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Original article

Soft tissue, skeletal and dentoalveolar changes following conventional anchorage molar distalization therapy in class II Non-growing subjects: a multicentric retrospective study

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ABSTRACT

Objectives: The purpose of this retrospective prolective study is to evaluate soft tissue, dentoalveolar and skeletal vertical changes following conventional anchorage molar distalization therapy in adult patients.

Materials and methods: Forty-six patients (34 females, mean age 25 years 6 months; and 12 males, mean age 28 years 4 months) were recruited from 4 specialists Board Certified. All subjects underwent molar distalization therapy according different distalization mechanics. Cephalometric headfilms were available for all subjects before (T0) and at the end of comprehensive treatment (T1). The initial and final measurements and treatment changes were compared by means of a paired t-test or a paired Wilcoxon test.

Results: Mean total treatment time was 3 years 3 months ± 8 months. Maxillary first and second molars distalized 2.16 ± 0.84 mm and 2.01 ± 0.69 mm respectively, but also maintained a slight distal tipping of 1.45° (min 2.22°, max -6.45°) and 3.35° (min 0.47°, max -15.48°) at the end of treatment. Distal movement of maxillary first molar contributed 57.6% to molar correction, and 42.4% was due to a mesial movement of mandibular first molar (1.59 ± 0.46 mm). Dentoalveolar changes contributed to overjet correction; maxillary incisors retroclined 5.78° ± 3.17°, lower incisors proclined 7.49° ± 4.52° and occlusal plane rotated down and backward 2.32° ± 2.10°. A significant clockwise rotation of the mandible (1.97° ± 1.32°) and a significant increase in lower facial height (3.35 ± 1.48) mm were observed. Upper lip slightly retruded (-1.76 ± 1.70 mm) and lower lip protruded (0.96 ± 0.99 mm) but these changes had a negligible impact on clinical appearance.

Conclusions: Although maxillary molar distalization therapy can be performed in adult patients, significant proclination of the lower incisors, clockwise rotation of the occlusal plane and increase in vertical facial dimension should be expected. Nevertheless, in absence of maxillary third molars and in presence of mandibular third molars this procedure could be recommended.

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1. Introduction

Class II malocclusions form a heterogeneous group, in which dentoalveolar and skeletal components play a role. Maxillary molar distalization is one of the most common strategy to correct class II molar relationship in growing subjects.[1] Maxillary first molars can be moved distally, in particular before eruption of the second molars[2] and mandibular growth can aid in correcting the dental discrepancy. This non-extraction treatment may be indicated in patients with minor mandibular crowding and maxillary dentoalveolar protrusion or mild skeletal discrepancies.[3] Originally, maxillary molars distalizing systems required compliance,[4,5] later others were introduced to reduce it[6,7] and to provide more predictable results[8]; however, mandibular growth remained the main factor involved in Class II correction.[9]

Dentoskeletal effects of maxillary molar distalization therapy have been widely investigated in growing patients,[10] but those relating to non-growing patients are lacking. Premolar-extraction treatment,[11] fixed functional appliances,[12,13] and orthognathic surgery[14,15] are usually proposed to resolve class II malocclusion in non-growing patient. Maxillary molar distalization is rarely taken into account, because it is very difficult to move the maxillary molars distally after full eruption of the maxillary second and third molars, and because mandibular growth cannot be expected. During the last years, the use of skeletal anchorage[16] and corticotomy-facilitated movement[17] has been proposed as effective alternatives.

The purpose of this retrospective prolective study is to evaluate dentoalveolar and skeletal vertical changes following conventional anchorage molar distalization therapy in Class II adult patients.

2. Materials and methods

A sample of 107 patients treated with distalization mechanics was obtained from 4 Board Certified orthodontists. Cephalometric headfilms at pre-treatment (T0) and at the end of orthodontic treatment after multibrackets therapy (T1) were evaluated. All patients met the following criteria:

1. Skeletal class I or class II malocclusion and a bilateral full-cusp or end-to-end class II molar relationship;
2. Male or female aged more than 18 years-old;
3. Non-extraction treatment plan;
4. SN/GoGn angle less than 40 degrees;
5. Use of distalization mechanics comprising Cetlin distalizing appliance[18] (n = 4), compressed Niti coil-spring[19] (n = 5), Loca-system wires[20] (n = 6), repelling magnets[21] (n = 1), intraoral palatal distalizing appliances[6,7–22] (n = 13) and "Zig-Zag loops" in conjunction with intermaxillary elastics (n = 17; Fig. 1a, 1b, 1c) to correct molar relationship;
6. Good quality radiographs, with adequate landmark visualization and minimal or no rotation of the head.

Patients were treated according different distalizing mechanics. Compliance-depending systems, ie Cetlin distalizing appliance and intermaxillary elastics, were asked to be worned at least 16-18 hours in a day and patient compliance was considered accettable. Maxillary molars were distalized to an overcorrected Class I molar relationship, and after distalization-phase intermaxillary elastics were used during fixed multibrackets therapy.

The records of 16 patients from the whole sample were excluded due to poor film quality or incomplete records and 7 patients were excluded because mandibular plane angle was greater than 40 degrees. An additional 16 patients were excluded because upper second molars were extracted before treatment, 14 patients were excluded because prosthesis on first molars were present at the end of treatment, and 8 patients were excluded because palatal implants were used. Thus, 46 patients from 4 specialists (GC = 19; MC = 10; CL = 9; AG = 8) were included in the study sample (Fig. 2).

The final sample consisted of 34 females with a mean age of 25 years 6 months (range, 18 years 10 months to 34 years 6 months) and 12 males with a mean age of 28 years 4 months (range, 18 years 7 months to 39 years 4 months). The mean time period between the initial T0 radiograph and the post-treatment T1 radiograph was 3 years 3 months ± 8 months (range, 2 years 1 month to 5 years 2 months). The average amount of class II molar relationship was 4.07 ± 1.27 mm, and the mean amount of overjet was 5.97 ± 2.79 mm at the beginning of treatment. Gender differences were not considered a factor because treatment was performed in non-growing patients.

2.1. *Cephalometric analysis*

The lateral cephalograms were traced in random order by one investigator (MF) with verification of anatomic outlines and landmark position by a second investigator (AC). In instances of disagreement, the structures in question were retraced to the mutual satisfaction of both. In instances of bilateral structures (eg, gonial angle, teeth), a single averaged tracing was made. Centroid points of the maxillary first and second molars, the maxillary first premolars and the mandibular first molars were obtained as the midpoint between the greatest mesial and distal convexity of the crowns, as seen on the cephalometric radiograph.[23] Table I shows the measurements made and summary statistics of the pooled sample before initiation of treatment.

A conventional analysis, including soft tissue, skeletal, (Fig. 3) and dental measurements (Fig. 4) was used.[23] Mandibular dental measurements and sagittal skeletal measurements were added in order to complete cephalometric analysis. FMA was not used due to the difficulty of detecting Porion point; SN/GoGn was used as an indicator of vertical facial dimension.

