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Soft tissue and incisor position changes in class I bimaxillary subjects after retraction using friction and frictionless mechanics

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Aim: Bimaxillary protrusion is a common condition observed irrespective of race and ethnicity and is a chief concern for patients who seek orthodontic treatment. The aim of this study was to compare and evaluate changes in soft tissue structures and incisor positions in class I bimaxillary protrusion subjects undergoing orthodontic therapy when friction and frictionless mechanics were used. **Methods:** Two groups with a total of 40 patients aged 18–30 years diagnosed with class I bimaxillary protrusion treated by extracting first premolars were considered for this study. Patients treated with friction mechanics were included in Group 1 and those treated with frictionless mechanics in Group 2. The digital lateral cephalograms were calibrated and analyzed using Nemoceph software. Selected landmarks were marked on pre- and post-treatment cephalograms and assessed for intra- and inter-group soft tissue and incisor position changes. Student's t-test was used to analyze the collected data using SPSS 20 software. **Result:** Intra-group comparison revealed significant changes in both groups. Inter-group comparison of the selected parameters between groups 1 and 2 showed differences but without any statistical significance, except for the inter-incisal angle. **Conclusion:** Pre- and post-treatment comparison analysis revealed significant soft tissue changes in both groups. However, the comparison between friction and frictionless mechanics showed no statistically significant changes.

Keywords: Tooth extraction. Friction. Malocclusion. Mechanics.

Introduction

Proclination of the upper and lower incisors, along with enhanced procumbency of the lips, are common characteristics observed in bimaxillary protrusion. Prominent facial characteristics such as lip incompetence, prognathic maxilla, toothy appearance due to apparent chin deficiency, thick-looking lips, lip strain, and an everted vermilion border are common features of bimaxillary protrusion[1]. It is a common condition observed in almost every ethnic group, with a higher incidence in the African-American and Asian populations[2,3].

Individuals with bimaxillary protrusion often seek a cure to improve their esthetics and are less concerned about the dental or functional aspects[4]. Successful treatment of bimaxillary protrusion can be achieved with orthodontic mechanotherapy[5]. Bimaxillary protrusion can be treated using either an extraction or a non-extraction treatment procedure[6,7]. The most frequently preferred treatment protocol is extraction of all four first premolars. Orthodontic extraction is correlated with statistically more satisfying facial esthetics than the non-extraction protocol[8].

Orthodontic space closure can be achieved using two methods: friction/sliding mechanics and frictionless/loop mechanics; both methods have their merits and demerits[9]. Orthodontic therapy, which includes straightening of the facial profile and improvement of lip posture, affects hard and soft tissue structures. Retraction using MBT mechanics is very effective in decreasing incisor protrusion and achieving favorable soft tissue improvements, such as a significant amount of lip retraction; increased nasolabial angle; decreased interlabial distance, lip thickness, and circumoral convexity, as well as improved lip strain and lip sulcus width[10].

Several studies have assessed hard and soft tissue changes before and after premolar extraction[11]. However, very little research has been conducted on the comparison of changes in soft tissue structures following the extraction of the four first premolars when friction and frictionless mechanics were used.

Hence, this study aimed to evaluate and compare the changes in soft tissue structures and incisal inclination after extracting all four first premolars in class I bimaxillary protrusion patients treated with either friction or frictionless mechanics.

Methodology

This retrospective study was conducted at Mangalore, India, in the Department of Orthodontics, A.B. Shetty Memorial Institute of Dental Sciences, Nitte (deemed-to-be-university). Clearance from the ethical committee and institutional review board was attained prior to the initiation of study (ABSM/EC/65/2018).

Healthy bimaxillary protrusion subjects with class I malocclusion, aged 18–30 years, were included in the study. Subjects with an inter-incisal angle of <125°, whose first premolars were therapeutically extracted, and who were treated using either friction or frictionless mechanics for en-masse retraction of the anterior teeth were included. Subjects with congenital anomalies, gross facial asymmetry, or missing teeth, except third molars, were excluded.

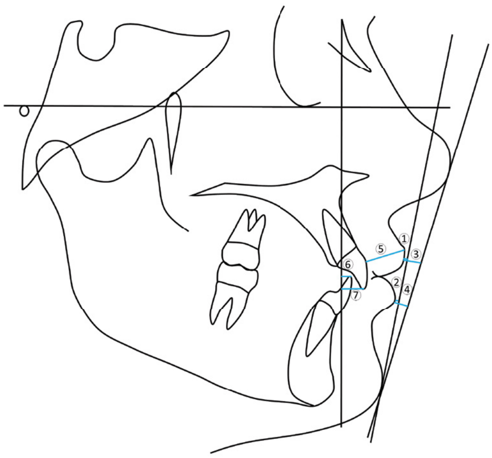
Two groups with 20 subjects in each group were included in the study:

Group 1: Subjects treated with friction mechanics.

