ORIGINAL RESEARCH

Skeletal Changes Seen in Nonsurgically Treated Patients with Skeletal Class II Malocclusion

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Abstract

Aims and objectives: To evaluate and compare the skeletal changes before and after the treatment of skeletal class II malocclusion with the extraction of premolars followed by fixed appliance therapy.

Materials and methods: Thirty individuals, with class II skeletal patterns due to a prognathic maxilla, were selected as per the inclusion criteria. Pretreatment and posttreatment lateral cephalograms of the selected study participants were obtained, analyzed, and compared to assess the changes that might have occurred. Descriptive statistics mean and standard deviation were calculated for all variables. The pretreatment and posttreatment changes were calculated using the paired *t*-test. A value of $p < 0.05$ is considered to be statistically significant.

Results: There was a decrease in mean SNA posttreatment, i.e., 1.82° and there was a decrease in mean SNB posttreatment, i.e., 0.65°. The mean ANB values also showed a significant decrease of 1.17°. Both the SN-GoGn and the FMA increased significantly by 0.83 and 1°, respectively. There was a significant increase in all facial height values [total anterior facial height (TAFH), lower anterior facial height (LAFH), and posterior facial height (PFH)]. The WITS values were observed to significantly decrease by 0.79 mm. There was also a statistically significant increase in the n-B and N-Pog values.

Conclusion: The results showed that extraction therapy in skeletal class II patients due to a prognathic maxilla (with class II div 1 malocclusion) has an overall improvement of the patients' skeletal profile since most of the reduction in the sagittal parameters was due to the remodeling of point A rather than the forward displacement of point B. An increase in the overall facial height was also observed in all the study participants. This in turn led to a backward displacement of point B leading to a potential worsening of the facial profile which was overcome by the significant remodeling of point A.

Clinical significance: An important factor to be taken into consideration is the control of vertical height while retracting the anteriors as this study proves that there was a definite increase in the anterior facial height and TAFH of patients at the end of the treatment. The use of head gear/mini implants is mandatory to maintain the vertical relationship of the molars especially while treating patients who have a hyperdivergent growth pattern.

Keywords: Camouflage, Class II, Extraction, Facial height, Orthodontic camouflage, Premolar, Prognathic maxilla, Skeletal class II, Vertical dimension of occlusion.

World Journal of Dentistry (2021): 10.5005/jp-journals-10015-1817

Introduction

Esthetic outlook, an active function, and balanced occlusion are the end goals of any orthodontic treatment.[1] One of the most studied malocclusions is class II malocclusion. It may result from dental/skeletal disharmony. Skeletal class II cases usually present with maxillary prognathism or mandibular retrognathism or a combination of both.

The Indian population has a diverse notion about individuals with a convex profile. This poses a big challenge to the orthodontist treating the patient as he/she has to choose one of the many options available for the treatment of class II malocclusion. The decision of choosing the appropriate treatment plan should be based on a visual perspective rather than evidence-based only.[2] The treatment options for adult skeletal class II malocclusion are either surgical intervention or camouflage therapy. These cases almost always present with an increased overjet and thereby require the extraction of premolars to distalize the anteriors.[1]

The debate on the validity of extraction to improve the profile of the patient is ongoing till today. To date, the effect of premolar extraction on the facial vertical dimension is controversial.[3] Some results have shown that the extraction of four premolars leads to an unaesthetic profile because of the "dishing" of the lips relative to the chin and nose.[4] It is known that the facial sagittal and vertical dimensions would be changed by the movement of the molar teeth.[5,6] The extrusion of molar teeth causes a clockwise rotation

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How to cite this article: Shashidhar K, Castelino C, Kuttappa MN, *et al.* Skeletal Changes Seen in Nonsurgically Treated Patients with Skeletal Class II Malocclusion. World J Dent 2021;12(2):144–149.

