.59±1.99	
	A PTV	49.85±4.65	50.04±4.85	51.03±4.43	0.18±2.20		0.99±3.18	
	B PTV	40.39±5.01	42.12±6.09	41.95±5.18	1.73±2.57	**	-0.17±2.45	
	ANS Me	65.58±5.27	64.70±5.92	65.34±6.27	-0.87±3.07		0.64±1.23	*
DENTAL	Overjet	4.86±1.56	7.14±1.99	6.69±1.93	2.28±1.49	***	-0.45±0.67	**
	Overbite	4.16±1.90	2.26±2.16	2.89±1.78	-1.89±1.14	***	0.63±0.91	**
	U1-FH angle	100.96±7.66	112.67±11.20	107.91±10.16	11.71±6.83	***	-4.75±3.81	***
	U1-FH mm	52.33±4.64	51.07±5.40	51.12±4.89	-1.25±3.60		0.05±1.79	
	U1-PTV	50.43±4.51	54.83±5.74	53.34±5.12	4.39±2.91	**	-1.49±2.65	*
	U5-FH angle	80.99±5.24	90.67±7.13	78.55±6.43	9.68±6.95	***	-12.12±7.02	***
	U5-FH mm	47.44±4.32	46.47±5.83	46.31±4.65	-0.97±4.60		-0.15±2.69	
	U5-PTV	23.49±3.68	28.44±4.78	25.16±3.10	4.94±2.88	***	-3.27±2.98	***
	U6-FH angle	91.88±5.42	86.67±6.55	87.21±5.45	-5.21±7.85	**	0.54±6.64	
	U6-FH mm	45.94±4.39	44.06±4.04	44.56±4.54	-1.88±2.49	**	0.40±1.14	
	U6-PTV	23.76±3.56	21.69±3.96	22.73±3.13	-2.16±3.33	**	1.13±2.43	*
	L6-FH angle	67.86±5.34	67.27±5.22	67.08±4.11	-0.58±5.88		-0.19±6.01	
	A6-PTV	21.14±3.46	22.55±4.05	23.20±2.92	1.41±3.33		0.65±2.80	
	L1-FH angle	57.16±7.09	55.84±5.73	56.12±5.57	-1.32±3.09		0.28±3.01	
	L1-PTV	46.56±4.48	48.50±5.11	48.64±4.51	1.93±2.30	**	0.14±1.88	
SOFT TISSUE	NLA	116.68±11.76	112.58±7.59	113.95±9.39	-4.10±9.70		1.37±5.72	
	Lu-E	-4.69±2.90	-3.24±2.1493	-3.59±2.16	1.45±1.46	***	-0.34±0.83	
	Li-E	-3.61±2.58	-2.60±2.07	-2.20±2.10	1.01±0.98	***	0.40±0.65	*

* p<0.05, ** p<0.01, *** p<0.001, SD: Standart deviation

Table 4. Model measurements of the MV and FC group for D1, D2 and D3 periods, statistical evaluation of changes after distalization (D2-D1) and reinforcement (D3-D2)

Model Measurement of MV and FC Groups Mean±SD		D1	D2	D3	D2-D1		D3-D2	
		Mean±SD	Mean±SD	Mean±SD	p	Mean±SD	p	
MV	Right U6-OHD	25.02±5.15	22.15±7.13	25.12±8.18	-2.87±6.19	-	2.97±6.63	-
	Left U6-OHD	29.75±4.06	26.50±6.22	26.87±6.61	-3.25±4.36	*	0.37±5.07	-
FC	Right U6-OHD	28.47±5.28	33.99±6.25	34.17±6.72	4.52±4.15	***	1.17±5.25	-
	Left U6-OHD	30.72±5.39	33.95±5.39	34.12±3.75	3.22±6.32	*	0.17±2.57	-

-p>0.05, * p<0.05, *** p<0.001, MV: Modified veltri, FC: First class, SD: Stantard deviation

Table 5. Measurements of D1, D2 and D3 periods, changes after distalization (D2-D1) and after reinforcement (D3-D2) and statistical evaluation of the FC group

