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# Evaluation of En Masse Retraction Using Microimplant versus Conventional Techniques: An in Vitro Study

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**الخلاصة**

**الاهداف**: لتقييم تقنيات مختلفة للسحب الاجمالي للاسنان على الموقع ودرجة الميلان و معدل اغلاق المسافة و نوع حركة السن القاطع العلوي. **المواد وطرائق العمل**: قسمت العينة الى ثلاث مجاميع وتم اخذ صور فوتوغرافية قبل وبعد عملية السحب وتم اخذ قياسات باستخدام برنامج اوتوكاد. لتحليل البيانات استخدم اختباري كروسكال ويلز و مان وتني U. **النتائج**: معدل اغلاق المسافة اظهر اختلافا غير معنوي بين المجاميع الثلاثة، نوع حركة الاسنان اظهرت اختلافا معنويا، حيث ان المجموعة الثالثة اظهرت حركة من الميلان المنضبط اكبر من المجموعة الاولى بينما المجموعة الثانية اظهرت حركة الميلان غير المنضبط. **الاستنتاجات**: السحب الاجمالي للاسنان باستخدام الزرعات التقويمية اعطى سيطرة افضل خلال السحب. التقنيات التقليدية ادت الى بزوغ الاسنان وادت الى حركة اقل انتقالية للاسنان اثناء السحب.

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## ABSTRACT

**Aims:** The study aims to evaluate the effect of different techniques of en masse retraction on the vertical and sagittal position, axial inclination, rate of space closure, and type of movement of maxillary central incisor. **Materials and methods:** Three groups were used group 1(N=10, T−loop), group 2(N=10, Time−Saving loop), and group 3(N=10, Microimplant). Photographs were taken before and after retraction and measurements were made using Autodesk AutoCAD© 2010. Kruskal−Wallis one−way ANOVA and Mann−Whitney U test ($p \leq 0.05$) were used. **Results:** The rate of space closure showed no significant difference among the groups ($p \leq 0.05$). The type of tooth movement showed a significant difference among the groups ($p \leq 0.05$), where group 3 showed a more degree of controlled tipping than group 1 while group 2 showed an uncontrolled tipping movement. **Conclusions**: It is concluded that microimplant anchored sliding mechanics gives better control over the en masse retraction mechanics and greater retraction. Conventional techniques result in extrusion and move the teeth in less degree of translation.

**Key words**: Microimplant, sliding mechanics, axial inclination.

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## INTRODUCTION

During premolar extraction treatment, the orthodontist has several options for space closure, a popular method is en−masse space closure with sliding mechanics and coil springs. The use of loops for closing spaces in orthodontics requires the professional to know the force systems offered by the orthodontic treatment mechanics, because if the mechanics associated with loops are used improperly, complications such as loss of anchorage, excessive verticalization of incisors, increase of overbite, dental mobility, root resorption, and an increase in treatment time may result, with irreversible damage to the patient.[1, 2] With increased use of preadjusted appliances, various forms of sliding mechanics have replaced closing loop arches. Sliding mechanics might have great benefits, such as minimal wire−bending time and adequate space for activations.[3] The retraction of four incisors after canine retraction is accepted as a method to minimize the mesial movement of the posterior teeth segment, whereas en masse retraction of six anterior teeth may create anchorage problems. In addition, the tipping action built into anterior brackets in preadjusted appliances may produce problems of anchorage. These problems may be aided by the use of a transpalatal bar and extraoral appliances.[3, 4] Skeletal anchorage using dental implants provides an absolute anchorage for tooth movement. Microimplants have many benefits such as ease of placement and removal and inexpensiveness. Most importantly, because of their small size, they can be placed in the intra–arch alveolar bone without discernable damage to tooth roots. In addition, orthodontic force applications can begin almost immediately after placement in contrast to dental implants.[5, 6] In this study a Typodont simulation system is used to show the possible effects of using variable factors on en masse retraction and rate of movement during space closure using microimplant and a conventional retraction technique.

## MATERIALS AND METHODS

A typodont simulation system (Ormco, Japan) is prepared according to manufacturer instructions to be used in the study with a wax form (maxillary arch Cl II division 2 malocclusion) and maxillary metallic teeth. Initial alignment is made by finger pressure on 0.018" stainless steel archwire and preadjusted mini ROTH 0.022"x0.030" slot bracket (one set) after immersing the typodont in the water bath,[7] then SS 0.019"x0.025" archwire is used and end with SS 0.0215"x0.025" archwire. The posterior portion of the typodont wax is replaced by cold cure acrylic resin in order to stabilize anchorage teeth (second premolar, first and second molars) and provide a site for microimplant placement. Wood table (length: 23cm, width: 10cm) with a custom made bases to receive and stabilize the typodont and the digital camera (Figure 1). The digital camera was fixed (10cm) from a vertical ruler which is fixed to the table opposite to the midline between central incisors when the typodont is in place. Horizontal bar was fixed on the ruler and be coincided with a long axis bar (0.022" SS wire) that is fixed to right central incisor by making a groove from lingual fossa to the incisal edge (Figure 2), this bar was placed in that groove and fixed with epoxy steel adhesive and adjusted to have the same axial inclination of the tooth. The point of intersection between horizontal and long axis bars is marked and used during repositioning of teeth after each experiment.

