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Intrusion and Retraction of Maxillary Anteriors with LVMA

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Abstract

Aim: To compare anterior intrusion and retraction effects of Long Vertical Molar Arm (LVMA) group and routine fixed mechanotherapy group cephalometrically.

Materials and Methods: A total of 42 patients undergoing orthodontic treatment after the extraction of first and second maxillary premolars were stratified into 2 groups (n=21 in each group). Patients in group 1 obtained maxillary incisor intrusion and retraction treatment using LVMA. While group 2 patients received conventional sliding mechanics with molar hook anchorage. Patients were bonded with MBT 0.022″ slot brackets and 0.019 × 0.025″ stainless steel (SS) arch wires, with 250–300 g retraction force applied by means of elastomeric chains. Before and after treatment cephalograms were assessed by means of Dolphin Imaging Software. Measurement reliability was verified by intraclass correlation. Intergroup and pre-post comparisons were analyzed using independent and paired t-tests in SPSS v21.

Results: With respect to skeletal malocclusion statistically no significant differences was found between two groups. LVMA group showed significantly greater upper incisor retraction (P = 0.007) and better vertical control, reflected in SN–OP, U1–MH, U6–MH with a P value of 0.017, 0.011, and 0.004 respectively. Soft tissue changes, including nasolabial angle, were not significant (P = 0.105).

Conclusion: LVMA mechanics provide effective maxillary incisor intrusion and retraction with superior dental control and reduced molar extrusion compared to conventional sliding mechanics, while producing favourable soft tissue effects.

Keywords: Long Vertical Molar Arm, Intrusion mechanics, Retraction mechanics, Maxillary incisors, Cephalometric analysis, Orthodontic anchorage, Fixed orthodontic appliance.

Introduction

A deep bite characterized by increased overlap between maxillary and mandibular anterior teeth. Hotz and Muhlemann[1] categorized deepbite into true deep bite and pseudo deep bite. True deep bite arises by infraocclusion of posterior segments (class II division II malocclusions) while pseudo deep bite occurs by dentoalveolar extrusion of the anterior teeth, as seen in (class II division I malocclusions). Deep bite was also classified into skeletal and dental deepbite by Rakosi[2].

Excessive gingival exposure of more than 2 mm is known as "high gingival" or "gummy smile."[3] Gummy smile is characteristically complex, multifactorial and results from combination of dental, skeletal, and soft tissue features. Those of dental etiology are excessive eruption and severe proclination of maxillary anterior teeth, disproportionate crown length and width of anteriors. Skeletal etiology are excessive vertical growth of maxilla and anterior-posterior skeletal cant. Those of soft tissue etiology are hypermobile upper lip, gingival enlargement, short upper lip and altered passive eruption of anteriors.[4] The preferred choice of treatment is intrusion of maxillary incisor if dento-alveolar extrusion of anterior region causes gummy smile.

Deepbite and gummy smiles patient, especially with vertical growth pattern require maxillary anterior teeth to intrude and retract.[5] Different approaches to intrude maxillary anteriors include intrusion arches, intrusion bends and curves, J hook headgear, temporary anchorage devices, Connecticut intrusion arches, utility arches, K sir Arch, Burstone intrusion arches, and tip back springs.[6] Headgears have a problem of patient compliance and are more often indicated only in growing patients. Although TADs are compliance free, their stability rates are inconsistent. Additionally, intrusion and retraction using TADs require at least two microimplants, which makes the procedure expensive and more invasive. [7]

The LVMA is a vertical wire of length 0.019 x 0.025" SS with a hook on the superior end with the free end facing distally. A horizontal component of the wire at the inferior end enters the auxiliary molar tube from the distal end. The biomechanical advantages offered by the LVMA arm are its ability to direct forces above, below and through center of resistance of maxillary tooth. Additionally, height of arm could be varied to alter the vector of force according to sulcus depth.[8]

Achieving controlled incisor retraction and intrusion is crucial for optimal esthetics and stability in orthodontic treatment. Conventional sliding mechanics often cause incisor tipping, extrusion, and anchorage loss, while skeletal anchorage systems, though effective, are invasive and technique-sensitive. The LVMA offers a simpler alternative that directs force near the center of resistance in anterior region, promoting controlled retraction and true intrusion without additional anchorage. In this study skeletal, dental, and soft tissue effects were compared between LVMA with conventional sliding mechanics during maxillary incisor retraction.