Cranial base superimpositions were used to evaluate dentoalveolar, craniofacial and soft tissue changes according to Björk and Skieller.[24,25] Sella-nasion (S-N) plane was used as the horizontal reference plane and PTV line as the vertical reference plane.[26] Maxillary local superimpositions were not traced because no significant differences occurred in palatal plane in non-growing patients. Mandibular local superimpositions according to Björk and Skieller[25] were needed to evaluate dentoalveolar changes, since they were influenced by the clockwise rotation of the mandible. Mesial cusp of the mandibular first molar and tip of the mandibular central incisor were used to evaluate horizontal and vertical dental changes in the mandibular superimpositions. Mandibular

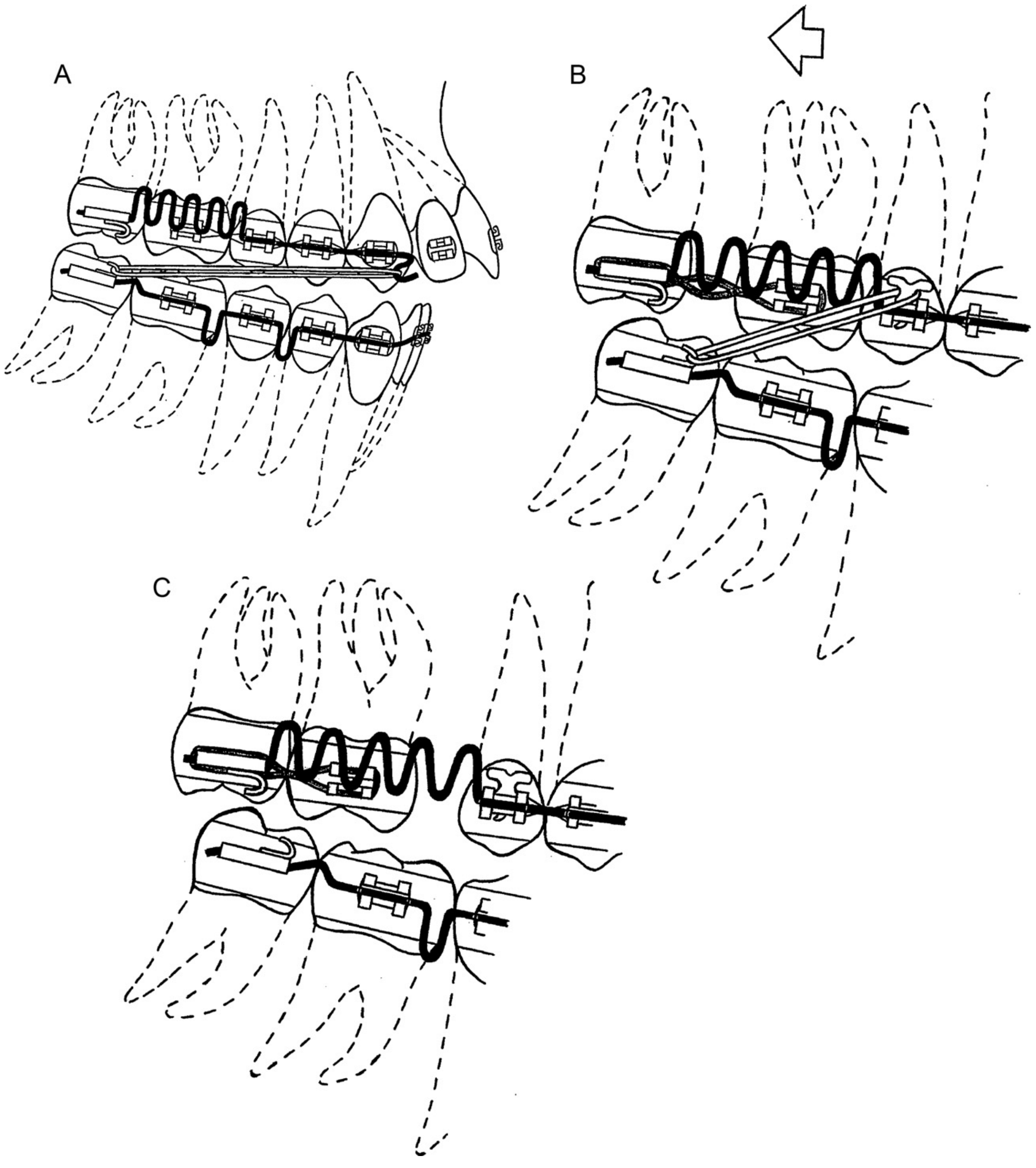

Fig. 1 – (a) "Zig-Zag Loops" in conjunction with the use of intermaxillary elastics were used to distalize maxillary second and first molars (Courtesy of Dr. Giuseppe Cozzani). A 0.019 × 0.025" stainless steel wire was used in the lower arch. A distal tipback on the mandibular second molars was used as an anchorage preparation to contrast the negative effects of the intermaxillary elastics. A 0.019 × 0.025" segmental stainless steel wire was used in the maxillary arch, from the canine to the second premolar, and compressed multiple loops were placed between the second molar and the second premolar. Intermaxillary elastics were used to minimize anchorage loss during distalization of the second molar; (b) After maxillary second molars were distalized to a Class I molar relationship, an elastic chain from the second and first molar was placed both in the buccal and in the palatal side in order to distalize maxillary first molars. Multiple loops were left passively, and intermaxillary elastics were placed between the mandibular second molar and maxillary second premolar to avoid mesial movement of the maxillary second molar; (c) Maxillary first and second molars were distalized to a Class I molar relationship.