Source of support: Nil

Conflict of interest: None

in the mandible. Accordingly, the backward mandibular tip would increase lower facial height and SN/MP angle.[7–10] Some authors believe that premolar extraction allows the posterior teeth to move mesially, thereby decreasing the vertical dimension of the face, while few authors have reported an average increase in lower anterior facial height (LAFH) and total anterior facial height (TAFH) values.[3] A few authors believe that the extraction of premolars causes TMJ issues due to over closure of the lower jaw and excessive retraction of the anteriors,[11] whereas some authors completely disagree with the relation of premolar extraction and TMJ issues that occur due to change in the vertical dimension of the face.[12–18] As indicated by the "Wedge concept", if the extraction of the lower second premolar is done, then the forward movement of the molar would reduce the vertical dimension of the face which might be ideal for patients with hyperdivergent faces. This, however, could still lead to TMD.[11,19,20] However, according to some researchers, extraction and nonextraction treatments do not produce very different results.[21–23]

Most of the studies on the effects of premolar extraction have focused on the dentoalveolar effects on the facial profile, only a few studies have focused solely on the skeletal changes following premolar extraction. Hence, the present retrospective cephalometric study intends to evaluate and compare the skeletal changes before and after the treatment of skeletal class II malocclusion with the extraction of premolars followed by fixed appliance therapy.

Materials and Methods

Source of Data

This retrospective study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, AB Shetty Memorial Institute of Dental Sciences over the course of 1 year and 8 months. Thirty skeletal class II patients with maxillary excess whose ages ranged from 14 to 30 years and who had undergone extraction of four premolars for their orthodontic treatment were selected for this study.

The ethical guidelines for the study were in accordance with the World Medical Association Declaration of Helsinki, 1975 as revised in 2013. Before the start of the study, the Institutional ethical Clearance was obtained (ABSM/EC89/2015).

Study materials consisted of pretreatment and posttreatment lateral cephalograms, case history records, and treatment logs of 30 skeletal class II patients with maxillary excess. The lateral cephalograms obtained were made under standardized conditions with the Frankfort Horizontal plane kept parallel to the floor and the midfacial plane kept in a vertical position. The tracing of lateral cephalograms was done using 0.003-inch acetate paper with a 2H lead pencil. All tracings were done by one investigator.

The inclusion criteria for the study were detailed and specific to the objective of the study. The cases to be studied should have been diagnosed with skeletal class II malocclusion with maxillary prognathism. The availability of full records, including pretreatment and posttreatment lateral cephalograms, case history, and treatment logs with clearly documented orthodontic treatment mechanics was a must. Only those treatments that involved the extraction of four premolars were included in the study. All cases to be studied should have been that with completed orthodontic treatment and the age of the study participants to be studied were to be in the range between 14 years and 30 years.

Cases that used headgear/functional appliances before or during the fixed appliance therapy were excluded from the study. Cases that had ANB of <4°, Sn-GoGn of >35° and SNB of <78° were excluded from the study. Cases that were diagnosed with any syndrome(s) and/or cleft lip and palate cases were excluded from the study. Lastly, cases whose treatment plan involved surgical intervention were also excluded from the study.

Of the 1,135 patients from the archive, only 424 patients had skeletal class II relation. Of the 424 patients, 169 patients required the extraction of 4 premolars. Of the 169 patients, only 43 of them were diagnosed with skeletal class II due to prognathic maxilla. Of the 43 patients, only 36 patients were within the age group of 14–30 years. Of the remaining 36 patients, 6 patients were eliminated from the study due to a lack of records. The remaining 30 cases that fulfilled the above-mentioned inclusion and exclusion criteria were selected for the study.

Cephalometric analysis was done by tracing the following anatomic points as Sella Turcica (S), Nasion (N), Supramentale (B), Subspinale (A), Pogonion (pog), Gonion (Go), Gnathion (Gn), Anterior Nasal Spine (ANS), Posterior Nasal Spine (PNS), Condylion (Co), and Planes such as Sella-Nasion Plane, Frankfort's Horizontal Plane, True Horizontal Plane, Mandibular plane (Steiners), Mandibular plane (Downs), Palatal Plane, Occlusal plane. Angular changes were recorded by measuring SNA, SNB, ANB, SNGoGn, MM, FMA, N-A Pg and linear changes were measured using TAFH, LAFH, posterior facial height (PFH), WITS, Co-A, Co-B, N-A, N-B, N-Pg.

