

EFFECT OF THERAPEUTIC EXTRACTION ON THE SKELETAL, DENTAL AND SOFT TISSUE RELATIONS. A RETROSPECTIVE COHORT STUDY

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ABSTRACT

Objective: Therapeutic extraction to treat various malocclusion cases is frequently used in orthodontic treatment plans. The aim of this retrospective study was to assess and compare the effects of four first premolar extraction, upper first premolar extraction and non-extraction treatment plans on the anteroposterior and vertical skeletal relations, as well as their effects on the facial soft tissues.

Materials and Methods: Lateral cephalograms of 75 patients who received a non-extraction treatment plan (GP I), four first premolar extractions plan (GP II) and upper first premolar extraction plan (GP III) were selected. Each group comprised 25 pre and post lateral cephalograms of skeletal class 2 hyperdivergent cases. A number of skeletal and dental anteroposterior, vertical and soft tissue parameters were measured using WebCeph online software. Comparison between the three groups was done using Kruskal-Wallis test followed by Dunn's multiple comparisons test.

Results: There was insignificant change in the mandibular plane inclination and nasolabial angle across the three groups. Sagitally, insignificant differences were found in the SNA and SNB angles across the three groups, with similar change $(1.5^0 \pm 0.57)$ in ANB angle in both GP I and GP III. Both extraction groups showed more flattening of the upper and lower lips compared to the non-extraction group.

Conclusions: Therapeutic extraction of the first premolars had limited effects on the sagittal, anteroposterior and soft tissue relations.

KEYWORDS: Therapeutic extraction, premolars, lateral cephalometry, vertical dimension.

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Comprehensive orthodontic treatment is a complex procedure, and decisions regarding tooth extraction should be based on thorough assessment, diagnosis, and treatment planning. There has been a considerable debate over the years about the use of extractions in orthodontics¹, yet, the removal of permanent teeth remains an effective and predictable way to create space for the relief of crowding, allow correction of anteroposterior and midline discrepancies and improving lip relations^{2,3}. Due to their location between the anterior and posterior segments, the most frequently extracted teeth are the premolars (first and second) as this allows for the relief of both labial and buccal crowding and retraction of the labial segments²⁻⁴. In Angle Class I bimaxillary dentoalveolar protrusion, retraction of the maxillary and mandibular incisors is required to decrease facial convexity and achieve lip competency⁵⁻⁸, hence, improving facial esthetics. Others however, have reported that the influence of premolar extraction on facial profile attractiveness and vertical dimension is overestimated and should not be always preferred over the non-extraction approach⁹⁻¹². It is believed that first premolar extractions cause temporomandibular joint disorders due to the reduction of the vertical dimension ^{13,14}. According to the "wedge effect" concept, it is hypothesized that premolar extraction allows more mesial molar movement, causing a counterclockwise mandibular rotation that contributes to a decrease in the overbite¹⁵⁻¹⁷. However, many other trials negated this hypothesis and claimed that premolar extractions do not affect neither the joints nor the vertical dimension¹⁸⁻²⁴. Despite all the data available in the literature, the effect of therapeutic extraction of premolars on the facial skeleton and esthetics is still unclear.

In the era of digital orthodontics, artificial intelligence (AI) algorithms have widely spread in an attempt to improve and facilitate the process of diagnosis and treatment planning. Webceph ²⁵ is one of the recently used advances in digital cephalometry. It is an online based software that allows efficient and accurate landmark detection, soft and hard tissue analysis and data extraction^{26,27}. Using Webceph online platform to compare pre and post extraction lateral cephalograms, the aim of this retrospective study is to analyze the effect of therapeutic extraction of the first premolars on the skeletal (vertical and anteroposterior), dental and soft tissue relations.

