J Stomatol Oral Maxillofac Surg 125 (2024) 101748

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com

Original Article

Nasal profile changes after orthodontic tooth extraction in Class II, Division 1 malocclusion patients: A retrospective study

Sanaz Sadry[a], Ela Eusmanaga[c], Emre Kayalar[b,c,*]

[a] Department of Orthodontics, Faculty of Dentistry, Istanbul Atlas University, Istanbul, Turkey
[b] Discipline of Orthodontics and Paediatric Dentistry, School of Dentistry, The University of Sydney, Sydney Dental Hospital, Surry Hills, Australia
[c] Department of Orthodontics, Faculty of Dentistry, Istanbul Aydin University, Istanbul, Turkey

ARTICLE INFO

Article History:
Received 17 August 2023
Accepted 20 December 2023
Available online 7 January 2024

Keywords:
Tooth extraction
Nose morphology
Aesthetics
Cephalometry

ABSTRACT

Introduction: This study aimed to investigate changes in the facial soft-tissue profile, especially the nose, following fixed orthodontic treatment, with or without tooth extraction, in individuals diagnosed with dental Class II malocclusion.
Materials and methods: Cephalometric images of 81 individuals with dental Class II malocclusion who underwent fixed orthodontic treatment were assessed before and after treatment. The participants were categorized into three groups: non-extraction; upper first premolar extraction; and four first premolar extractions. The parameters measured were: upper lip height, upper lip to E-plane, lower lip to E-plane, lower lip height, nasolabial angle, nasomental angle, facial convexity, lower anterior face height, soft-tissue facial convexity, nasal tip angle, nasal bridge length, N′-nasal bridge point, nasal bone length, nasal bone angle, nasal depth, columella convexity, and nose height.
Results: Within the upper two extraction group, there were significant increases at the start and end periods in nasolabial angle ($P = 0.023$), nasal depth Pr to Ac ($P = 0.027$), and nasal depth Pr to N-Prn ($P = 0.040$); and decreases in columella convexity ($P = 0.010$), upper lip to E-plane ($P = 0.009$), and nasomental angle ($P = 0.009$). There were significant results in comparisons between measurements based on the extraction status in the mean nasolabial angle ($P = 0.011$), mean columella convexity ($P = 0.028$), and mean lower lip to E-plane ($P = 0.045$).
Conclusion: Orthodontic treatment involving tooth extraction may potentially affect the nasolabial angle and nasal depth. During treatment planning, it is crucial to consider the potential changes that may occur to the nose and any alterations that may be needed to achieve the desired esthetic outcome.

1. Introduction

Debate over the outcomes of orthodontic treatment after premolar extraction continues to be a topic of substantial interest and an area for comprehensive research [1]. Orthodontists often express concern regarding the potential negative impact of premolar extraction on facial aesthetics. Numerous investigations have explored this influence, reporting conflicting results [2–10]. In a systematic review, Konstantonis et al. [2] concluded that extraction treatment was associated with increases in upper and lower lip retraction and in the nasolabial angle, and changes in soft-tissue profile convexity. Some studies have indicated that premolar extraction results in a flatter facial profile [4,7,10]. Another systematic review suggested that premolar extraction resulted in a slightly more concave lip profile due to incisor retraction, in comparison with a non-extraction group [3]. On the other hand, some studies have disputed this claim, asserting that if premolar extraction is carried out according to appropriate diagnostic criteria, it should not adversely affect the facial profile in most cases [5,10]. It can even improve the frontal profile when it is performed in bimaxillary protrusion cases [9]. Historically, "extraction orthodontic treatment" meant the removal of the first premolar teeth, until Nance [11] challenged this practice by suggesting that removing the second premolar teeth results in less alteration to a patient's soft-tissue profile. This suggestion was supported by a study that measured the Holdaway soft-tissue angle and concluded that the group with four first premolar extractions had poorer outcomes in comparison with other extraction patterns. In another study, Omar et al. [6] found contradictory results, as no significant differences were detected for upper and lower lip positions with first or second

* Corresponding author at: Department of Orthodontics, Faculty of Dentistry, Istanbul Aydin University, Besyol mah, Inonu cad, Akasya sok, No:6, Kucukcekmece, Istanbul, 34295, Turkey. & Discipline of Orthodontics and Paediatric Dentistry, School of Dentistry, The University of Sydney, Sydney Dental Hospital, 2 Chalmers St, Surry Hills, NSW 2010, Australia.
E-mail addresses: emre.kayalar@sydney.edu.au, emrekayalar@aydin.edu.tr (E. Kayalar).

https://doi.org/10.1016/j.jormas.2023.101748

premolar extraction, and less than one degree of change for the nasolabial angle.

Harmony and balance among the various components of the face contribute to a well-proportioned facial structure. The nose, located centrally on the face, plays a crucial role in determining an individual's distinctive appearance [12]. In addition, orthodontic treatment also has an age-related perspective. For this reason, during treatment planning orthodontists should always bear in mind the dynamic changes that occur with age and their direct influence on the nose and lips. Posen noted that typical nasal bone growth is a linear process from the ages of 3 months to 13 years, with growth spurts at 15 and 18 years. Notably, facial profiles that appear harmonious when an individual is 13 can undergo significant changes by the age of 18 [13].

In recent years, the field of orthodontics has witnessed a growing awareness of the importance of contemporary esthetic norms. For this reason, when determining treatment options, it is essential to enhance the esthetic appeal instead of strictly and exclusively adhering to cephalometric norms, as emphasized by Profitt in his soft-tissue paradigm [12]. As society's perception of facial aesthetics continues to evolve, orthodontists are increasingly challenged to strike a balance between functional occlusion and harmonious facial features [14]. The present article aims to fill an existing gap in reports assessing the impact of tooth extraction on the nose and facial soft tissues during orthodontic treatment.

The specific aims of this study were: (1) to examine whether there were any changes in the nasal profile after orthodontic treatment involving the extraction of maxillary first premolars, maxillary and mandibular first premolars, or non-extraction treatment; and (2) to assess whether the nasal profile changes were greater when maxillary first premolars were extracted in comparison with maxillary and mandibular first premolars.

2. Materials and methods

2.1. Study design

This retrospective cohort study involved analyzing cephalometric x-rays of patients categorized into three groups: Group A (no tooth extraction), Group B (upper two premolar teeth extracted), and Group C (four premolars extracted). The total sample size was determined to be n = 81, based on face convexity angle data from a previous study [15], with an effect size of 0.4, a power of 80%, and a margin of error of 0.05, as calculated by the G-Power program. The cephalometric x-ray samples were obtained from the XXX Orthodontics Department archive, with at least 27 x-rays being selected from each group. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki for medical research involving human subjects. The study received approval from the local ethics committee on September 15th, 2021, with the reference number XXX/XXX.

