Original Article

Evaluation of anchorage loss after en masse retraction in orthodontic patients with maxillary protrusion using friction vs frictionless mechanics: randomized clinical trial

Amr Mahmoud Attia[a]; Leena A. Shibl[a]; Heba M. Dehis[b]; Yehya A. Mostafa[c]; Amr R. El-beialy[b]

ABSTRACT

Objectives: To evaluate anchorage loss after en masse retraction in bimaxillary dentoalveolar protrusion patients using friction vs frictionless mechanics.

Materials and Methods: Thirty patients with bimaxillary dentoalveolar protrusion needing extraction of upper first premolars and en masse retraction with maximum anchorage were included in this two-arm, parallel, single-center, single-blinded randomized clinical trial with a 1:1 allocation ratio using fully sealed opaque envelopes. Friction group retraction utilized elastomeric power chain between miniscrews and hooks crimped mesial to upper canines on 17 $\times$ 25 stainless steel archwire. Frictionless group used customized T-loop springs loading upper first molars indirectly anchored to miniscrews. Activation was every 4 weeks until full retraction. The primary outcome assessed was anchorage loss evaluated at cusp tip and root apex of the first molar. First molar rotation, incisor tip and torque, and root resorption of anterior teeth were evaluated on digital models and cone beam computed tomography taken before and after space closure.

Results: Anchorage loss at crown of first molar was significantly more in frictionless group by 2.1 mm (95% CI $= -0.4$ to 3.5), ($P = .014$), while there was no significant difference in anchorage loss at root apex between groups. Significant mesial in molar rotation of 6.672° (95% CI = 12.2–21.2), ($P = 0.02$) was greater in the frictionless group. Both groups showed comparable tip, torque, and root resorption values. No severe harms were reported. There was mild gingival overgrowth and inflammation in the frictionless group due to T-loop irritation.

Conclusions: Extra anchorage considerations are needed during en masse retraction when frictionless mechanics is implemented as higher anchorage loss and molar rotation were detected. No difference in tip, torque, and root resorption was observed. (*Angle Orthod*. 0000;00:000–000.)

KEY WORDS: Friction mechanics; Frictionless mechanics; En masse retraction; Bimaxillary dentoalveolar protrusion; Orthodontic tooth movement; Anchorage loss

[a] Resident, Department of Orthodontics and Dentofacial Orthopedics, Faculty of Oral and Dental Medicine, Future University in Egypt, Cairo, Egypt.

[b] Associate Professor, Department of Orthodontics and Dentofacial Orthopedics, Faculty of Dentistry, Cairo University, Cairo, Egypt.

[c] Professor and Chairman, Department of Orthodontics and Dentofacial Orthopedics, Faculty of Oral and Dental Medicine, Future University in Egypt, Cairo, Egypt.

Corresponding author: Dr Amr R El-Beialy, 11 ElSaraya Street, Manial, Cairo, Egypt
(e-mail: amr.elbeialy@dentistry.cu.edu.eg)

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INTRODUCTION

The main goal of orthodontic treatment for patients with bimaxillary dentoalveolar protrusion is to decrease proclination and improve the facial convexity by extracting first premolars and retracting anterior teeth with maximum anchorage.[1] Different techniques are used for space closure after extraction including "Two-step retraction," where canines are retracted as a first step, followed by the four incisors, and "en masse retraction" where the six anterior teeth are retracted as one unit.

According to Xu et al.,[2] the "en masse retraction" technique was reported to have less anchorage loss tendency and takes less time than the "two-step retraction" technique because closing the extraction space in

Table 1. Inclusion/Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Males and females	Systemic diseases or syndromes interfering with tooth movement
Age 18.3 ± 3.7 y	Extracted or missing permanent teeth (except for third molars)
Patients requiring first premolars extraction followed by en masse retraction (maxillary protrusion cases)	Badly decayed teeth
Patients with fully erupted permanent teeth (not necessarily including the third molar)	Parafunctional habits (ie, bruxism, tongue thrusting, mouth breathing, etc.)
Cases requiring maximum anchorage during en masse retraction	Previous orthodontic treatment
Cases with minimal crowding (2–3) mm	Anti-inflammatory medication

two steps increases treatment time and has more mesial drifting tendency of maxillary first molars, thus requiring further time and effort. On the other hand, several authors claimed that the en masse retraction technique may risk the anchorage unit, thus increasing the posterior anchorage is essential to minimize the anchorage loss.[3,4] The use of temporary anchorage devices (TADs) as absolute anchorage was superior to conventional molar anchorage as reported by Reynders and Ladu.[5]