Thus, this research compares the anterior intrusion and retraction effects of the LVMA group and routine fixed mechanotherapy group cephalometrically.

Materials and Methods

This prospective, randomized controlled study was conducted in patients undergoing fixed appliance therapy after extraction of 1st and 2nd maxillary premolars, who reported to Department of Orthodontics over a period of 2 years. Institutional ethical committee provided the necessary ethical approval (RDC/IEC/10/2022/2685).

Patients included in the study had no previous history of orthodontic treatment and required therapeutic extraction of the upper premolars during their fixed appliance therapy. Patients with previously extracted permanent teeth (except third molars), congenitally missing teeth, medically compromised cases, or any craniofacial disorders (cleft palate and lip) were excluded. Additionally, patients with local or systemic diseases, a history of trauma affecting orthodontic treatment outcomes, or those taking systemic medications were also excluded from the study. Sample size was predicted by means of G *power version 3.1.9.4. For the power at 0.80 and Type I error rate, α=5%, and effect size of 0.93. The total sample size calculated was 42, divided into two groups- 21 subjects per group.

Methodology

42 subjects were randomly stratified into two groups (n=21). In Group 1 subjects for whom intrusion and of maxillary incisors with anchorage from the LVMA was carried out. Group 2 consisted of a control group of 21 subjects for whom orthodontic treatment was done using routine sliding mechanics for retraction with anchorage from the molar hook. Pre and post standardized cephalograms were obtained and assessed for 20 parameters (8 linear and 12 angular measurements, which included dental, skeletal, and soft tissue parameters (Figure 1 and 2). Cephalometric analysis was done to determine amount of intrusion and extrusion effects produced in both groups. Cephalometric measurements were carried out using dolphin software (version 11.95 premium), except for one variable which included the M point, was traced manually on acetate paper with a 0.3H pencil. The reliability was checked by intraclass correlation.