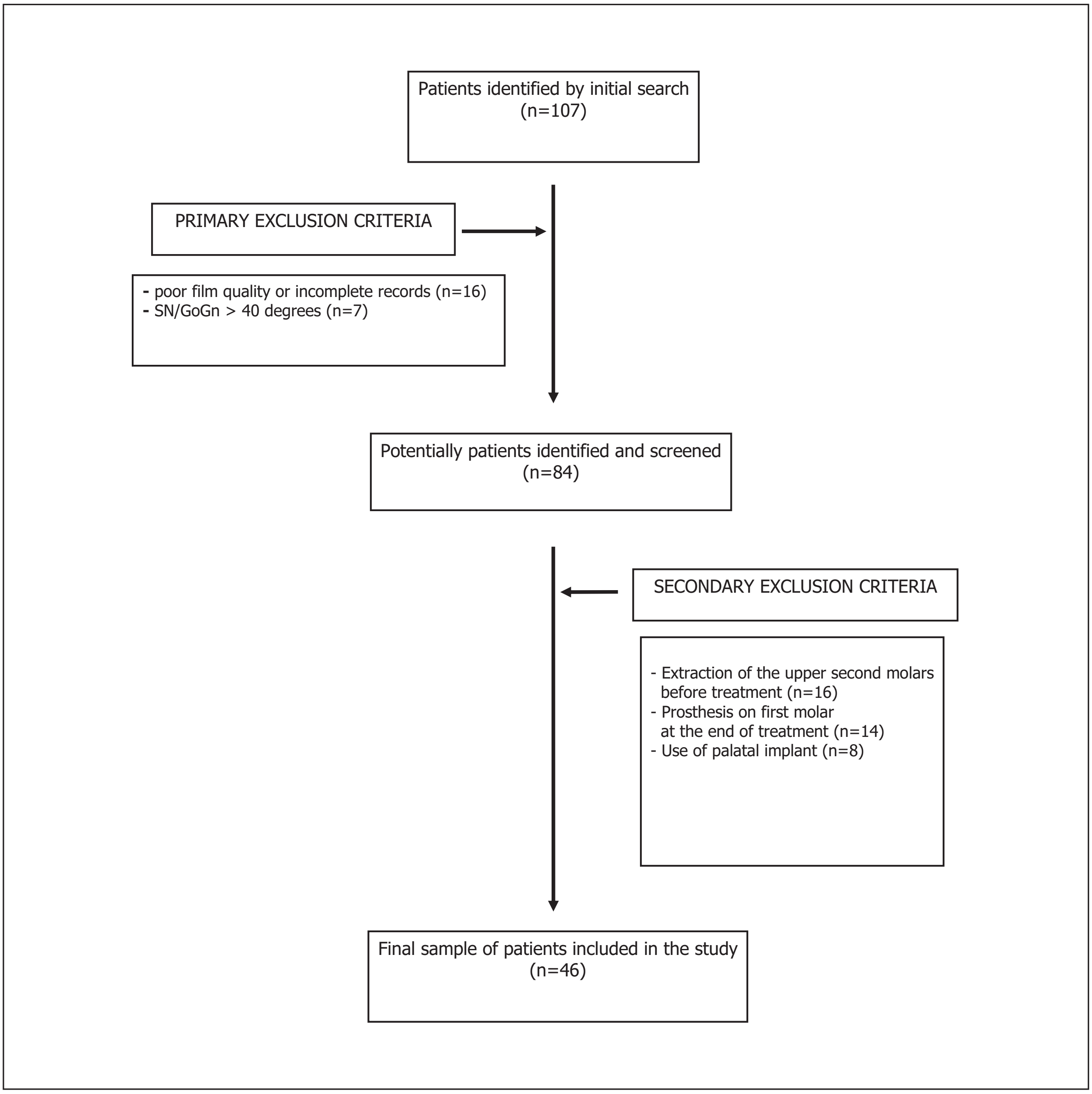

Fig. 2 – Flow diagram summarizing inclusion criteria for sample selection.

plane was used as the horizontal reference plane (mand HR) and a perpendicular to mandibular plane through S point (mand VR) as the vertical reference plane in mandibular tracings (Fig. 5). A conventional analysis, including dental mandibular measurements was used.[27] Table II shows the dental changes occurred in mandibular jaw before and at the end of orthodontic treatment.

2.2. *Statistical analysis*

In order to compare pre-treatment cephalometric data from 4 different specialists a non-parametric independent sample Mann-Whitney test was performed before treatment. A parametric *t*-test was not used because of the small size of the samples. No significant differences between the 4 groups was found. In order to identify the sample normal distribution of the data a D'Agostino-Pearson test was performed for each cephalometric variable; if normal distribution was detected a paired *t*-test was used to identify significant between-group differences for each cephalometric variable; if normal distribution was rejected a paired data Wilcoxon test was used. Statistical significance was tested at $p < .05$, $p < .01$ and $p < .001$. All computations were performed with a statistical software package MedCalc® Version 9.3.7.0 (Belgium).

2.3. *Method error*

Ten randomly selected cephalograms were retraced by the same author (MF) after a period of 2 month. No significant mean differences between the two series of records were

Table I – Mean, standard deviation, minimum and maximum values for pre-treatment cephalometric soft tissue, skeletal and dental measurements ($n = 46$).

Measurement	Mean	SD	Minimum	Maximum
Soft tissue				
Upper lip to E-plane (mm)	−5,19	2,62	−10,30	−0,10
Lower lip to E−plane (mm)	−3,64	2,90	−12,40	1,30
Skeletal				
SNA	80,61	4,89	69,10	86,30
SNB	78,04	4,12	70,90	86,10
ANB	2,41	2,74	−1,80	6,70
SN-palatal plane angle (degrees)	7,68	2,39	3,70	14,80
SN-occlusal plane angle (degrees)	15,48	4,67	5,90	24,01
SN-GoGn angle (degrees)	28,47	5,50	16,90	39,20
SnaSnp-GoGn (degrees)	21,32	5,79	11,10	28,30
PTV-A point (mm)	53,24	3,26	45,20	63,50
PTV-B point (mm)	53,40	6,61	41,10	67,02
ANS-menton (mm) - LAFH	65,60	5,03	52,70	73,01
Dental-angular (degrees)				
SN-maxillary U1	109,40	11,87	75,30	136,30
SN-maxillary U4	82,73	4,90	76,90	95,03
SN-maxillary U6	75,95	5,82	66,10	100,30
SN-maxillary U7	68,86	7,20	55,20	100,70
Mandibular plane-L1 (IMPA)	92,46	7,05	87,20	106,30
Mandibular plane-L6	79,63	7,26	64,10	91,00
Interinc angle U1L̂1	122,78	15,94	107,90	156,20
Dental-linear (mm)				
PTV-maxillary U1 tip	61,24	6,06	47,60	74,50
PTV-maxillary U4 centroid	42,34	3,77	33,40	51,20
PTV-maxillary U6 centroid	26,42	3,68	18,10	34,80
PTV-maxillary U7 centroid	16,05	4,03	7,70	28,10
PTV-mandibular L6 centroid	25,28	4,25	16,50	34,20
PTV-mandibular L1 tip	54,09	4,57	43,20	62,80
L1-A Pog	0,96	2,56	−3,80	5,70
PP-maxillary U1 tip	28,59	2,84	20,20	33,20
PP-maxillary U4 centroid	21,37	2,45	18,50	25,30
PP-maxillary U6 centroid	20,69	2,77	16,50	30,80
PP-maxillary U7 centroid	18,21	3,19	12,50	30,01
Mandibular plane-L6 centroid	27,68	2,43	21,90	35,03
Mandibular plane-L1 tip	40,53	2,58	34,70	46,10
Overjet	5,97	2,79	2,10	13,70
Overbite	3,75	2,00	−3,10	7,20

found by employing paired *t*-tests. Dalhberg's formula was used to establish the method error.[28] A range from 0.5 to 0.8 mm for linear measurements and 0.5° to 1.0° for angular measurements was found. Reliability coefficient (*r*)[29] ranged from 0.94 to 0.98 and from 0.92 to 0.97 respectively.