Different methods of retraction are utilized, including frictionless and friction mechanics. The use of friction mechanics is widely used due to its simplicity but, on the other hand, it might lead to uncontrolled tipping or rotation of the anterior teeth.[6] Additionally, frictionless mechanics can provide better control over the moment/force ratio and, thus, the position of anterior teeth. However, minor errors in loop design can result in major differences in tooth movement, and some patients may find the loops uncomfortable.[7]

There has been little research regarding anchorage loss using friction and frictionless mechanics, thus necessitating further well-designed studies to reach conclusive answers.[8] Consequently, a properly designed study could offer valuable insights into the effectiveness of different mechanics on anchorage loss. This information could help guide orthodontists in selecting the most appropriate treatment mechanics, leading to improved patient satisfaction and compliance during the course of treatment.

Specific Objectives and Hypotheses

The specific aim of the current study was to evaluate anchorage loss after en masse retraction using friction vs frictionless mechanics. The null hypothesis was that there would be no difference between friction and frictionless mechanics after maxillary en masse retraction regarding molar anchorage loss. Additionally, assessment of both techniques regarding their effects on first molar rotation, incisors tip and torque, as well as root resorption of anterior teeth was evaluated.

MATERIALS AND METHODS

Trial Design

This study was a randomized, two-arm, parallel, single-center, single-blinded, randomized clinical trial with a 1:1 allocation ratio following the CONSORT 2010 statement reporting guidelines. This trial was registered in www.clinicaltrials.gov [(13)/7-2019].

Participants, Eligibility Criteria, and Settings

A total of 42 patients with bimaxillary dentoalveolar protrusion seeking orthodontic treatment who required extraction of the upper first premolars and maxillary en masse retraction with maximum anchorage requirements were screened, and 30 patients were included according to the eligibility criteria in Table 1. Patients or their parents were requested to sign an informed consent after explanation of the study design, interventions, and potential side effects.

Full pretreatment records were taken, including intraoral and extraoral digital photographs, and panoramic and lateral cephalometric radiographs. After bonding 0.022-inch slot Roth brackets (American Orthodontics, Sheboygan, Wis), leveling and alignment was done until 0.017 × 0.025-inch stainless steel (SS) archwire was reached and ligated for 2 weeks. Mini-screws (1.6 × 8 mm, bracket head design; Dual Top Anchor System, Jeil Medical Corp, Seoul, Korea) were then inserted at the mucogingival junction, in the interradicular region between the second premolars and first molars in the quadrants where extraction of the first permanent premolar was planned. After primary stability was secured, a ligature wire was braided to ligate the second premolar bracket to the miniscrew throughout the entire duration of en masse retraction. Two cone beam computed tomography (CBCT) images (Planmeca ProMax 3D CBCT machine, Asentajankatu, Helsinki, Finland), were obtained for each patient; the first (T0) was immediately before allocation into the two groups, and the second (Tf) after completion of retraction in accordance with the ALARA (as low as reasonably achievable) guidelines.

In the friction group (F), an elastomeric power chain (PC) extending from a crimpable hook (variable crimpable

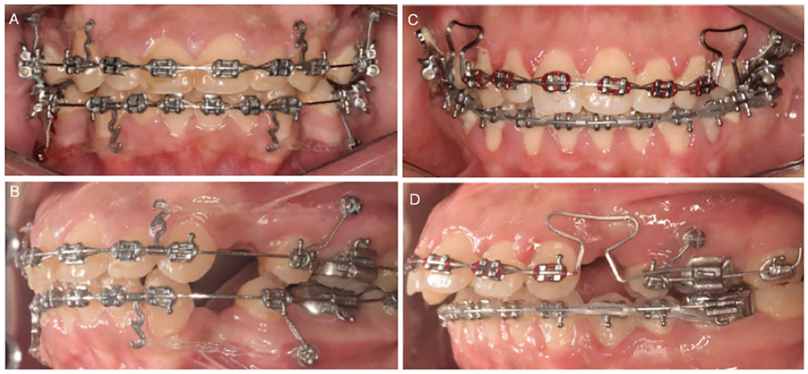

Figure 1. Appliance setup. (A) Friction mechanics from frontal view, (B) friction mechanics from lateral view, (C) frictionless mechanics from frontal view, (D) frictionless mechanics from lateral view.

hook; Dentos, Daegu, South Korea) at a height of 9 mm, was placed distal to the maxillary lateral incisors on a 0.017 × 0.025-inch SS archwire and tied directly to the miniscrew head to deliver 200g force/side. The PC was reactivated every 4 weeks using a force gauge (Orthodontics Tensiometer 5g-500g, MORELLI Orthodontics, Sorocaba, Brazil) (Figure 1A,B).