Statistical Analysis

Descriptive statistics mean and standard deviation were calculated for all variables. The paired *t*-test was used to calculate pretreatment and posttreatment changes. A value of $p < 0.05$ is considered to be statistically significant. Microsoft Excel and SPSS software version 22 were used for statistical analysis.

Results

The study consisted of 30 study participants. Sixteen of them were males and 14 of them were females. All individuals belonged to the state of Karnataka or Kerala.

The data collected presented the following findings.

The angular changes have been tabulated and also represented in graphical form (Table 1 and Fig. 1).

The mean values of SNA pretreatment and posttreatment were found to be 87.27 ± 2.94 and 85.45 ± 2.69, respectively. The statistically significant decrease ($p < 0.05$) in SNA values signifies a substantial improvement in the skeletal profile.

The mean values of SNB pretreatment and posttreatment were found to be 81.20 ± 2.66 and 80.55 ± 2.74, respectively. Contrary to the SNA values, the statistically significant decrease ($p < 0.05$) in SNB values signifies a potential worsening of the patient's skeletal profile.

The mean values of ANB pretreatment and posttreatment were found to be 6.07 ± 1.42 and 4.90 ± 1.69, respectively, which also showed a statistically significant decrease ($p < 0.05$) in value. This value indicates an overall improvement in maxilla-mandibular harmony.

The mean values of SN-GoGn pretreatment and posttreatment were found to be 31.62 ± 4.57 and 32.45 ± 4.13, respectively. The increase in mean SNGoGn posttreatment was statistically significant compared to pretreatment ($p = 0.008$) and showed that the mandible rotated in a clockwise manner.

Table 1: Comparison of cephalometric measurements (angular) pretreatment and posttreatment

	N	*Mean*	*SD*	*Mean difference*	*T*	*p*	*95% confidence interval of the difference*	
							Lower	*Upper*
SNA Pre	30	87.27	2.94	1.82	11.362	<0.001	1.49	2.14
SNA Post	30	85.45	2.69					
SNB Pre	30	81.20	2.66	0.65	3.791	0.001	0.30	1.00
SNB Post	30	80.55	2.74					
ANB Pre	30	6.07	1.42	1.17	6.664	<0.001	0.81	1.52
ANB Post	30	4.90	1.69					
SNGoGn Pre	30	31.62	4.57	−0.83	−2.864	0.008	−1.43	−0.24
SNGoGn Post	30	32.45	4.13					
MM Pre	30	28.93	5.43	0.65	1.961	0.06	−0.03	1.33
MM Post	30	28.28	4.95					
FMA Pre	30	29.07	5.70	−1.0	−2.693	0.012	−1.76	−0.24
FMA Post	30	30.07	5.26					
N-A Pg Pre	30	11.82	3.61	0.63	1.363	0.184	−0.32	1.58
N-A Pg Post	30	11.18	3.20					