First Class n=20		D1 Mean±SD	D2 Mean±SD	D3 Mean±SD	D2-D1 Mean±SD	p	D3-D2 Mean±SD	p
SKELETAL	SNA	80.94±4.97	81.08±4.81	81.00±4.04	0.14±1.61		-0.08±2.41	
	SNB	76.63±3.32	76.48±3.30	76.70±3.07	-0.15±1.18		0.22±1.72	
	ANB	4.30±2.08	4.59±1.81	4.28±1.67	0.28±1.00		-0.31±1.23	
	SN-GoMe	30.90±4.08	31.22±4.12	30.91±5.31	0.31±2.39		-0.31±2.07	
	FMA	23.55±5.52	23.59±5.23	25.16±6.19	-0.04±2.55		1.57±5.19	
	PD-FH	0.63±3.85	0.07±3.88	1.39±2.93	-0.55±1.94		1.32±4.78	
	OD- FH	7.16±4.81	7.64±4.78	8.95±5.32	0.47±3.44		1.31±4.30	
	A PTV	49.18±4.97	49.34±3.61	48.94±3.74	0.16±2.68		-0.60±2.68	
	B PTV	41.15±4.99	40.76±4.38	39.26±5.48	-0.39±3.22		-1.50±5.09	
	ANS Me	62.16±6.22	61.12±5.15	61.17±4.96	-1.03±2.48		0.04±1.92	
DENTAL	Overjet	4.11±1.24	5.43±2.25	4.76±1.46	1.32±1.21	***	-0.67±0.97	**
	Overbite	3.56±1.09	2.62±1.27	2.62±1.27	-0.94±1.05	***	0.15±1.47	
	U1-FH angle	103.11±7.57	106.61±10.64	103.23±9.52	3.49±5.83	*	-3.38±8.30	
	U1-FH mm	48.99±6.66	48.63±5.68	49.70±3.63	-0.35±2.21		1.06±5.90	
	U1-PTV	50.37±5.43	51.97±5.29	49.07±5.65	1.59±2.97	*	-2.90±5.23	*
	U5-FH angle	85.79±4.64	90.99±5.20	81.83±8.40	5.19±6.84	**	-9.16±9.66	***
	U5-FH mm	45.83±6.28	46.06±6.19	45.58±3.30	0.23±2.25		-0.48±4.49	
	U5-PTV	24.68±4.51	28.03±3.53	24.41±4.06	3.35±4.08	**	-3.62±2.62	***
	U6-FH angle	88.64±7.30	87.45±9.90	87.01±8.74	-1.19±8.21		-0.43±7.98	
	U6-FH mm	44.21±5.76	44.48±5.47	43.73±3.29	0.72±2.03		-0.24±3.56	
	U6-PTV	23.88±4.80	21.46±4.13	21.76±4.23	-2.42±2.43	***	0.30±4.12	
	L6-FH angle	69.53±3.44	67.46±5.82	68.89±4.60	2.07±5.17		1.43±6.92	
	A6-PTV	23.03±4.77	23.46±4.04	22.58±4.14	0.43±2.81		-0.88±4.13	
	L1-FH angle	59.47±6.43	58.81±6.34	57.58±6.46	-0.65±2.63		-1.23±6.8	
	L1-PTV	46.47±5.51	46.06±4.42	45.77±4.73	-0.40±2.89		-0.29±4.27	
SOFT TISSUEU	NLA	112.33±7.76	108.05±7.97	108.42±9.43	-4.28±10.28		0.37±6.97	
	Lu-E	-5.16±2.28	-3.77±2.41	-3.22±2.29	1.38±1.25	***	0.55±1.95	
	Li-E	-3.95±2.61	-2.65±2.63	-1.92±2.90	1.30±1.84	**	0.72±2.51	

* p<0.05, ** p<0.01, *** p<0.001, SD: Standart deviation

After reinforcement, U1 moved statistically significantly mean, dimensional (U1-PTV) 2.90 mm distally (p<0.05).

After distalization, U5 moved statistically significantly mean, angular 5.19° (U5-FH angle) and dimensional 3.35 mm (U5-PTV) mesially (p<0.01). After consolidation, U5 moved in a statistically significant mean, angular 9.16° (U5-FH angle) and dimensional 3.62 mm (U5-PTV) distally (p<0.001).

After distalization, U6-PTV decreased by a statistically significant mean of 2.42 mm, IE U6 moved distally (p<0.001).

After distalization, the upper lip (Lu) and lower lip (Li) moved forward in the sagittal direction by a statistically significant mean of 1.38 mm (Lu-E) and 1.30 mm (Li-E), respectively (p<0.001, p<0.01).

The evaluation of the model measurements is shown in Table 4, accordingly;

After distalization, right U6-OHD increased by an average of 4.52° (p<0.001) and left U6-OHD increased by an average of 3.22° (p<0.05) at a statistically significant level.