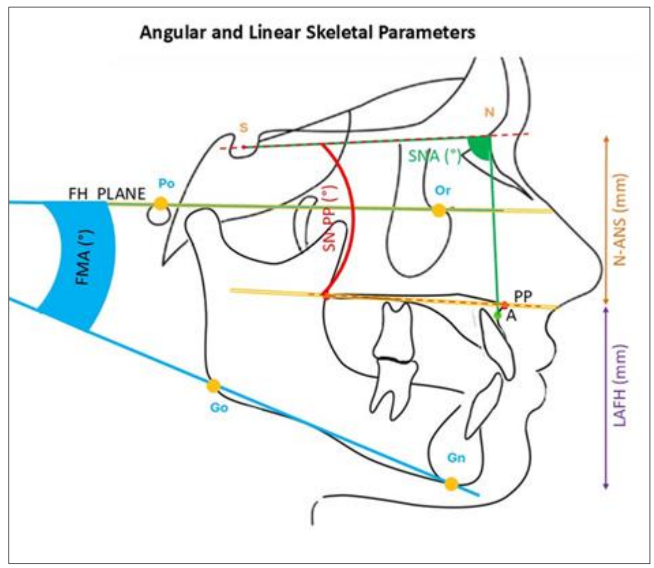

Figure 1: Skeletal Parameters

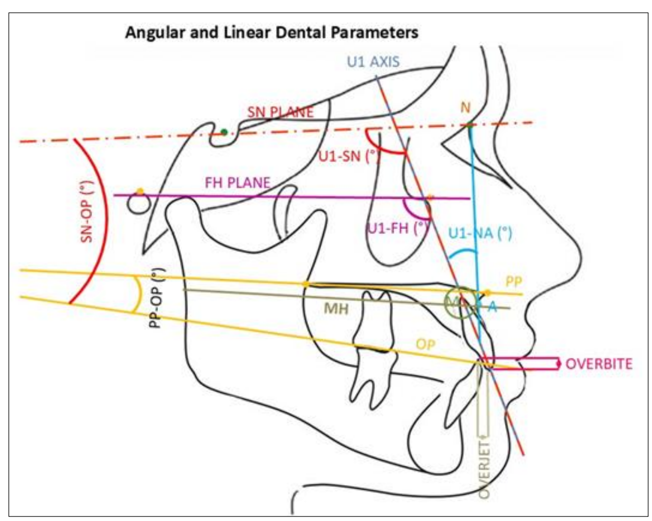

Figure 2: Dental Parameters

Intervention

All patients were strapped up a with MBT prescription 0.022 slot bracket system and retraction was executed with 0.019 x 0.025” SS posted arch wire after all 1st bicuspid extractions using sliding mechanics with a force range of 250-300g rendered with elastomeric chains. In group 1, a long vertical arm was made with 0.019 x 0.025” SS wire. LMVA (Figure 3) consists of a horizontal section which enters the auxiliary molar tube from the distal with the vertical arm of approximately 10mm which ends up in a hook with the free end facing distally. During retraction, elastomeric chains were engaged from hook at the posterior to posted arch wire in the anterior (Figure 4A). In group 2 during retraction the elastomeric chain was engaged from the ball end hook on the molar tube at the posterior to the posted arch wire in the anterior as in conventional mechanics (Figure 4B).

Pre and post retraction standardized lateral cephalograms were taken and a total of 20 cephalometric parameters using the dolphin software (Version 11.95 premium) were taken for the study.

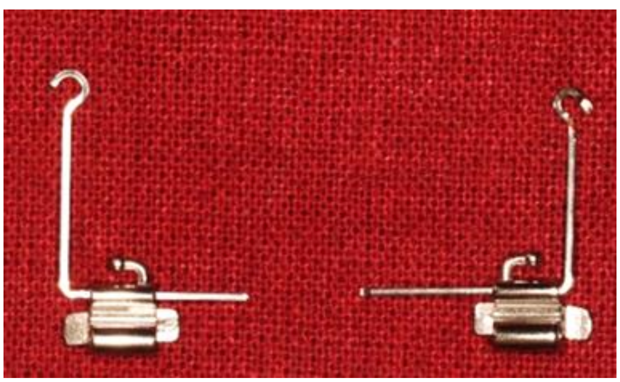

Figure 1: Long vertical molar arm

Figure 2: A) Force applied on to the LVMA; B) regular conventional class 1 mechanics

Outcomes assessed

In this study, 10 cephalometric – landmarks namely Gonion (Go), Sella (S), Nasion (N), Subspinale (Point A), Orbitale (Or), Menton (Me), Porion (Po), Point M (M), Posterior Nasal Spine (PNS), and Anterior Nasal Spine (ANS),; and 7 reference planes including Sella-Nasion (SN) plane, Occlusal Plane (OP), Frankfort Horizontal Plane (FHP), Nasion–Point A (N-A) plane, Palatal Plane (PP), Mandibular Plane (Go–Me), and M Horizontal (MH) plane were used for analysis. Cephalometric analysis included skeletal angular measurements comprised SNA, FMA, SN–PP, and PP–FH, while linear parameters included ANS–Me (lower anterior facial height) and N–ANS. Dental angular measurements evaluated maxillary incisor and molar inclinations namely U1 to NA, U1 to SN, U1 to MH, and U1 to FH; U6 to MH; PP to OP; and SN to OP. Linear dental parameters included U1 to NA, U1 to MH, U6 to MH, overjet, and overbite. The soft tissue parameter was assessed using nasolabial angle. Superimposition of cephalometric tracings on the ANS-PNS plane compared pretreatment and post-treatment changes.

Statistical analysis

Data were entered on Microsoft Excel Spreadsheet and descriptive statistics were generated. Statistical analysis were done using IBM SPSS Statistics Version 21. Independent samples t-test assesed intergroup differences, while paired samples t-test assesed pre and post treatment intervention within the group.

Results

Table 1: Comparison of skeletal parameter between groups

Parameter	Study Group	Control Group	p value
SNA (°)	-0.50 ± 0.65	-0.40 ± 0.63	0.439
FMA (°)	+0.52 ± 3.46	+0.85 ± 2.02	0.305
SN-PP (°)	-0.33 ± 1.15	+0.14 ± 1.93	0.184
FH-PP (°)	-1.62 ± 1.96	+0.43 ± 1.43	0.104
LAFH (mm)	+0.82 ± 1.10	+1.14 ± 0.93	0.741
N-ANS (mm)	+0.13 ± 0.60	+0.27 ± 0.35	0.680

Skeletal measurements showed no significant difference between two groups. Both the groups had minimal changes in sagittal and vertical measurements. The average reduction in the SNA angle was similar for both groups, at −0.50° ± 0.65 and −0.40° ± 0.63, indicating a slight sagittal skeletal change. Vertical measurements (SN-PP, FMA, and FH-PP) showed statistically non-significant mild increases or decreases suggesting that intrusion mechanics used in the study group did not cause meaningful changes to vertical skeletal structure. Linear parameters, such as LAFH and N-ANS, also showed slight increases, but these were not statistically significant between two groups (Table 1).