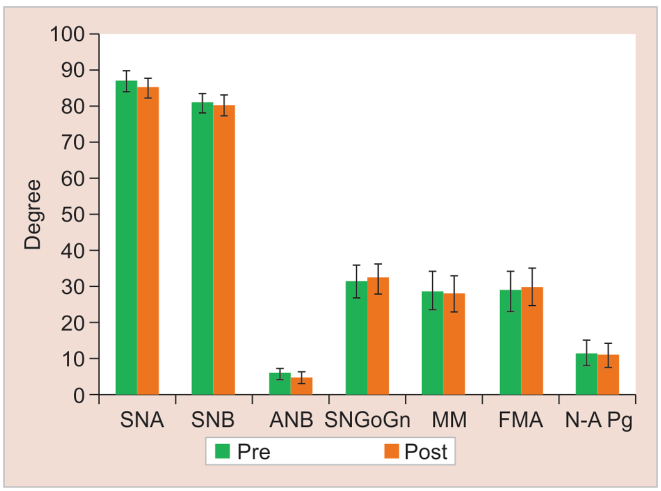

Fig. 1: Cephalometric angular measurements pretreatment and posttreatment

The mean values of FMA pretreatment and posttreatment were found to be 29.07 ± 5.70 and 30.07 ± 5.26, respectively. The increase in mean FMA posttreatment was statistically significant compared to pretreatment ($p = 0.012$). This also showed us that at the end of the treatment, the mandible had rotated in a clockwise manner.

The mean MM and N-A Pg did not differ significantly posttreatment when compared to pretreatment ($p > 0.05$).

The linear changes have been tabulated and also represented in graphical form (Table 2, Figs 2 and 3).

Posttreatment, there was an increase in mean TAFH, LAFH, and PFH compared to pretreatment and it was statistically significant ($p < 0.05$). The mean difference of the pretreatment and posttreatment TAFH, LAFH, and PFH was 2.8, 2.39, and 0.8 mm, respectively. The increase in the values of TAFH, LAFH, and PFH shows us that there is an overall increase in the facial height of the subject at the end of the treatment.

There was a decrease in mean WITS posttreatment, and it was statistically significant compared to pretreatment ($p = 0.001$). The mean difference between the pretreatment and posttreatment WITS was 0.79 mm. The decrease in WITS value shows that there was an improvement in the subject's facial profile.

The mean Co-A, Co-B, and N-A did not differ significantly posttreatment compared to pretreatment ($p > 0.05$).

There was also a decrease in mean N-B and mean N-Pg posttreatment compared to pretreatment and they were statistically significant ($p < 0.05$). The mean difference between the pretreatment and posttreatment N-B and N-Pg were 1.1 and 1 mm, respectively. The decrease in both the values signifies a potential worsening of the subject's facial profile.

Discussion

This retrospective study aimed to evaluate and compare the skeletal changes before and after the treatment of skeletal class II malocclusion with the extraction of premolars followed by fixed appliance therapy. Although severe skeletal class II cases require surgical intervention, not all patients agree for the same. In such cases, extraction treatment can be used as an alternative to slightly improve the profile. Knowledge of the skeletal changes that occur in a patient after the extraction of premolars is vital to understand how the profile of the patient improves. The data acquired sheds light on the pros and cons of extraction therapy on the patient's profile. Using this knowledge, we can better prepare ourselves to arrive at an accurate treatment plan for the patient. Various studies have tried to show the skeletal changes that occur after extraction therapy. However, none of them have used the many detailed cephalometric parameters such as is in our study. Nanda has shown that when cervical headgears and fixed functional appliances were used, there was an extrusive effect on the posterior teeth, thereby increasing the facial height.[24] Hence, cases that had undergone headgear therapy, fixed functional therapy, or both were excluded from the study. We did not include a nonextraction group to compare the results with because nonextraction treatment of a class II div 1 malocclusion invariably involves the use of headgear and/or fixed functional therapy.

In this study, we included cases that had a skeletal pattern of class II with maxillary prognathism and dental malocclusion of class II div 1 pattern. The age group of the patients ranged between 14 and 30 years and since some patients were still in the circum

Table 2: Comparison of cephalometric measurements (linear) pretreatment and posttreatment