3. Results

The mean, standard deviation, minimum and maximum values of the changes in the soft tissue, and skeletal and dental measurements as measured from the cephalometric radiographs relative to cranial base superimposition are summarized in Table II.

The upper lip retruded an average of 1.76 ± 1.70 mm at the end of treatment, whereas the lower lip protruded a mean amount of 0.96 ± 0.99 mm.

There was a significant clockwise rotation of the occlusal plane (2.32° ± 2.10°), but no significant change occurred in palatal plane; mandibular plane, on the other hand, rotated down and backward a mean of 1.97° ± 1.32°. The lower anterior facial height, measured between ANS and menton, increased by 3.35 ± 1.48 mm at the end of treatment.

The mean amount of maxillary first and second molar distalization at the end of treatment was 2.16 ± 0.84 mm and 2.01 ± 0.69 mm respectively; maxillary first molars tipped distally an average of 1.45° (minimum -2.22, maximum 6.45), and maxillary second molars an average of 3.35° (minimum -0.47, maximum 15.48). Maxillary first premolar showed a distal movement at the end of treatment (1.77 ± 0.98 mm) as well as the upper incisors (3.26 ± 2.72 mm). Upper incisors significantly retroclined according to SN (-5.78° ± 3.17°).

Vertically, maxillary first and second maxillary molars extruded an average of 0.75 mm (minimum 0.21, maximum 1.36) and 0.67 mm (minimum -0.83, maximum 1.12) respectively. The first premolars also extruded 0.46 ± 0.25 mm, as well as the upper incisors (0.80 ± 1.31 mm).

The correction of Class II molar relationship was aided by the mesial movement of mandibular first molar (1.59 ± 0.46 mm), and proclination of the lower incisors

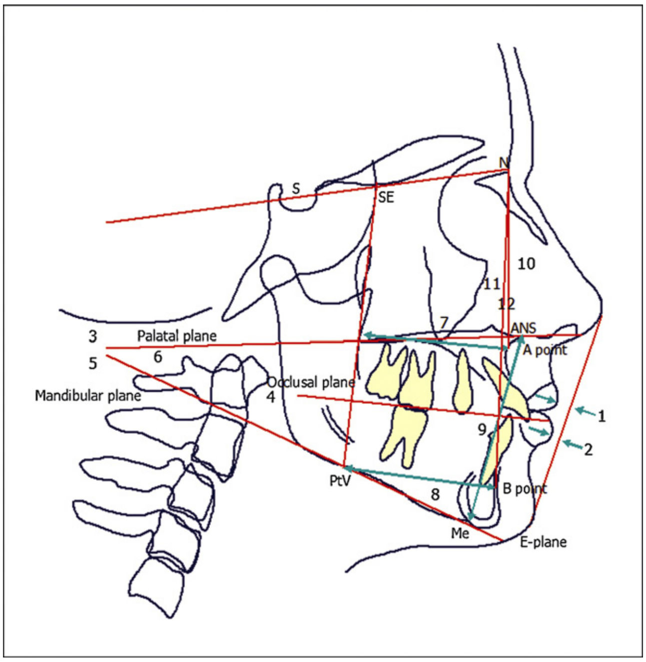

Fig. 3 – Cephalometric soft tissue and skeletal measurements used in the study: *(1)* upper lip to E-plane; *(2)* lower lip to E-plane; *(3)* SN-palatal plane angle; *(4)* SN-anatomic occlusal plane; *(5)* SN-mandibular plane angle; *(6)* SnaSnp-GoGn; *(7)* PTV to A point; *(8)* PTV to B point; *(9)* ANS to menton; *(10)* SNA; *(11)* SNB; *(12)* ANB.

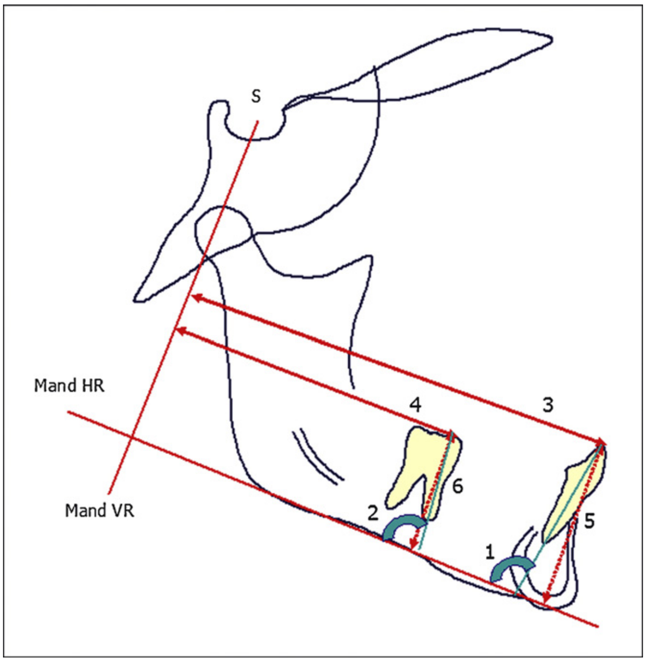

Fig. 5 – Measurements on mandibular local tracing. 1: L1/mand HR (degrees); 2: L6/mand HR (degrees); 3: L1-mand VR (mm horizontal); 4: L6-mand VR (mm horizontal); 5: L1–mand HR (mm vertical); 6: L6-mand HR (mm vertical).