The study was conducted on a total of 81 patients, with ages ranging from 13 to 40 years, of whom 49 (60.5%) were female and 32 (39.5%) were male. Their mean age was 18.93 ± 4.82 years. The patients were evaluated in three groups: "non-extraction" (n = 24), "upper two premolar extractions" (n = 25), and "four premolar extractions" (n = 32). Table 1 lists the mean ages and gender of the groups.

The investigation of patient records in the Orthodontics Department archive involved a comprehensive analysis of both cephalometric x-rays and clinical files for patients treated by the same specialist between 2015 and 2021. The patients' records were included in the study if they had Angle dental Class II malocclusion on both sides, pretreatment and post-treatment cephalograms were available without imaging errors, and the patients had a need for comprehensive labial fixed orthodontic treatment as per the American Board of Orthodontists (ABO) index. For patients requiring tooth extraction, Hayes−Nance analysis was performed, involving the subtraction of the required arch length from the patient's existing arch length to assess crowding. This analysis was conducted on individuals in Group B and Group C. Patients with pretreatment crowding greater than or equal to 5 mm were included in the extraction groups. For all three groups, patients with complete records and compliance with the treatment plan were included. Exclusion criteria encompassed patients with craniofacial anomalies, cleft lip and palate, syndromes, or any systemic conditions affecting growth, as well as those with a history of facial trauma or tumors, severe skeletal discrepancies necessitating orthognathic surgery, supernumerary teeth and/or peg lateral teeth, missing or impacted teeth (except for wisdom teeth), active caries, poor oral hygiene, a previous history of orthodontic treatment, orthognathic or rhinoplasty surgery, or functional orthopedic treatment. Before being included, each patient was assessed to determine the occlusal and esthetic outcomes at the end of treatment. A positive occlusal result was determined on the basis of a subjective evaluation of factors using the American Board of Orthodontists (ABO) index. The same evaluations followed for defining normal occlusion. Achieving a complete Class II molar relationship alongside a Class I canine relationship was deemed indicative of a favorable outcome for patients with upper two first premolar extractions.

Table 1
Evaluation of groups in terms of age and gender.

		Non-extraction n (%)	Upper 2 extraction n (%)	4 x 4 extraction n (%)	p
Age	<18	11 (%45,8)	11 (%44)	14 (%43,8)	0,987
	>18	13 (%54,2)	14 (%56)	18 (%56,3)	
Gender	Female	16 (%66,7)	16 (%64)	17 (%53,1)	0,538
	Male	8 (%33,3)	9 (%36)	15 (%46,9)	

Chi-square test.

Our main hypothesis was that changes in the nose and facial soft-tissue profile following fixed orthodontic treatment would be influenced by the extraction pattern. The secondary hypothesis was that in patients with four extractions, the nasal profile would be affected more than in patients with two maxillary premolar extractions.

2.2. Cephalometric analysis

Twenty points were defined for each cephalogram, and 12 linear and six angular measurements were obtained (Fig. 1). The cephalometric films for all the patients were reviewed by a single researcher. The Planmeca 2011−05 Proline Pan/Ceph X-ray device (Planmeca, Helsinki, Finland) was used to obtain the lateral cephalometric radiographs. The Facad 3.8 trial version software program (Ilexis AB, Linkoping, Sweden) was utilized to analyze the cephalometric parameters, as illustrated in Fig. 1.

Out of the sample pool, 40 cephalometric radiographs were chosen at random and reevaluated after a period of 4 weeks. The measurements were analyzed for intraclass correlation coefficients, which were found to be greater than 0.990. The cephalometric x-rays were marked with anatomical points located on the cranial bones and soft tissues of the face, as shown in Fig. 1.The linear and angular measurements obtained from the points on the cephalometric x-rays before and after orthodontic treatment are shown in Figs. 2 and 3 and explained in Table 2.

2.3. Statistical analysis

The results obtained in the study were evaluated using the IBM SPSS Statistics program for statistical analysis, version 22. The normal distribution of parameters was evaluated using the Kolmogorov

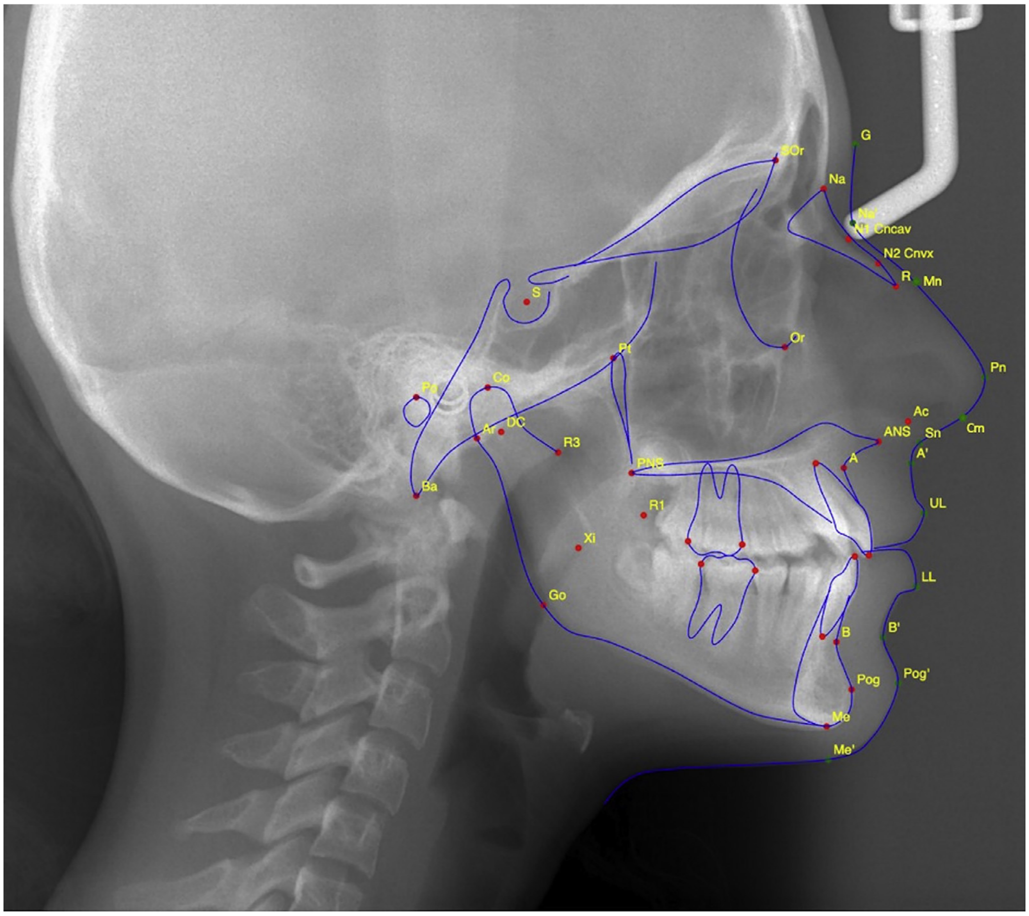

Fig. 1. Point Cephalometric landmarks,
-Soft-tissue glabella (G'): Most prominent or anterior point in the mid sagittal plane of the forehead.
-Soft-tissue nasion (N'): The point of greatest concavity in the midline between the forehead and the nose -Midnasale (Mn): The halfway point on nasal length (N'-Pr) that divides the dorsum into upper and lower dorsum
-N1: The most concave point of the nasal bone
-N2: The most convex point of the nasal bone
-Rhinion (R): The most anterior and inferior point on the tip of the nasal bone
-Pronasale (Pr): The tip of nose (nasal tip)
-Columella (Cm): The most convex point on the columellar-lobular junction
-Subnasale (Sn): The point at which the columella merges with the upper lip in the mid-sagittal plane
-Alar curvature point (Ac): The most convex point on the nasal alar curvature
-A: The point located at the deepest midpoint concavity on the maxilla between the anterior nasal spine and prosthion.