	N	*Mean*	*SD*	*Mean difference*	*T*	*p*	*95% confidence interval of the difference*	
							Lower	*Upper*
TAFH Pre	30	121.03	7.60	−2.8	−7.992	<0.001	−3.52	−2.08
TAFH Post	30	123.83	7.65					
LAFH Pre	30	72.28	6.38	−2.39	−7.355	<0.001	−3.05	−1.72
LAFH Post	30	74.67	6.43					
PFH Pre	30	79.87	5.39	−0.8	−3.449	0.002	−1.27	−0.33
PFH Post	30	80.67	5.14					
WITS Pre	30	2.72	2.08	0.79	3.684	0.001	0.35	1.22
WITS Post	30	1.93	2.04					
Co-A Pre	30	91.30	6.55	0.691	2.04	0.66	−0.93	−0.58
Co-A Post	30	90.60	6.58					
Co-B Pre	30	108.23	7.24	−0.033	−0.114	0.91	−0.63	0.57
Co-B Post	30	108.27	7.51					
N-A Pre	30	3.05	4.14	0.5333	1.727	0.095	−0.10	1.16
N-A Post	30	2.52	4.04					
N-B Pre	30	−5.08	5.96	1.1	3.886	0.001	0.52	1.68
N-B Post	30	−6.18	5.86					
N-Pg Pre	30	−5.37	6.36	1	3.042	0.005	0.33	1.67
N-Pg Post	30	−6.37	6.11					

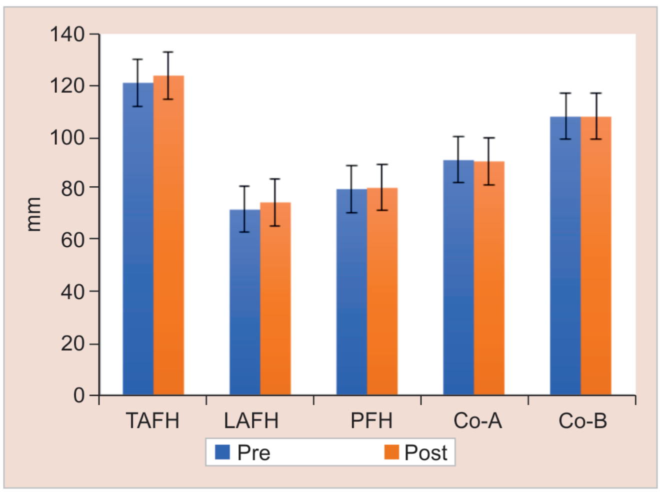

Fig. 2: Cephalometric linear measurements pretreatment and posttreatment (TAFH, LAFH, PFH, Co-A, Co-B)

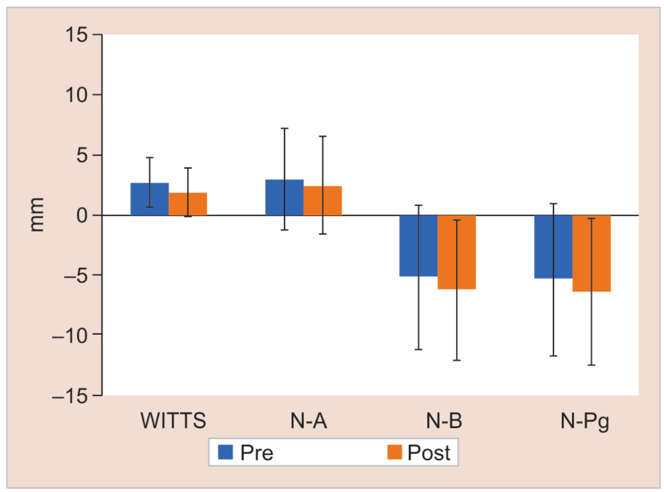

Fig. 3: Cephalometric linear measurements pretreatment and posttreatment (WITTS, N-A, N-B, N-Pg)

pubertal period, the residual growth was taken into consideration while analyzing the results of this study.

Significant reductions in SNA angle in our study suggest that there was definitely a remodeling of point A that occurred, which led to a decrease in these values. This is in accordance with a study done by Kafle and Ulrich[25] where they noticed a significant decrease in the SNA angle of study participants with class II div 1 malocclusion who underwent extraction of premolars for the orthodontic treatment. The SNB angle in our study also showed a statistically significant reduction with a mean value of 0.65° when compared to the pretreatment values which is in accordance with a study done by Heravi et al.[26] where there was a decrease of 0.74°. The decrease in the SNB angle can be attributed to the opening of the mandibular plane angle which leads to a clockwise rotation of the mandible.