In the frictionless group (FL) posterior segments were consolidated using a 0.017 × 0.025-inch SS archwire. A T-loop was fabricated using 0.017 × 0.025-inch TMA wire by the principal operator, according to the design suggested by Burstone et al., was inserted in the auxiliary tube of first molars and engaged in the anterior teeth with a distal activation of 6 mm, delivering 200g force per side.[9] During the monthly follow-up visits, the distance between the two legs of the T-loop was measured. When they were found to be 2–3 mm, reactivation was performed to regain 200g force per side (Figure 1C,D).

Only the maxillary arch was included in this study, provided that there was ample overjet to permit retraction of the maxillary anterior segment. In cases where the overjet was inadequate, full-arch bonding of the mandibular teeth was done together with extraction of the mandibular first premolars for retraction of the mandibular anterior segment. This was carried out along with retraction of the maxillary anterior segment to allow for uninterrupted retraction.

In both groups, the second CBCT (Tf) was obtained when Class I canine, normal overjet, and a balanced facial profile were achieved.

Measurements

The digital imaging and communications in medicine (DICOM) images from CBCT scans were imported into Invivo Dental 5 software (version 5.3.1, Anatomage, Santa Clara, Calif) and three-dimensional (3D) images were constructed. Three reference planes were identified in this study to position the skull spatially: midsagittal plane (MSP), palatal plane (PP), and frontal plane (FP) (Figure 2A). The midsagittal plane passed through nasion

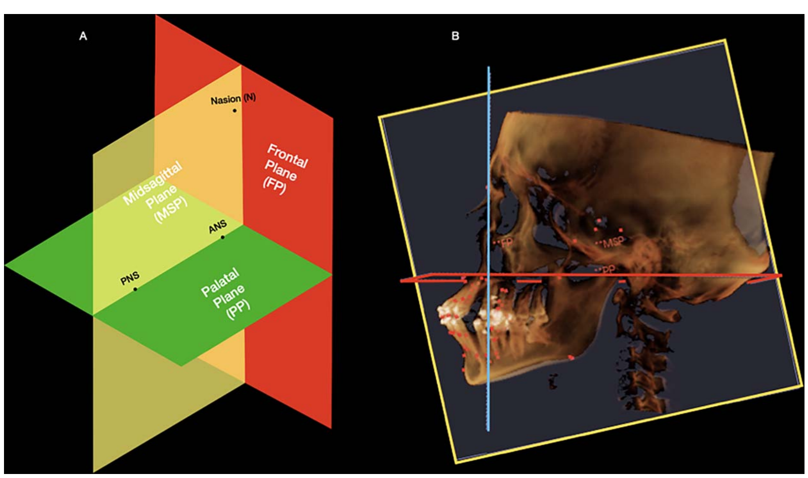

Figure 2. Three reference planes. (A) Schematic representation of the three reference planes: midsagittal plane (MSP), palatal plane (PP), and frontal plane (FP). (B) Three main reference planes on CBCT: yellow, MSP; red, PP; blue, FP. CBCT indicates cone beam computed tomography.