Figure (1): Wood table with the vertical and horizontal bars, custom made base for typodont and digital camera fixation.

Figure (2): Long axis bar on Maxillary right central incisor.

*AutoCAD Measurements*

A. Photograph Analysis:

The standardized photographs were captured on a scale and transferred to the computer to be analyzed in Autodesk AutoCAD© software 2010 and to measure the accurate readings (Figure 3). Photograph analysis is made by drawing three lines:

1. The horizontal line is drown over the horizontal bar.
2. The long axis line is drown over the long axis bar with a constant length (36mm) and locating the incisal edge (8.25mm) from the tip of long axis bar, the end of this line is considered the

apex of the tooth and the estimated midpoint of the root is localized on this line (8.25mm) from tooth apex.

3. The vertical line is drown from the point of intersection between horizontal and vertical bars and extends down vertically.

B. Measurements: For each experiment of en masse retraction a photograph was taken before starting retraction process, while another photograph was taken after completing retraction process (i.e. after cooling of the typodont). The two photographs were analyzed by AutoCAD software 2010 and measurements were made as follows:

1. Sagittal movement of incisal edge (SE): The distance from incisal edge to the vertical line was measured in each photograph, and the sagittal movement of incisal edge is denoted by "SE".
2. Vertical movement of the incisal edge (VE): The vertical distance from incisal edge to the horizontal line was measured in each photograph and this distance will represent the change in vertical position of the incisal edge [7]. Positive values will indicate extrusion while negative values indicate intrusion of the tooth.
3. Sagittal movement of tooth apex (SA): The distance from tooth apex to the vertical line was measured in each photograph, and the sagittal movement of tooth apex is denoted by "SA".
4. Vertical movement of the estimated midpoint of the root (EMP): The vertical distance from EMP of the root to the horizontal line was measured in each photograph. The vertical change in the position of the EMP of the root is used to determine the extent of true intrusion/extrusion.[8] Positive values will indicate true extrusion while negative values indicate true intrusion of the tooth.
5. Axial Inclination Change ($I^{o}$): The angle between long axis line and the vertical line was measured in each photograph.
6. Rate of Space Closure (SC): The distance between the distal wing of canine bracket and the mesial wing of second premolar bracket was measured in each photograph.[9]
7. Type of tooth movement (R): To determine and quantify the movement of the central incisor, the ratio of SA and the SE were calculated. If the apical point moved in the opposite direction to the coronal point, the amount received a negative sign. Tooth movements were classified on the basis of the quotient (R) obtained (SA/SE): < 0, uncontrolled tipping; 0, controlled tipping; >0, controlled tipping and bodily movement; 1, bodily movement; and >1, root movement.[10]

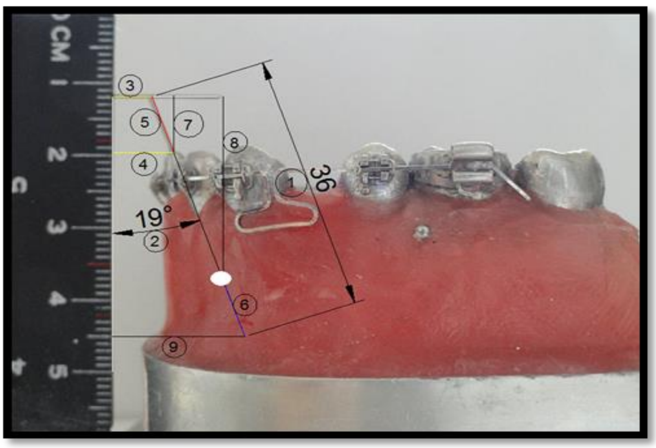



Figure (3): Photograph analysis by Autodesk AutoCAD© software 2010: (1) line indicates tooth position before retraction, (2) axial inclination, (3) distance between top of long axis bar and vertical bar, (4) distance between incisal edge and vertical bar, (5) length of long axis bar, (6) distance from apex to EMP of the root (White point), (7) distance between incisal edge and horizontal bar, (8) distance between EMP and horizontal bar, (9) distance between apex and vertical bar.