Table 2: Comparison of dental parameter between groups

Parameter	Study Group	Control Group	p value
U1-NA (°)	-9.25 ± 4.84	-6.06 ± 6.04	0.310
U1-NA (mm)	-5.53 ± 2.10	-2.96 ± 5.23	0.007*
U1-SN (°)	-10.20 ± 6.25	-1.94 ± 10.52	0.271
U1-MH (°)	-8.76 ± 6.52	-4.33 ± 5.98	0.687
U1-FH (°)	-9.67 ± 5.82	-5.31 ± 4.63	0.558
U6-MH (°)	+4.95 ± 3.11	-0.71 ± 3.99	0.207
PP-OP (°)	-1.07 ± 2.49	-0.28 ± 3.35	0.530
SN-OP (°)	-1.89 ± 2.22	-0.97 ± 3.76	0.017*
U1-MH (mm)	-2.19 ± 0.68	+0.90 ± 0.30	0.011*
U6-MH (mm)	+0.93 ± 0.18	+1.05 ± 0.67	0.004*
Molar Mesial Movement (mm)	+0.43 ± 0.60	+1.33 ± 0.48	0.189
Overjet (mm)	-2.29 ± 1.23	-1.38 ± 1.24	0.559
Overbite (mm)	-2.14 ± 0.79	-1.14 ± 1.20	0.231

* Statistically significant p- value (P < 0.05)

The study group exhibited significantly greater dental changes with greater reduction in U1-NA linear measurement (−5.53 ± 2.10 mm) compared with the control group (−2.96 ± 5.23 mm), with a statistically significant difference (P = 0.007), indicating enhanced upper incisor retraction in the study group. Additionally, changes in SN-OP (P = 0.017), U1-MH (P=0.011), and

U6-MH (P=0.004) were significant, reflecting improved intrusion and control of the maxillary anterior segment when using LVMA. Other angular and linear dental parameters showed comparable changes between groups without significant differences (Table 2).

Table 3: Comparison of soft tissue changes between groups

Parameter	Study Group	Control Group	P-Value
Nasolabial Angle (°)	+12.48 ± 7.39	+7.86 ± 4.84	0.105

Soft-tissue analysis revealed a larger nasolabial angle increase in the study group, suggesting increased soft tissue response following retraction of upper anteriors using vertical molar arm mechanics. However, this did not show statistical significance (P = 0.105) (Table 3).

Even though the present study did not intend to study the changes on the smile, it was very evident that almost all patients with gummy smiles were corrected satisfactorily (Figure 5). This addition was not made as the control group did not have gummy smile and there could not be any comparisons.

Figure 3: Pre-treatment (A) and post-treatment (B) result using LVMA

The greater upper incisor intrusion observed in the study group can be attributed to the retraction force vector acting above the maxillary centre of resistance (C_{RES}), generating an anticlockwise moment of the occlusal plane and increased intrusive forces (Figure 6A). In contrast, in the control group, the force vector passed below the C_{RES}, producing an anticlockwise moment associated with anterior extrusion. After extraction of first premolar, C_{RES} shifted distally toward root of second premolar, positioning the hook superior to it (Figure 6B).

The upper molar exhibited reduced extrusion in the study group, as the force vector passed above its C_{RES}, producing a clockwise moment (Figure 7A), whereas in the control group, the vector passed below, inducing an anticlockwise moment (Figure 7B). The longer vertical arm in the study group significantly increased the clockwise moment. This force caused distal molar tipping, which was enough to effectively counteract unwanted molar extrusion providing enhanced anchorage which explains the greater upper incisor retraction when compared to the control group (Figure 8).

