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Dentoskeletal And Soft Tissue Changes in Frictional and Frictionless Mechanics -A Retrospective Cephalometric Study

[1]Kumar Arvindh, Ex Resident, Department of Orthodontics and Dentofacial Orthopaedics, King George's Medical University, Lucknow, Uttar Pradesh, India.

[2]Singh Gyan, Professor, Department of Orthodontics and Dentofacial Orthopaedics, King George's Medical University, Lucknow, Uttar Pradesh, India

[3]Tandon Pradeep, Professor, Department of Orthodontics and Dentofacial Orthopaedics, King George's Medical University, Lucknow, Uttar Pradesh, India

[4]Singh Alka, Professor, Department of Orthodontics and Dentofacial Orthopaedics, King George's Medical University, Lucknow, Uttar Pradesh, India

[5]Singh Gulshan, Professor and Officiating Head, Department of Orthodontics and Dentofacial Orthopaedics, King George's Medical University, Lucknow, Uttar Pradesh, India.

[6]Munusamy Naveen, Senior Resident, Department of Orthodontics and Dentofacial Orthopaedics, King, George's Medical University, Lucknow, Uttar Pradesh, India.

Corresponding Author: Munusamy Naveen, Senior Resident, Department of Orthodontics and Dentofacial Orthopaedics, King, George's Medical University, Lucknow, Uttar Pradesh, India.

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Abstract

Objectives: To evaluate and compare the dento-skeletal and soft tissue changes in frictional and frictionless space closure techniques.

Material and methods: This retrospective cephalometric study was done in 60 female subjects who were divided into two groups of 30 each in frictional space closure technique and frictionless space closure technique. Both groups were also divided into subgroup IIA (Pre-treatment) and Subgroup IIB (Post-treatment). In Group I space closure was achieved in two steps by using NiTi closed coil spring 9 mm (150 gm). In Group-II space closure was achieved by using Kalra Simultaneous Intrusion and Retraction arch (K-SIR) made up of 0.019 x 0.025 TMA wire. Pre and Post Lateral cephalograms were taken by positioning the patients on Rotagraph plus (Model MR05, Villa System Medical, Italy). 6 skeletal variables, 10 dento-skeletal variables (anchorage variables) and 2 soft tissue variables were evaluated. All the categorical data was compared by using chi square test, while the parametric data was compared using chi square test.

Results: Upper incisor retraction was found to be slightly more in Frictionless but these changes were insignificant. More extrusion of maxillary molars was seen in Frictionless technique. Soft tissue changes were more prominent in frictionless mechanics.

Conclusion: Frictionless mechanics are better in terms of amount of incisor retraction, less extrusion of molars, and soft tissue changes.

Keywords: Frictional Mechanics, Frictionless Mechanics, Retrospective Study

Introduction

Extraction of teeth to gain space is a common procedure in orthodontics. Even though non extraction is getting popular over the years, extraction is being done in a variety of skeletal and dental discrepancies like tooth size arch length discrepancy, dento-alveolar protrusion, anteroposterior dento-alveolar malrelationships and pre-surgical arch decompensation in orthognathic surgery cases.[1]

Orthodontic tooth movement during space closure is achieved through two types of mechanism.the first type is sliding mechanics that involves either moving the brackets along an arch wire or sliding the arch wire through brackets and molar buccal tubes.[2] the second type segmental or sectional mechanics, developed by burstone involving closing loops, fabricated either with a full or sectional arch wire[3]. The segmented arch technique, utilizes various types of loops for space closure by anterior retraction, symmetric space closure or posterior protraction. The optimal activation of the loops with adequate moment to force ratio will help in achieving the desired tooth movement in great control.[4] the simple and most commonly used loop for en-masse retraction is k-sir arch wire which exerts about 125g of intrusive force on the anterior segment and a similar amount of extrusive force distributed between the two buccal segments generally the first permanent molars and the second premolars, connected by segments of heavy wire[5].

Space closing techniques utilizing sliding movement of the arch wire along the orthodontic bracket (s) which tend to create friction at the bracket/wire interface[6]. Friction hampers the orthodontist to predict the forces acting on the teeth which may leads to difficulty in controlling the tooth movement.on the other side, frictionless system is designed to generate the forces and moments needed to close the space, being the predictable force systems[7].