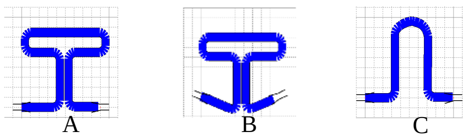
*Reposition of Typodont Teeth*

After each experiment, typodont teeth was repositioned to their original position by immersing the typodont in the water bath and placing an acrylic bite plane made from cold cure acrylic resin (Figure 4), a precise final alignment for the teeth was done, with SS rectangular archwire of size (0.019"x0.025"), then SS (0.0215"x 0.025"),[11] these archwires are ligated to typodont teeth with SS ligature. The criteria for successful repositioning of the teeth are passive insertion of SS rectangular archwire of size (0.0215"x0.025") in the bracket slots, the distance between the tip of long axis bar and the vertical bar is (5mm±0.1) measured by digital vernia, the distance between the incisal edge and the vertical bar is (7.6mm±0.1) measured by digital vernia, and the distance between the distal wing of canine bracket and the mesial wing of second premolar bracket is (13mm±0.1) measured by digital vernia. In order to avoid the possible alteration of the characteristics of the wax after successive experiments could interfere in the fidelity of the results, the wax was replaced for each experimental group.[11]

Figure (4): Acrylic bite plane.

*Experimental Groups*

1. In group 1 (10 closing loops), en masse retraction with T−Loop (T) (Figure 5A, B), the archwire used is SS 0.018"×0.025". [12]
2. In group 2 (10 closing loops), en masse retraction with time−saving closing loop (TS): This loop is made according to the inventor of SS 0.018"x0.025" archwire (Figure 5C). [13]
3. In group 3 (10 archwires), en masse retraction with microimplant (MI) and a crimpable hook was crimped on the SS 0.019"x0.025" archwire between lateral incisors and canines through which a force will be applied on the anterior teeth, hook length used is (6mm) from the base archwire, then the force is applied through NiTi closed coil spring to the microimplant. [12, 14]



A B C

Figure (5): Template used to make the deactivated and preactivated loops used in this study operated by Loop software version 1.7.

*Statistical Analysis*

Statistical analysis was undertaken using the (SPSS Version 11.5) including descriptive statistics (Table 1). After examining the distribution of the sample, nonparametric tests were used including Kruskal−Wallis one−way analyses of variance (Table 2) and Mann−Whitney U test ($p \leq 0.05$) (Table 3) to compare means among the groups.

Table (1): Linear and Angular Changes.

| Measurement | Group 1 | | Group 2 | | Group 3 | |
|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| **SE** | 1.7 | 0.22 | 2.11 | 0.33 | 2.84 | 0.31 |
| **VE** | 0.54 | 0.24 | 1.29 | 0.21 | -0.12 | 0.09 |
| **EMP** | 0.19 | 0.18 | 0.60 | 0.19 | -0.44 | 0.11 |
| **SA** | 0.25 | 0.34 | -0.97 | 0.47 | 1.81 | 0.29 |
| **I$^o$** | 2.06 | 0.87 | 7.35 | 0.94 | 1.84 | 0.65 |
| **SC** | 1.10 | 0.57 | 1.56 | 0.42 | 1.41 | 0.41 |
| **R** | 0.33 | 0.19 | -0.50 | 0.09 | 0.59 | 0.09 |

SE: sagittal movement of incisal edge, VE: vertical movement of incisal edge, EMP: vertical movement of estimated midpoint of the root, SA: sagittal movement of apex, I$^o$: axial inclination change, SC: rate of space closure, R: type of tooth movement, ($^o$) degree (angular measurement), Linear measurement (mm).

Table (2): Kruskal−Wallis Analyses of Variance.

| | **SE** | **VE** | **EMP** | **SA** | **I** | **SC** | **R** |
|---|---|---|---|---|---|---|---|
| **Chi−Square** | 19.992 | 25.876 | 24.586 | 25.061 | 19.559 | 4.254 | 23.118 |
| **df** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Asymp. Sig.** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.119 | 0.00 |

Table (3): Mann−Whitney U Test.

| **Method** | | **SE** | **VE** | **EMP** | **SA** | **I** | **SC** | **R** |
|---|---|---|---|---|---|---|---|---|
| T | TS | 0.00 | 0.016 | 0.001 | 0.00 | 0.00 | NS | 0.00 |
| | MI | 0.00 | 0.00 | 0.00 | 0.00 | NS | NS | 0.001 |
| TS | T | 0.00 | 0.016 | 0.001 | 0.00 | 0.00 | NS | 0.00 |
| | MI | 0.00 | 0.001 | 0.00 | 0.00 | 0.00 | NS | 0.00 |
| MI | T | 0.00 | 0.00 | 0.00 | 0.00 | NS | NS | 0.00 |
| | TS | 0.00 | 0.001 | 0.00 | 0.00 | 0.00 | NS | 0.00 |