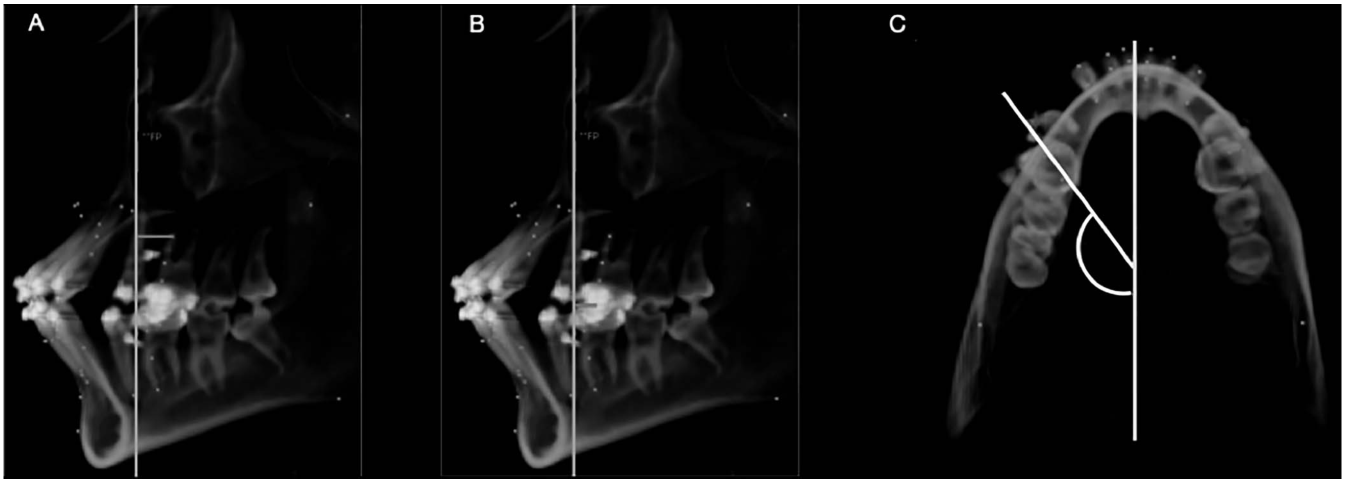

Figure 3. (A) Measurement of anchorage loss from mesiobuccal root apex to frontal plane in millimeters. (B) Measurement of anchorage loss from mesiobuccal cusp tip to frontal plane in millimeters. (C) Measurement of molar rotation as the outer angle between diagonal passing through the mesiobuccal and distobuccal cusps and midsagittal plane in degrees.

(N), anterior nasal spine (ANS) and posterior nasal spine (PNS) on the pre-intervention CBCT;[10] the palatal plane was perpendicular to the midsagittal plane and passed through ANS and PNS;[11] the frontal plane was perpendicular to the midsagittal plane and palatal plane and passed through N. Reference planes were defined on the pre-intervention CBCT and became the reference lines for assessment of anchorage, tip, torque, and root resorption in the postintervention CBCT (Figure 2B).

Anchorage loss was measured as the distance between the mesiobuccal root apex and the frontal plane, and distance between the mesiobuccal cusp tip and the frontal plane viewed from the sagittal aspect (Figure 3A,B). Molar rotation was measured as the outer angle between a diagonal line passing between the mesiobuccal cusp and the distopalatal cusp of the maxillary first molar and the midsagittal plane viewed from the palatal aspect (Figure 3C).

For the incisor tip, torque, and root resorption measurements, and for the canine root resorption measurements, each tooth was measured and averaged for each patient, and then the overall mean per group was presented. Tip was measured as the inner angle between the long axis of each incisor and the midsagittal plane viewed from the frontal aspect (Figure 4A). Torque was measured as the inner angle between the long axis of each incisor and the palatal plane viewed from the sagittal aspect (Figure 4B). Root resorption was measured as the distance between the anterior teeth centroid point[12,13] and the root apex viewed from the frontal aspect pre- and post-retraction (Figure 4C). Intrarater reliability was evaluated by remeasuring 12 randomly selected CBCTs and another