There are very scarce of literature available for evaluating the treatment effects in both these mechanics. Hence, the aim of the present study was to evaluate the treatment outcome after closure of the premolar extraction spaces with frictional (sliding mechanics) and frictionless (loop mechanics) techniques and it has been designed to assess the likely changes in anchorage loss and hard and soft tissue with the following aims and objectives:

1. To evaluate the treatment outcomes in frictional and frictionless space closure techniques.
2. To differentiate the soft tissue changes and treatment outcomes in frictional and frictionless space closure techniques.

Material and methods

The present study was conducted on lateral cephalograms of total 60 female subjects who were already treated in the department of orthodontics and dentofacial orthopaedics, after an approval was obtained from the institutional ethics committee records were taken to evaluate and differentiate the treatment outcome (skeletal, dental and soft tissue changes) in frictional and frictionless space closure mechanics, based on the various pre-treatment and post-treatment lateral cephalogram parameters. The test sample were divided into two equal groups as: group I (frictional space closure technique) and group II (frictionless space closure technique).

The subjects fulfilled the inclusion criteria and were allocated into group i (n=30), using frictional space closure technique and group ii (n=30) with frictionless space closure technique group i (frictional space closure technique) was further divided into subgroup ia (pre-treatment) and subgroup ib (post-treatment). Group ii (frictionless space closure technique) was also divided in to subgroup iia (pre-treatment) and subgroup iib (post-treatment).

In group i space closure was achieved in two steps by using niti closed coil spring 9 mm (150 gm) on 0.018 x 0.025 ss wire in 0.022 standard edgewise bracket slot. First only canine and retracted and included in the posterior anchor unit and then all the four incisors retracted (fig. 1a and fig. 1b).

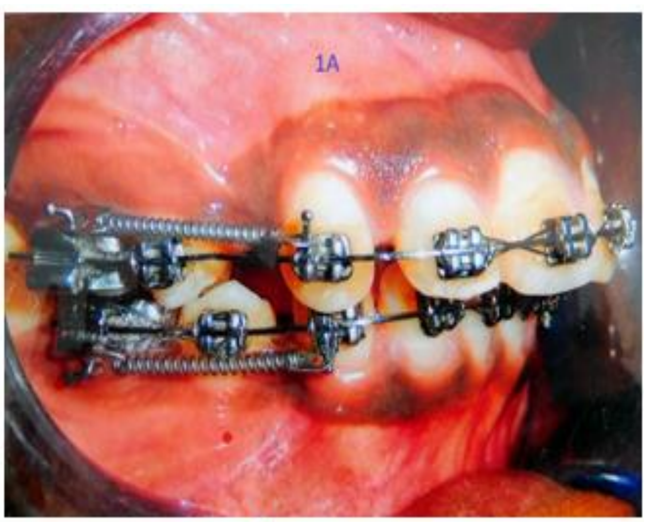

Figure 1: a) frictional mechanics- canine retraction

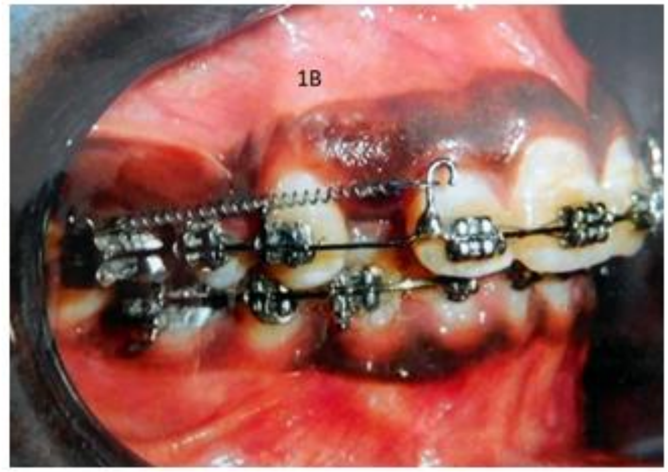

Figure 1: b) frictional mechanics- incisor retraction

In group-ii space closure was achieved by using kalra simultaneous intrusion and retraction arch (k-sir)[5] made up of 0.019 x 0.025 tma wire.(fig. 2).

Figure 2: friction less mechanics

Inclusion criteria

The subjects for this study were selected on the basis of the following criteria:

1. Lateral cephalogram of females in age group of 13-20 years.
2. Lateral cephalogram of angle's class i, class ii malocclusion were selected which were treated with first premolar extraction followed by retraction mechanics.
3. Maximum anchorage with 75% to 100% of space closure used for retraction of anterior segment.
4. Presence of intact first molar.
5. Normo divergent pattern cases (sn-mp 32 ± 4^0)

Exclusion criteria

1. Lateral cephalogram of patients with severe dento-skeletal dysplasia.
2. Distorted lateral cephalograms.
3. Non-co-operative and non-regular patients.
4. Syndromic patients with missing 1st molar.