−Smirnov and Shapiro−Wilks tests. In the evaluation of study data, besides descriptive statistical methods (mean, standard deviation, frequency), one-way analysis of variance (ANOVA) testing was used to compare parameters showing a normal distribution among the groups, and Tukey's honest significant difference (HSD) test was used to determine the group causing the difference. The Kruskal−Wallis test was used for comparison of parameters that did not show a normal distribution among the groups, and Dunn's test was used to determine the group causing the difference. Paired-sample *t*-testing was used for within-group comparisons of parameters with a normal distribution, and Wilcoxon's signed rank test was used for within-group comparisons of parameters without a normal distribution. The chi-square test was used to compare qualitative data. Significance was set at the level of $P < 0.05$.

2.4. Ethics statement

We confirm that in this study we have adhered to all regulations outlined in the "Higher Education Institutions Scientific Research and Publication Ethics Directive," and that we have not committed any acts deemed "Actions Contrary to Scientific Research and Publication Ethics."

The research study adhered to the ethical principles outlined in the Declaration of Helsinki for medical research involving human subjects. The study was granted approval by the ethics committee at Istanbul Aydin University with reference number 2021/556 and a date of approval of September 15th, 2021.

3. Results

3.1. Sample characteristics

The records for 124 patients who met the inclusion criteria were reviewed. Among them, patients were eliminated due to a lack of high-quality records or meeting one of the exclusion criteria. The final sample consisted of 81 patients divided between groups A, B, and C. The age and gender of the sample in each group and the initial pretreatment values are outlined in Table 1.

The findings presented in Table 3 show the results obtained from comparing the groups within themselves by periods. The decrease in the nasal tip angle was statistically significant ($P = 0.005$). The reduction seen in the average columella convexity was also statistically

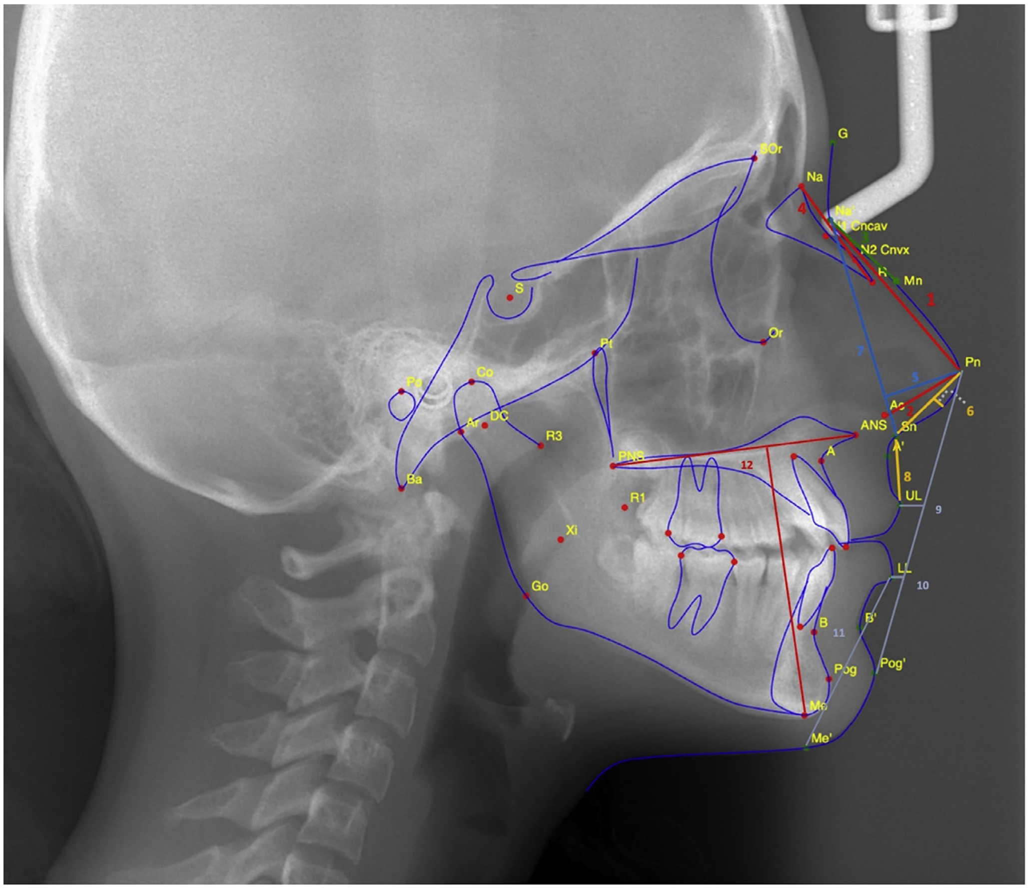

Fig. 2. Linear measurments, 1) Nasal Bridge Length (N-prn), 2) Nasal Depth (Pr-Ac), 3)Hump (N'-Nasal bridge point), 4)Nasal bone length (N-R), 5)Nasal depth (Pr to N'-Sn), 6)Columella convexity (Columella-Pr-Sn), 7)Nose Height (N'-Sn), 8)Upper lip height, 9)Upper lip to E-plane, 10)Lower lip to E-plane, 11)Lower lip height, 12)Lower anterior face height.

significant (P = 0.010). The table also presents the results obtained from comparison of the upper-two extraction group within itself by periods. Statistically significant increases were observed in nasal depth Pr to Ac (P = 0.027), nasal depth Pr to N-Prn (P = 0.040), and in the nasolabial angle (P = 0.023). The decreases observed in columella convexity (P = 0.010), upper lip to E-plane (P = 0.009), and nasomental angle were statistically significant (P = 0.009).

Comparison of the four-extraction group within itself also showed increases in the mean nasal bridge length (P = 0.014), nasal depth Pr to Ac (P = 0.038), nose height (P = 0.026), upper lip height (P = 0.018), lower lip to E-plane (P = 0.002), lower lip height, and lower anterior face height (P = 0.005) that were statistically significant (P = 0.011). The decrease in facial convexity observed was statistically significant (P = 0.026).