MATERIALS AND METHODS:

Participants, eligibility and settings:

In this retrospective cohort study, pretreatment pre-debonding (post treatment) and lateral cephalometric radiographs of 75 adult male and female patients (16-25 years) who received their orthodontic treatment in the Department of Orthodontics, Faculty of Oral and Dental Medicine, Cairo University, were collected. Mild to moderate skeletal class 2 hyperdivergent cases who received upper and lower preadjusted fixed appliances with an MBT bracket prescription (0.022 x 0.028-inch slots) were selected. Cephalograms of patients who received treatment plans with intrusion, extrusion or distalization were excluded, as well as those with previous orthodontic or orthognathic treatments, spacing, congenitally missing or supernumerary teeth and craniofacial syndromes. The study was approved by the Research Ethics Committee of the Faculty (reference number: 33-11-23).

Records and data measurement:

The sample comprised three groups of 25 patients each:

- 1. Group I (GP I); lateral cephalograms of patients who received a non-extraction orthodontic treatment plan.
- 2. Group II (GP II); lateral cephalograms of

patients who had extraction of their four first premolars during their orthodontic treatment plan.

 Group III (GP III); lateral cephalograms of patients who had extraction of their upper first premolars only during their orthodontic treatment plan.

WebCeph²⁵ online software was used to identify the landmarks needed for the analysis²⁸ of all the lateral cephalograms included in the study (Table 1). To increase the accuracy of the measurements, the landmarks were manually adjusted when needed²⁶. Two experienced examiners (an orthodontist and an oral radiologist) who were blinded to the three groups, measured the pre- and post-treatment x-rays separately and the recorded measurements were then exported to an excel sheet for data collection (**fig. 1**).

Sample size was calculated by using Independent- t test (P.S. power 3.1.6) taking Porto et al ²⁹ results as a reference. Using the mean and

standard deviation of SN.GoGn (0.88 \pm 2.45), with an estimated mean difference of 2, power 0.8 and Type I error probability associated with this test of 0.05; 25 cases were needed in each group. Hence, pre and post-treatment lateral cephalograms of 75 cases (a total number of 150 lateral cephalograms) were included and measured using the Webceph software.

Statistical analysis:

both effectiveness efficiency For and measurements, quantitative data were expressed as means and SD. Shapiro-Wilk and Kolmogorov-Smirnov test were used to test the normality of the variables' distribution. All data originated from normal distribution (parametric data) resembling a normal Bell curve. Accordingly, comparison between pre and post measurements was performed by using Paired- t test. Comparison between the three groups was performed by using Kruskal-Wallis followed by Dunn's multiple comparisons test.



Fig. (1): The landmarks and analysis performed using the WebCeph software.

	Measurement	Definition
Anteroposterior	SNA (⁰)	Angle formed between SN plane and A point on the maxilla.
Skeletal	SNB (⁰)	Angle formed between SN plane and B point on the mandible.
measurements	ANB (⁰)	Measures the anteroposterior relationship of the maxilla and mandible.
	A-Nperp (mm)	Linear distance between A point and a perpendicular line from N (Nasion) to Frankfurt
		horizontal plane
	B- Nperp (mm)	Linear distance between B point and a perpendicular line from N (Nasion) to Frankfurt
		horizontal plane.
	Pog-Nperp (mm)	Linear distance between pogonion (Pog) point and a perpendicular line from N
		(Nasion) to Frankfurt horizontal plane.
Anteroposterior	U1/SN (°)	Upper central incisor inclination relative to the SN plane
Dental	U1/FH (°)	Upper central incisor inclination relative to the FH plane
measurements	U1/PP (⁰)	Upper central incisor inclination relative to the palatal plane
	IMPA (⁰)	Lower central incisor inclination relative to the mandibular plane
	U1/L1 (°)	Interincisal angle
	U1/FP (mm)	Upper central incisor position relative to the facial plane
Vertical Skeletal	FMA (⁰)	Frankfurt horizontal (FH) plane to MP derived by the line connecting the landmarks
Measurements		Go (gonion) and Me (Menton)
	SN/Go-Me (⁰)	The angle between sella nasion (SN) plane and mandibular plane (MP)
	$MMP(^{0})$	Maxillary-mandibular plane angle.
	TAFH (mm)	Total anterior facial height: The distance between nasion (N) and menton (Me)
	LAFH	Lower anterior facial height: The distance between anterior nasal spine (ANS) and Me.
	PFH/AFH (%)	Jaraback's Ratio: ratio between posterior facial height (The distance between sella (S)
		and gonion (Go) and anterior facial height).
Soft tissue	$NLA(^{0})$	Nasolabial angle
measurements	UL/E-line (mm)	Upper lip position relative to the E-line
	LL/E- line (mm)	Lower lip position relative to the E-line

TABLE (1) Definition of the cephalometric measurements used:

RESULTS

Participants and descriptive data

Since this is a retrospective study, there was no missing data or drop-outs and all the 150 cephalograms were measured and analyzed. The demographic data of the sample collected is shown in table 2.