Method

The lateral head cephalograms were taken by positioning the patients on rotagraph plus (model mr05, villa system medical, italy). All lateral head cephalogram were taken with the frankfort horizontal plane parallel to the floor. Patient head was kept in natural head position (nhp) while the patient was in standing position and teeth were kept in centric occlusion. Lips were kept in relaxed position. Kodak x-ray films (8" × 10") were exposed at 80 kvp; 10 ma for 0.8 seconds for lateral cephalogram from a fixed distance of 60 inches and 70-85 kvp [8].

The lateral head cephalograms were traced on acetate tracing sheets of 50 mµ in thickness using a sharp 4h pencil on a view box having trans-illuminated light in a dark room. Any stray light dispersion was eliminated by covering the margins of the view box with a black paper leaving only that part which was required for radiographic visibility. Each radiograph met the following essential requirements:

- Good definition of hard and soft tissue structures.
- Teeth in centric occlusion for lateral cephalogram.
- When there was a lack of superimposition of the right and left structural outline, the average between the two were drawn by inspection and the cephalometric points were located in reference to the arbitrary line so obtained.

The linear and angular measurements were made to the nearest 0.5 mm and 0.5° respectively with the help of protractor and a metallic scale of sensitivity up to 0.5 degrees and 0.5 mm respectively. Various cephalometric landmarks (table 1 and fig. 3) and reference planes (table 2 fig. 4) were used in the study to analyze various skeletal(table 3 fig 5,6.), dental (table 3.), and dento-skeletal variables (table 3 and fig 7.)