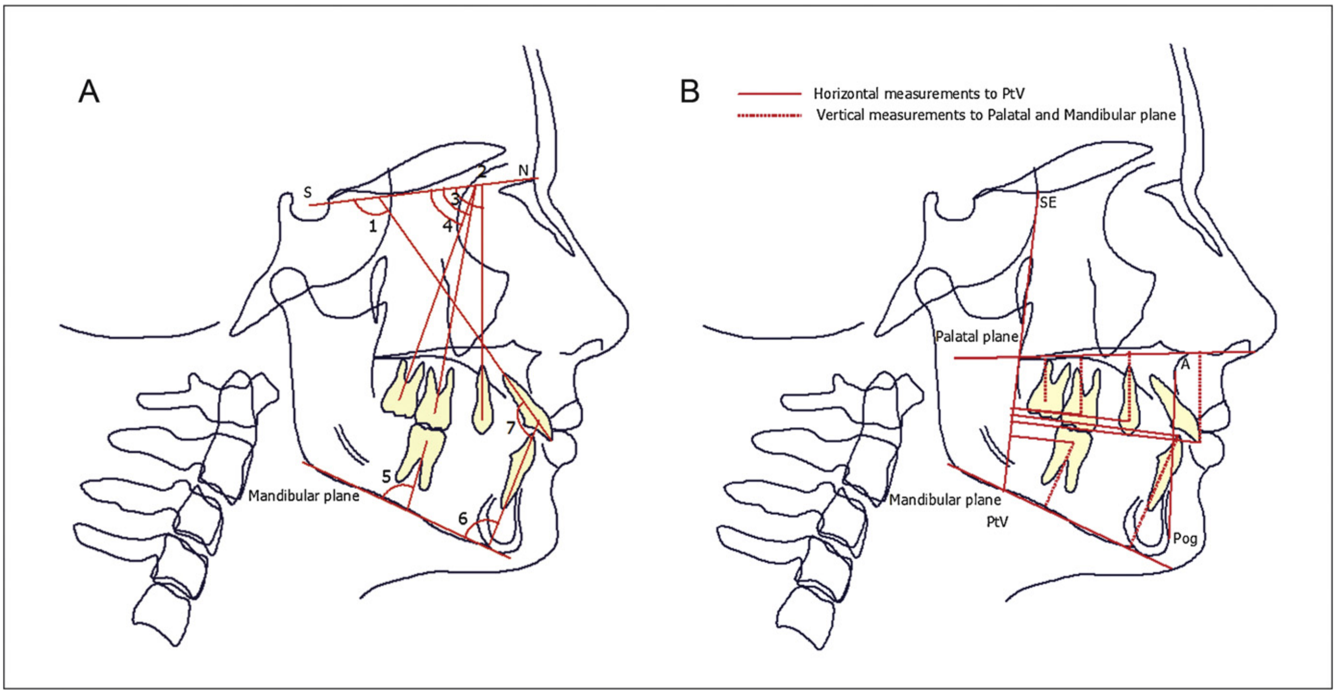

Fig. 4 – A Cephalometric dental angular measurements: *(1)* SN-maxillary incisor; *(2)* SN-maxillary first premolar; *(3)* SN-maxillary first molar; *(4)* SN-maxillary second molar; *(5)* MP-mandibular first molar; *(6)* MP-mandibular incisor; *(7)* interincisal angle.

B. Cephalometric dental linear measurements. Vertical measurements to maxillary incisor tip, maxillary premolar and molars centroids were made from palatal plane, whereas vertical measurements to mandibular first molar centroid and mandibular incisor tip were made from mandibular plane. Horizontal measurements to incisor tip, premolar and molar centroids were made from the pterygoid vertical (PTV) plane.

Table II – Means of differences, standard deviation of the differences (for paired *t*-test), differences of medians (for paired data Wilcoxon test), minimum and maximum values for changes in the cephalometric soft tissue, skeletal and dental measurements relative to cranial base superimposition (*n* = 46). The *p* values from a paired *t*-test or a paired data Wilcoxon test are also given.

Measurement	Mean	SD	Median	Minimum	Maximum	p value	Test
Soft tissue							
Upper lip to E-plane (mm)	−1,76**	1,70	–	−0,15	−2,97	0,0030	t-Test
Lower lip to E-plane (mm)	+0,96**	0,99	–	−1,14	1,97	0,0070	t-Test
Skeletal							
SNA	−0,32	0,15	–	−0,60	0,20	NS	t-Test
SNB	−0,93	0,58	–	−1,12	0,30	NS	t-Test
ANB	0,56	0,28	–	−0,40	1,03	NS	t-Test
SN-palatal plane angle (degrees)	+0,19	1,34	–	−1,70	1,92	NS	t-Test
SN-occlusal plane angle (degrees)	+2,32***	2,10	–	0,99	3,44	0,0003	t-Test
SN-GoGn angle (degrees)	+1,97***	1,32	–	0,88	3,17	0,0001	t-Test
SnaSnp-GoGn (degrees)	1,45	0,56	–	0,50	2,50	NS	t-Test
PTV-A point (mm)	−0,18	0,26	–	−0,23	0,26	NS	t-Test
PTV-B point (mm)	−0,56**	0,49	–	−0,42	−0,71	0,0070	t-Test
ANS-menton (mm) – LAFH	+3,35***	1,48	–	1,37	5,28	0,0001	t-Test
Dental-angular (degrees)							
SN-maxillary U1	−5,78***	3,17	–	3,63	−7,20	0,0001	t-Test
SN-maxillary U4	−1,30	1,51	–	0,64	−1,96	NS	t-Test
SN-maxillary U6	–	–	−1,45***	2,22	−6,45	0,0001	Wilcoxon
SN-maxillary U7	–	–	−3,35***	0,47	−15,48	0,0001	Wilcoxon
Mandibular plane-L1 (IMPA)	+7,49***	4,52	–	4,14	11,83	0,0001	t-Test
Mandibular plane-L6	0,27	1,14	–	−0,54	0,61	NS	t-Test
Interinc angle U1L̂1	−4,95	11,98	–	−24,40	9,20	NS	t-Test
Dental-linear (mm)							
PTV-maxillary U1 tip	−3,26***	2,72	–	1,25	−7,46	0,0008	t-Test
PTV-maxillary U4 centroid	−1,77*	0,98	–	−0,98	−2,37	0,0312	t-Test
PTV-maxillary U6 centroid	−2,16***	0,84	–	−1,08	−3,28	0,0001	t-Test
PTV-maxillary U7 centroid	−2,01***	0,69	–	−1,04	−2,65	0,0004	t-Test
PTV-mandibular L6 centroid	+1,59***	0,46	–	1,12	2,33	0,0001	t-Test
PTV-mandibular L1 tip	+3,01***	2,58	–	1,54	6,98	0,0001	t-Test
L1-A Pog	2,60***	1,08	–	1,20	4,40	0,0004	t-Test
PP-maxillary U1 tip	+0,80**	1,31	–	0,41	1,19	0,0076	t-Test
PP-maxillary U4 centroid	+0,46*	0,25	–	0,39	0,54	0,0401	t-Test
PP-maxillary U6 centroid	–	–	+0,75***	0,21	1,36	0,0001	Wilcoxon
PP-maxillary U7 centroid	–	–	+0,67***	−0,83	1,12	0,0001	Wilcoxon
Mandibular plane-L6 centroid	+1,28***	0,43	–	1,07	1,52	0,0001	t-Test
Mandibular plane-L1 tip	−0,47*	0,64	–	−0,11	−0,66	0,0386	t-Test
Overjet	–	–	−5,20***	2,78	−7,62	0,0001	Wilcoxon
Overbite	–	–	−1,87***	4,10	−4,56	0,0001	Wilcoxon

*Implies significance at $p < 0.05$; **implies significance at $p < 0.01$; ***implies significance at $p < 0.001$; NS: not significant.

(7.49° ± 4.52°) contributed to overjet correction. Distal movement of the maxillary molar contributed for 57.6%, and mesial movement of the mandibular molar for 42.4% to the correction of class II molar relationship. Mandibular first molar also extruded a mean amount of 1.28 ± 0.43 mm.