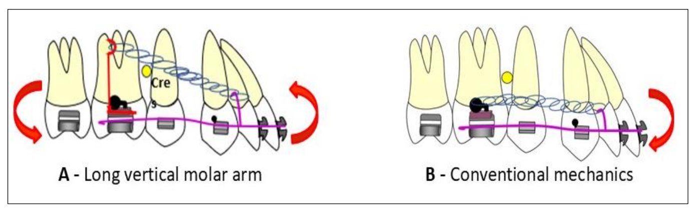

Figure 6: Retraction vector force in A) study group; B) control group

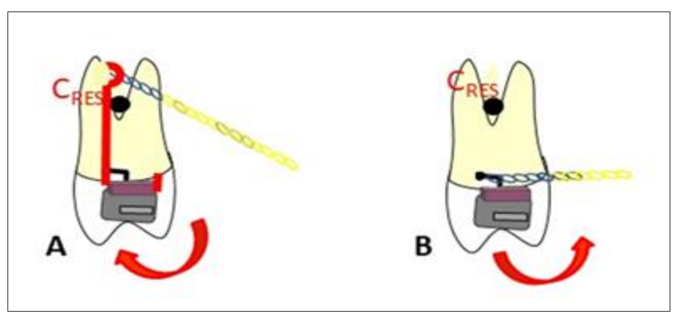

Figure 7: A) Anti-clockwise moment and mesial tipping of molar B) Clockwise moment and distal tipping of molar

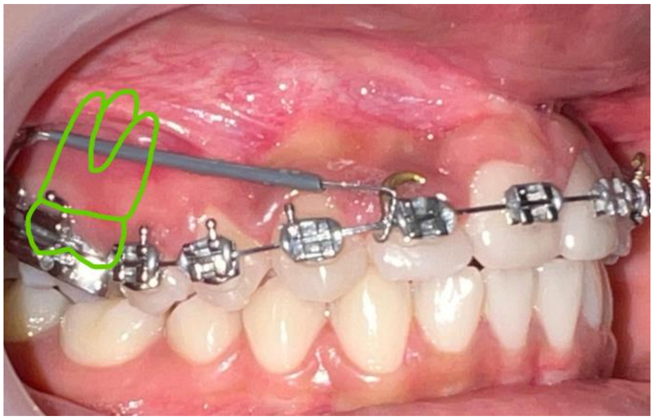

Figure 4: Distally tipped molar

Discussion

Achieving a favorable facial profile in orthodontics depends on retraction and intrusion of maxillary incisors. Intrusion of maxillary incisor is essential when treating space closure, severe deep bites, correcting excessive gingival display, thus enhancing both dental aesthetics and function which relies mainly on controlled forces. To minimize potential damage to root and surrounding tissues, it is essential to lower effective force. Applying excessive force, increases risk of root resorption and unwanted reciprocal extrusion of posterior teeth. To address these challenges LVMA system was designed to precisely direct forces above, below, and through center of resistance of maxillary teeth, thereby optimizing intrusion and retraction for better orthodontic outcomes.9 Therefore, this study aims to cephalometrically compare anterior intrusion and retraction effects of the LVMA with routine fixed mechanotherapy.

In the skeletal parameters, the mean difference in FMA angle between study and control groups was 0.33° with the study group showing a minimal increase of 0.52°, which was not significant statistically. This confirmed that LVMA and conventional fixed therapy maintained vertical skeletal movement. Other investigators like Kaushik et al.[10], Varlik et al.[11] and Amasyali et al.[12] reported that mandibular plane angle open up in Connecticut intrusion arch and utility arch groups. On contrary to the present study, Kaushik et al[10] reported that mandibular plane angle was reduced slightly in the miniscrew group. This could probably be because in the mini-implant group, there was no extrusive forces on the posteriors as the wires were sectional.

In the present study, mean difference of LAFH showed an increased mean difference of 0.3mm between the study and control groups. However, this was not statistically significant. This indicates that both the groups demonstrated an increase in LAFH. In the study by Kaushik et al1[0], the LAFH increased in the utility arch group compared to the Connecticut group which is in accordance with the present study. This may be due to slight extrusion of posteriors as it provides anchorage in the utility arch and the Connecticut arch mechanics. Contrarily, absence of increase in facial height in their mini screws validate that eliminating vertical strain on posterior anchorage is key to vertical control. Any remaining discrepancies between the current study and previous research may be due to differences in overall treatment duration or specific occlusal plane management protocols.

With respect to dental parameter changes the mean difference in the linear measurement from U1 to MH plane between study and control groups was 3.09 mm, a statistically significant result that demonstrates a pronounced intrusion effect on upper incisors in the study group. Within the study group, mean decrease in U1 to MH was 2.19 mm. These findings align with Polat-Ozsoy et al.[13], whose study achieved mean intrusion of maxillary incisor 1.92 mm using miniscrews (1.2 mm × 6 mm) placed distal to maxillary lateral incisors. In their comparison group using a utility arch made of blue Elgiloy wire, a mean intrusion of 1.81 mm was observed. Minor differences from prior studies may stem from force magnitude, wire stiffness, or reference plane selection.