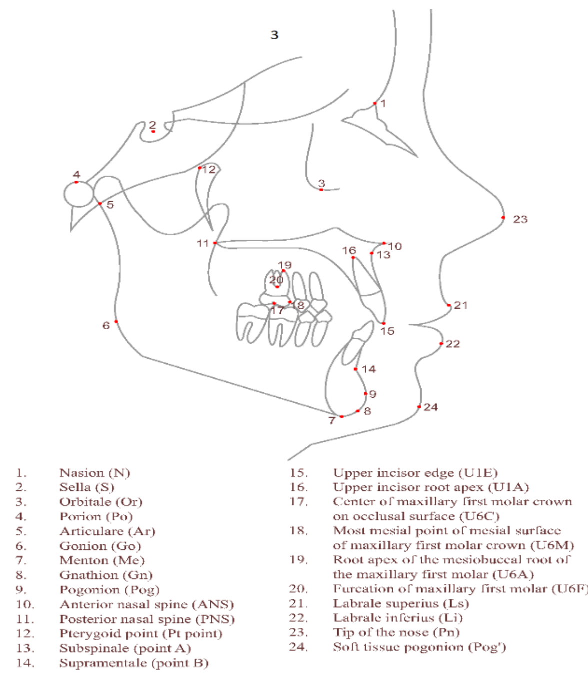

Fig. 3

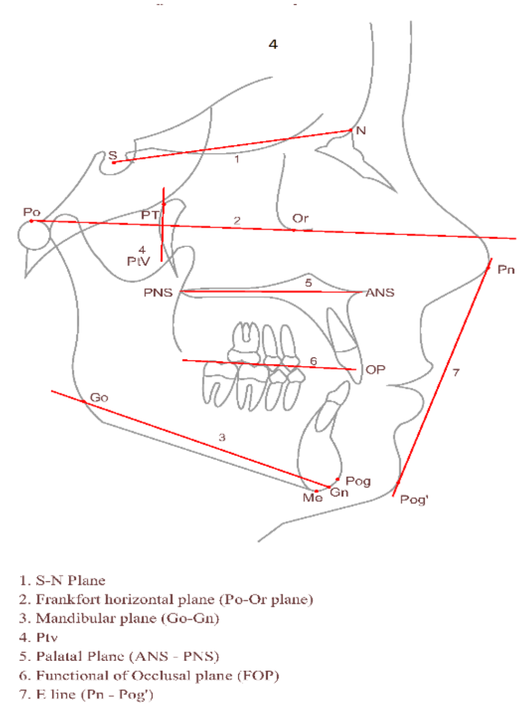

Fig. 4

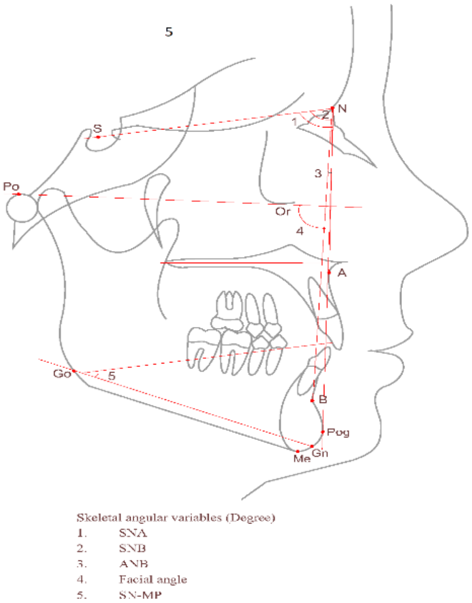

Fig. 5

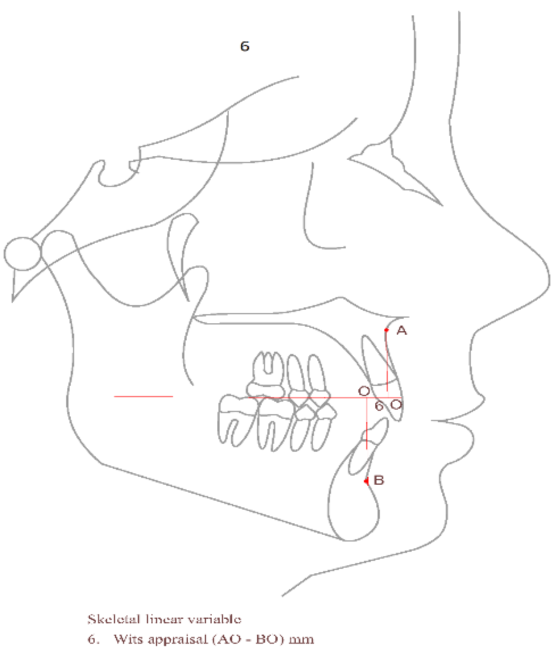

Fig. 6

Statistical analysis

All the statistical analysis were performed using spss 16.0 windows software. Comparisons between groups were assessed by using independent "t" test. All the categorical data was compared by using chi square test, while the parametric data was compared using chi square test. A p-value of <0.05 was considered. ANOVA test used for compare within group and post-hoc tests (tukey-hsd) were used.