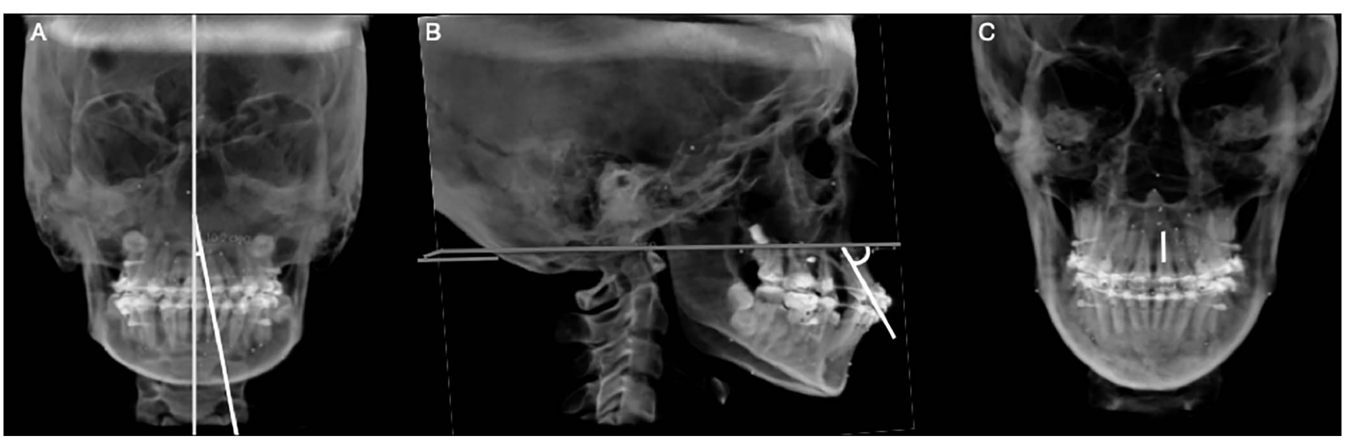

Figure 4. (A) Tip measurement of incisors as the inner angle between long axis of each incisor and the midsagittal plane in degrees. (B) Torque measurement of incisors as the outer angle between each incisor and the palatal plane in degrees. (C) Root resorption measurement as the linear distance between the centroid point of each of the six anterior teeth and root apex in millimeters.

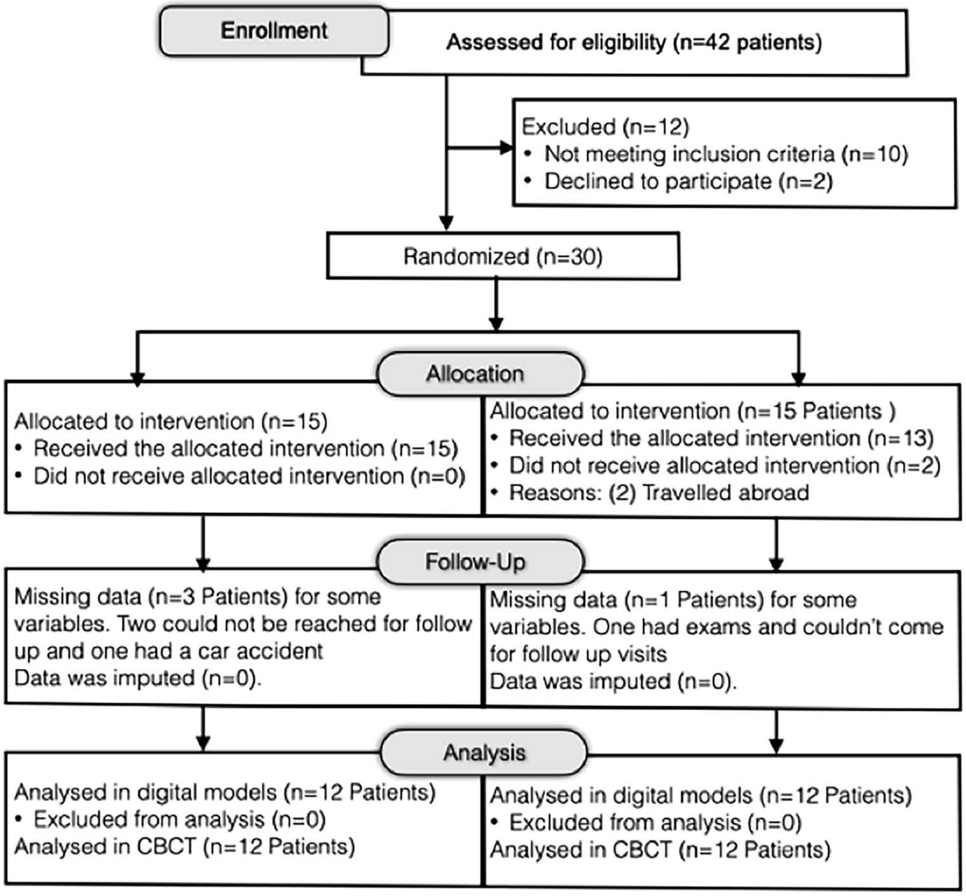

Figure 5. CONSORT flow chart of participants during the trial.

investigator measured these records for interrater reliability.

Sample Size Calculation

A priori sample size of 20 patients was determined from the data of Tawfik et al.[14] that reported a difference in anchorage loss of 1.6 mm (95% CI = 0.01–3.4) during incisor retraction, using Minitab software. Observations were required in each group for a study power of 0.8 and an 0.05 alpha value error. Ten additional patients were included in consideration of sample attrition. Thus, the final sample size was 30 patients for the current study.

Randomization and Blinding

Microsoft Office Excel 2013 was used for random sequencing. Allocation concealment was done using fully sealed and opaque envelopes. This was a single blinded study in which blinding of the patients and operator was not possible because of the nature of the study. Blinding of the outcome assessor was done through data concealment during assessment. The primary researcher (AA) was assigned to make the measurements. Four weeks afterward, the primary observer repeated the measurements on 25% of the sample. The secondary observer (LS) made the measurements on 25% of the sample.