Table III shows the mean, standard deviation, minimum and maximum values of the dentoalveolar changes occurred in the mandibular jaw measured from the cephalometric radiographs relative to mandibular local superimpositions (n = 46).

Most changes occurred in lower incisors; they significantly intruded 0.42 ± 0.70 mm and protruded 3.01 mm. Their proclination relative to mandibular plane increased an average of 6.46° ± 3.46°. Mandibular first molar significantly extruded 1.68 ± 0.47 mm and showed a mean mesial movement of 1.85 mm (minimum 0.60, maximum 3.10). No significant mandibular molar angular change relative to mandibular plane was noted.

In order to identify any significant difference between the data obtained from cranial base superimposition (CBS group) and mandibular local superimposition (MLS group) cephalometric dentoalveolar changes occurred in mandibular jaw during treatment were compared (Table IV).

The mean amount of intrusion, mesial movement and proclination of the lower incisors was similar in both groups. However lower incisors appeared more retruded relative to PtV line (-1.35 mm) and more proclined relative to mandibular plane (+1.18° ± 2.78°) in CBS group than in MLS group. Extrusion of the mandibular first molars was significantly greater in MLS group than in CBS group (an average of 0.38 ± 0.51 mm), whereas any significant changes occurred in mesial movement of the first molars.

Table III – Means of differences, standard deviation of the differences (for paired *t*-test), differences of medians (for paired data Wilcoxon test), minimum and maximum values for changes in the cephalometric dental measurements relative to mandibular local superimposition ($n = 46$). The *p* values from a paired *t*-test or a paired data Wilcoxon test are also given.

Measurement	Mean	SD	Median	Minimum	Maximum	p value	Test
L1-Mand HR (mm – vertical)	−0,42***	0,70	–	1,80	−1,50	0,0002	t-Test
L1-Mand VR (mm – horizontal)	–	–	3,41***	1,10	6,70	0,0001	Wilcoxon
L1 / Mand HR (degrees) - IMPA	6,46***	3,46	–	2,90	13,80	0,0001	t-Test
L6-Mand HR (mm – vertical)	1,68***	0,47	–	0,90	2,50	0,0001	t-Test
L6-Mand VR (mm – horizontal)	–	–	1,85***	0,60	3,10	0,0001	Wilcoxon
L6 / Mand HR (degrees)	0,23	1,64	–	(4,90	4,10	NS	t-Test

*Implies significance at $p < 0.05$; **implies significance at $p < 0.01$; ***implies significance at $p < 0.001$; NS: not significant.

Table IV – Comparison of the means of differences and standard deviation of the means between the data obtained from cranial base superimposition (CBS group) and mandibular local superimposition (MLS group) relative to dental vertical, horizontal and angular changes occurred in the mandibular jaw after treatment. The p values from a paired *t*-test or a paired data Wilcoxon test are also given.

Parameters	CBS			MLS			Difference (Means)	Difference (Medians)	p value	Test
	Mean	SD	Median	Mean	SD	Median				
L1 vertical (mm)	−0,47	0,64	–	−0,42	0,70	–	–	−0,65	NS	Wilcoxon
L1 horizontal (mm)			+3,01	–	–	+3,41	–	1,35***	0,0001	Wilcoxon
L1 angulation (°)	+7,49	4,52	–	+6,46	3,46	–	−1,18**	–	0,0059	t-Test
L6 vertical (mm)	+1,28	0,43	–	+1,68	0,47	–	0,38***	–	0,0001	t-Test
L6 horizontal (mm)	+1,59	0,46	–	–	–	+1,85	0,04	–	NS	t-Test
L6 angulation (°)			+0,27	+0,23	1,64	–	–	−0,35*	0,0384	Wilcoxon

*Implies significance at $p < 0.05$; **implies significance at $p < 0.01$; ***implies significance at $p < 0.001$; NS: not significant.

4. Discussion

There are several strategies to correct class II malocclusion in adult patients. Premolar-extraction treatment,[11,30] fixed functional appliances,[12,13] and orthognathic surgery[14,15] are most commonly used, whereas distalizing maxillary molars at growth completion might not be considered a conventional procedure, due to the difficulty of moving the maxillary molars distally after full eruption of the maxillary second and third molars,[2] and because mandibular growth cannot be expected. As confirmed by our findings, ANB angle was not subjected to significant changes during treatment. During the last years, the introduction of skeletal anchorage[16] and corticotomy-facilitated movement[17] could be considered as effective alternatives.

Among the above-mentioned treatment strategies, an orthodontic camouflage requiring premolar-extraction treatment limited to the maxillary arch may be reasonable in adult patients. However, in absence of maxillary third molars and in presence of mandibular third molars may not be indicated because mandibular third molars could be out of occlusion at the end of treatment. In these cases distalizing maxillary first and second molars could be recommended. On the other hand, such an approach occasionally could result in posterior crowding, ectopic eruption of the third molars, and root resorption of the second molars in presence of maxillary third molars.[16]

Dentoskeletal effects of maxillary molar distalization therapy in growing patients have been extensively investigated, while those relating to non-growing patients are lacking. Kinzinger et al[31] showed molar distalization in adult patients using modified pendulum, Horiuchi et al[32] described a nonextraction treatment by means of maxillary molars uprighting procedure, and Sugawara et al[16] advised the use of skeletal anchorage to move maxillary molars distally in non growing subjects.

Since the aim of the study was not to compare different appliances in terms of efficacy or effectiveness, but more in general, to describe dentoskeletal and soft tissue changes occurring when maxillary molar distalization with conventional anchorage design was accomplished in non-growing subjects, the use of different distalizing mechanics was not considered a concern. Patient's compliance was considered accettable, since adult subjects revealed a marked level of consciousness towards treatment. Intermaxillary elastics were asked to be worned full-time, as well as Cetlin intraoral appliance, whereas extraoral traction[18] was asked to be worned only during the night. For this reason data from compliance-depending systems were considered comparable with those mechanics in which compliance was not required.

Several differences can be observed between treatment carried on in adolescents or in adults.

Our findings showed that total treatment time was longer in adult patient (3 years 3 months ± 8 months) than in adolescents as reported in other studies.[33,34] It is stated that a general decrease in bony turn-over can be observed in adult subjects, since bony remodelling processes and cellular activities start slowing down.[35] Furthermore, remodelling processes occurring in the alveolar bone can require a longer time, since skeletal maturation is completed and bone quality is completely different in respect with an adolescent.[35] It should be considered that when molar distalization therapy is accomplished in a growing patient, the concomitant mandibular growth can be one of the major component involved in class II correction; this cannot be present in a non-growing subject and could be a responsible factor increasing total treatment time.