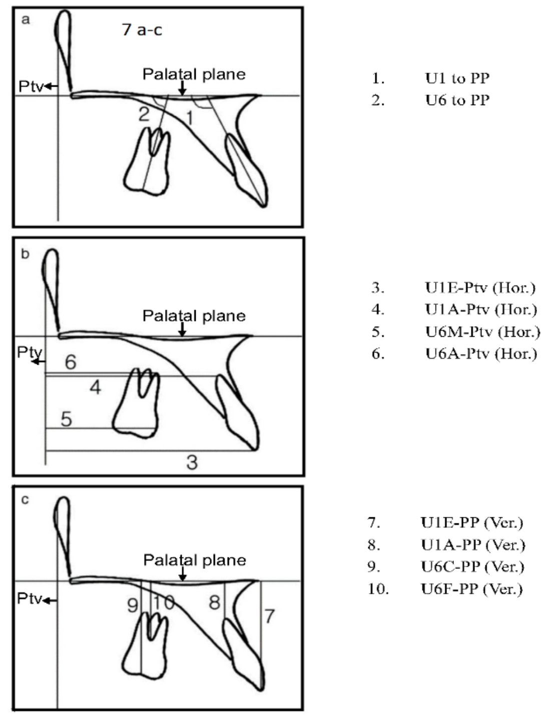

Fig. 7

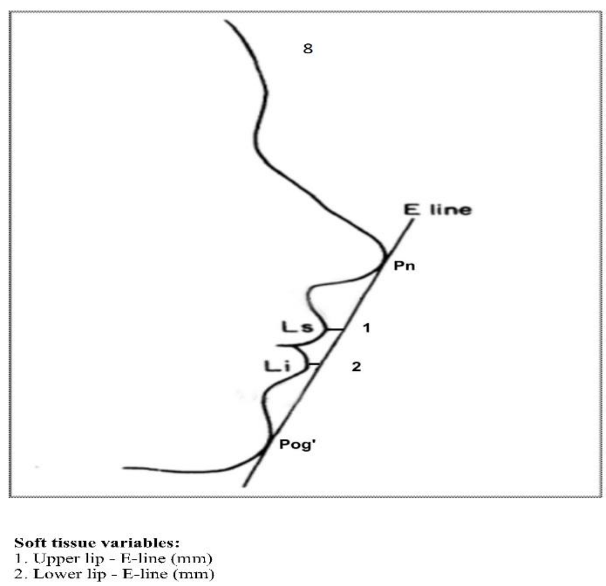

Fig. 8

Intra-observer error: the assessment of intra-observer variability and reproducibility of landmark location and measurement errors were analyzed by retracing 5 randomly selected lateral cephalograms after an interval of one week. The method error was calculated according to dahlberg formula. (dahlberg g **1948**)[9]. Pearson's correlation coefficient (r) was calculated. Only five pre-treatment and post-treatment lateral cephalograms were analyzed on an average in a day to eliminate the error due to fatigue of investigator.

Observation and results

Data was summarized as Mean±SD and the data so obtained was subjected to statistical analysis. The pre-treatment age Mean±SD of the patients of group i (frictional) and group ii (frictionless) were 15.70±1.95 years and 14.40±1.61 years. (Table 4). Treatment changes observed in skeletal, dental and soft tissue variables in friction mechanics and non-friction mechanics are summarized in (table 5) and (table 6) respectively. Comparision of the treatment changes observed in both friction and frictionless mechanics are summarized in table 7. (Fig 9).

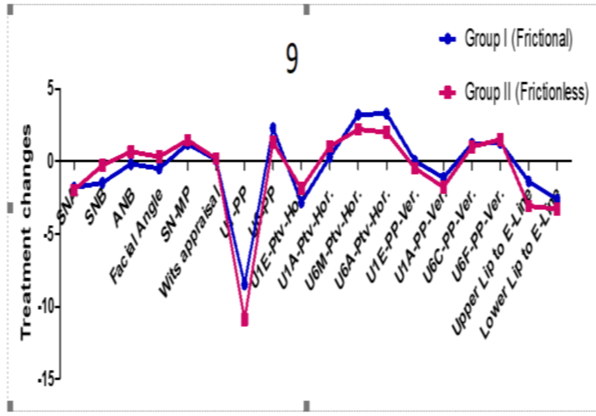

Fig 9

Table 1: Cephalometric landmarks used in the study.

Nasion (N)	The most anterior point of the frontonasal suture in the median plane
Sella (S)	The mid-point of the hypophyseal fossa
Orbitale (Or)	The deepest point on the infraorbital margin
Porion (Po)	The mid-point of the upper contour of the metal ear rod of the cephalometer [Machine Porion]
Articulare (Ar)	The point of intersection of the posterior border of the ramus of mandible and inferior border of the basilar part of the occipital bone
Gonion (Go)	The point on the bony contour of the gonial angle located by bisection of angle formed by the tangents to posterior
Menton (Me)	The lowermost point on the symphyseal shadow as seen from normalateralis
Gnathion (Gn)	The most anterio-inferior point on the bony chin
Pogonion (Pog	The most anterior point on the contour of the chin
Anterior nasal spine (ANS)	The tip of the anterior nasal spine
Posterior nasal spine (PNS)	It is defined as the sharp and well-defined posterior extremity of the nasal crest of the hard palate
PT	It is the junction of pterygomaxillary fissure and the foramen rotandum it can be approximated at 10.30 (face of clock) position on the circular outline of the superior border of the pterygomaxillary fissure
Subspinale (point A)	The innermost point on the contour of the pre maxilla between anterior nasal spine

	and the incisor tooth
Supramentale (point B)	The innermost point on the contour of the mandible between the incisor tooth and the bony chin
Upper incisor edge (U1E	Lower most point on incisal edge of maxillary central incisal.
Upper incisor root apex (U1A)	Defined as the root apex of the most prominent maxillary central incisor
(U6C)	Center of maxillary first molar crown on occlusal surface.
U6M	Most mesial point of mesial surface of maxillary first molar crown.
U6A	Defined as the root apex of the mesiobuccal root of the maxillary first molar.
U6F	Furcation of maxillary first molar
Labrale superius (Ls)	A point indicating the mucocutaneous border of the upper lip, usually the most anterior point of the upper lip.
Labrale inferius (Li)	The median point in the lower margin of the lower membranous lip.
Pronasale (Pn)	The most prominent point on the tip of the nose
Soft tissue pogonion (Pog)	The most prominent or anterior point on the soft tissue chin in the mid sagital plane.

