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A photographic analysis of soft tissue changes following Class II Division 1 malocclusion treatment with and without extraction

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Abstract

Background: There is a continuous debate on the issue of comparison between extraction and non-extraction treatment results in terms of subsequent soft tissue changes in Class II division 1 patients. So far, however, little attention has been paid to the photographic evaluation of treatment results. The aim of this study was to assess the impact of extraction and non-extraction treatment of Class II division 1 malocclusion on soft tissue profile by means of pre- and post- treatment photographs

Methods: The pre- and post- treatment profile photographs of 41 borderline Class II division 1 malocclusion patients (ANB ≤5 degrees, and overjet ≤ 5 mm) were evaluated. The photographs were digitized into the computer and 19 angular measurements were evaluated. Paired *t*-tests and Independent-sample *t*-tests were performed to compare the pre- and post- treatment values between the extraction and non- extraction groups. The level of significance was set to be $P < .05$.

Results: Significant differences between pre- and post- treatment values in extraction group existed for Z angle and N-Sn-Pog. In non-extraction group, significant differences were observed in N-Pn-Pog, G-Sn-Pog, N-Sn-Pog and N-Sn-B. When comparing the extraction and non-extraction groups before and after treatment, the results showed that the only significant difference was in PFH/AFH proportion.

Conclusion: The results of this study revealed that for both extraction and non-extraction groups, there were straightening and improvement of soft tissue profile without significant impact on lips or nasolabial angle.

Keywords: Orthodontics, Tooth extraction, Class II Malocclusion, Division 1, Photography

1. Introduction

Esthetic issues are among the top reasons for orthodontic patients to seek treatment nowadays [1]. A systematic review showed that facial attractiveness was the main motivational factor that urged people to undergo orthodontic treatment [2]. Facial profile and soft tissue factors including nasal prominence, nasolabial angle, lip positions, labio-mental sulcus and some other soft tissue values are important determinants in treatment planning and assessment of treatment outcomes in terms of facial esthetics [3,4]. In a systematic review to evaluate soft tissue profile changes following orthodontic treatment, significant retraction of lips, increase in nasolabial angle, and increase in upper lip thickness were reported as effects of orthodontic extraction on soft tissue profile in class I malocclusion patients [5].

The emergence of soft tissue paradigm in orthodontics has shifted the diagnostic emphasis from dental casts and cephalometric radiographs toward clinical examination of intraoral and facial soft tissues [6]. In line with the concept of soft tissue paradigm, patient's soft tissue assessment is one of the most important contributors of a correct diagnosis of underlying skeletal discrepancy [7-10]. In cephalometric radiography, where the structures are only recorded in profile and only in the anterior-most outline, there is limited possibility to

assess soft tissues [11]. Instead, we have the photographic assessments of patient's profile and frontal views as a noninvasive diagnostic tool for soft tissue evaluation [11]. Various photogrammetric analyses have been proposed by authors [11] and the photographic method has been proved as a repeatable and reproducible method; if the standard protocol is observed [12].

There is a continuous debate on the issue of comparison between extraction and non-extraction treatment results in terms of subsequent soft tissue changes for Class II division 1 patients. Concerns exist regarding the effect of extraction treatment on the lip position and possible deleterious effects on resulting profile [13]. Despite the various studies that have evaluated the pros and cons of theses available options for Class II division 1 malocclusion treatment [13-22], soft tissue response to treatment is still an issue of controversy. Therefore, the aim of this study was to assess the impact of extraction and non-extraction treatment of Class II division 1 malocclusion on soft tissue profile by means of pre- and post- treatment photographs.

2. Methods

Study population

In this retrospective study, the pre- and post- treatment profile photographs of 41 borderline Class II division 1 malocclusion patients (ANB ≤5 degrees, and overjet ≤ 5 mm) who underwent orthodontic treatment between October 2016 and August 2021 at a private office were evaluated. The patients were over 12 years old, with borderline class II malocclusion who were treated for the class II malocclusion with conventional edgewise appliances. In the extraction group, mainly the first or second premolars were extracted, and the space closure was done with moderate anchorage, since the subjects had borderline Class II malocclusion. Patients with a history of plastic or orthognathic surgery, craniofacial syndromes, and trauma or patients with low quality photographs were excluded from the study.