All treated subjects showed a class I molar relationship at the end of treatment, but maxillary molar distalization did not contribute in correcting Class II malocclusion as a whole. In fact this correction was partially due to a distal movement of maxillary molars (57.6%), but also to a mesial movement of the mandibular molars (42.4%) following the use of intermaxillary elastics. Previous studies[36] showed that when intermaxillary elastics were used in adolescents, distal maxillary molar movement contributed only 29%, and mesial mandibular dental movement another 22% of the Class II correction. Moreover, lower incisors significantly proclined, upper incisors retroclined and a significant clockwise rotation of the occlusal plane was observed.[37,38] Dentoalveolar changes occurring at incisors must be considered the main responsible of the overjet correction; accordingly, Nelson et al[39] reported that skeletal part of the overjet reduction was 4% in patients treated with class II elastics. Orthodontic treatment of adult patients with slight skeletal class II malocclusion must include labial tipping of the mandibular incisors over the basal bone to achieve an acceptable overjet and overbite.[40] In these cases, proclined mandibular incisors could need permanent retention to ensure long-term stability. This treatment plan has to be accurately chosen according to facial profile,[41] amount of crowding, vertical skeletal pattern and periodontal conditions. In fact, labial movement of the mandibular incisors could result in mucogengival problem[42] and loss of alveolar bone. Periodontal considerations and labiolingual width of the alveolar bone[43,44] should be carefully taken into account in order to minimize the risk of bone dehiscences.

A significant clockwise rotation of the mandibular plane and an increase in lower anterior facial height were reported. Although it can be mostly observed in adolescents,[45,46] this side-effect resulted more pronounced in adults. However, posterior tooth extrusion can be partially counteracted by posterior occlusion in non-growing subjects, especially in a patient with a hypodivergent skeletal pattern. A significant extrusion of the maxillary and mandibular molars, together with the maxillary molars moving distally into the wedge[9] could be responsible factors involving the increase in vertical facial dimension; when residual vertical growth of the condyle and the ramus is still present,[25] extrusion of posterior teeth can be compensate because mandibular condylar growth allow for dentoalveolar growth. For this reason, increasing lower anterior facial height in adult patients by molar extrusion is not advisable and probably, the use of skeletal anchorage may be recommended. In fact, the use of class II elastics cannot be a benefit and should be reduced at minimum in an adult patient to avoid undesirable side-effects such as proclination of the mandibular incisors, extrusion of the lower molars and increase in vertical facial dimension.[47]

As a consequence of the clockwise rotation of the mandible, dental mandibular measurements could be wrongly assessed in a cranial base superimposition. Therefore, mandibular local superimposition have been traced to evaluate dental changes occurred in mandibular jaw during treatment. Significant differences at horizontal and angular measurements of lower incisors were observed. Total superimposition on cranial base could detect a greater proclination and a more retruded position of the lower incisors relative to PtV line when the mandible rotates down and backward.

Maxillary first and second molars resulted in a more distal position relative to PtV line at the end of treatment, but also maintained a slight degrees of distal tipping of the crowns. The forward movement of the maxillary molars as part of a normal process of dentoalveolar compensation occurs during growth. Accordingly, some authors reported that maxillary first molars distalized and tipped distally after distalization-phase, but they were mesial of their original positions and showed mesial tipping at the end of comprehensive treatment after uprighting mechanics were applied to the molar roots.[34–48] Since the mandible does not continue to outgrow the maxilla in adults, the maxillary molars do not tend to move mesially in order to maintain the Class I molar relationship.[49]

Many authors described significant soft tissue changes during distalization period and at the end of multibracket therapy in adolescents. Some authors reported that upper lip protruded as a consequence of anchorage loss during distalization period,[48–50] but retruded at the end of multibracket therapy.[34] Our findings showed that upper lip slightly retruded while lower lip protruded in consequence of dentoalveolar changes occurring in maxillary and mandibular incisors. Our subjects showed a certain amount of overjet at the beginning, and maxillary incisors significantly retroclined during treatment; repositioning of the maxillary incisors and a considerable proclination of the lower incisors could have affected the upper and lower lip projection. However, these changes in soft tissues had only a negligible clinical relevance and a slight impact on clinical appearance.

5. Conclusions

In non-growing patients maxillary and mandibular skeletal modifications cannot be expected, therefore, maxillary molar distalization therapy should be limited to treat dentoalveolar class II malocclusion with no or minimal skeletal discrepancies. However, in presence of mandibular third molars and absence of maxillary third molars could be a reasonable treatment strategy.

Our findings can be summarized as follows:

- Total treatment time was longer in adult patient than in adolescents as reported in other studies.
- Maxillary molars distalized, but also maintained a slight degrees of distal tipping of the crowns at the end of comprehensive treatment; molar distalization contributed for 57.6% of the molar correction; mandibular molars showed a mesial movement and contributed for 42.4%.
- Significant dentoalveolar changes were the main responsible of the overjet correction; maxillary incisors retroclined, lower incisors proclined and occlusal plane showed a significant clockwise rotation following the use of intermaxillary elastics. As a consequence, upper lip slightly retruded and lower lip protruded, but these changes were not clinically relevant.
- Maxillary and mandibular molars significantly extruded. The mandibular plane rotated down and backward, the

lower anterior facial height significantly increased and the overbite decreased.
- In order to avoid undesirable side-effect such as proclination of the mandibular incisors, extrusion of the lower molars and increase in vertical facial dimension, the use of intermaxillary elastics should be reduced at minimum in an adult patient and the use of skeletal anchorage may be recommended
- Significant differences at incisors were reported between cranial base superimposition and local mandibular superimposition; lower incisors appeared more retruded relative to PtV line and more proclined relative to mandibular plane in cranial base superimposition compared with local mandibular tracing.

Conflict of interest

The authors have reported no conflicts of interest.

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Riassunto

Obiettivi: *Questo studio retrospettivo ha lo scopo di valutare i cambiamenti dentoalveolari, scheletrici verticali, e dei tessuti molli a seguito del trattamento di distalizzazione con ancoraggio convenzionale nei pazienti adulti.*

Materiali e metodi: *46 pazienti (34 femmine, età media 25 anni 6 mesi; e 12 maschi, età media 28 anni 4 mesi) sono stati reclutati da 4 specialisti Board Certified. Tutti i soggetti sono stati sottoposti ad una terapia di distalizzazione molare utilizzando differenti metodiche distalizzanti. Lo studio è stato condotto utilizzando teleradiografie latero-laterali, le quali erano disponibili per tutti i pazienti prima (T0) e alla fine del trattamento complessivo (T1). Le misurazioni iniziali e finali e i cambiamenti durante il trattamento sono stati confrontati utilizzando un t-test per dati appaiati o un test di Wilcoxon.*