NS: No significant difference at $p \leq 0.05$

## RESULTS

1. Sagittal movement of the incisal edge: Changes in sagittal position of incisal edge were group 1(1.7±0.22). Group 2(2.11±0.33). Group 3(2.84±0.31). Group 3 shows a more degree of retraction than other groups with a significant difference among them (P≤0.05).
2. Vertical movement of incisal edge: Changes in vertical position the tooth were group 1(0.54±0.24), group 2(1.29±0.21), group 3(-0.12±0.09). Significant difference was recorded among the three groups (P≤0.05), where extrusion movement in group1 and 2 while intrusion in group 3.
3. Vertical movement of the estimated midpoint of the root: Changes in vertical position of the EMP were group 1(0.19±0.18), group 2(0.60±0.19), group 3(-0.44±0.11). Significant difference was recorded among the three groups (*P*≤0.05), where true extrusion movement in group1 and 2 while true intrusion in group 3.
4. Sagittal movement of tooth apex: Changes in sagittal position of tooth apex were group 1(0.25±0.34), group 2(-0.97±0.47), group 3(1.81±0.29). Significant difference was recorded among the three groups (*P*≤0.05), in group 2 apex movement in opposite direction to that of the incisal edge, in group 1 and 3 the apex moved in the same direction.
5. Axial inclination change: Changes in axial inclination measurements were group 1(2.06°±0.87°), group 2(7.35°± 0.94°), group 3(1.84°±0.65°). Significant difference was recorded in group 2 (*P*≤0.05).

6. Rate of space closure: No significant difference was recorded among the three groups (*P*>0.05).
7. Type of tooth movement: The ratio of tooth movement were group 1 (0.33±0.19), group 2(-0.5±0.09), group 3(0.59±0.09). Significant difference was recorded among the three groups (*P*≤0.05). Group 1 and 3 showed controlled tipping movement, while uncontrolled tipping movement was recorded in group 2.

## DISCUSSION

The upper incisors were retracted in group 1 and 3 with a combination of tipping and bodily movement. However, the upper incisor in group 2 moved in a relatively uncontrolled tipping manner and showed a resultant extrusion movement of the upper incisal edge. In group 1 there was a greater sagittal change of incisal edge (1.7mm) and least change in the root apex in sagittal direction (0.25mm), while in group 3 more degree of incisal edge and apex sagittal movement (2.84mm), (1.81mm) respectively, whereas group 2 the root apex moved in sagittal direction opposite to that of the incisal edge (-0.97mm).

The reason behind the relatively greater movement of incisal edge in group 1 when compared with group 3 after retraction was mainly due to the wholesome tipping movement that took place around the root apex in group 1 and the translatory movement in group 3 [10, 14, 16].

As the force application shifted towards the apex as in group 3, the force applied was more closer to the center of resistance, and the perpendicular distance between the level of force application and the center of resistance of the incisor was reduced resulting in the decrease of the magnitude of tipping moment generated during retraction, and resulting in the maintenance of the torque of the anterior teeth throughout the retraction period [15].

Regarding axial inclination change, group 3[1.84°±0.65°], group 1[2.06°±0.87°], and group 2[7.35°±0.94°], spaces present between the archwire and the bracket slot 0.019"×0.025" (group 3) and the 0.018"x0.025" (group 1 and 2) lead to a small loss of torque. In addition group 2, the central incisor moved in an uncontrolled tipping manner as a result of producing less M/F ratio than in group 1.[12, 16]

Upper incisor was intruded in group 3 and extruded in group 1 and 2 (0.21mm intrusion: 0.54mm, 1.29mm extrusion respectively), suggesting that the microimplant can demonstrate its ability to intrude the upper anterior teeth during retraction due to distal and intrusive force vector, which is in accordance with Ma *et al*. This appears to be due to the direction of pull by the Ni−Ti closed coil spring from the microimplant head to the hooks on the archwire.[17]

From Table (1), it can be noticed that vertical position of central incisor is controlled by the change in both (VE) and (EMP) of the root, {in group 1 and 2, nearly two thirds (VE) and one third (EMP) of the root, while in group 3, nearly one fourth (VE) and three fourth (EMP) of the root}. It is concluded that in group 1 and 2 the extrusion of the tooth is attributed to the (EV), while in group 3 the intrusion is attributed to the vertical change in (EMP) of the root.

The rate of space closure showed no significant difference among the three groups (*p*>0.05). This might be due to the effect of immobilization of posterior teeth which might move mesially in conventional retraction techniques.

## CONCLUSION

No significant difference existed in the rate of space closure among the three groups. Microimplant achieved better control in both the anteroposterior and vertical directions during en masse retraction. Retraction with time−saving closing loop results in the greatest extrusion, greatest change in axial inclination, and an uncontrolled tipping movement. The intrusion of central incisor with microimplant is mainly a true intrusion, while during retraction with T−loop or time−saving closing loop, tooth extrusion occurs mainly as a result of change in axial inclination of the tooth.

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