The ANB angle also showed a statistically significant reduction. However, what has to be noted is that the apparent reduction in the ANB was due to the reduction in SNA than the decrease in SNB.

The significant increase in SN-GoGn Angle and the FMA angle indicates rotation of the mandible in the clockwise direction, which is similar to the observations done by Gianelly et al.,[14] Kim and Kim,[27] and Kocadereli.[28]

The difference in the MM angle was statistically insignificant when compared between the pretreatment and posttreatment groups which are contrary to the findings of Dwivedi et al.[3] who reported an increase in the MM angle. The N–A–Pog angle also showed a nonsignificant decrease between the pretreatment and posttreatment values. This suggests a mild improvement in the convexity of the profile. The increase in TAFH could be due to the extrusion of the molars during the bite opening process or could also be attributed to the use of class II elastics during space closure/settling. The findings of this study are in accordance with the findings of Tarvade,[29] Heravi,[26] Ahn and Schneider,[30] and Kim and Kim.[27]

The LAFH also showed a mean increase of 2.39 mm which are in accordance with the findings of Sivakumar and Valiathan,[31] Tarvade et al.,[29] and Zafarmand and Zafarmand.[32] We account for the increase in the LAFH due to the unwanted extrusion of the molars during bite opening mechanics and/or due to class II elastics.

The increase of PFH can be attributed to the fact that some of the patients in this study still had some amount of growth left. Our results are closely related to the findings of Tarvade et al.,[29] who found a significant increase in the posterior facial height in both the Beggs (2.20 mm) and pre-adjusted edgewise (1.8 mm) group.

A decrease in Wits appraisal values suggests an improvement in the profile of the patient, however, as stated before, the reduction in SNA could be due to the remodeling of point A, and hence the improvement in the profile is more apparent than real which are similar to the findings of Saniç et al.[1] and Makino et al.[33] The findings of this study contradict the findings of Shetty et al.[2] who reported a nonsignificant change in the Wits appraisal.

The changes noted for the effective maxillary length (Co-A) and the effective mandibular length (Co-B) were statistically insignificant. A study done by Dyer et al.[34] showed a statistically significant reduction of the maxillary length in both adolescent and adult samples. The results of their adult samples are similar to the findings of our study.

A statistically insignificant decrease in N-A values noted was 0.53 mm which is very similar to the findings of Saniç et al.[1] who also noted a statistically insignificant decrease of 0.52 mm. The slight reduction in the value could be due to the backward remodeling of point A due to retraction of the anteriors and/or due to the use of class II elastics.

The N-B and N-Pg showed statistically significant increases that suggest that there is a slight worsening of the patient's profile after the treatment by increasing the convexity of the face.

This study was retrospective in nature and therefore while collecting the samples for the study, the diagnosis and treatment planning could have varied from patient to patient. This is one limitation of our study. A prospective randomized clinical study would yield more accurate results. Another factor to be taken into consideration is that our study involved the hand traced analysis of lateral cephalograms to assess the skeletal changes. This can be considered as another limitation of the study. In today's age of technology, it can be fairly said that digitized cephalograms with software for cephalometric analysis would provide higher consistency. Unfortunately, the department archives did not have digitized cephalograms and that is why we could not use the same for cephalometric analysis. Although the skeletal changes following the extraction of four premolars were studied in this study, the need for its correlation with dental and soft tissue changes are necessary to have a complete and thorough understanding of the overall changes that occur to a patient's profile after the orthodontic therapy.

Conclusion

The findings of this study can be used to understand the impact of orthodontic treatment on the facial profile of the patients. The results show us an overall improvement in the facial profile of the patient who involved significant correction of the maxillary relation to the cranium than the mandibular. The results also show that an increase in the facial height was evident after the orthodontic treatment that involved the extraction of premolars. Although this can be advantageous while treating a hypodivergent patient (low facial height), this can be deleterious while treating a hyperdivergent patient (increased facial height).