Risultati: *Il tempo medio totale di trattamento è stato di 3 anni 3 mesi ± 8 mesi. I primi e i secondi molari mascellari sono stati distalizzati rispettivamente di 2.16 ± 0.84 mm e 2.01 ± 0.69, ma hanno mantenuto un leggero grado di tipping distale delle corone di 1.45° (min 2.22°, max - 6.45°) e 3.35° (min 0.47°, max -15.48°) alla fine del trattamento. Il movimento distale del primo molare mascellare ha contribuito per il 57.6% alla correzione del rapporto molare, mentre il 42.4% è stato attribuibile alla mesializzazione del primo molare mandibolare (1.59 ± 0.46 mm).*

Modificazioni dentoalveolari hanno contribuito alla correzione dell'overjet; gli incisivi superiori hanno subito una retroinclinazione di 5.78° ± 3.17°, gli incisivi inferiori una vestibolarizzati di 7.49° ± 4.52° e il piano occlusale è post-ruotato di 2.32° ± 2.10°. A seguito del trattamento si sono verificate una significativa rotazione oraria della mandibola (1.97° ± 1.32°) e un significativo aumento dell'altezza facciale inferiore (3.35 ± 1.48 mm). Il labbro superiore è arretrato (-1.76 ± 1.70 mm) mentre il labbro inferiore è avanzato (0.96 ± 0.99 mm), ma questi cambiamenti hanno avuto un impatto clinico trascurabile.

Conclusioni: *Nonostante la distalizzazione dei molari mascellari sia una metodica che può essere effettuata in pazienti adulti, questa potrebbe accompagnarsi ad una vestibolarizzazione degli incisivi inferiori, una post-rotazione del piano occlusale e un aumento della dimensione verticale. Tuttavia, in assenza dei terzi molari mascellari e in presenza dei terzi molari mandibolari potrebbe essere una procedura raccomandabile.*

Résumé

Objectifs: *Cette étude prolective retrospective évalue le tissu mou, les changements dentoalvéolaires et du squelette en axe vertical après thérapeutique de distalisation de molaires à l'aide d'un ancrage conventionnel chez des patients adultes.*

Matériels et méthodes: *Quarante-six patients (34 femmes, âge moyen 25 ans et 6 mois, et 12 hommes, âge moyen 28 ans et 4 mois) ont été recrutés par 4 Médecins Spécialistes Agréés. Tous les sujets ont été soumis à une prise en charge de distalisation de molaires conformément à différentes techniques.*

Des téléradiographies céphalométriques étaient disponibles pour tous les patients avant (T0) et à la fin du traitement (T1). Comparaison des mesures initiales et finales et des changements de traitement à l'aide d'un test-t à échantillons pairés ou d'un test pour échantillons pairés de Wilcoxon.

Résultats: *Le temps de traitement moyen total a été de 3 ans et 3 mois ± 8 mois. Les premières et deuxièmes molaires maxillaires ont été distalisés à hauteur de 2,16 ± 0.84 mm et 2,01 ± 0.69 respectivement; elles ont gardé, toutefois, une légère inclinaison distale de 1.45° (mini 2.22°, maxi -6,45°) et 3.35° (mini 0.47°, maxi -15.48°) à la fin de la prise en charge. Le mouvement distal de la première molaire maxillaire a contribué 57.6% à la correction de la molaire, et 42,4% a été dû au mouvement mésial de la première molaire mandibulaire (1,59 ± 0,46 mm). Les changements dentoalvéolaires ont contribué à la solution du surplomb. Palatoversion des incisives maxillaires (5.78° ± 3.17°), vestibulo-version des incisives inférieures (7.49° ± 4.52°), le plan occlusal ayant eu un mouvement en bas et en arrière (2.32° ± 2.10°). Il y a lieu de mentionner une rotation dextrogyre importante de la mandibule (1.97° ± 1.32°) et une hausse remarquable de la hauteur faciale inférieure (3,35 ± 1,48 mm). Légère rétrusion de la lèvre supérieure (-1,76 ± 1,70 mm) et protrusion de la lèvre inférieure (0,96 ± 0,99 mm); toutefois, ces changements n'ont eu aucun impact significatif sur le tableau clinique.*

Conclusions: *Bien que la distalisation de molaires maxillaires puisse être réalisée chez des patients adultes, il faut s'attendre à une vestibulo-version des incisives inférieures, à une rotation dextrogyre du plan occlusal et à une augmentation de la dimension faciale verticale. Néanmoins, dans l'absence des troisièmes molaires maxillaires et en présence des troisièmes molaires mandibulaires cette prise en charge pourrait être recommendée.*

Resumen

Objetivos: *Se realizó este estudio prolectivo retrospectivo para valorar el tejido blando, los cambios verticales de esqueleto y dentoalveolares después de una terapia de distalizacion de molares, por anclaje convencional, en pacientes adultos.*

Materiales y métodos: *Cuarenta y seis pacientes (34 mujeres, edad media 25 años y 6 meses, y 12 varones, edad media 28 años* *y 4 meses) fueron reclutados por 4 Especialistas Médicos Certificados. Todos los sujetos fueron sometidos a distalización de molares, de acuerdo con diferentes técnicas de distalización. Radiografías cefalométricas estaban disponibles para todos los sujetos al principio (T0) y al final del tratamiento integral (T1). Se compararon las medíciones iniciales y finales y los cambios de tratamiento por medio del Test T de muestras pareadas o de la Prueba de Wilkoxon.*

Resultados: *El tiempo de tratamiento medio fue de 3 años ± 8 meses. Los primeros y segundos molares maxilares distalizaron 2,16 ± 0,84 mm y 2,01 ± 0,69 mm respectivamente, pero también mantuvieron una ligera inclinación distal de 1.45° (mínimo 2.22°, máximo -6.45°) y 3.35° (mínimo 0.47°, máximo -15.48°) al final del tratamiento. El movimiento distal del primer molar maxilar contribuyó un 57,6% a la corrección del molar y un 42,4% fue debido a un movimiento mesial del primer molar mandibular (1,59 ± 0,46 mm). Los cambios dentoalveolares contribuyeron a la corrección del overjet: los incisivos maxilares se inclinaron hacia atrás 5.78° ± 3.17°, los incisivos inferiores se inclinaron hacia adelante 7.49 ± 4.52 y el plano oclusal rotó hacia abajo y hacia atrás 2.32° ± 2.10°. Fueron experimentados una rotación dextrorsa significativa de la mandibula (1,97° ± 1,32°) y un incremento considerable de la altura facial inferior (3,35 ± 1,48 mm). Ligera retrusión del labio superior (-1,76 ± 1,70 mm) y protrusión del labio inferior (0,96 ± 0,99 mm); sin embargo, estos cambios tuvieron un impacto descuidable en el cuadro clínico.*

Conclusiones: *Aunque la terapia de distalización de molares pueda llevarse a cabo en pacientes adultos, son de esperar una inclinación significativa hacia adelante de los incisivos inferiores, una rotación dextrorsa del plano oclusal y un incremento en la dimension facial vertical. Sin embargo, podría recomendarse este procedimiento faltando los terceros molares maxilares y en presencia de terceros molares mandibulares.*

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