Main results:

Intra and interobserver reliability tests showed excellent agreement (ICC>0.9) in all the measurements across the three groups and between the two observers. In GP I (Table 3), a significant increase in both the IMPA and L1/ A-Pog by $3.74^{\circ}\pm6.15$ (P=0.01) and 1.74 ± 2.11 (P=0.0001) respectively was recorded, together with a significant decrease in the U1/FH by $3.71^{\circ}\pm8.68$ (P=0.04).

In GP II, insignificant changes were detected among all the vertical skeletal and nearly all the anteroposterior dental measurements. A significant decrease was recorded in SNA and ANB angles of $1.97^{\circ}\pm3.74$ and $1.1^{\circ}\pm2.17$ respectively. The NLA remained unchanged while a significant decrease in both the UL-Eline and LL-Eline by 2.25 ± 2.5348 and 1.79 ± 2.10 (P=0.0001) respectively was detected (table 4). With the exception of the SNA, ANB, IMPA and L1/A-pog, all the anteroposterior parameters showed significant changes in GP III (table 5). The SNB significantly decreased by $1.00^{\circ}\pm 1.95$ (P=0.017) while a significant decrease was detected in U1/SN by $10.6^{\circ} \pm 9.18$. A significant increase was also detected in FMA by $2.02^{\circ}\pm 2.92$ leaving the rest of the vertical angular measurements unaffected. The NLA was also unaffected while the upper and lower lip measurements significantly decreased.

Comparison between the three treatment groups (table 6) demonstrated significant differences in all anteroposterior dental measurements. No significant differences were detected in the mandibular plane rotation across the three groups. Both extraction groups retracted the upper and lower lips equally as compared to the NE group.

TABLE (2)	Gender and	age distribution	in the three	e groups:

		Gr	oup I	Gro	oup II	Gro	P value	
GENDER	Male	7	28.0%	5	20.0%	3	12.0%	0.04
N(%)	Female	18	72.0%	20	80.0%	22	88.0%	0.36
Age M (SD)		18.24	2.37	18.40	2.87	20.72	4.65	0.02

*Significant difference as $P \le 0.05$.

Means with different superscript letters were significantly different as P < 0.05. Means with the same superscript letters were insignificantly different as P > 0.05.

			Group	I									
		F	Pre	I	Post		Std.	Std. Error	95% Con the	fidence Int Differenc	erval of e	t	P value
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Deviation	Mean	Lower	Upper			
Anteroposterior	SNA	81.46	3.93	80.89	4.40	0.58	1.84	0.37	-0.18	1.34	1.56	24.00	0.13
Skeletal Measurements	SNB	75.23	3.74	74.67	4.56	0.56	1.96	0.39	-0.25	1.37	1.43	24.00	0.17
	ANB	6.21	1.52	6.22	1.63	-0.01	1.20	0.24	-0.50	0.49	-0.03	24.00	0.98
	A-Nperp	2.85	3.50	1.58	3.35	1.27	2.38	0.48	0.29	2.26	2.68	24.00	0.01*
	B-Nperp	-6.25	5.40	-7.47	6.50	1.21	5.34	1.07	-0.99	3.42	1.14	24.00	0.27
	Pog-Nperp	-6.41	5.99	-8.53	6.34	2.12	4.28	0.86	0.35	3.88	2.47	24.00	0.02*
Anteroposterior	U1/SN	103.84	6.62	101.23	7.01	2.61	8.40	1.68	-0.86	6.08	1.55	24.00	0.13
Measurements	U1/FH	115.16	7.42	111.45	6.27	3.71	8.68	1.74	0.13	7.29	2.14	24.00	0.04*
	U1/PP	113.59	6.36	110.27	6.96	3.33	8.98	1.80	-0.38	7.03	1.85	24.00	0.08
	IMPA	96.19	7.16	99.94	5.61	-3.74	6.15	1.23	-6.28	-1.20	-3.04	24.00	0.01*
	U1/L1	119.08	10.82	118.28	8.73	0.80	11.66	2.33	-4.02	5.61	0.34	24.00	0.74
	U1-Facial Plane	13.72	4.27	13.36	2.59	0.36	2.84	0.57	-0.81	1.53	0.64	24.00	0.53
	L1/A-Pog	4.96	2.66	6.70	2.22	-1.74	2.11	0.42	-2.61	-0.87	-4.13	24.00	0.0001*