Group 2: Subjects treated with frictionless mechanics.

Cephalograms were obtained using the Planmeca Promax (Plameca Oy, Finland), which uses a charge-coupled device sensor chip as an image receptor. The exposure parameters were standardized at 68 kVp, 5 mA, and 18.7 s.

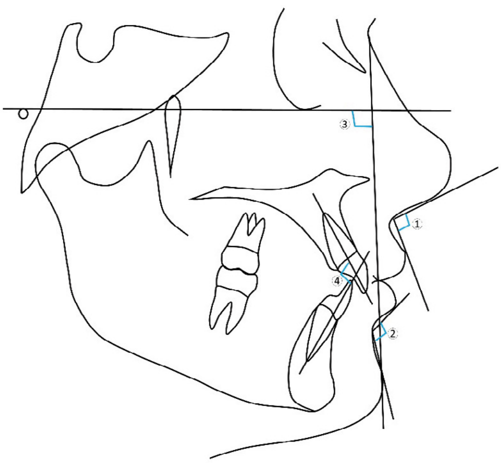
Once the subjects were finalized, Nemoceph v.12 software (Nemotec, Spain) was used to analyze the measurements in pre- and post-treatment cephalograms. Angular and linear measurements used in this study are summarized in Figures 1 and 2. Pre- and post-treatment intra-group comparisons were performed for both Group 1 and 2. Inter-group comparisons were also performed between groups 1 and 2.



Linear measurements

1. Upper lip to S-line (UL – S)
2. Lower lip to S-line (LL – S)
3. Upper lip to E-line (UL – S)
4. Lower lip to E-line (LL – S)
5. Lip strain
6. N – Perpendicular to Upper incisor (UI – NP)
7. N – Perpendicular to Lower incisor (LI – NP)

Figure 1. Linear measurements



Angular measurements

1. Naso-labial angle (NLA)
2. Mento-labial angle (LMA)
3. Facial angle
4. Inter-incisal angle (ILL)

Figure 2. Angular measurements

A customized Microsoft Excel sheet was used to enter the data obtained from the cephalograms, and the data were analyzed using SPSS 20 software. Means, confidence intervals, and standard deviations were used to document quantitative variables. Frequencies and percentages were used to present quantitative variables. Student's t-test was used to compare the changes in soft tissues and incisor position, with p<.05 considered as a significant value.

Results

Intra-group comparisons of the soft tissue changes performed between the pre- and post-treatment records showed statistical significance in both Group 1 and 2. These values are summarized in Tables 1 and 2. Inter-group comparisons of changes between friction and frictionless mechanics are summarized in Table 3.

Table 1. Comparison of pre-treatment and post-treatment values for friction mechanics group

Variable		N	Mean	SD	Mean Difference	p-value
IIA (Degrees)	Pre	20	107.36	7.63	14.31	<0.001*
	Post	20	121.67	8.22		
NLA (Degrees)	Pre	20	95.65	10.94	6.49	0.002*
	Post	20	102.14	11.45		
LMA (Degrees)	Pre	20	120.14	18.60	1.91	0.65(NS)
	Post	20	122.05	17.92		
UL – S (mm)	Pre	20	2.12	1.61	1.52	<0.001*
	Post	20	0.60	1.38		
LL – S (mm)	Pre	20	4.89	2.03	2.51	<0.001*
	Post	20	2.38	1.50		
UL – E (mm)	Pre	20	-0.31	1.58	1.33	<0.001*
	Post	20	-1.64	1.58		
LL – E (mm)	Pre	20	2.69	2.53	1.83	0.001*
	Post	20	0.86	1.77		
FACIAL ANGLE (Degrees)	Pre	20	88.52	3.33	-0.46	0.26(NS)
	Post	20	88.98	3.84		
LIP STRAIN (mm)	Pre	20	1.98	1.84	1.35	0.007*
	Post	20	0.63	1.61		
UI – NP (mm)	Pre	20	7.55	4.45	4.30	<0.001*
	Post	20	3.25	4.27		
LI – NP (mm)	Pre	20	4.13	4.67	3.50	<0.001*
	Post	20	0.62	4.56		