Right profile photographs were taken in natural head position (NHP) while forehead, neck, and ears were clearly visible. To obtain NHP, subjects were asked to stand with an upright posture in front of an adjustable mirror hung on a tripod at a distance of 120 cm and look straight into the image of their eyes in the mirror. Teeth were in centric occlusion and lips were relaxed. In the same way that was described by de Carvalho et. al. [11,12] ,a 15-cm vertical scale was used to indicate the true vertical line (TVL) and correct the magnification differences between the photographs. The same digital camera (Canon Digital SLR EOS 80D, Canon, Tokyo, Japan) with the same lens (EF 100mm f/2.8L USM Macro Lens, Canon, Tokyo, Japan) and ring flash (Canon MR-14EX II Macro Ring Lite) was used for all photographic images which was fixed on a tripod at a distance of 210 cm from the patients and could be adjusted based on the patients' height. The 100-mm macro lens provided natural proportions and was selected to prevent image deformations.

The photographs were digitized into the computer and 13 landmarks on the profile photographs were marked (Figure 1). Following landmark identification, different angular measurements were made on the photographs using Digimizer version 5.4.9.0 image analysis software. The correction for magnification was achieved using the metric scale image as a reference. The landmarks and measurements which were used in this study are as follows:

Landmarks on profile photographs

G: Glabella, N: Nasion, Po:Porion, Nd: Nasal dorsum, Prn: Pronasale, Cm: Columella, Sn: subnasale, A point, Ls: Labiale superior, Li: Labiale inferior, B point, Pog: Pogonion, Gn: Gnathion, Go: Gonion.

Angular measurements on profile photographs

1. Z angle: the angle between the Frankfort plane and profile line (a line joining the extreme point of the soft tissues of the chin and the more prominent lip, usually the upper)
2. Nose tip angle: the angle between N- Prn- Cm
3. Nasolabial angle: the angle between Cm- Sn- Ls
4. Nasomental angle: the angle between these two lines: N- Prn/ N-Pog
5. Upper lip projection: the angle between these two lines: N- Ls/ N- Pog
6. Lower lip projection: the angle between these two lines: N- Li/ N- Pog
7. Soft tissue ANB: the maxillomandibular soft tissue discrepancy; the angle between N-A/ N-B
8. Mentolabial angle: the angle between Li- B- Pog
9. Nasofrontal angle: the angle between G- N- Nd
10. Facial convexity including the nose: the angle between N- Prn- Pog

11. Facial convexity excluding the nose: the angle between G- Sn- Pog
12. The angle between N- Sn- Pog
13. The angle between N- Sn- B
14. The angle between N- Po- Sn
15. The angle between Sn- Po- Gn
16. Soft tissue facial angle: the angle between FH line (the line connecting soft tissue Porion to Orbitale) and N- Pog line
17. Gonial angle: the angle between Po- Go- Me
18. PFH/AFH: The ratio of posterior facial height (PFH) (the distance between Po- Go) to anterior facial height (AFH) (the distance between N- Me)
19. LAFH/AFH: The ratio of lower anterior facial height (LAFH) (the distance between Sn- Me) to anterior facial height (AFH) (the distance between N- Me)

Error of the photographic analysis

All measurements were performed by the same operator. By using a table of random numbers, 20 photographs were selected for a second analysis, and the error standard deviation for two measurements was calculated using Dahlberg's formula [33].

Statistical analysis

Means and standard deviations for the previously mentioned 19 variables were calculated in both extraction and non-extraction groups before and after treatment. The Kolmogorov Smirnov test showed that the data distribution was normal. Therefore, Paired *t*-tests were used to evaluate the differences in pre- and post- treatment values of measured parameters in each group and Independent-sample *t*-tests were performed to compare the pre- and post- treatment values between the extraction and non-extraction groups. The level of significance was set to be $P < .05$ (significant) and $P < .001$ (highly significant).