The results of comparison between the measurements on the basis of extraction status are presented in Table 4. There was a statistically significant difference between the groups with regard to the mean nasolabial angle (P = 0.011) in the upper-two extraction group. There were statistically significant differences in mean columella convexity (P = 0.028) and mean lower lip to E-plane (P = 0.045). The significance originated in the decrease observed in the four-extraction group and the increase observed in the non-extraction group.

In another comparison, the patients were divided into two age groups — those under 18 years old and those over 18 years old (Table 5), and comparisons were made to identify differences between the groups relative to the extraction pattern. There were no significant differences between the groups with regard to the amount of change seen in the study parameters in patients under the age of 18 ($P > 0.05$). However, in patients over 18 years old, there was a statistically significant difference (P = 0.046) between the groups in the lower lip to E-plane. There was also a statistically significant difference (P = 0.021) in the nasolabial angle.

4. Discussion

The aim of this study was to assess changes in the nasal profile after orthodontic tooth extraction treatment. The measurements used were mostly adopted from a study conducted by Umale et al. [16] to evaluate sexual dimorphism in nasal proportions of Class I and Class II skeletal malocclusions. To eliminate changes related to malocclusion, only Class II patients were selected in the present study. The same parameters were also used in a systematic review assessing nasal profile [17].

Many studies have indicated that the impact of premolar extraction on the facial profile is often exaggerated in most cases [3,5,10]. However, Kocadereli [18] suggested that extracting premolars can negatively affect facial aesthetics by causing a flattening of the facial profile due to retraction of the upper and lower lips. In addition, a study by Freitas et al. [19] to analyze soft-tissue facial profile changes after orthodontic treatment, with or without tooth extraction, found that only the interlabial angle and H.NB angle showed statistically significant changes after treatment, resulting in a less convex facial profile with lip retraction. Their findings suggest that changes in the soft-tissue facial profile are similar in Class I patients treated with or without tooth extraction. Verma et al. [20] also reported that changes in the N′-Sn-Pog′ angle showed that the soft-tissue profile, excluding the nose, developed a less convex form in the extraction group and became more convex in the non-extraction group. In the present study, the results were similar in the four-premolar extraction group,

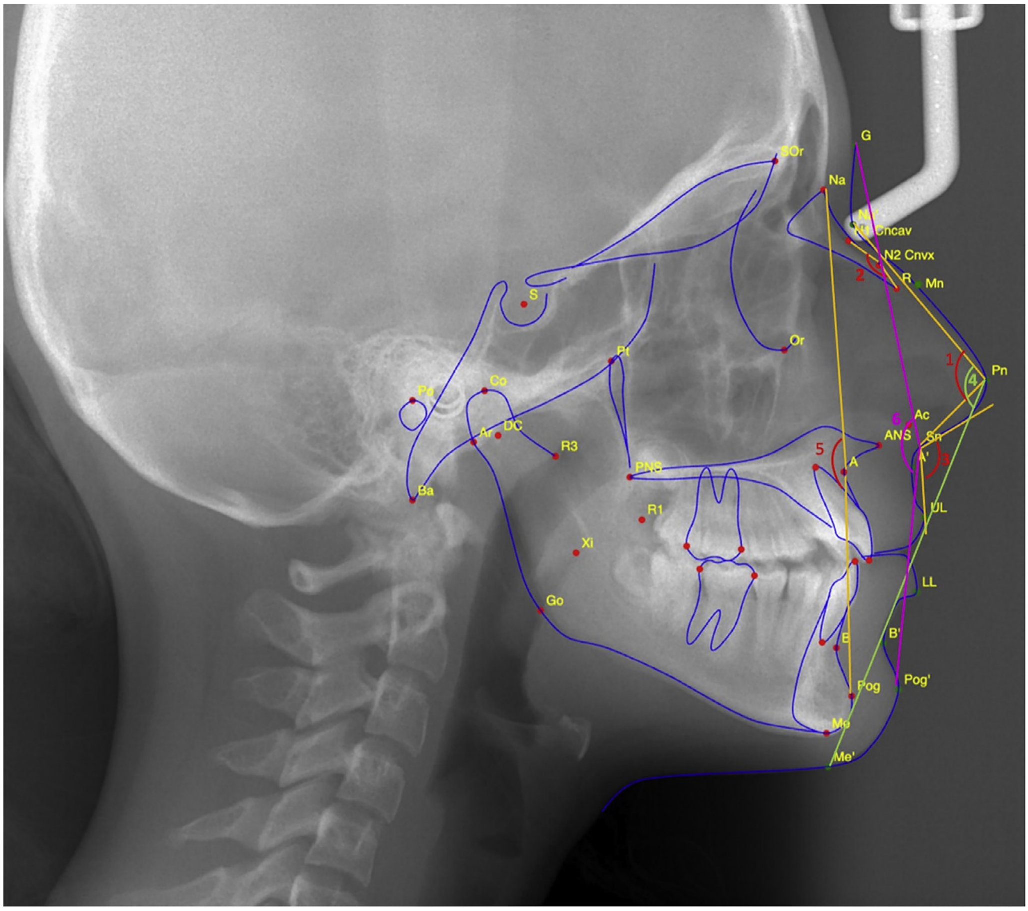

Fig. 3. Angular measurements 1) Nasal tip angle (N'- Pr- Sn) 2) Nasal bone angle (N1-N2-R) 3) Nasolabial angle 4) Nasomental angle (N'-Pr-Me') 5) Facial convexity 6) Soft tissue facial convexity (G'- Sn-Pg').

Table 2
Inter- and intra-group evaluations of measurements.

		Non-extraction Mean+Ss(median)	Upper 2 extraction Mean+Ss(median)	4 x 4 extraction Mean+Ss(median)	P
Nasal tip angle	T0	96,22±5,42 (95,07)	95,25±6,94 (94,41)	94,92±5,26 (94,36)	[1]0,707
	T1	94,62±5,31 (93,41)	94,19±5,51 (93,35)	94,09±5,49 (94,18)	
	[2]p	0,005*	0,212	0,145	[1]0,934
Nasal Bridge Length	T0	64,49±41,82 (45,82)	60,31±32,11 (47,8)	56,22±29,9 (46,1)	[3]0,518
	T1	53,75±30,71 (46,73)	60,13±33,28 (47,41)	57,99±30,34 (46,75)	
	[4]p	0,954	0,809	0,014*	[3]0,773
Nasal Depth Pr to Ac	T0	31,28±18,7 (22,41)	27,9 ± 15,1 (21,73)	26,79±13,21 (22,13)	[3]0,690
	T1	25,99±13,82 (22,69)	28,64±15,15 (22,55)	27,45±13,34 (22,95)	
	[4]p	0,511	0,027*	0,038*	[3]0,944
N-Nasal bridge point	T0	23,4 ± 16,4 (16,04)	22,44±13,09 (17,15)	19,53±10,81 (16,29)	[3]0,498
	T1	19,73±13,61 (16,43)	21,58±14,01 (16,73)	20,47±11,62 (16,86)	
	[4]p	0,511	0,227	0,361	[3]0,877
Nasal bone length N-R	T0	37,96±24,15 (27,33)	32,97±18,69 (25,89)	30,2 ± 14,81 (25,23)	[3]0,221
	T1	30,89±17,53 (26,61)	33,06±19,41 (26,53)	30,94±15,39 (25,83)	
	[4]p	0,440	0,616	0,076	[3]0,683
Nasal bone angle	T0	171,02±6,85 (174,39)	171,44±5,55 (171,61)	171,79±6,92 (173,42)	[3]0,755
	T1	170,43±5,84 (171,76)	171,26±5,78 (172)	171,35±6,98 (173,79)	
	[4]p	0,548	0,629	0,830	[3]0,751
Nasal depth Pr to N-Prn	T0	23,32±14,62 (16,87)	21,24±10,88 (16,92)	20,55±11,23 (17,04)	[3]0,903
	T1	19,28±10,69 (16,93)	21,76±11,26 (17,49)	20,98±11,45 (17,34)	
	[4]p	0,775	0,040*	0,063	[3]0,556
Columella convexity	T0	4,33±2,41 (3,28)	3,95±2,07 (3,48)	3,46±1,71 (3,19)	[3]0,259