*p< 0.05 significant, p>0.05 non-significant and p< 0.001 highly significant

Table 2. Comparison of pre-treatment and post-treatment values for frictionless mechanics group

Variable		N	Mean	SD	Mean Difference	p-value
IIA (Degrees)	Pre	20	105.83	9.23	21.28	<0.001*
	Post	20	127.11	6.52		
NLA (Degrees)	Pre	20	94.72	11.47	-9.65	<0.001*
	Post	20	104.37	10.33		
LMA (Degrees)	Pre	20	121.63	19.81	-8.59	0.04*
	Post	20	130.22	13.04		
UL – S (mm)	Pre	20	2.39	1.78	1.44	0.003*
	Post	20	0.94	1.56		
LL – S (mm)	Pre	20	4.74	2.84	2.24	<0.001*
	Post	20	2.50	2.11		
UL – E (mm)	Pre	20	-0.50	2.70	1.80	<0.001*
	Post	20	-2.29	2.58		
LL – E (mm)	Pre	20	3.19	3.45	2.84	<0.001*
	Post	20	0.35	3.04		
FACIAL ANGLE (Degrees)	Pre	20	87.77	3.49	-0.14	0.82(NS)
	Post	20	87.92	3.73		
LIP STRAIN (mm)	Pre	20	3.26	2.31	1.99	<0.001*
	Post	20	1.27	1.08		
UI – NP (mm)	Pre	20	7.71	6.08	3.54	0.001*
	Post	20	4.18	4.79		
LI – NP (mm)	Pre	20	3.78	6.52	2.67	0.02*
	Post	20	1.12	4.50		

*p< 0.05 significant, p>0.05 non-significant and p< 0.001 highly significant

Table 3. Comparison of variables between friction and frictionless groups

Outcome	Time points	Group	N	Mean	SD	p-value
IIA (Degrees)	Pre-treatment	Frictionless	20	105.83	9.23	0.57(NS)
		Friction	20	107.36	7.63	
	Post-treatment	Frictionless	20	127.11	6.52	0.03*
		Friction	20	121.67	8.22	
	Comparison	Frictionless	20	21.28	9.42	0.03*
		Friction	20	14.31	9.84	
NLA (Degrees)	Pre-treatment	Frictionless	20	94.72	11.47	0.79(NS)
		Friction	20	95.65	10.94	
	Post-treatment	Frictionless	20	104.37	10.33	0.52(NS)
		Friction	20	102.14	11.45	
	Comparison	Frictionless	20	9.65	7.73	0.22(NS)
		Friction	20	6.49	8.33	

Continue

Continuation

LMA (Degrees)	Pre-treatment	Frictionless	20	121.63	19.81	0.81(NS)
		Friction	20	120.14	18.6	
	Post-treatment	Frictionless	20	130.22	13.04	0.11(NS)
		Friction	20	122.05	17.92	
	Comparison	Frictionless	20	8.59	17.91	0.25(NS)
		Friction	20	1.91	18.5	
UL – S (mm)	Pre-treatment	Frictionless	20	2.39	1.78	0.63(NS)
		Friction	20	2.12	1.61	
	Post-treatment	Frictionless	20	0.94	1.56	0.47(NS)
		Friction	20	0.6	1.38	
	Comparison	Frictionless	20	-1.44	1.91	0.88(NS)
		Friction	20	-1.52	1.14	
LL – S (mm)	Pre-treatment	Frictionless	20	4.74	2.84	0.84(NS)
		Friction	20	4.89	2.03	
	Post-treatment	Frictionless	20	2.5	2.11	0.84(NS)
		Friction	20	2.38	1.5	
	Comparison	Frictionless	20	-2.24	2.02	0.63(NS)
		Friction	20	-2.51	1.56	
UL – E (mm)	Pre-treatment	Frictionless	20	-0.5	2.7	0.80(NS)
		Friction	20	-0.31	1.58	
	Post-treatment	Frictionless	20	-2.29	2.58	0.34(NS)
		Friction	20	-1.64	1.58	
	Comparison	Frictionless	20	-1.8	1.53	0.28(NS)
		Friction	20	-1.33	1.17	
LL – E (mm)	Pre-treatment	Frictionless	20	3.19	3.45	0.61(NS)
		Friction	20	2.69	2.53	
	Post-treatment	Frictionless	20	0.35	3.04	0.52(NS)
		Friction	20	0.86	1.77	
	Comparison	Frictionless	20	-2.84	2.04	0.13(NS)
		Friction	20	-1.83	2.09	
Facial Angle (Degree)	Pre-treatment	Frictionless	20	87.77	3.49	0.49(NS)
		Friction	20	88.52	3.33	
	Post-treatment	Frictionless	20	87.92	3.73	0.38(NS)
		Friction	20	88.98	3.84	
	Comparison	Frictionless	20	0.14	2.82	0.68(NS)
		Friction	20	0.46	1.75	