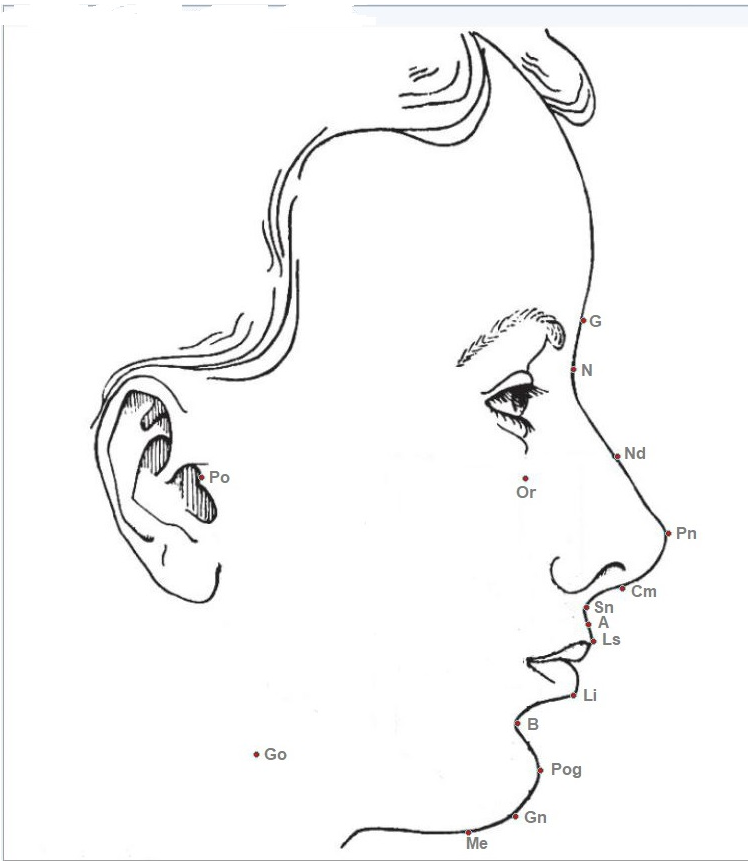

Figure 1. landmarks on profile photographs, which were used in this study

3. Results

As we mentioned before, the pre- and post-treatment profile photographs of 41 patients (7 males and 34 females) with the age range of 12-40 years were entered in the study. Among them, 23 patients (56.1%) had been treated with extraction and 18 (43.9%) without extraction. The

means and standard deviations for the studied parameters before and after treatment for the two groups are listed in Tables 2 and 3.

As shown in Table 2, significant differences between pre- and post- treatment values in the extraction group existed for Z angle and N-Sn-Pog. In the non-extraction group (Table 2), significant differences were observed in N-Pn-Pog, G-Sn-Pog, N-Sn-Pog and N-Sn-B. When comparing the extraction and non-extraction groups before and after treatment, the results showed that the only significant difference was in PFH/AFH proportion (Tables 4, 5). The intraoperation errors for the 19 variables are listed in Table 6.

Table 1. Distribution of subjects by age, group and sex

group	12-19	20-27	28-35	36-44	Male	Female	Total
Ext	8	9	5	1	3	20	23
Nonext	7	9	2	0	4	14	18
Total	15	18	7	1	7	34	41

Table 2. Extraction group: Descriptive and Inferential Statistics of the soft tissue analysis results