References

1. Saniç K, Novruzov Z, Aliyeva R. The effect of tooth extraction on vertical dimension change in patients with class II malocclusion. Mod Dentis. 2015;5:90–93.
2. Shetty A, Patil A, Ganeshkar S. Comparison of skeletal, dental and soft tissue changes in young adults with class II malocclusion, treated either by camouflage, fixed functional appliance or orthognathic surgery—A prospective study on Indian subjects. Open J Stomatol 2012;2(04):373–382. DOI: 10.4236/ojst.2012.24065.
3. Dwivedi S, Sonwane S, Chokotiya H, et al. Effect of premolar extractions on facial vertical dimension — a cephalometric study. Indian J Orthodont Dentofac Res 2016;2(4):194–196. DOI: 10.18231/2455-6785.2016.0012.
4. Zierhut EC, Joondeph DR, Artun J, et al. Long-term profile changes associated with successfully treated extraction and nonextraction class II division 1 malocclusions. Angle Orthod 2000;70:208–219.
5. Paquette DE, Beattie JR, Johnston Jr LE. A long-term comparison of nonextraction and premolar extraction edgewise therapy in "borderline" Class II patients. Am J Orthod Dentofacial Orthop 1992;102(1):1–14. DOI: 10.1016/0889-5406(92)70009-Y.
6. Bishara SE, Cummins DM, Jacobsen JR, et al. Dentofacial and soft tissue changes to class II division 1 cases treated with and without extractions. Am J Orthod Dentofacial Orthop 1995;107(1):28–37. DOI: 10.1016/S0889-5406(95)70154-0.
7. Young T, Smith R. Effects of orthodontics on the facial profile: a comparison of change during nonextraction and four premolar extraction treatment. Am J Orthod Dentofacial Orthop 1993;103(5):452–458. DOI: 10.1016/S0889-5406(05)81796-2.
8. Klapper L, Navarro SF, Bowman D, et al. The influence of extraction and nonextraction orthodontic treatment on brachyfacial and dolichofacial growth patterns. Am. J Orthod. Dentofac. Orthop. 1992;101(5):426–430. DOI: 10.1016/0889-5406(92)70116-R.
9. Staggers JA. Vertical changes following first premolar extractions. Am J Orthod Dentofacial Orthop 1994;105(1):19–24. DOI: 10.1016/S0889-5406(94)70095-8.
10. Ülgen M. Ortodontik Tedavi Prensipleri. Ankara: Ankara Üniversitesi; 1983. p. 71.
11. Wyatt WE. Preventing adverse effects on the temporomandibular joint through orthodontic treatment. Am J Ortho Dentofac Orthod 1987;91(6):493–499. DOI: 10.1016/0889-5406(87)90006-0.
12. McLaughlin RP, Bennett JC. The extraction-nonextraction dilemma as it relates to TMD. Am J Ortho Dentofac Orthod 1995;65(3):175–186.
13. Major P, Kamelchuk L, Nebbe B, et al. Condyle displacement associated with premolar extraction and nonextraction orthodontic treatment of class I malocclusion. Am J Orthod Dentofacial Orthop 1997;112(4):435–440. DOI: 10.1016/S0889-5406(97)70052-0.
14. Gianelly A, Hughes H, Wohlgemuth P, et al. Condylar position and extraction treatment. Am J Orthod Dentofacial Orthop 1988;93(3):201–205. DOI: 10.1016/S0889-5406(88)80004-0.
15. Gianelly AA, Cozzani M, Boffa J. Condylar position and maxillary first premolar extraction. Am J Orthod Dentofacial Orthop 1991;99(5):473–476. DOI: 10.1016/S0889-5406(05)81581-1.