Continue

Continuation

L strain (mm)	Pre-treatment	Frictionless	20	3.26	2.31	0.06(NS)
		Friction	20	1.98	1.84	
	Post-treatment	Frictionless	20	1.27	1.08	0.14(NS)
		Friction	20	0.63	1.61	
	Comparison	Frictionless	20	-1.99	2	0.32(NS)
		Friction	20	-1.35	2	
UI – NP (mm)	Pre-treatment	Frictionless	20	7.71	6.08	0.92(NS)
		Friction	20	7.55	4.45	
	Post-treatment	Frictionless	20	4.18	4.79	0.52(NS)
		Friction	20	3.25	4.27	
	Comparison	Frictionless	20	-3.54	4.05	0.50(NS)
		Friction	20	-4.3	3.02	
LI – NP (mm)	Pre-treatment	Frictionless	20	3.78	6.52	0.85(NS)
		Friction	20	4.13	4.67	
	Post-treatment	Frictionless	20	1.12	4.5	0.73(NS)
		Friction	20	0.62	4.56	
	Comparison	Frictionless	20	-2.67	4.63	0.51(NS)
		Friction	20	-3.5	3.26	

*p< 0.05 significant, p>0.05 non-significant and p< 0.001 highly significant

The mean values for the inter-incisal, nasolabial, mentolabial, and facial angles were higher in the post-treatment cephalograms than in pre-treatment cephalograms for both Group 1 (mean difference: 21.28°, 6.49°, 1.91°, and −0.46°, respectively) and 2 (mean difference: 14.31°, 9.65°, −8.59°, and −0.14°, respectively). Differences in the inter-incisal and nasolabial angles for the friction and frictionless groups and the mentolabial angle in the frictionless group were statistically significant (p<.05).

Conversely, the mean values for the upper lip to S-line, lower lip to S-line, upper lip to E-line, lower lip to E-line, lip strain, upper incisor to N-perpendicular, and lower incisor to N-perpendicular were higher in pre-treatment cephalograms than in post-treatment cephalograms for both Group 1 (mean difference: 0.25 mm, 2.51 mm, 1.33 mm, 1.83 mm, 1.35 mm, 4.30 mm, and 3.50 mm, respectively) and 2 (mean difference: 1.44 mm, 2.24 mm, 1.80 mm, 2.84 mm, 1.99 mm, 3.54 mm, and 2.67 mm, respectively). Only the difference between the lower lip and E-line in Group 2 was not statistically significant (p>.05).

Furthermore, inter-group comparison showed a statistically significant difference in the inter-incisal angle in post-treatment cephalograms (p=0.03). Overall, on comparing the cephalometric parameters, the change seemed to be higher in Group 2 than in Group 1 (except the facial angle and E-line to the upper and lower lip, where the change was higher in Group 1), albeit without statistical significance.

Discussion

This retrospective study was designed to analyze changes in soft tissue structures and incisor position following en-masse retraction of the anterior segment. Space closure can be performed using an elastomeric chain or active tiebacks, i.e., friction mechanics (sliding mechanics), or by forming loops in the archwires, i.e., frictionless mechanics[9]. Both methods have their advantages and disadvantages. Friction mechanics is relatively simple, less time-consuming, and comfortable to the patient. However, friction at the wire-bracket interface may lead to anchor loss and increased tipping of the teeth, which can result in undesirable torque loss and loss of anchorage[9,12]. Frictionless mechanics provides a continuous force and controlled tooth movement compared with friction mechanics, although it requires more chairside time, thorough knowledge of biomechanics, and extensive wire bending, which might cause discomfort to the patient in cases with a small vestibular length[9,13].

A survey of the recent literature revealed several studies that evaluated changes in soft tissue profiles after extracting all four premolars[11,14-17]. However, very few studies have compared the resultant soft tissue changes based on the mechanics used, i.e., friction versus frictionless. This study evaluated and compared soft tissue changes following the retraction of the anterior segment using friction mechanics, frictionless mechanics, and inter-group comparison between the two. Both groups reported an increase in the inter-incisal angle post-treatment. This result is in agreement with the findings reported by Kocadereli[16] and Parayaruthottam et al.[18]. When inter-group comparisons were performed to evaluate the changes in the inter-incisal angle, the frictionless group showed better correction of the inter-incisal angle than the friction group, with statistical significance. This contradicts the findings of the study by Goyal et al.[19], in which more tipping was shown in the friction group than in the frictionless group where more torque control was present.