Variable	Pre-treatment Mean	Post-treatment Mean	Difference in means	SD	t Value	p value
Z angle	66.0740	68.8508	2.7768	4.91417	-2.768	0.011*
N-Pn-Cm	104.3744	104.0958	0.5836	1.68797	0.808	0.427
Cm-Sn-Ls	102.6825	103.5275	0.845	8.99558	-0.460	0.650
N-Pn.N-Pog	31.6396	31.5225	-0.1171	2.12038	0.271	0.789
N-Pog.N-Ls	9.5754	9.1654	-0.41	1.54026	1.304	0.205
N-Pog.N-Li	4.0367	3.5087	-0.528	1.38557	1.867	0.075
ANB	9.2754	8.9863	-0.2891	0.30032	0.963	0.346
Li-B-Pog	124.9138	128.9006	3.9868	1.97253	-2.021	0.055
G-N-Nd	141.8188	141.0863	-0.7325	0.62149	1.179	0.251
N-Pn-Pog	126.5374	126.9136	0.3762	0.67068	-0.565	0.578
G-Sn-Pog	162.0825	163.0013	0.9188	0.57307	-1.603	0.123
N-Po-Sn	28.0338	28.3154	0.2816	0.29151	-0.966	0.344
Sn-Po-Gn	31.4479	32.1342	0.6863	0.35779	-1.918	0.068
FNP	87.7296	88.6267	0.8971	0.74775	-1.200	0.242
N-Sn-Pog	157.5400	158.8429	1.3029	0.63424	-2.054	0.05*
N-Sn-B	153.5350	154.8533	1.3483	0.80973	-1.628	0.117
Po-Go-Me	126.0992	126.0087	-0.0905	0.51860	0.174	0.863
PFH.AFH	0.5010	0.4977	0.9934	.00441	0.736	0.469
LAFH.AFH	0.5953	0.5962	0.0009	.00248	-0.369	0.716

*p, .05 **p, .01

Table 3. Non-extraction group: Descriptive and Inferential Statistics of the soft tissue analysis results

Variable	Pre-treatment Mean	Post-treatment Mean	Difference in means	SD	t Value	p value
Z angle	68.9612	70.7188	1.7576	0.92940	-1.891	0.077
N-Pn-Cm	104.0441	106.3762	2.3321	1.05462	-2.211	0.052
Cm-Sn-Ls	102.0794	102.0906	0.0112	1.93311	-.0006	0.995
N-Pn.N-Pog	32.5665	31.2306	-1.3359	0.70573	1.893	0.077
N-Pog.N-Ls	8.9794	8.9316	-0.0478	0.27724	0.172	0.866
N-Pog.N-Li	3.9171	3.9706	0.0535	0.22286	-0.240	0.813
ANB	8.7194	8.6112	-0.1082	0.23879	0.453	0.656
Li-B-Pog	124.4018	124.1100	-0.2918	2.29906	0.127	0.901
G-N-Nd	142.1394	142.2500	0.1106	0.48693	-0.227	0.823
N-Pn-Pog	126.1261	128.3878	2.2617	1.07191	-2.110	0.05*
G-Sn-Pog	163.8924	165.4565	1.5741	0.46663	-3.352	0.004**
N-Po-Sn	27.5088	27.3071	-.12964	0.29077	0.694	0.498
Sn-Po-Gn	30.1035	30.3118	.2083	0.44806	-0.465	0.648
FNP	88.3576	89.0935	0.7359	0.57173	-1.287	0.216
N-Sn-Pog	161.3200	162.3435	1.24325	0.47971	-2.134	0.049*
N-Sn-B	156.2618	157.6624	1.4006	0.57328	-2.443	0.027*
Po-Go-Me	122.8541	124.2094	1.3553	0.99462	-1.360	0.193
PFH.AFH	.5348	.5318	-.003	0.00551	0.553	0.588
LAFH.AFH	.5917	.5979	.0062	0.00326	-1.880	0.078

*p, .05 **p, .01

Table 4. Extraction vs Non-extraction: Descriptive and Inferential Statistics of Mean Value Differences: Soft Tissue Analysis Pretreatment Results