Statistical Method

Paired *t*-test was used for comparison between the study groups. Data were described in terms of mean ±, standard deviation (SD). The significance level was set at $P \leq .05$. Paired *t*-test was used for intragroup and intergroup comparison of the tip and torque changes between groups. Interobserver and intraobserver reliability was assessed using interclass correlation coefficients (ICCs). The confidence level was set at 95%.

RESULTS

Participant Flow and Baseline Characteristics

The progress of patient selection and recruitment is shown in Figure 5. Forty-two patients were assessed for the study, of which 10 did not meet the inclusion criteria and two declined to participate. The remaining 30 patients were randomized in a 1:1 ratio either in the friction or frictionless group. Two patients in the frictionless

Table 2. Baseline Characteristics of Subjects in Each Group[a]

	Friction Group		Frictionless Group			
Baseline Characteristics	Mean	SD	Mean	SD	Difference (95% CI)	*P* Value
Age y	17.6	3.1	18.0	2.9	0.4 (0.04–1.7)	.160
SNA, °	88	2.15	86.8	1.05	1.1 (0.4–1.0)	.150
SNB, °	84	2.9	83.2	1.7	1.2 (0.3–1.1)	.201
ANB, °	3.89	1.03	4.23	0.97	0.342 (0.6–1.3)	.140
SN/Mx plane, °	9.21	1.10	10.01	1.38	0.894 (0.3–2.0)	.174
SN/Md plane, °	34.21	3.00	34.87	2.63	0.655 (2.0–3.3)	.520
Mx/Md plane, °	28.98	2.20	30.13	1.67	1.15 (0.7–3.0)	.257
U1/Mx, °	117.51	2.29	118.16	1.94	0.644 (1.3–2.6)	.545
U1/L1, °	110.09	4.37	109.39	3.83	0.695 (3.2–4.6)	.705

* Significance level, $P \leq .05$ Data are presented as mean and standard deviation.
[a] CI indicates confidence interval; SD, standard deviation.

group were excluded due to travel plans. Missing data were reported for three patients in group 1 (Friction: group F), and 1 patient in group 2 (Frictionless: group FL). The model and CBCT analysis were done for 12 patients in each group. The baseline characteristics for the subjects are displayed in Table 2. Inter- and intra-observer reliability showed excellent correlation (ICC $>$ .98).

Numbers Analyzed for Each Outcome

The total number of months (SD) to achieve space closure in each group was 6.42 (1.08) and 5.67 (1.5) for the friction and frictionless groups, respectively, with no significant difference between them ($P =$ .174). The amount of anchorage loss measured from the first molar mesiobuccal cusp tip to the frontal plane was 1.924 (95% CI = 0.3–0.9) and 3.985 (95% CI = 2.7–4.5) mm for the friction and frictionless group, respectively with a significant difference between the two groups ($P =$ .014). However, the amount of anchorage loss measured from the first molar root apex to the frontal plane was 0.641 (95% CI = 0.2–0.7) and 1.58 (95% CI = 1.3–2.5) mm for the friction and frictionless group, respectively, which was not statistically significant ($P =$ .236). Greater mesial in molar rotation was observed in the frictionless group by 6.67° (95% CI = 12.2–21.2) (Table 3). Distal crown tip of incisors was observed in both groups, although it was greater (nonsignificantly) in the frictionless group by 1.5° (95% CI = −1.1 to 4.1), while palatal crown torque was more pronounced (nonsignificantly) in the frictionless group by 3.8° (95% CI = 1.16–4.1). There were no statistically significant differences between groups for either the tip or torque changes ($P >$ .05; Table 4). The difference in root resorption between the groups was not statistically significant. In the friction group, the difference between the preretraction and the postretraction intragroup measurements was highest in lateral incisors by 0.4 mm (95% CI = −0.4–0.2) and was lowest in the canines (Table 5).

Harms

No severe harms were reported. Gingival overgrowth and inflammation occurred in the frictionless group due to irritation from the loops.