(*continued*)

Table 2 (*Continued*)

		Non-extraction Mean+Ss(median)	Upper 2 extraction Mean+Ss(median)	4 x 4 extraction Mean+Ss(median)	P
	T1	3,45±2,16 (3,19)	3,54±1,92 (3,09)	3,6 ± 1,89 (3,12)	
	[4]p	0,010*	0,010*	0,915	[3]0,959
Nose Height	T0	72,16±46,2 (50,8)	67,09±36,49 (53,52)	62,38±32,84 (51,05)	[3]0,537
	T1	59,32±33,25 (51,02)	66,58±36,94 (51,03)	63,98±33,67 (52,26)	
	[4]p	0,775	0,687	0,026*	[3]0,737
Upper lip height	T0	31,9 ± 20,07 (23,05)	28,04±16,8 (21,32)	26,54±13,59 (21,78)	[3]0,401
	T1	26,01±13,81 (23,52)	28,47±17,29 (21,52)	27,18±13,96 (22,14)	
	[4]p	0,530	0,469	0,018*	[3]0,585
Upper lip to E-plane	T0	−3,97±4,75 (−2,89)	−2,93±3,19 (−2,27)	−3,89±4,08 (−3,63)	[3]0,649
	T1	−2,91±1,95 (−2,88)	−4,3 ± 2,65 (−4,14)	−4,52±3,99 (−3,79)	
	[4]p	0,670	0,009*	0,074	[3]0,213
Lower lip to E-plane	T0	−2,35±4,47 (−1,87)	−1,84±3,28 (−1,71)	−1,72±4,05 (−1,93)	[3]0,910
	T1	−1,5 ± 2,7 (−0,96)	−2,69±2,59 (−2,03)	−3,25±3,98 (−2,29)	
	[4]p	0,558	0,059	0,002*	[3]0,178
Lower lip height	T0	65,92±39,61 (48,11)	57,83±33,9 (45,29)	56,88±30,07 (46,28)	[3]0,258
	T1	54,42±27,07 (48,38)	59,65±36,42 (43,85)	58,43±29,59 (49,17)	
	[4]p	0,954	0,305	0,011*	[3]0,277
Nasolabial angle	T0	102,6 ± 11,84 (103,05)	105,91±17,63 (103,28)	105,83±12,45 (103,69)	[1]0,637
	T1	101,5 ± 12,66 (100,46)	111,3 ± 12,28 (112,61)	108,68±9,88 (106,56)	
	[2]p	0,543	0,023*	0,062	[1]0,011*
Nasomental angle	T0	120,16±5,1 (121,24)	118,12±3,62 (117,82)	118,38±4,98 (118,43)	[1]0,247
	T1	119,44±4,32 (119,67)	117,71±3,88 (117,88)	118,5 ± 5,06 (117,96)	
	[2]p	0,196	0,314	0,769	[1]0,409
Facial convexity	T0	7,71±6,37 (6,93)	9,18±6,05 (10,36)	8,82±6,44 (7,9)	[1]0,697
	T1	7,95±4,95 (8,8)	9,69±5,79 (10,36)	7,82±6,67 (7,21)	
	[2]p	0,729	0,532	0,026*	[1]0,448
Lower anterior face height	T0	92,86±58,87 (65,77)	81,92±47,2 (63,24)	79,52±39,92 (65,43)	[3]0,419
	T1	76±39,98 (67,61)	83,46±49,28 (63,4)	81,11±39,99 (66,36)	
	[4]p	0,977	0,398	0,005*	[3]0,497
Soft tissue facial convexity	T0	163,9 ± 6,88 (162,81)	159,91±4,53 (160,12)	160,88±6,7 (161,97)	[1]0,067
	T1	163±5,55 (162,66)	159,61±4 (159,01)	160,44±6,37 (161,29)	
	[2]p	0,272	0,588	0,291	[1]0,083

[1] Oneway ANOVA Test.
[2] Paired samples *t*-test.
[3] Kruskal Wallis Test.
[4] Wilcoxon sign test.
* $p<0.05$.

in which the decrease in facial convexity was statistically significant ($P = 0.026$) — so that the profile was less convex after four premolar extractions.

In a similar study conducted by Khan et al., the group that underwent four-tooth extraction showed a notable decrease in upper and lower lip protrusion, with statistical significance ($P = 0.004$ and 0.021). Conversely, the non-extraction group experienced a minor increase in lower lip protrusion ($P = 0.009$), attributed to a significant increase in the incisor mandibular plane angle (IMPA; $P = 0.046$). Although the premolar extraction group displayed more pronounced soft-tissue changes during treatment, subsequent comparisons indicated that the two groups concluded the treatment with similar soft-

Table 3
Evaluations of changes between groups.