Comparison of Differences in the D2-D1 and D3-D2 Periods of MV AND FC Groups

The comparison of cephalometric changes in the MV and FC groups in the D2-D1 and D3-D2 periods is shown in Table 6. Accordingly; After distalization (D2-D1), there was a statistically significant difference between the groups in SNB, ANB, SN-GoMe angles and B-PTV distances (p<0.05). After consolidation (D3-D2), a statistically significant difference was found between the groups in SNA and SNB angles (p<0.05). Statistically significant differences were found between the groups in overjet distance and U5-FH angle after distalization (p<0.05). Statistically significant differences were found between the groups in overbite, U1-PTV and A1-PTV distances (p<0.01). There was a statistically significant difference between the groups in the U1-FH angle (p<0.001). The comparison of the model measurements after distalization and reinforcement in MV and FC groups is shown in Table 7, according to this; a statistically significant (p<0.001) difference was observed in right U6-OHD° and left U6-OHD° after distalization.

Table 6. Comparison of the findings of distalization (D2-D1) and reinforcement periods (D3-D2) between MV and FC groups							
Comparison Between Groups		D2-D1			D3-D2		
		MV n=20 Mean±SD	FC n=20 Mean±SD	p	MV n=20 Mean±SD	FC n=20 Mean±SD	p
SKELETEAL	SNA	-0.09±3.34	0.14±1.61		0.27±1.38	0.08±2.41	*
	SNB	0.64±1.27	-0.15±1.18	*	-0.80±0.90	0.22±1.72	*
	ANB	-0.70±1.30	0.28±1.00	*	0.46±0.96	-0.31±1.23	
	SN-GoMe	-0.73±1.39	0.31±2.09	*	-0.05±1.06	-0.31±2.07	
	FMA	-1.35±2.30	-0.04±2.55		-0.15±1.45	1.57±5.19	
	PD-FH	-0.25±1.93	-0.55±1.94		-0.11±1.61	1.32±4.78	
	OD-FH	-1.13±3.37	0.47±3.44		0.59±1.99	1.31±4.30	
	A PTV	0.18±2.20	0.16±2.68		0.99±3.18	0.60±2.68	
	B PTV	1.73±2.57	-0.39±3.22	*	-0.17±2.45	-1.50±5.09	
	ANS Me	-0.87±3.07	-1.03±2.48		-0.64±1.23	0.04±1.92	
DENTAL	Overjet	2.28±1.49	1.32±1.21	*	-0.45±0.67	-0.67±0.97	
	Overbite	-1.89±1.14	-0.94±1.05	**	0.63±0.91	0.15±1.47	
	U1-FH angle	11.71±6.83	3.49±5.83	***	-4.75±3.81	-3.38±8.30	
	U1-FH mm	-1.25±3.60	-0.35±2.21		0.05±1.79	1.06±5.90	
	U1-PTV	4.39±2.91	1.59±2.97	**	-1.49±2.65	-2.90±5.23	
	U5-FH angle	9.68±6.95	5.19±6.84	*	-12.12±7.02	-9.16±9.66	
	U5-FH mm	-0.97±4.60	0.23±2.25		-0.15±2.69	-0.48±4.49	
	U5-PTV	4.94±2.88	3.35±4.08		-3.27±2.98	-3.62±2.62	
	U6-FH angle	-5.21±7.85	-1.19±8.21		0.54±6.64	-0.43±7.98	
	U6-FH mm	-1.88±2.49	0.72±2.03		0.40±1.14	0.24±3.56	
	U6-PTV	-2.16±3.33	-2.42±2.43		1.13±2.43	0.30±4.12	
	L6-FH angle	-0.58±5.88	-2.07±5.17		-0.19±6.01	1.43±6.92	
	L6-PTV	1.41±3.33	0.43±2.81		0.65±2.80	-0.88±4.13	
	L1-FH angle	-1.32±3.09	-0.65±2.63		0.28±3.01	-1.23±6.18	
	L1-PTV	1.93±2.30	-0.40±2.89	**	0.14±1.88	-0.29±4.27	
SOFT TISSUEU	NLA	-4.10±9.70	-4.28±10.28		1.37±5.72	0.37±6.97	
	Lu-E	1.45±1.46	1.38±1.25		-0.34±.083	0.55±1.95	
	Li-E	1.01±0.98	1.30±1.84		0.40±0.65	0.72±2.51	
*p<0.05, ** p<0.01, *** p<0.001, MV: Modified veltri, FC: First class, SD: Standart deviation							