Table 2: Various reference planes used in the study

S-N plane	A line joining midpoint of sella turcica and point nasion. It depicts anterior posterior extent of cranial base.
FH plane	The Frankfort plane is constructed by joining porion (Po) and orbitale (Or).
MP plane (Go-Gn)	The plane extending from gonion to gnathion.
Ptv	Vertical reference plane through Pt point (tangent to palatal plane).
Palatal plane	Plane passing through anterior nasal spine and posterior nasal spine.
Functional occlusal plane	A line passing through the overlapping cusp of premolars and molars.
E line:	A line connecting the tip of nose (Pn) and soft tissue pogonion (pog').

Table 3 : Age Distribution of Subject in Pre-treatment Subgroups (in years)

Subgroup	Mean Age (Years)	Min	Max	t-value	p-value
Subgroup IA	15.70±1.95	13	20	2.815	0.007
Subgroup IIA	14.40±1.61	13	19		
Total	15.05±1.89	13	20		

Table 4 : Treatment changes in Subgroup IA (Pre-treatment Frictional) and Subgroup IB (Post-treatment Frictional)

Variables			Subgroup I A (Pre-treatment) Frictional	Subgroup I B (Post-treatment) Frictional	Paired t-value	p-value
I. Skeletal						
(a)	1	SNA	81.7±4.66	79.9±4.89	5.34	<0.001**

Angular (degree)	2	SNB	77.9±3.95	76.43±4.70	3.99	<0.001**
	3	ANB	3.83±1.98	3.67±2.32	0.43	0.672
	4	Facial Angle	81.73±4.69	81.23±5.50	1.45	0.158
	5	SN-MP	30.6±3.15	31.80±3.27	1.89	0.289
(b) Linear (mm)	6	Wits appraisal	1.68±2.82	1.86±2.73	.22	0.831
II. Dento-Skeletal						
(a) Angular (degree)	7	U1-PP	121.13±7.27	112.67±5.66	7.437	<0.001**
	8	U6-PP	79.47±5.71	81.77±5.34	-6.291	<0.001**
(b) Linear (mm)	9	U1E-Ptv-Hor.	59.90±5.32	57.07±4.99	7.269	<0.001**
	10	U1A-Ptv-Hor.	47.30±3.77	47.60±4.01	-0.496	0.624
	11	U6M-Ptv-Hor.	28.03±3.56	31.27±3.40	-8.137	<0.001**
	12	U6A-Ptv-Hor.	28.57±3.07	31.87±3.45	-6.359	<0.001**
	13	U1E-PP-Ver.	28.67±2.70	28.70±2.48	-0.066	0.947
	14	U1A-PP-Ver.	5.50±2.24	4.37±1.75	2.482	0.019*
	15	U6C-PP-Ver.	20.93±3.42	22.13±2.29	-2.175	0.038*
	16	U6F-PP-Ver.	11.23±6.13	12.53±3.59	-2.049	0.05
III Soft Tissue						
Linear (mm)	17	Upper Lip to E-Line	1.67±2.40	0.30±2.61	3.40	<0.001**
	18	Lower Lip to E-Line	4.90±2.88	2.19±2.67	5.75	<0.001**

('p' value: ns >0.05 Nonsignificant; *<0.05 Just significant; **<0.01 Moderately significant; ***<0.001 Highly significant).

Table 5 : Treatment changes in Subgroup IIA (Pre-treatment Frictionless) and Subgroup IIB (Post-treatment Frictionless)