	Non-extraction Mean+Ss(median)	Upper 2 extraction Mean+Ss(median)	4 x 4 extraction Mean+Ss(median)	p
Nasal tip angle	−1,6 ± 2,51 (−0,84)	−1,05±4,11 (−0,14)	−0,83±3,14 (0)	0,610
Nasal Bridge Length	−10,73±31,56 (0,63)	−0,17±5,17 (0)	1,77±4,11 (0,4)	0,344
Nasal Depth Pr to Ac	−5,29±14,98 (−0,49)	0,75±2,64 (0,52)	0,66±1,64 (0)	0,312
N-Nasal bridge point	−3,67±12,45 (−0,28)	−0,86±4,46 (0)	0,94±3,54 (0)	0,308
Nasal bone length N-R	−7,07±18,58 (−0,11)	0,09±2,2 (0)	0,74±2,12 (0)	0,241
Nasal bone angle	−0,59±6,37 (−0,95)	−0,17±5,05 (0)	−0,44±4,37 (0)	0,862
Nasal depth Pr to N-Prn	−4,04±11,52 (−0,18)	0,52±1,35 (0,16)	0,43±1,25 (0)	0,461
Columella convexity	−0,87±1,52 (−0,48)	−0,41±0,76 (−0,11)	0,14±1,36 (0)	0,028*
Nose Height	−12,84±35,45 (1,06)	−0,51±5,58 (0)	1,61±4,08 (0,13)	0,386
Upper lip height	−5,89±15,69 (−0,41)	0,42±2,03 (0)	0,64±1,95 (0,45)	0,147
Upper lip to E-plane	1,05±4,14 (−0,46)	−1,36±2,49 (−0,53)	−0,62±1,75 (0)	0,238
Lower lip to E-plane	0,85±3,88 (0,35)	−0,85±1,93 (0)	−1,53±2,86 (−0,78)	0,045*
Lower lip height	−11,5 ± 31,74 (0,83)	1,82±7,38 (0)	1,56±3,29 (0,72)	0,454
Nasolabial angle	−1,1 ± 8,74 (−1,71)	5,39±11,1 (1,73)	2,85±8,32 (0)	0,009*
Nasomental angle	−0,72±2,64 (−0,08)	−0,41±1,99 (0)	0,12±2,22 (0)	0,778
Facial convexity	0,23±3,26 (−0,39)	0,51±4,02 (0)	−0,99±2,41 (0)	0,446
Lower anterior face height	−16,85±46,57 (0,44)	1,54±5,89 (0)	1,59±3,03 (0,59)	0,440
Soft tissue facial convexity	−0,9 ± 3,91 (−0,37)	−0,31±2,78 (0)	−0,44±2,33 (0)	0,948

Kruskal Wallis Test.
* $p<0.05$.

Table 4
Evaluations of changes between groups in patients under 18 years old.

<18 Age	Non-extraction Mean+Ss(median	Upper 2 extraction Mean+Ss(median)	4 x 4 extraction Mean+Ss(median)	p
Nasal tip angle	−2,92±2,93 (−3,47)	−2,97±4,01 (−1,14)	−0,98±2,44 (0)	0,094
Nasal Bridge Length	1,25±8,44 (2,07)	1,4 ± 5,65 (0)	2,65±5,59 (0,09)	0,811
Nasal Depth Pr to Ac	0,31±3,77 (0,57)	1,04±3,93 (0)	0,65±1,19 (0)	0,947
N-Nasal bridge point	0,5 ± 4,21 (0,04)	0,28±4,7 (0)	1,62±4,2 (0)	0,750
Nasal bone length N-R	−0,51±4,6 (1,12)	0,52±3,09 (0)	1,68±2,61 (0,23)	0,305
Nasal bone angle	−0,04±5,72 (0,78)	−1,61±3,35 (0)	0,28±2,89 (0)	0,533
Nasal depth Pr to N-Prn	0,14±2,89 (0,88)	0,91±1,68 (0,09)	0,8 ± 1,34 (0,22)	0,991
Columella convexity	−0,61±1,02 (−0,35)	−0,46±1,03 (0)	0,43±1,95 (0)	0,152
Nose Height	0,17±9,38 (1,54)	0,13±7,11 (0)	2,67±5,16 (0,13)	0,354
Upper lip height	−0,38±3,1 (0,62)	1,24±2,2 (0,05)	1,36±1,86 (0,34)	0,410
Upper lip to E-plane	−0,53±2,03 (−1,22)	−1,72±3,37 (0)	−0,86±2,2 (0)	0,880
Lower lip to E-plane	−0,48±2,51 (0,39)	−0,95±2,03 (0)	−2,11±3,84 (0)	0,463
Lower lip height	−0,08±7,27 (1,75)	4,06±10,7 (0)	1,94±4,23 (0)	0,981
Nasolabial angle	−0,41±11,21 (−4,64)	3,25±13,37 (0)	2,8 ± 7,42 (0)	0,154
Nasomental angle	−0,32±2,4 (0,23)	−0,33±1,45 (0)	−0,04±1,93 (0)	0,966
Facial convexity	−1,24±2,8 (−1,7)	2,05±4,67 (0)	−0,82±2,5 (0)	0,091
Lower anterior face height	0,38±10,39 (2,89)	3,89±8,09 (0)	2,42±3,76 (0,71)	0,899
Soft tissue facial convexity	−0,09±4,37 (0,85)	−0,88±2,78 (0)	−0,55±2,54 (0)	0,828

Kruskal Wallis Test.

tissue characteristics [21]. In the present study, upper lip protraction was observed in upper-two extractions, while lower lip retraction was observed with four extractions, with an increase in the upper and lower lip heights. These results suggest that changes in lip position are not solely attributable to extraction cases, and that other factors such as growth patterns and skeletal structure may also play a role in influencing lip position changes.

Guo et al. concluded from a regression analysis that when extraction decisions are being made for Angle Class II, Division 1 malocclusions, the most significant factors were lower anterior crowding, molar relationship, and growth pattern, with their impact decreasing over time [22]. An important consideration in the relevant literature is the way in which the extraction spaces are managed during orthodontic treatment. If the anchorage mechanics employed during extraction-based treatment involve minimum posterior anchorage, then it would make sense that no changes to the profile would be observed, regardless of the extraction pattern [23].

The appearance of the nose plays a significant role in facial aesthetics and can be influenced by factors such as age and gender. Meng et al. [24] conducted a study to assess age-related changes in the nose in relation to the pterygomaxillary plane. The study found that increases in nose height, depth, and inclination were fully completed in females by the age of 16, while in males, these changes continued to increase beyond 18 years of age. In their study, the researchers found that the ratio of upper to lower nose height remained consistent from ages 7 to 18 in both males and females. However, the ratio of nose depth to sagittal depth in the underlying skeleton changed from 1 : 2 at age 7 to 1 : 1.5 in males, particularly after age 10. These findings suggest that the nose undergoes significant changes in morphology and position during development, with males experiencing greater changes in nose depth and inclination than females.

In the present study, age was found to be an important factor in nasal profile changes, as there were no significant differences between

Table 5
Evaluations of T0-T1 changes between groups in participants over 18 years old.