Table 7. Statistical comparison of model measurements, changes after distalization (D2-D1) and after reinforcement (D3-D2) in MV and FC groups						
Model Comparison Between MV and FC Groups	D2-D1			D3-D2		
	MV n=20 Mean±SD	FC n=20 Mean±SD	p	MV n=20 Mean±SD	FC n=20 Mean±SD	p
Right U6-OHD	-2.87±6.19	4.52±4.15	***	2.97±6.63	1.17±5.25	-
Left U6-OHD	-3.25±4.36	3.22±6.32	***	0.37±5.07	0.17±2.57	-
-p>0.05, ***:p<0.001, MV: Modified veltri, FC: First class, SD: Standart deviation						

DISCUSSION

Molar distalization is a method applied to obtain a Cl I molar and canine relationship in the treatment of class II malocclusions. For this purpose, many distalization appliances have been developed from past to present.[6,12,17,20] Clinicians evaluate the advantages and disadvantages of these appliances compared to each other and prefer the mechanics that are suitable for each case. There are no studies in the literature comparing the effects of Modified Veltri and first class appliances. For this purpose, in this study, the effects of molar distalization with Modified Veltri and first class appliances on skeletal teeth and soft tissues were compared. In the cephalometric comparison of the groups at the beginning of the study, it was determined that the groups were mostly similar, with a difference only in OD-FH and U5-FH angle measurements.

Evaluation of Changes in Skeletal Structure

In the study, the decrease in FMA, SNGoGn angles after distalization in the Modified Veltri group indicates that the plane of the mandible rotated counterclockwise. The counterclockwise displacement of point B due to this rotation suggests that it causes differences in SNB, ANB and B-PTV values. The fact that the distalized molar tooth also intrudes in the vertical direction indicates the possibility of a reduction and rotation in the mandibular plane angle. In the literature, some researchers.[26,27] reported that the upper first molar was intruded while distalizing. However, they did not make a skeletal evaluation. Haydar et al.[28] reported in their study that extrusion occurred in the molars with intraoral molar distalization, but this did not have an effect on the mandibular plane angle. There was no difference in statistical values after distalization in the first class group. Fortini et al.[17] reported that 1.22 mm molar extrusion occurred with molar distalization but did not cause any sagittal or vertical skeletal change. Moschos et al.[29] also reported no skeletal change in their study.

The results of our study are compatible with this study. However, changes in some skeletal values were observed in the studies of some researchers.[30,31] It has been interpreted that these changes may be due to the upper first molars being pushed backwards in the arch. In this study, the fact that dental differences were observed only in the sagittal direction in the first class group and the upper first molars moved vertically only in the Modified Veltri group caused statistical differences in skeletal values between the groups.

In the Modified Veltri appliance group, it was determined that the skeletal values that changed due to the movement of the upper first molars after distalization recurred to some extent after reinforcement (D3-D2). Dental recurrence also caused recurrence in skeletal changes. It reinforces the idea that the skeletal changes occurred due to dental movements.

Evaluation of Changes in Dental Structures

In both groups with modified Veltri and first class appliances, an increase in overjet distance and a decrease in overbite distance were observed due to the protrusion of the incisors after distalization. This situation shows the loss of anchorage reflected to the incisors with distalization. In many studies[12,17,18,32] protrusion of the incisors and increases in overjet distance are inevitably seen in all intraoral distalization mechanics consisting of conventional anchorage units. In this study, less protrusion was observed in the first class group compared to the modified Veltri group. The large acrylic area of the first class appliance suggests that it strengthens the anchorage against the distalization force with tissue support in the palatinal region. Thus, the reciprocal force transferred to the incisors may have decreased compared to the modified Veltri appliance.

When the position of the upper second premolar after distalization was evaluated in the modified Veltri group, 4.94 mm of anchorage was lost compared to 2.16 mm of distalization. In the literature, Küçükkeleş et al.[18] reported that 25%-80% anchorage loss can be seen in their study. In our study, anchorage was tried to be increased with the nance button added to the Hyrax screw that creates the distalization force. However, since the distalization force was close to the deepest point of the palate, it created a clockwise moment. This moment on the screw may have further increased the loss of anchorage. This moment caused the appliance to move clockwise in the mouth. The rotation of the appliance caused distalization and intrusion of the posterior teeth. This suggests that the anchorage should be increased in future studies on this appliance. In the study of Küçükkeleş et al.,[18] it was reported that anchorage loss occurred at 4.17 mm. against 4.17 mm. distalization. Therefore, they suggested that anchorage units should be increased. In the light of this information; tooth and palate tissue supported intraoral distalization mechanics show that it is difficult to provide distalization without anchorage loss.