Variables			Sub Group II A (Pre-treatment) Frictionless	(Sub Group II B (Post-treatment) Frictionless	Unpaired t-value	p-value
I. Skeletal Variables						
(a) Angular (degree)	1	SNA	79.73±3.87	77.77±3.81	4.601	<0.001**
	2	SNB	75.70±3.80	75.43±3.84	.680	0.502
	3	ANB	4.07±2.05	3.40±1.87	2.043	0.050
	4	Facial Angle	82.87±4.48	83.20±4.52	-.727	0.473
	5	SN-MP	30.90±2.29	32.37±2.33	-3.416	0.324
(b) Linear (mm)	6	Wits appraisal	2.45±2.81	2.74±2.89	-.247	0.807
II. Dento Skeletal Variables						
(a) Angular (degree)	7	U1-PP	120.63±7.49	109.67±7.67	6.635	<0.001**
	8	U6-PP	79.83±6.19	81.17±6.23	-4.891	<0.001**
(b) Linear (mm)	9	U1E-Ptv-Hor.	58.63±3.71	56.77±4.10	6.805	<0.001**
	10	U1A-Ptv-Hor.	43.77±5.08	44.80±3.75	-1.085	0.287
	11	U6M-Ptv-Hor.	25.07±3.41	27.27±3.49	-10.697	<0.001**
	12	U6A-Ptv-Hor.	26.93±3.51	28.93±3.44	-11.569	<0.001**
	13	U1E-PP-Ver.	29.23±2.27	28.77±3.19	1.157	0.257
	14	U1A-PP-Ver.	5.98±2.70	4.16±2.29	5.425	<0.001**
	15	U6C-PP-Ver.	20.10±2.64	21.10±2.29	-1.769	0.087
	16	U6F-PP-Ver.	9.70±2.14	11.20±2.92	-3.117	0.004
III Soft Tissue Variables						
Linear (mm)	17	Upper Lip to E-Line	2.15±2.05	-0.93±2.38	7.351	<0.001**
	18	Lower Lip to E-Line	3.92±3.11	0.65±2.66	6.145	<0.001**

('p' value: ns >0.05 Non significant; *<0.05 Just significant; **<0.01 Moderately significant; ***<0.001 Highly significant

Table 6: Comparison of treatment changes observed in Group I (Frictional) v/s Group II (Frictionless)

Variables			Group I	Group II	t-value	p-value
I. Skeletal						
(a) Angular (degree	1	SNA	-1.80 ± 1.85	-1.97 ± 2.34	-0.31	0.761
	2	SNB	-1.47 ± 2.01	-0.27 ± 2.15	2.23	0.029*
	3	ANB	-0.17 ± 2.13	-0.67 ± 1.79	-0.98	0.329
	4	Facial Angle	-0.5 ± 1.89	0.33 ± 2.51	1.45	0.152
	5	SN-MP	1.20 ± 1.81	1.47 ± 1.25	0.66	0.509
(b) Linear (mm)	6	Wits appraisal	0.12 ± 2.39	0.20 ± 3.70	0.10	0.918
II. Dento-Skeletal						
(a) Angular (degree)	7	U1-PP	-8.47 ± 6.24	-10.97 ± 9.05	-1.25	0.218
	8	U6-PP	2.30 ± 2.00	1.33 ± 1.49	-2.12	0.038*
(b) Linear (mm)	9	U1E-Ptv-Hor.	-2.83 ± 2.13	-1.87 ± 1.50	2.03	0.047*
	10	U1A-Ptv-Hor.	0.30 ± 3.31	1.03 ± 5.22	0.65	0.518
	11	U6M-Ptv-Hor.	3.23 ± 2.18	2.20 ± 1.13	-2.31	0.024*
	12	U6A-Ptv-Hor.	3.30 ± 2.84	2.00 ± 0.95	-2.38	0.021*
	13	U1E-PP-Ver.	0.03 ± 2.75	-0.47 ± 2.21	-0.78	0.440
	14	U1A-PP-Ver.	-1.13 ± 2.50	-1.77 ± 1.81	-1.12	0.266
	15	U6C-PP-Ver.	1.20 ± 3.02	1.00 ± 3.10	-0.25	0.801
	16	U6F-PP-Ver.	1.30 ± 3.48	1.50 ± 2.64	0.25	0.803
III Soft Tissue						
Linear (mm)	17	Upper Lip to E-Line	-1.37 ± 2.20	-3.08 ± 2.30	-2.95	0.005*
	18	Lower Lip to E-Line	-2.62 ± 2.54	-3.27 ± 2.91	-0.92	0.361

('p' value: ns >0.05 Non-significant ; *<0.05 Just significant; **<0.01 Moderately significant; ***<0.001 Highly significant)

Discussion

Space closure is one of the most routine procedures in Orthodontics. Two common biomechanical approaches can be used to close the extraction spaces: Frictional (Sliding mechanics) and Frictionless (Loop mechanics). Frictional (Sliding) mechanics involves either moving the brackets along the arch wire or sliding the arch wire through the brackets and molar tubes. Frictionless (Loop) mechanics involves movement of teeth without the brackets sliding along the arch wire but with the help of loops[10] Closing loop mechanics – activated loop creates force only at the bracket level and control is created by generating moments via pre activation bends. But in sliding menchanics retraction forces can be transferred to any height level on a power arm to move a tooth in pre-programmed direction.