Similarly, Jain et al.,[14] reported statistically significant true intrusion of incisors (U1–PP) achieved with both mini-implants and utility arches. Their mini-implants (6 mm × 1.4 mm) placed between maxillary central and lateral incisors, loaded with 1.5 oz NiTi coil springs, achieved mean true intrusion of 2.1 mm, with maximum of 3 mm in one subject. The Ricketts utility arch group attained an average intrusion of 1.33 mm. Raj et al. [15] also compared miniscrew-assisted intrusion with Burstone's intrusion arch and reported mean true intrusions of 2.20 ± 1.13 mm and 4.3 mm, respectively, though difference was not statistically significant. Kumar et al. 16, using a 0.016 × 0.022-inch NiTi Connecticut intrusion arch, reported 2.07 mm of maxillary intrusion with 60 g of force. In comparison, the present study achieved a mean intrusion of 2.19 mm, greater than those reported for the implant, utility arch, and Connecticut intrusion arch groups. This may be attributed to the increased length of the LVMA, producing a force vector that passed above center of resistance of maxillary dentition, thereby enhancing intrusive effect.

The mean difference in U6 to MH (linear) between the two groups was 0.11 mm, indicating a significant extrusive effect on the upper molars in control group relative to study group. This finding aligns with Jain et al.[14], who observed significant molar extrusion (0.75 mm) with the utility arch. Kumar et al. [16] reported molar extrusion in Connecticut intrusion arch group of 1.20 ± 0.32 mm. Phor et al. [17] noted a 3.33 mm increase in molar position with the utility arch but only 0.16 mm (nonsignificant) with miniscrews. In our present study, the minimal extrusion (0.11 mm) was lower than that reported for other groups, likely due to the longer LVMA generating a clockwise moment on the molar as force vector passed above its center of resistance.

The mean change in upper incisor to SN displayed a difference of 8.26° between groups, though not statistically significant, suggesting both groups achieved comparable maxillary incisor retraction. Deguchi et al. [18] and Goel et al. [19], reported similar outcomes despite differing mechanics (miniscrews and KSIR arch, respectively). Conversely, Kaushik et al[10], DeVincenzo and Winn20, and Sensik et al. [21] observed slight proclination of maxillary incisors, which might be due to their non-extraction protocols.

Overbite changes in this study revealed a 1 mm difference between groups, with the study group showing a reduction of 2.14 mm, though not statistically significant. This result agrees with Namrawy, El Namrawy et al.,[22] who reported overbite reductions of 2.9 ± 0.8 mm with Connecticut intrusion arches and 2.6 ± 0.8 mm with miniscrews. Similarly, Phor et al. [17] observed greater overbite reduction with miniscrews (2.75 mm) than with utility arches (0.67 mm). Polat-Ozsoy[13] also reported an overbite reduction of 2.25 ± 1.73 mm using segmental arches with miniscrews. The slightly lower overbite reduction in present study may be attributed to reduced molar extrusion in the LVMA group primarily due to true incisor intrusion, reflecting controlled and precise vertical correction.

The main limitation of this study is its relatively small sample size, which may decrease generalizability of the findings. As a short-term analysis, it did not assess the long-term stability or relapse potential of the intrusion and retraction effects. The use of 2-dimensional cephalometry limits evaluation of three-dimensional tooth and soft tissue changes. Being a single-center study, results may be influenced by operator technique or patient demographics.

Conclusion

The LVMA group had an increased intrusion effect on the upper incisors compared to routine fixed mechanotherapy group. Additionally, the upper first molars had an extrusion effect which was lesser in the long vertical molar arm group compared to the routine fixed mechanotherapy group. The study showed that the upper incisors were retracted more with the long vertical molar arm compared to fixed mechanotherapy group. The molar extrusion effect resulted in an increase in mandibular plane angle with both groups, but increased more with routine fixed mechanotherapy group. It was also observed that there was an increase in the lower anterior facial height, with both the groups, but was greater with the fixed mechanotherapy group compared to the long vertical molar arm group. The long vertical molar arm can be used successfully for the intrusion and retraction of the maxillary incisors.

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