In our study, 5.19° mesial tipping and 3.35 mm mesial movement of the upper second molar was found in the first class group after distalization. Fortini et al.[17] found 2.2° mesial tipping and 1.7 mm mesial movement of the upper second premolars after distalization. Moschos et al.[29] reported that premolars or deciduous second molars moved mesially with a tipping of 1.86 mm and 1.85 degrees. In this study, the fact that the activation of the appliance was performed at different speeds and the age of the patients was different suggests that the presence of second molars may have increased the loss of anchorage.

Since the designs of the anchorage units of the first class and Veltri appliances and the point of origin of the distalization force are different in both appliances, it may have caused different anchorage losses in the supported teeth. In our study, in the modified Veltri group, 1.88 mm intrusion and 2.16 mm molar distalization were achieved with 5.21° distal tipping in approximately five months. The fact that the crown distalization rate is higher than the root distalization rate with this appliance and the moment motion generated in the appliance affect the formation of body molar distalization. In the study of Küçükkeleş et al.,[18] 4.61° distal tipping and 1.11 mm. intrusion movement were reported along with 4.17 mm molar distalization amount. The results of our study are similar to this study, but less molar distalization was obtained.

In the model analysis of the modified Veltri group, distobuccal rotation was observed in the right and left upper first molars after distalization. This rotation is thought to be caused by the relationship of the distalization force with the resistance point of the upper molar and the moment motion of the appliance. More body movement was obtained in the first class group compared to the Modified Veltri group. In the model analysis of the first class group, it was observed that mesiobuccal rotation occurred in the right and left upper first molars after distalization. In our study, doubling the activation amount of the vestibular screw in the appliance may have created a more severe buccal force and therefore may have caused mesiobuccal rotation. Itoh et al.[33] reported that mesiobuccal rotation ranging between 0°-29° occurred in their study with magnets.

The MV and FC appliances utilized in the present study employed conventional anchorage systems. Nevertheless, the anchorage losses observed in the present study could be mitigated through the utilization of the widely utilized mini screw-assisted molar distalization appliances. However, rotations were observed in maxillary molars.[34] No statistically significant differences were observed in the magnitude of molar distalization, molar distal tipping, or molar intrusion among appliances used in distalization, with the anchorage being placed in the palate, zygoma, or buccal area.[35]

In the modified Veltri group, there was an increase in the distance of the lower incisors to the reference PTV plane after distalization. We think that this increase, which occurred without protrusion of the lower incisors, is due to the counterclockwise rotation of the mandibular plane angle (SN-GoMe) during the distalization period. In our study, in both first class and Modified Veltri groups, almost all of the anchorage lost during the distalization period was recovered spontaneously with the distal movement of the second molars and even the second molar was dragged further distal than its initial position with the effect of interdental fibrils. It was observed that the distalization achieved during the stabilization period in the Modified Veltri group was lost by 1.13 mm and 0.3 mm in the first class group as a result of mesial movement. We think that more recurrences occurred in the Modified Veltri group due to excessive tipping of the upper first molar caused by molar distalization.

Changes in Soft Tissue

In the group with Modified Veltri and first class, it is seen that the lips approach the E plane in the sagittal direction due to the protrusion of the upper incisors after distalization. It suggests that the lower lip position at the end of reinforcement approaches to the E plane to some extent with the effect of growth. In the upper lip profile change, lip thickness is also important as well as the position of the incisors.[36] Although the amount of overjet was higher in the modified veltri group compared to the first class group, no statistically significant difference was found when the amount of soft tissue protrusion was compared between the groups.

CONCLUSION

Molar distalization was achieved in a similar time and at a similar rate with the modified veltri and first class appliances. Anchorage loss was less in the first class group. At the end of reinforcement, recurrence was observed similarly in the anchored tooth group and molars. The modified Veltri appliance was rotated in the mouth. Due to this rotation, intrusion movement occurred in the molars. In the clinical applications of these appliances, more effective clinical results can be achieved if anchorage losses are prevented with skeletal support applications.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study is a doctoral thesis completed before 2020. Institutional approval has been obtained.

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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