One of the disadvantages of the frictional technique is the force applied may dissipates into a Frictional force and only remnant of force will be transferred to the surrounding tissues via brackets and teeth[11].Which leads to reduced amount of desired orthodontic movement and the friction between each individual bracket and the wire is difficult to predict.

Skeletal variables like SNA, ANB and FACIAL ANGLE found to be decreased in post treatment of both friction and frictionless group but the difference observed was not statistically significant. Which were supported by **Heo W et al, 2007**[12] **s**tudy which reported similar changes who also noted only minor changes which were not significant in Frictional technique. In Frictionless technique, ANB was decreased more as maximum changes in SNA has taken place because of the retraction of Point A.

SN-MP was found to be slightly increased in both Frictional and Frictionless but the difference observed was not statistically significant. **Porto VS et al, 2012**[13] found in their study that the treatment with or without premolar extractions tend to increase the mandibular plane angle.

In our study, upper incisor retraction was found to be slightly more in Frictionless but the observed changes were insignificant. But study done by **Heo W et al, 2007**[12] showed more amount of change in inclination of the upper incisor in Frictional technique. In our study U1E-PP-Ver. was found to be slightly increased in Frictional and slightly decreased in Frictionless. The difference in result may be due to K-SIR was used in Frictionless technique that leads to simultaneous intrusion as well as retraction where as in Frictional technique, only retraction was done in two step that leads to slight extrusion of incisal edge. **Sibaie and Mohammad, 2014**[14]compared the treatment outcomes with regard to retraction of upper anterior teeth between the techniques of en-masse and two-step sliding retraction to close space following first premolar extraction. They had found a slight intrusion of the upper anterior teeth. In our study, there was more retraction of upper incisors in Frictional technique and this was supported by **Heo W et al, 2007**[12]**.**Increase in U6-PP was may be due to more mesial displacement of Upper molar in Frictional technique and distal tipping effect of upper molar in Frictionless technique (K-SIR archwire).Our findings were similar to that of the study by **Heo W et al, 2007**[12] which showed more amount of change in inclination of the upper molar in Frictional technique.

More mesial displacement of upper molars was found in frictional technique and this may be attributed to the friction involved in this technique. This finding correlates with study by **Xu et al, 2010**[15] who also found similar results in frictional technique. In contrast to this **Heo W et al, 2007**[12] did not find any significant difference in degree of anchorage loss in upper posterior teeth and amount of retraction of upper anterior teeth associated with en-mass and two step retraction of anteriors. There was a slightly greater change of U6A-PTV-Hor. in frictional group. The amount of mesial drift of the apex of maxillary molars was more in frictional technique as compared to frictionless technique. This finding was supported by a study conducted by **Chandra P et al, 2016**[16] which reported a net mesial movement of upper molars in en-mass retraction via sliding mechanics.

There was a slightly greater change of U6F-PP-Ver. in Group II than Group I but the difference was not statistically significant. More extrusion of maxillary molars was seen in Frictionless technique. A study done by **Chandra P et al, 2016**[16] reported that after doing en-mass retraction via sliding mechanics there was more vertical movement of the maxillary anchor molars which was statistically significant in frictional technique.

There was a slightly greater change of Upper Lip to E-line in Group II than Group I but the difference was statistically significant. **Rains and Nanda, 1982**[17] reported that the upper lip was found to be more variable with increased retraction of the upper incisors. There was a slightly greater change of Lower Lip to E-line in Group II than Group I but the difference was not statistically significant ($p>0.05$) as shown in **(Table 7.). Rains and Nanda, 1982**[17]reported that the lower lip was more variable than the upper lip to differences in the upper incisor movement. **Drobocky et al, 1989**[18] on soft tissue profile changes found that about 10-15% of cases had excessively flat profile post treatment while rest of them has improved profile post treatment[18].

Clinical Significance of The Study

When anchorage requirements are greater, better to use Frictionless mechanics.

To achieve better soft tissue outcomes, friction -less mechanics has to be preferred over frictional mechanics

Conclusion

1. In Friction less mechanics, more retraction of upper incisors can be achieved due to their better anchorage/distal tipping tendency of molars.
2. Frictional mechanics shows more anchorage loss, than Frictionless mechanics.
3. Change in soft tissue profile was more in the frictionless mechanics.

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