TABLE (3) Mean and standard deviation of pre and post measurements of Group I:

Vertical	FMA	29.57	2.85	30.93	4.08	-1.36	3.27	0.65	-2.71	-0.01	-2.08	24.00	0.05*
Skeletal Measurements	SN/ Go-Me	40.89	3.68	41.47	5.09	-0.58	2.94	0.59	-1.79	0.63	-0.99	24.00	0.33
(Angular)	MMP	31.34	3.86	31.47	3.45	-0.13	2.92	0.58	-1.34	1.07	-0.23	24.00	0.82
Vertical	TAFH	125.25	7.00	127.45	8.73	-2.19	5.56	1.11	-4.49	0.10	-1.97	24.00	0.06
Skeletal Measurements	LAFH	70.09	5.16	71.84	5.47	-1.75	3.27	0.65	-3.10	-0.40	-2.68	24.00	0.01*
(Linear)	PFH/AFH x100	60.15	2.70	59.86	3.63	0.28	2.36	0.47	-0.69	1.26	0.60	24.00	0.55
Soft Tissue	NLA	102.76	12.21	99.83	15.18	2.93	13.06	2.61	-2.46	8.32	1.12	24.00	0.27
Measurements	UL-Eline	45	2.44	89	2.26	0.44	1.71	0.34	-0.27	1.15	1.28	24.00	0.21
	LL-Eline	1.51	3.28	1.78	2.53	-0.27	2.20	0.44	-1.18	0.64	-0.61	24.00	0.55

*Significant difference as P<0.05.

TABLE (4) Mean and standard deviation of pre and post measurements of Group II, comparison between them using Paired t test:

		Group IIA					1				-		
			Pre		Post		Std.	Std.	95% Conf of the	idence Interval Difference	t	df	P value
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Deviation	Error Mean	Lower	Upper			
Anteroposterior Skeletal Measurements	SNA	82.50	4.77	80.53	4.24	1.97	3.74	0.75	0.43	3.51	2.63	24.00	0.015*
	SNB	75.84	4.95	74.97	3.97	0.87	3.73	0.75	-0.67	2.41	1.16	24.00	0.256
	ANB	6.66	1.45	5.56	2.03	1.10	2.17	0.43	0.20	2.00	2.53	24.00	0.018*
	A-Nperp	2.40	4.41	0.87	4.84	1.52	4.31	0.86	-0.26	3.31	1.77	24.00	0.090
	B-Nperp	-8.42	7.12	-8.66	7.42	0.24	6.17	1.23	-2.31	2.78	0.19	24.00	0.849
	Pog-Nperp	-9.74	7.76	-10.17	8.13	0.43	6.63	1.33	-2.31	3.16	0.32	24.00	0.750
Anteroposterior	U1/SN	103.89	9.56	99.56	6.92	4.33	11.67	2.33	-0.49	9.15	1.86	24.00	0.076
Dental Measurements	U1/FH	113.75	9.09	109.94	7.44	3.81	10.96	2.19	-0.72	8.33	1.74	24.00	0.095
	U1/PP	113.62	10.19	109.53	6.97	4.09	11.34	2.27	-0.59	8.77	1.80	24.00	0.084
	IMPA	96.05	7.96	93.23	6.18	2.82	8.08	1.62	-0.51	6.16	1.75	24.00	0.093
	U1/L1	117.14	15.41	123.85	9.46	-6.71	16.03	3.21	-13.32	-0.09	-2.09	24.00	0.047*
	U1-Facial Plane	16.10	5.05	11.74	2.66	4.36	4.41	0.88	2.54	6.18	4.94	24.00	0.0001*
	L1/A-Pog	6.96	4.25	5.05	2.09	1.90	3.63	0.73	0.40	3.40	2.62	24.00	0.015*
Vertical Skeletal	FMA	33.05	3.42	32.98	5.26	0.07	4.41	0.88	-1.75	1.90	0.08	24.00	0.934
(Angular)	SN/ Go-Me	42.91	5.03	43.36	5.45	-0.45	3.96	0.79	-2.09	1.19	-0.57	24.00	0.576
(i inguini)	MMP	33.18	3.96	33.39	5.30	-0.21	3.69	0.74	-1.73	1.32	-0.28	24.00	0.781
Vertical Skeletal	TAFH	133.60	13.92	129.22	9.09	4.38	15.67	3.13	-2.09	10.85	1.40	24.00	0.175
Measurements (Linear)	LAFH	76.88	10.29	73.92	5.57	2.96	10.18	2.04	-1.24	7.16	1.45	24.00	0.159
(121110417)	PFH/AFH x100	58.67	4.24	58.65	3.96	0.02	3.42	0.68	-1.39	1.43	0.03	24.00	0.979
Soft Tissue	NLA	103.46	17.22	102.00	16.62	1.46	18.10	3.62	-6.01	8.93	0.40	24.00	0.690
Measurements	UL-Eline	-0.37	3.24	-2.62	2.80	2.25	2.53	0.51	1.21	3.30	4.45	24.00	0.0001*
	LL-Eline	1.62	3.27	-0.17	2.63	1.79	2.10	0.42	0.92	2.66	4.27	24.00	0.0001*

*Significant difference as P<0.05.

			Grou	ıp IIB			Paireo						
			Pre		Post	Mean	Std.	Std. Error	95% Confidence Interval of the Difference		t –	df	P value
		Mean	Standard Deviation	Mean	Standard Deviation		Deviation	Mean	Lower	Upper			
Anteroposterior	SNA	81.82	3.73	81.22	3.03	0.60	2.68	0.54	-0.50	1.70	1.12	24.00	0.273
Measurements	SNB	75.97	4.27	74.97	4.12	1.00	1.95	0.39	0.20	1.81	2.57	24.00	0.017*
	ANB	5.86	1.34	6.26	2.64	-0.40	1.87	0.37	-1.17	0.37	-1.07	24.00	0.294
	A-Nperp	2.15	3.05	05	4.65	2.02	3.76	0.77	0.43	3.61	2.62	23.00	0.015*
	B-Nperp	-7.21	5.29	-10.53	5.71	3.32	4.79	0.96	1.35	5.30	3.47	24.00	0.002*
	Pog-Nperp	-7.99	6.45	-11.31	5.64	3.32	3.82	0.76	1.74	4.90	4.35	24.00	0.0001*
Anteroposterior	U1/SN	108.00	11.86	97.40	8.68	10.60	9.18	1.84	6.81	14.39	5.77	24.00	0.0001*
Measurements	U1/FH	118.24	10.01	106.21	6.76	12.03	10.46	2.09	7.71	16.34	5.75	24.00	0.0001*
	U1/PP	116.86	9.45	106.30	6.99	10.56	9.52	1.90	6.63	14.49	5.55	24.00	0.0001*
	IMPA	96.04	7.10	98.08	6.67	-2.04	7.35	1.47	-5.07	1.00	-1.39	24.00	0.179
	U1/L1	116.65	11.25	124.35	9.54	-7.69	13.44	2.69	-13.24	-2.15	-2.86	24.00	0.009*
	U1-Facial Plane	16.52	4.16	11.21	3.46	5.31	4.54	0.91	3.44	7.18	5.85	24.00	0.0001*
	L1/A-Pog	4.70	2.55	4.52	2.47	0.18	1.99	0.40	-0.64	1.00	0.45	24.00	0.659
Vertical Skeletal	FMA	29.83	4.04	31.85	3.62	-2.02	2.92	0.58	-3.22	-0.81	-3.46	24.00	0.002*
(Angular)	SN/ Go-Me	39.55	5.65	40.34	6.06	-0.79	2.22	0.44	-1.71	0.13	-1.78	24.00	0.088
	MMP	31.56	4.29	32.03	3.68	-0.47	1.40	0.28	-1.05	0.11	-1.68	24.00	0.107
Vertical Skeletal	TAFH	126.92	21.52	123.91	8.61	3.01	20.75	4.15	-5.56	11.58	0.73	24.00	0.475
(Linear)	LAFH	71.35	13.88	69.81	5.99	1.55	12.34	2.47	-3.55	6.64	0.63	24.00	0.537
	PFH/AFH x100	60.72	4.23	60.33	4.45	0.39	2.27	0.45	-0.54	1.33	0.87	24.00	0.394
Soft Tissue Measurements	NLA	101.09	9.15	103.73	7.65	-2.64	9.60	1.92	-6.60	1.32	-1.38	24.00	0.182
	UL-Eline	.09	2.50	-1.86	2.60	1.95	2.09	0.42	1.09	2.81	4.68	24.00	0.0001*
	LL-Eline	2.04	3.01	31	2.34	2.34	2.63	0.53	1.26	3.43	4.45	24.00	0.0001*