Variable	Non-extraction	Extraction	Mean Difference	t Value	P value
Z angle	68.9612	66.0740	-2.8872	0.658	0.514
N-Pn-Cm	104.0441	104.3744	0.3303	1.202	0.237
Cm-Sn-Ls	102.0794	102.6825	0.6031	-0.366	0.716
N-Pn.N-Pog	32.5665	31.6396	-0.9269	-0.253	0.802
N-Pog.N-Ls	8.9794	9.5754	0.596	-0.284	0.778
N-Pog.N-Li	3.9171	4.0367	0.1196	0.555	0.582
ANB	8. 7194	9.2754	0.556	-1.339	0.549
Li-B-Pog	124.4018	124.9138	0.512	-0.064	0.320
G-N-Nd	142.1394	141.8188	-0.3206	-1.008	0.711
N-Pn-Pog	126.1261	126.5374	0.4113	0.374	0.362
G-Sn-Pog	163.8924	162.0825	-1.8099	0.922	0.250
N-Po-Sn	27.5088	28.0338	0.525	1.167	0.352
Sn-Po-Gn	30.1035	31.4479	1.344	-0.942	0.099
FNP	88.3576	87.7296	-0.628	0.322	0.749
N-Sn-Pog	161.3200	157.5400	-3.78	1.426	0.162
N-Sn-B	156.2618	153.5350	-2.7268	1.196	0.079
Po-Go-Me	122.8541	126.0992	3.2451	-0.705	0.239
PFH.AFH	0.5348	0.5010	-0.0338	2.102	0.042*
LAFH.AFH	0.5917	0.5953	0.0036	0.213	0.832

*p, .05 **p, .01

Table 5. Extraction vs Non-extraction: Descriptive and Inferential Statistics of Mean Value Differences: Soft Tissue Analysis Posttreatment Results

Variable	Non-extraction	Extraction	Mean Difference	t Value	P value
Z angle	70.7178	68.8508	-1.867	0.836	0.408
N-Pn-Cm	106.3762	104.0958	-2.2804	-0.156	0.877
Cm-Sn-Ls	104.0985	102.0906	-2.0079	-0.147	0.884
N-Pn.N-Pog	31.2306	31.5225	0.2919	0.716	0.478
N-Pog.N-Ls	8.9318	9.1654	0.2336	-0.650	0.519
N-Pog.N-Li	3.9706	3.5078	-0.3982	-0.149	0.883
ANB	8.6112	8.9863	0.3751	-0.690	0.494
Li-B-Pog	124.1100	128.9008	4.7908	-0.109	0.914
G-N-Nd	142.2500	141.0863	-1.1637	0.112	0.912
N-Pn-Pog	128.3878	126.9163	-1.4715	-0.238	0.813
G-Sn-Pog	165.4565	163.0013	-2.4549	0.800	0.429
N-Po-Sn	27.3071	28.3154	1.0083	-0.406	0.648
Sn-Po-Gn	30.3118	32.1342	1.8224	-1.271	0.211
FNP	89.0935	88.6267	-0.4668	0.418	0.678
N-Sn-Pog	162.3435	158.8429	-3.5006	1.528	0.135
N-Sn-B	157.6624	154.8533	-2.8091	1.179	0.246
Po-Go-Me	124.2094	126.0087	1.7993	-1.229	0.226
PFH.AFH	0.5318	0.4977	-0.0341	2.284	0.028*
LAFH.AFH	0.5979	0. 5962	-.001	-0.427	0.671

*p, .05 **p, .01

Table 6. Method errors for studied parameters

Measurement	Method error
Z angle	0.41
N-Pn-Cm	0.33
Cm-Sn-Ls	0.56
N-Pn.N-Pog	0.64
N-Pog.N-Ls	0.12
N-Pog.N-Li	0.27
ANB	0.32
Li-B-Pog	0.98
G-N-Nd	0.40
N-Pn-Pog	0.57
G-Sn-Pog	1.02
N-Po-Sn	0.46
Sn-Po-Gn	0.57
FNP	0.97
N-Sn-Pog	0.63
N-Sn-B	0.58
Po-Go-Me	0.45
PFH.AFH	0.08
LAFH.AFH	0.09

4. Discussion

Extraction and non-extraction modalities are common options in treatment of patients with Class II division 1 malocclusion. The effects of these treatment options on the soft tissue profile have been studied by several authors [13-22]. What we found in this study was the increase in Z angle and N-Sn-Pog in extraction group, which is suggestive of general flattening of soft tissue profile. In the non-extraction group, we observed an increase in angles presenting the facial convexity (N-Pn-Pog, G-Sn-Pog, N-Sn-Pog and N-Sn-B), which means non-extraction treatment in our study resulted in total flattening of the face. Retraction of upper lip in both groups, retraction of lower lip in the extraction group, and protraction of lower lip in the non-extraction group occurred following treatment; however, the amount of those changes was insignificant. The decreasing and increasing direction of changes for nasolabial angle in non-extraction and extraction groups, respectively, was also insignificant. Therefore, we can summarize the results of this study of either extraction or non-extraction treatments as a general flattening effect on soft tissue profile without significant impact on lips or nasolabial angle.