>18 age	Non-extraction Mean+Ss(median)	Üst 2 çekimli Mean+Ss(median)	4×4 çekimli Mean+Ss(median)	p
Nasal tip angle	−0,48±1,4 (−0,38)	0,45±3,65 (−0,07)	−0,71±3,65 (-0,47)	0,635
Nasal Bridge Length	−20,87±40,09 (0,28)	−1,41±4,59 (−1,01)	1,08±2,39 (1,26)	0,226
Nasal Depth Pr to Ac	−10,02±19,12 (−1,83)	0,52±0,94 (0,55)	0,68±1,95 (0)	0,114
N-Nasal bridge point	−7,2 ± 15,9 (−1,19)	−1,76±4,22 (−0,62)	0,41±2,95 (0)	0,414
Nasal bone length N-R	−12,62±23,89 (−0,49)	−0,25±1,14 (−0,11)	0,01±1,3 (0)	0,236
Nasal bone angle	−1,05±7,07 (−1,36)	0,96±5,94 (−1)	−1 ± 5,26 (−0,06)	0,895
Nasal depth Pr to N-Prn	−7,57±14,75 (−0,75)	0,21±0,97 (0,18)	0,14±1,13 (0)	0,202
Columella convexity	−1,1 ± 1,85 (−0,56)	−0,37±0,51 (−0,4)	−0,08±0,6 (0)	0,155
Nose Height	−23,84±45,27 (−0,47)	−1,01±4,23 (−0,41)	0,78±2,88 (0,18)	0,352
Upper lip height	−10,55±20,32 (−0,67)	−0,22±1,69 (−0,18)	0,07±1,88 (0,47)	0,290
	2,39±5,01 (0,32)	−1,08±1,6 (−0,66)	−0,45±1,36 (-0,01)	0,131
Lower lip to E-plane				0,046
	1,97±4,55 (0,3)	−0,78±1,93 (−0,58)	−1,09±1,77 (−0,9)	*
Lower lip height	−21,16±40,82 (−0,6)	0,06±2,18 (−0,25)	1,26±2,41 (0,93)	0,150
Nasolabial angle				0,021
	−1,68±6,39 (−1,25)	7,08±9,11 (7,39)	2,88±9,17 (1,02)	*
Nasomental angle	−1,05±2,89 (−0,36)	−0,47±2,38 (−0,14)	0,24±2,47 (0)	0,662
Facial convexity	1,48±3,19 (0,07)	−0,7 ± 3,07 (−0,07)	−1,13±2,4 (−0,11)	0,241
Lower anterior face Height	−31,44±59,7 (−0,5)	−0,3 ± 2,31 (−0,13)	0,95±2,22 (0,59)	0,168
Soft tissue facial convexity	−1,59±3,5 (−0,42)	0,15±2,8 (−0,02)	−0,36±2,22 (-0,25)	0,536

Kruskal Wallis Test.
* $p<0.05$.

the groups in patients under the age of 18. On the other hand, there were significant differences in the amount of change observed in the lower lip to E-plane among patients over 18 years old. The four-extraction group had a decrease in lower lip to E-plane, while the non-extraction group had an increase, which was found to be statistically significant. There was also a significant difference in the changes in nasolabial angle. While a decrease was observed in the non-extraction group, an increase was observed in the other groups. The amount of decrease in the non-extraction group was significantly different from that of the upper-two extraction group. This means that extraction treatment administered in adult patients affects their profile more than when it is carried out in young patients. This may be because treatment that causes significant upper lip retraction in combination with several millimeters of remaining nose growth may produce less than an optimal final relationship between the lips and nose. This finding is similar to that in a study by Peng et al.: changes in the nasolabial angle among adolescents with a vertical growth pattern in Class II, Division 1 malocclusion after extraction treatment are associated with both upper anterior teeth hard tissue and upper lip soft tissue, whereas in adults, the relationship is limited to upper anterior teeth hard tissue [25]. In the present study, the lower anterior face height increased significantly after premolar extraction, which may happen due to remaining growth. When the groups were divided according to age, a difference was not observed.

Facial aesthetics and appearance norms are becoming increasingly important in orthodontic decision-making. For instance, studies have suggested ideal nasolabial angle values for both males and females. For females, the ideal values for the nasolabial angle fall between 95 and 110, whereas for males, the ideal range is between 90 and 95 [26]. Several studies have examined the impact of extraction versus non-extraction orthodontic treatment on the nasolabial angle. Finnoy et al. [27] observed a significantly greater increase in the nasolabial angle in their extraction group (6.5°) than in their non-extraction group (2.9°). Scott Conley and Jernigan reported a mean increase in the nasolabial angle of 6.4 in their study sample, due to strict retraction requirements in the patient sample and a larger mean maxillary incisor retraction than in previous studies [28]. In the present study, the nasolabial angle was affected by different extraction patterns. Non-extraction treatment resulted in a decrease in the nasolabial angle, while extraction treatments led to an increase in it. This may be due to the fact that non-extraction treatment typically involves proclination of the incisors, which can result in a decrease in the nasolabial angle. On the other hand, extraction treatments involve retraction of the anterior teeth, leading to an increase in the nasolabial angle. In a systematic review on soft-tissue changes in Class II malocclusion patients treated with extractions, Janson et al. concluded that there was a significant statistical alteration in soft tissue, including an increase in the nasolabial angle (NLA) from 2.4° to 5.40° in the two-premolar extraction protocol and from 1° to 6.84° in the four-premolar extraction protocol. Retrusion of the upper and lower lips was also evident, with the two-premolar extraction groups showing comparatively less retraction of the lower lip [29].

In their investigation into the esthetic scores for various nose morphologies and treatment plans, Cankaya et al. [30] noted a substantial influence of different nose shapes on the ultimate facial profile ratings. Convex nasal profiles were seen as a greater concern and orthognathic surgery did not result in a significant change in scores, while extraction treatment did not have a significant impact on esthetic scores for any profiles. The study concluded that nose shape should be taken into consideration when planning skeletal and dental orthodontic treatments.

In conclusion, different patient groups in this study, classified by age and extraction status, were analyzed to determine the impact of orthodontic treatment on profile measurements. The results suggest that significant changes in facial parameters such as nasolabial angle, nasal depth, nose height, upper and lower lip height, facial convexity, columella convexity, and nasal tip angle occur in particular in groups with two extractions. Moreover, significant variances were discovered between the groups with regard to mean columella convexity and mean lower lip to E-plane results, as well as the nasolabial angle. On the other hand, when the groups were sorted according to age, no significant differences in the parameters studied were seen in young patients, suggesting that extraction in younger patients may affect the profile less than it does in adult patients. In general, the lips and nose profile should be carefully assessed if the decision is taken to carry out two-premolar extraction.

Funding

This study did not receive any financial support.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Istanbul Aydin University Non-Invasive Clinical Research Ethics Committee (ref. no. 2021/556) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Declaration of competing interest

The authors declare that they have no competing interests.