The nasolabial angle increased significantly in both groups. This was due to the retraction of the upper anterior teeth followed by soft tissue retraction. Retraction of the incisors causes the soft tissue drape of the lip to fall back slightly, thereby increasing the nasolabial angle. This is in accordance with the findings of studies conducted by Lo and Hunter[20] and Moseling and Woods[21]. The mentolabial angle showed a significant increase in both friction and frictionless mechanics owing to mandibular incisor retraction, which is in agreement with the findings of studies conducted by Moseling and Woods[21] and Sukhia et al.[22]. Although a greater change was observed in the frictionless group, the difference was not statistically significant.

Significant changes were observed in the S-line to lower and upper lip in both friction and frictionless groups, which is supported by the findings of a study conducted by Alqahtani et al.[23]. However, inter-group comparisons revealed no significant changes. Similarly, significant changes were observed in the E-line to upper and lower lip in both groups, which corroborates the findings of previous studies by Huqh et al.[24] and Parayaruthottam et al.[18]. Inter-group comparisons revealed no significant differences. This change may be due to the growth of soft tissues in the nose and chin.

The facial angle showed a statistically insignificant increase in both friction and frictionless mechanics, similar to the results obtained in previous studies by Sharma[25] and Sundareswaran and Vijayan[10], which may be attributed to changes in the lip and soft tissue chin placement following extraction and retraction[26]. Inter-group comparison revealed no significant differences.

There was a reduction in lip strain as a result of incisor retraction in both the friction and frictionless groups, and their comparison yielded statistically insignificant changes, which is in concordance with the results of studies conducted by Sundareswaran and Vijayan[10] and Hugh et al.[24]. The decrease in lip strain is attributed to osseous changes following retraction, which further leads to soft tissue retraction and a decrease of lip strain[25,27].

Statistically significant changes were observed in the linear parameters, including the upper and lower incisors to N-perpendicular in both groups owing to a greater amount of incisal tipping, which is more commonly observed in friction mechanics. This is in accordance with the findings of a study conducted by Suntornlohanakul et al.[28]. This increase was greater in the frictionless group, although the difference was not significant. Thus, a positive correlation was observed between the changes in soft tissue structures and anterior teeth retraction in class I bimaxillary subjects. However, comparison between the two groups revealed minor differences. This suggests that the choice of treatment mechanics does not directly influence the esthetic outcomes of the soft tissue profile.

As this was a retrospective study, we could not compare the comfort levels and duration of space closure between the patients in both groups. This can be considered as a limitation of this study. There are many types of loops that can be used to close spaces. Each loop has its advantages and limitations. Keeping this in mind, another limitation of our study is that the type of loop used to close the space was not standardized.

Prospective studies with larger sample sizes are necessary to validate other factors related to the selection of modality for space closure, perhaps using questionnaires to identify patient satisfaction throughout treatment. 3D laser scanning technique can be utilized to analyze the three-dimensional changes occurring during space closure.

In conclusion, friction and frictionless mechanics were proven to be equally effective treatment modalities in the evaluation of facial soft tissue changes following en-masse retraction in the treatment of class 1 bimaxillary protrusion by extracting all the first premolars. Both groups showed significant changes in the soft tissue profiles. These include increased nasolabial angle, increased mentolabial angle, increased inter-incisal angle, decreased E-line to lower and upper lip, decreased S-line to lower and upper lip, and decreased lip strain. Inter-group comparison showed changes; however, these values were not statistically significant. An increase in the inter-incisal angle, nasolabial angle, mentolabial angle, lip strain, upper incisor, and lower incisor to N-perpendicular was observed in the frictionless group, whereas an increase in the E-line to lower and upper lip and S-line to upper and lower lip was observed in the friction group.

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Nil.

Data availability

Datasets related to the study will be available upon request to the corresponding author.

Author Contribution

S.K.M and M.R.R. actively participated in conducting the study and assessing the manuscript findings. **P.S., M.S.R., and K.S.** played an active role in revising and approving the final version of the manuscript. All authors actively participated in the manuscript's findings, revised and approved the final version of the manuscript.

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