TABLE (5) Mean and standard deviation of pre and post measurements of group III, comparison between them using Paired t test:

*Significant difference as P<0.05.

TABLE (6) Mean difference and standard deviation between pre and post measurements of all three groups, comparison between them using Kruskal Walis test followed by Dunn's multiple comparisons test:

			Group							Paired difference						
		GI			GII	(3111	P value	group I vs Group II		group I vs Group III		group Grou	II vs p III		
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	-	MD	SE	MD	SE	MD	SE		
Anteroposterior	SNA	-0.58 a	1.84	-1.97 a	3.74	-0.6 a	2.68	0.23	1.39	0.83	0.02	0.65	-1.37	0.92		
Skeletal Measurements	SNB	-0.56 a	1.96	-0.87 a	3.73	-1 a	1.95	0.67	0.31	0.84	0.44	0.55	0.13	0.84		
	ANB	0.006 a	1.2	-1.1 b	2.17	0.400 ab	1.87	0.004*	1.11	0.50	-0.39	0.44	-1.50	0.57		
	A-Nperp	-1.27 a	2.38	-1.52 a	4.31	-1.94 a	3.71	0.83	0.25	0.99	0.66	0.88	0.41	1.14		
	B-Nperp	-1.21 a	5.34	-0.24 a	6.17	-3.32 a	4.79	0.17	-0.98	1.63	2.11	1.43	3.09	1.56		
	Pog-Nperp	-2.12 a	4.28	-0.43 a	6.63	-3.32 a	3.82	0.12	-1.69	1.58	1.20	1.15	2.89	1.53		
Anteroposterior	U1/SN	-2.61 a	8.40	-4.33 ab	11.67	-10.60 b	9.18	0.01*	1.72	2.88	7.99	2.49	6.27	2.97		
Dental Measurements	U1/FH	-3.71 a	8.68	-3.81 ab	10.96	-12.03 b	10.46	0.01*	0.10	2.80	8.32	2.72	8.22	3.03		
	U1/PP	-3.33 a	8.98	-4.09 ab	11.34	-10.56 b	9.52	0.02*	0.76	2.89	7.23	2.62	6.47	2.96		
	IMPA	3.74 a	6.15	-2.82 b	8.08	2.04 ab	7.35	0.005*	6.57	2.03	1.71	1.92	-4.86	2.18		
	U1/L1	-0.80 a	11.66	6.71 ab	16.03	7.69 b	13.44	0.02*	-7.50	3.96	-8.49	3.56	-0.99	4.18		
	U1-Facial Plane	-0.36 a	2.84	-4.36 b	4.41	-5.31 b	4.54	0.0001*	4.00	1.05	4.95	1.07	0.95	1.27		
	L1/A-Pog	1.74 a	2.11	-1.90 b	3.63	-0.18 b	1.99	0.0001*	3.64	0.84	1.92	0.58	-1.72	0.83		
Vertical Skeletal	FMA	1.36 a	3.27	-0.07 a	4.41	2.02 a	2.92	0.16	1.43	1.10	-0.66	0.88	-2.09	1.06		
(Angular)	SN/ Go-Me	0.58 a	2.94	0.45 a	3.96	0.79 a	2.22	0.88	0.13	0.99	-0.21	0.74	-0.34	0.91		
	MMP	0.13 a	2.92	0.21 a	3.69	0.47 a	1.4	0.73	-0.07	0.94	-0.34	0.65	-0.26	0.79		
Vertical Skeletal	TAFH	2.19 a	5.56	-4.38 b	15.67	-3.01 ab	20.75	0.04*	6.58	3.33	5.21	4.30	-1.37	5.20		
Measurements (Linear)	LAFH	1.75 a	3.27	-2.96 b	10.18	-1.55 ab	12.34	0.04*	4.71	2.14	3.30	2.55	-1.41	3.20		
	PFH/AFH x100	-0.28 a	2.36	-0.02 a	3.42	-0.39 a	2.27	0.91	-0.26	0.83	0.11	0.65	0.37	0.82		
Soft Tissue	NLA	-2.93 a	13.06	-1.46 s	18.1	2.64 a	9.6	0.25	-1.47	4.46	-5.57	3.24	-4.10	4.10		
Measurements	UL-Eline	-0.44 a	1.71	-2.25 b	2.53	-1.95 b	2.09	0.002*	1.81	0.61	1.51	0.54	-0.30	0.66		
	LL-Eline	0.27 a	2.2	-1.79 b	2.10	-2.34 b	2.63	0.0001*	2.06	0.61	2.61	0.69	0.55	0.67		