DISCUSSION

Proclination of anterior teeth is commonly seen in patients seeking orthodontic treatment when there is an increase in facial convexity as well as incompetent lips.[15] Extraction of the first premolars is a common

Table 3. Anchorage Loss and Molar Rotation Changes Between Groups[a]

	Friction Group				Frictionless Group					
	Preretraction, Mean ± SD	Postretraction, Mean ± SD	Difference (95% CI)	*P* Value	Preretraction, Mean ± SD	Postretraction, Mean ± SD	Difference (95% CI)	*P* Value	Difference (95% CI)	*P* value
Anchorage loss (cusp tip), mm	18.5 ± 6.1	16.5 ± 6.2	1.924 (0.3–0.9)	<.001*	19.7 ± 8.1	15.7 ± 7.5	3.985 (2.7–4.5)	.001*	2.1 (−0.4 to 3.5)	.014*
Anchorage loss (apex), mm	17.2 ± 5.5	16.6 ± 5.8	0.641 (0.2–0.7)	.326	19.0 ± 6.5	17.4 ± 6.5	1.580 (1.3–2.5)	.005*	.9 (−0.7 to 2.5)	.236
Molar rotation, °	148.7 ± 9.1	154.8 ± 5.6	6.113 (0.45–7.01)	.014*	152.1 ± 5.0	164.9 ± 5.4	12.785 (6.43–12.97)	<.001*	6.67 (12.2–21.2)	.020*

* Statistically significant results; the difference is presented as value (95% CI). Significance level, $P \leq .05$.
[a] CI indicates confidence interval; SD, standard deviation.

Table 4. Intragroup and Intergroup Comparisons of Tip and Torque Changes[a]

	Friction Group				Frictionless Group					
	Preretraction, Mean ± SD	Postretraction, Mean ± SD	Difference (95% CI)	*P* Value	Preretraction, Mean ± SD	Postretraction, Mean ± SD	Difference (95% CI)	*P* Value	Difference (95% CI)	*P* Value
U Tip, °	8.1 ± 2.1	7.6 ± 2.4	0.474 (0.23–0.87)	.563	8.8 ± 3.4	6.8 ± 2.6	1.976 (1.53–2.41)	.068	1.5 (−1.1 to 4.1)	.245
U Torque, °	60.1 ± 8.3	69.6 ± 7.5	9.511 (6.76–9.89)	.015*	61.1 ± 8.8	74.4 ± 9.4	13.302 (11.69–13.63)	< .001*	−3.8 (−1.16 to 4.1)	.327

* Statistically significant results; the difference is presented as value (95% CI). Significance level, $P \leq .05$.
[a] CI indicates confidence interval; SD, standard deviation; U, upper incisors.

treatment plan in this type of case.[16] However, there is a scarcity of literature concerning the appropriate mechanics to minimize anchorage loss while retracting anterior teeth.

Among the factors that influence the reaction forces on the posterior anchor segment is the force value used for anterior segment retraction. The force value used in the current study was 200 g/side as reported by Sumathi[17] to be the optimum force per side for en masse retraction. This force magnitude was also used by Monga et al.[18] and Koyama et al.[19] in which intermittent forces were applied using elastomeric power chains and T-loops in the friction and frictionless groups, respectively. Elastomeric chains were changed every 4 weeks as recommended by Kassir et al.[20,21] since they lose 55% of their activation after the third week as reported by Andhare et al.[21] Additionally, elastomeric chains were found to be superior to closed titanium springs in delivering intermittent forces, which are comparable to the intermittent forces delivered by T-loops in the frictionless group.[22] In the frictionless group, force was applied by a 6mm distal activation of the T-loop fabricated from 0.017 × 0.025-inch TMA wire as reported by Burstone et al.[9]

CBCT was used to measure anchorage loss of upper first molars from two points: the cusp tip and root apex, as they were reported to be more reliable, accurate, and reproducible than conventional two-dimensional radiographs.[23] The results were in line with those of Tawfik et al.,[24] who reported more molar anchorage loss and molar rotation in the frictionless group than the friction group. On the contrary, Sardana et al.,[25] reported an insignificant difference in the anchorage loss between the two groups in their intergroup comparison. For the intragroup comparison before and after retraction, Sardana et al.[25] showed more significant molar anchorage loss in the friction group than the frictionless group while, in the current study, a significant intragroup difference was found within the two groups separately. The difference in anchorage loss measured from the cusp tip, and molar rotation between the two-retraction mechanics in the current study, was statistically significant. In the friction group, the crown moved 1.924 mm (95% CI = 0.3–0.9) ($P < .001$), while the root moved 0.641 mm (95% CI = 0.2–0.7) in both molars. On the other hand, in the frictionless group the crown movement was 3.985 mm (95% CI = 2.7–4.5) ($P < .001$), and the root movement was 1.58 mm (95% CI = 1.3–2.5). Therefore, the majority of anchorage loss occurred due to mesial tipping and slight bodily movement of the first molars. These findings were in agreement with results reported by Dincer et al.,[26] although there was statistically insignificant distal molar tip and significant anchorage loss. Xu et al.[2] also reported mesial displacement of the molars, but it was statistically insignificant. In contrast, Upadhyay et al.[27] reported distal movement of the first molars of 0.55 mm after implant-supported en masse retraction.