References

[1] Bishara SE, Cummins DM, Jakobsen JR. The morphologic basis for the extraction decision in Class II, Division 1 malocclusions: a comparative study. Am J Orthod Dentofacial Orthop 1995;107:129–35. doi: 10.1016/s0889-5406(95)70127-3.
[2] Konstantonis D, Vasileiou D, Papageorgiou SN, Eliades T. Soft tissue changes following extraction vs. nonextraction orthodontic fixed appliance treatment: a systematic review and meta-analysis. Eur J Oral Sci 2018;126:167–79. doi: 10.1111/eos.12409.
[3] Kirschneck C, Proff P, Reicheneder C, Lippold C. Short-term effects of systematic premolar extraction on lip profile, vertical dimension and cephalometric parameters in borderline patients for extraction therapy - a retrospective cohort study. Clin Oral Invest 2016;20:865–74. doi: 10.1007/s00784-015-1574-5.
[4] Konstantonis D. The impact of extraction vs nonextraction treatment on soft tissue changes in Class I borderline malocclusions. Angle Orthod 2012;82:209–17. doi: 10.2319/051911-339.1.
[5] Iared W, da Silva EMK, Iared W, Macedo CR. Esthetic perception of changes in facial profile resulting from orthodontic treatment with extraction of premolars: a systematic review. J Am Dent Assoc 2017;148:9–16. doi: 10.1016/j.adaj.2016.09.004.
[6] Omar Z, Short L, Banting DW, Saltaji H. Profile changes following extraction orthodontic treatment: A comparison of first versus second premolar extraction. Int Orthod 2018;16(1):91–104. doi: 10.1016/j.ortho.2018.01.017.
[7] Janson G, Mendes LM, Junqueira CH, Garib DG. Soft-tissue changes in Class II malocclusion patients treated with extractions: a systematic review. Eur J Orthod 2016;38:631–7. doi: 10.1093/ejo/cjv083.
[8] McGuinness NJ, Burden DJ, Hunt OT, Johnston CD, Stevenson M. Long-term occlusal and soft-tissue profile outcomes after treatment of Class II Division 1 malocclusion with fixed appliances. Am J Orthod Dentofacial Orthop 2011;139:362–8. doi: 10.1016/j.ajodo.2009.05.035.
[9] Trisnawaty N, Ioi H, Kitahara T, Suzuki A, Takahashi I. Effects of extraction of four premolars on vermilion height and lip area in patients with bimaxillary protrusion. Eur J Orthod 2013;35:521–8. doi: 10.1093/ejo/cjs035.
[10] Verma SL, Sharma VP, Tandon P, Singh GP, Sachan K. Comparison of esthetic outcome after extraction or non-extraction orthodontic treatment in class II division 1 malocclusion patients. Contemp Clin Dent 2013;4:206–12. doi: 10.4103/0976-237X.114886.
[11] Nance HN. The removal of second premolars in orthodontic treatment. Am J Orthod 1949;35(9):685–96. doi: 10.1016/0002-9416(49)90125-6.
[12] Proffit WR. The soft tissue paradigm in orthodontic diagnosis and treatment planning: a new view for a new century. J Esthet Dent 2000;12(1):46–9. doi: 10.1111/j.1708-8240.2000.tb00198.x.
[13] Posen JM. A longitudinal study of the growth of the nose. Am J Orthod 1967;53(10):746–56. doi: 10.1016/0002-9416(67)90119-4.

[14] Sarver DM. Interactions of hard tissues, soft tissues, and growth over time, and their impact on orthodontic diagnosis and treatment planning. Am J Orthod Dentofacial Orthop 2015;148:380–6. doi: 10.1016/j.ajodo.2015.04.030.
[15] Sadry S, Koru BE, Kayalar E. Analyzing the effects of tooth extraction on the lip in orthodontic treatment. J Stomatol Oral Maxillofac Surg 2022;123(4):e126–32. doi: 10.1016/j.jormas.2022.04.004.
[16] Umale VV, Singh K, Azam A, Bhardwaj M, Kulshrestha R. Evaluation of Nasal Proportions in Adults with Class I and Class II Skeletal Patterns: A Cephalometric Study. J Orthod Sci 2017;6(2):41–6. doi: 10.4103/2278-0203.205453.
[17] Jankowska A, Janiszewska-Olszowska J, Jedliński M, Grocholewicz K. Methods of Analysis of the Nasal Profile: A Systematic Review with Meta-analysis. Biomed Res Int 2021:6680175. doi: 10.1155/2021/6680175.
[18] Kocadereli I. Changes in soft tissue profile after orthodontic treatment with and without extractions. Am J Orthod Dentofacial Orthop 2001;122:67–72. doi: 10.1067/mod.2002.125235.
[19] Freitas BV, Rodrigues VP, Rodrigues MF, de Melo HVF, Dos Santos PCF. Soft tissue facial profile changes after orthodontic treatment with or without tooth extractions in Class I malocclusion patients: A comparative study. J Oral Biol Craniofac Res 2019;9(2):172–6. doi: 10.1016/j.jobcr.2018.07.003.
[20] Verma SL, Sharma VP, Tandon P, Singh GP. The Impact of Extraction vs Nonextraction Treatment on Soft Tissue Profile in Borderline Class I Malocclusion: A Cephalometric Study. J Ind Orthod Soc 2014;48(1):47–53. doi: 10.5005/jp-journals-10021-121.
[21] Khan M, Fida M. Soft tissue profile response in extraction versus non-extraction orthodontic treatment. J Coll Physicians Surg Pak 2010;20(7):454–9 PMID: 20642945.
[22] Guo Y, Han X, Xu H, Ai D, Zeng H, Bai D. Morphological characteristics influencing the orthodontic extraction strategies for Angle's class II division 1 malocclusions. Prog Orthod 2014;15(1):44. 9. doi: 10.1186/s40510-014-0044-y.
[23] Burashed H. Changes in the vertical dimension after orthodontic treatment in response to different premolar extraction patterns. Cureus 2023;15(5):e38893. 11. doi: 10.7759/cureus.38893.
[24] Meng HP, Goorhuis J, Kapila S, Nanda RS. Growth changes in the nasal profile from 7 to 18 years of age. Am J Orthod Dentofacial Orthop 1988;94(4):317–26. doi: 10.1016/0889-5406(88)90057-1.
[25] Peng M, Kang J, Zhou J, Du B. Correlation analysis of the nasolabial angle of Angle's Class II division 1 malocclusion patients with vertical growth pattern after tooth extraction orthodontic treatment. Hua Xi Kou Qiang Yi Xue Za Zhi 2015;33 (4):397–400. doi: 10.7518/hxkq.2015.04.015.
[26] Niamtu J. Cosmetic facial surgery. Amsterdam: Elsevier Health Sciences; 2016.
[27] Finnöy JP, Wisth PJ, Böe OE. Changes in soft tissue profile during and after orthodontic treatment. Eur J Orthod 1987;9(1):68–78. doi: 10.1093/ejo/9.1.68.
[28] Scott Conley R, Jernigan C. Soft tissue changes after upper premolar extraction in Class II camouflage therapy. Angle Orthod 2006;76(1):59–65 PMID: 16448270. doi: 10.1043/0003-3219(2006)076[0059:STCAUP]2.0.CO;2.
[29] Janson G, Mendes LM, Junqueira CH, Garib DG. Soft-tissue changes in Class II malocclusion patients treated with extractions: a systematic review. Eur J Orthod 2016;38(6):631–7. doi: 10.1093/ejo/cjv083.
[30] Cankaya OS, Celebi F, Bicakci AA. Effects of different nose types on class II treatments for female patients. Prog Orthod 2019;20(1):44. 2. doi: 10.1186/s40510-019-0296-7.