*Significant difference as P<0.05.

Means with the same superscript letters were insignificantly different as P>0.05.

Means with different superscript letters were significantly different as P<0.05.

DISCUSSION

Diving deeper into the effects of therapeutic extraction can definitely affect our future extraction decisions in every treatment plan. Despite the available data regarding this topic, our knowledge as orthodontists still runs thin as there is weak/ insufficient evidence^{24,30} supporting the effects of premolar extraction on the skeletal, dental and soft tissues.

Key results

The current study aimed to evaluate the shortterm effects of the most commonly extracted teeth in orthodontics; four and upper first premolars. Our results revealed that therapeutic extraction of either the upper first premolars or all the 4 first premolars didn't affect neither the mandibular plane inclination nor the vertical skeletal pattern as compared to the non-extraction group. Both extraction groups reduced the upper incisor inclination equally and allowed more flattening of the upper and lower lips compared to NE group. Regarding the sagittal cephalometric parameters, none of the treatment modalities had a significant effect on points A, B or Pog. However, there was a statistically significant yet clinically modest decrease in the ANB angle by $1.11^{0}\pm0.5$ in the four 4's extraction group compared to the NE group.

An increased overjet and proclined incisors are characteristic features of class II div 1. In cases with moderate skeletal discrepancies and protruded lips, extraction of the upper premolars is usually performed for improvement of the soft tissue profile and lip relationship^{6,31}. In the current study, extraction of the U4's allowed more upper incisor uprighting and retraction where their inclination was significantly decreased as compared to the non-extraction (7.99^o± 2.49). The lower incisors inclination was similar in both extraction groups and was significantly increased in the non-extraction group. Despite the huge amount of anterior segment retraction in both extraction groups, a significant decrease of $1.97^{0\pm} 3.74$ in the SNA angle was only detected in the four premolars extraction group with insignificant differences between the rest of the treatment groups. It was reported that both points A and B are affected by dentoalveolar bone remodeling with orthodontic treatment and growth³² where each 10⁰ of upper incisor retroclination result in a change of 0.4mm horizontally and 0.6mm superiorly³³. Agreeing with our results, other trials ^{9,34} reported insignificant changes in skeletal sagittal cephalometric parameters despite pronounced retraction of the upper incisors.