Soft tissue changes in extraction group

Verma et. al evaluated the effect of extraction/ non-extraction treatment via cephalometric analysis on Hundred post-pubertal female patients of Class II Division 1 malocclusion, and found more retruded lower lip and a more pronounced lower labial sulcus in the extraction group [14]. They found an increase in Z angle for the extraction group, which is in line with our findings; however, they also reported increased nasolabial angle for the extraction group which was not shown in our study [14]. The increase in Z angle for the extraction group has also been reported by James et.al [23]. In the present study, the improvement of the relationship between nose, lip, and chin, which is reflected in Z angle was more pronounced in the extraction group. This is further corroborated by Verma [14], James [23], Saelens and Smit [24], and Finnöy et al [25]. Increased nasolabial angle in the extraction group has been reported by several authors [14-23,26,28]. However, we failed to find any difference in NLA. This difference can be attributed to the fact that we studied the borderline Class II patients for whom the extraction decision possibly had been made based on tooth size, arch length discrepancy and space requirements and the extent of incisor retraction might be comparable to the non-extraction group. This explanation is further supported by the reported proportional relationship of NLA to the occlusal antero-posterior malocclusion severity [15] and the greater increase in NLA for more severe Class II patients who need more anterior retraction. Increase in NLA has been reported in a range of 2.4 to 5.4 degrees for 2-premolar extractions, 1 to 6.84 degrees for 4-premolar extractions, and up to 11.55 degrees when mini-implants are used [15].

Retraction of both lips has been reported as a result of extraction treatment [15,16]. However, we found insignificant differences regarding lip projections which can be related to the borderline nature of patients in this study. Therefore, it has been suggested that extraction treatments should be selected when facial aesthetics and excessive lip protrusion dictate this type of treatment [15].

Soft tissue changes in non- extraction group

Changes in upper lip position are the results of both upper and lower incisor movements [29]. Some authors believe that the perioral soft tissues are self-supporting and factors other than dental movements cause the wide variability of individual response to treatment [30,31]. Some of previous reports support the more protrusive lip profile for non-extraction group [14,23-25]. What we found was an insignificant change in lip projections. The improvement of soft tissue profile and facial convexity which we observed in this study, was supported by some of previous researches in this regard [14,15,23-25].

Differences between the two study groups

The only difference between the two treatment groups in this study was the PFH/AFH ratio which was larger for the non-extraction group both in pre-treatment and post-treatment measurements. The larger value of PFH/AFH for non-extraction group that shows more horizontal growth compared to the extraction group seems logical, since the vertical growth tendency is in favor of choosing extraction treatment. Lack of significant differences between the two treatment groups in this study shows that the baseline imbalances were minimal and the decision whether to extract or not has been made based on various factors; among them are arch length discrepancy, incisor inclination, space requirements, and soft tissue limitations.

We included both growing and adult patients in our study sample. This inclusion may have a possible impact on the results achieved. For future research in this regard, we suggest to

limit the study to growing or adult subjects in order to prevent any confounding factor from negatively affect the results.

Conclusion

The results of this study showed that extraction treatment for Class II division 1 malocclusion patients is mainly associated with an increase in Z angle and straightening of the soft tissue profile. In the non-extraction group, we observed an increase in angles presenting the facial convexity, which means that non-extraction treatment in our study resulted in total flattening of the face and improvement of soft tissue profile. The results of this study for both extraction and non-extraction groups included the straightening and improvement of soft tissue profile without significant impact on lips or nasolabial angle. The main difference between the two groups, whether before or after treatment, was longer anterior facial height in the extraction group.

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