16. Gianelly AA, Anderson CK, Boffa J. Longitudinal evaluation of condylar position in extraction and nonextraction treatment. Am J Orthod Dentofacial Orthop 1991;100(5):416–420. DOI: 10.1016/0889-5406(91)70080-G.
17. Luecke 3rd PE, Johnston Jr LE. The effect of maxillary first premolar extraction and incisor retraction on mandibular position: testing the central dogma of “functional orthodontics”. Am J Orthod Dentofacial Orthop 1992;101(1):4–12. DOI: 10.1016/0889-5406(92)70075-L.
18. Reynders RM. Orthodontics and temporomandibular disorders: a review of the literature (1966-1988). Am J Orthod Dentofacial Orthop 1990;97(6):463–471. DOI: 10.1016/S0889-5406(05)80026-5.
19. Schudy FF. The rotation of the mandible resulting from growth: its implications in orthodontic treatment. Angle Orthod 1965;35:36–50.
20. Schudy FF. The control of vertical overbite in clinical orthodontics. Angle Orthod 1968;38(1):19–39.
21. Kuhn R. Control of anterior vertical dimension and proper selection of extraoral anchorage. Angle Orthod 1968;38:340–349.
22. Pearson LE. Vertical control in treatment of patients having backward rotational growth tendencies. Angle Orthod 1978;48:132–140.
23. Isaacson JR, Isaacson RJ, Speidel TM, et al. Extreme variation in vertical facial growth and associated variation in skeletal and dental relations. Angle Orthod 1971;41:219–229.
24. Nanda SK. Patterns of vertical growth in the face. Am J Orthod Dentofacial Orthop 1998;93(2):103–116. DOI: 10.1016/0889-5406(88)90287-9.
25. Kafle D, Ulrich Z. Skeleto-dental changes after camouflage treatment in class II div 1 adult patients with average mandibular plane angle. Orthodontic Journal of Nepal 2011;1(1):31–35. DOI: 10.3126/ojn.v1i1.9364.
26. Heravi F, Shojaeian S, Sadafi M. A comparative study of dentoskeletal changes following orthodontic treatment with first premolar extraction in long face and normal patients. J Dent Mater Tech 2012;1(2):63–69.
27. Kim TK, Kim JT. First or second premolar extraction effects on facial vertical dimension. Angle Orthodontist 2005;75:177–182.
28. Kocadereli I. The effect of first premolar extraction on vertical dimension. Am J Orthod Dentofacial Orthop 1999;116(1):41–45. DOI: 10.1016/S0889-5406(99)70301-X.
29. Tarvade S, Chaudhari C, Satish H. Vertical changes during Begg’s and PEA — a comparative study. IOSR-JDMS 2017;9(4):48–53. DOI: 10.9790/0853-0944853.
30. Ahn JG, Schneider BJ. Cephalometric appraisal of posttreatment vertical changes in adult orthodontic patients. Am J Orthod Dentofacial Orthop 2000;118(4):378–384. DOI: 10.1067/mod.2000.109312.
31. Sivakumar A, Valiathan A. Cephalometric assessment of dentofacial vertical changes in class I subjects treated with and without extraction. Am J Orthod Dentofacial Orthop 2008;133(6):869–875. DOI: 10.1016/j.ajodo.2006.05.041.
32. Zafarmand AH, Zafarmand MM. Premolar extraction in orthodontics: does it have any effect on patient’s facial height? J Int Soc Prevent Communit Dent 2015;5(1):64–68. DOI: 10.4103/2231-0762.151980.
33. Makino M, Choi Y, Nojima K, et al. Characteristics of dentoskeletal morphology and treatment changes in 2-maxillary premolar extraction: a comparison with 4-premolar extraction. J World Federat Orthod 2013;2(2):e71–e76. DOI: 10.1016/j.ejwf.2013.02.004.
34. Dyer G, Harris E, Vaden J. Age effects on orthodontic treatment: adolescents contrasted with adults. Am J Orthod Dentofacial Orthop 1991;100(6):523–530. DOI: 10.1016/0889-5406(91)70092-B.