A significant decrease in the SNB, B/N-perp and Pog/N-perp were noticed in GP III. This could be linked to the increase in the mandibular plane rotation (FMA = $2.02^{\circ} \pm 2.92$) also recorded in this group. The inevitable vertical component of the class II elastics (regularly used with almost all class II div2 cases requiring U4's extraction) might have caused lower molar extrusion, producing a modest mandibular backward rotation with the backward displacement of points B and Pog. In accordance with this finding, it was previously reported²⁰ that premolar extractions do not decrease the vertical relations but either maintain or slightly increase the vertical dimensions. Yet, the modest increase in the FMA value described in this study didn't seem to alter any other vertical relationship and was insignificant when compared to the rest of the treatment groups. This conclusion augments other findings negating the effect of premolar extraction on the skeletal sagittal and vertical dimensions^{9,36}, and questioning the concept of the wedge effect ^{29,30,35-36}

Regarding the soft tissue relations, extraction of the 1st premolars did affect the soft tissue profile were the upper and lower lips were significantly retracted in both extraction groups. Similar to the results of our study, a trial comparing the soft tissue profile silhouettes of patients who received four premolar extraction and a NE treatment protocol reported that soft-tissue changes were highly significant in the extraction group, but both treatment modalities did not significantly affect the skeletal parameters as seen on the lateral cephalogram ¹⁰. Lim et al⁷ reported a clinically insignificant retraction and flattening of the upper lip following four premolar extractions. On the other hand, flattening of the NLA after premolar extraction is reported in the literature^{6,9,12,30} and with a flattening up to 6.4⁰ ¹², without producing deleterious effects on the facial profile.

Limitations:

It is worth mentioning that minimal residual growth was expected to affect the results of this study since the average age of the samples in Groups I, II and III was 18.24 ± 2.3 , 18.4 ± 2.87 and 20.72 \pm 4.65 years respectively. In all the three treatment groups, patients who underwent any intrusive, extrusive or molar distalization mechanics in their treatment plans were not included in the study to avoid any confounding factors that might affect the skeletal and soft tissue relationships37-40. Despite this, our study is still limited by being retrospective in nature, which did not allow blinding of the operator and by not specifying neither the amount of initial crowding and overjet nor the type of anchorage requirements needed in each case. To overcome such limitations, randomized prospective studies are recommended.

Generalizability:

The interpreted results of this study allow the understanding the effects of therapeutic extraction of the first premolars in mild to moderate skeletal class 2 hyperdivergent male and female patients during orthodontic treatment.

CONCLUSIONS

Within the aforementioned limitations of the current study, as compared to a non-extraction treatment plan, the following can be concluded:

- 1. Extraction of four 1st premolars and upper premolars didn't affect the sagittal skeletal measurements. None of the treatment modalities had any effect on point A or B.
- 2. Extraction of four 1st premolars and upper premolars didn't affect the vertical skeletal relations.
- 3. Both extraction groups equally flattened the soft tissue facial profile.

List of Abbreviations:

- Artificial intelligence: AI
- Group: GP
- Upper 1st premolars: U4's
- Four 1st premolars: 44's
- Non-extraction: NE

Declarations:

Ethical approval and consent to participate:

The study was approved by the Research Ethics Committee of the Faculty of Oral and Dental Medicine, Cairo University (Code number: 33- 11-23). All methods were carried out in accordance with relevant guidelines and regulations. A written informed consent was taken from each patient participating in this study.

Consent for publication:

Not applicable.

Availability of data and materials:

The datasets used and/or analysed during the current study are available from the corresponding author (email: <u>nouran.fouad@dentistry.cu.edu.eg</u>) on reasonable request.

Competing Interests:

The authors declare that they have no competing interests.

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Authors' Contributions:

NS came out with the idea and design of this research. NA constructed the analysis performed on the software and measured the samples. AE and NE both analyzed and interpreted measurements obtained. NS wrote the main manuscript file and all authors shared in editing, reviewing and approving the final manuscript.

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