A statistically significant intragroup molar rotation and intergroup difference was observed between groups; it was double in the frictionless group compared to the friction group. This finding could be attributed to the indirect anchorage twisted ligature wire connecting the miniscrews to the second premolar brackets used in both groups. However, in the friction group, the elastomeric chain was attached directly to the miniscrew rather than to the molar. Similarly, Tawfik et al.[14] reported more molar rotation in the frictionless group after two-step retraction.

Table 5. Root Resorption Changes Between Groups[a]

	Friction Group				Frictionless Group					
	Preretraction, Mean ± SD	Postretraction, Mean ± SD	Difference (95% CI)	*P* Value	Preretraction, Mean ± SD	Postretraction, Mean ± SD	Difference (95% CI)	*P* Value	Difference (95% CI)	*P* Value
U1 centroid, mm	11.6 ± 0.9	11.2 ± 1.0	0.400 (0.2–0.75)	.008*	11.3 ± 1.0	10.9 ± 1.0	0.338 (0.17–0.79)	.002*	−0.1 (−0.4 to 0.2)	.680
U2 centroid, mm	10.9 ± 1.5	10.1 ± 1.2	0.754 (0.53–1.02)	.020*	10.6 ± 1.0	10.2 ± 0.9	0.344 (0.19–0.87)	.032*	−0.4 (−1.1 to 0.2)	.202
U3 centroid, mm	12.6 ± 1.3	12.3 ± 1.4	0.234 (0.09–0.63)	.352	12.0 ± 1.4	11.9 ± 1.4	0.142 (0.09–0.2)	.454	−0.1 (−0.7 to 0.5)	.765

* Statistically significant results; the difference is presented as value (95% CI). Significance level: $P \leq .05$.
[a] CI indicates confidence interval; SD, standard deviation; U1, upper central incisor; U2, upper lateral; U3, upper canine.

The difference in the tip and torque of the upper anterior teeth between the groups was not found to be statistically significant. The incisors expressed nonsignificant distal tip after retraction in both groups. Variation in tip could have been due to play between the 0.017 $\times$ 0.025 wire and the 0.022-slot bracket; however, unwanted tip was avoided by ligating the six anterior using 0.012-inch stainless steel wire. Unwanted palatal crown torque loss was reduced by the addition of 9 mm hooks in the friction group,[28] while in the frictionless group, alpha and beta bends were incorporated in the TMA wire to prevent undesirable excessive tooth uprighting.[29] Similarly, Xu et al.[2] observed that anterior tooth retraction resulted in reduced incisor torque. However, Gioka and Eliades[30] suggested that a high-torque prescription should be selected to maintain incisor buccolingual inclination.

There was a statistically insignificant difference in root resorption of the six anterior teeth between the friction and frictionless mechanics groups. This finding was in agreement with Xu et al.[2] and Huang et al.[31] who reported no significant difference in root resorption while using both retraction methods. However, in the friction group, the difference between the preretraction and the postretraction intragroup measurements was highest for the lateral incisors by 0.4 mm (95% CI $= -0.4$ to 0.2) and was the lowest for the canines. This finding agreed with previously published data reporting the upper lateral incisor to be the most affected by root resorption during the course of orthodontic treatment.[32–34]

Limitations

The total number of patients analyzed was 24, which could result in type II error due to the small sample size ($<$30). No sham device was given to the other group. Further information regarding the rate of space closure could have added some insights about the efficiency of both techniques.

In conclusion, the use of friction or frictionless mechanics did not result in significant differences in the resultant tip, torque, and root resorption of the anterior teeth. However, molar anchorage loss was significantly greater in the frictionless group. Therefore, within the limits of this study, the choice of mechanics for en masse retraction should be based on the skills and preferences of the orthodontist.

CONCLUSIONS

- Anchorage loss was observed in both groups with greater anchorage loss in the frictionless group.
- The frictionless group showed more mesial in molar rotation.
- There was no advantage of frictionless mechanics over friction mechanics regarding the tip and torque changes of incisors in 3D measurements.
- There was no significant difference in root resorption between the friction and the frictionless mechanics groups.

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