Comparison of cephalometric changes resulting from different upper incisor intrusion methods

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Received: 2 March 2021
Accepted: 19 May 2021

Abstract

Aim: The aim of this study was to provide intrusion of upper incisors with applying Connecticut Intrusion Arch (CIA) and Miniscrew and to evaluate the dental and skeletal cephalometric effects of these intrusion methods on individuals with deep bite caused by supraocclusion of upper incisors.

Methodology: The study includes 40 adults, without making sexual distinction, who have at least 4 mm deep bite caused by supraocclusion of upper incisors. Two study groups each consisting 20 individuals formed as CIA and Miniscrew groups. Skeletal, dental, soft tissue measurements were done on lateral cephalograms and apical root resorption measurements were done on standard periapical radiographs that were taken from upper four incisor teeth. Statistically, Paired Student’s t-test was used in intragroup comparements and independent Student’s t-test was used in the investigation of differences between groups. Nevertheless, the concern of variables that seen as risk factors with the amount of resorption was investigated with Pearson correlation analysis.

Results: Successful intrusion of four upper incisor teeth with CIA and Miniscrew methods and in-significant difference was determined between two methods. Protrusion of upper and lower incisor teeth decrease in interincisal angle and overbite and increase in overjet was stated by intrusion at both of the methods. The decline of the mesiobuccal cusp of the upper first molar was observed in the CIA method. In soft tissue evaluation, decrease of upper lip length, upper lip thickness and distance of upper and lower lip to the Rickett’s plane was observed.

Conclusion: The methods used for intrusion showed to cause similar ratio of root resorption.

Keywords: deep overbite, CIA, miniscrew, maxillary incisor intrusion

Introduction

In recent years, the aesthetic needs of individuals have been increasing; thus, facial and dental aesthetics have become very important. Facial aesthetics is an important variable in social life and relationships. One of the primary purposes of orthodontic treatment is to improve dental aesthetics (1). A beautiful and attractive smile is known to have a positive effect on individuals. It also improves self-confidence, communicative success, careers, and private life. Thus, smile design aims to give a beautiful, healthy, ideal smile through a combination of medicine and art. In smile design, the relationship between the teeth and surrounding soft tissues is well known (2). Less visible
gums during a smile are considered more aesthetically pleasing (2-4).

Deep bite is defined as the amount and percentage of excessive overlap of the lower incisors by the upper incisors (5, 6). Deep bite can be functional, skeletal (morphological), or dental. It must be corrected to achieve a harmonious facial profile, a balanced intraoral bite relationship, and good function (7). Correcting a deep bite with orthodontic treatment is very difficult. Generally, three treatment methods have been used: (a) true incisor intrusion, (b) posterior tooth extrusion, and (c) a combination of posterior extrusion and incisor intrusion (8). Orthognathic surgery is a further option (7, 9). The ideal deep bite treatment is incisor intrusion because it does not change the vertical facial dimensions. If an intrusion greater than 4 mm is required, lower incisor intrusion is recommended besides the upper incisors (10, 11).

A review of the literature indicates that the following appliances have been used in intrusion: anterior bite planes, functional appliances, J-hook headgear (J-HG), intrusion arches (three-piece base arch, utility arches [UIAs], Connecticut intrusion arches [CIAs]), reverse curve archwire, interarch elastics, clear aligners, and miniscrews. The CIA, which is manufactured from a nickel titanium alloy, has the advantages of shape memory, springback, and light, continuous force distribution. It has the characteristics of not only the utility arch but also the conventional intrusion arch. The CIA is fabricated with the types of bends that facilitate easy insertion and use (12).

Miniscrews recently gained popularity because they provide maximum anchorage in incisor intrusion, reduce the need for patient cooperation, and simplify further treatment. Experimental and clinical studies have demonstrated that miniscrews provide effective and stable anchorage for orthodontic treatment (13-20). Their advantages include easy application, small size, simple surgery, immediate loading, minimal anatomic limitations, high patient comfort, no laboratory procedure, easy post-treatment removal, and low cost (21).

The aim of this study was to evaluate the effects of the CIA and miniscrews on skeletal, dental, and soft tissues. For patients with deep bites, the CIA and miniscrew are most commonly used methods for upper anterior incisor intrusion.

Materials and Methods

The study included 40 adult patients with upper incisor supraocclusion, deep bites, and complete growth. Participant selection was based on the following criteria: (1) at least 4 mm overbite, (2) dental angle Cl-I or angle CI-II relationship, (3) optimum SN-GoMe angle of 28-38°, and (4) excessive gingival display when smiling. Detailed information was given to the patients and their parents about the treatments to be performed. They were then asked to sign a treatment consent form. The study was approved by the Dicle University Faculty of Dentistry Ethics Committee (July 27, 2008; Issue 2008 / 0006-821).

For all the patients, intraoral and extraoral photography, lateral cephalometric radiography, and panoramic radiography were performed at the beginning of treatment. Plaster models were also made. The 40 participants were placed into two groups: CIA and Miniscrew (Table 1).

| Table 1. The distribution of gender, and mean of age in study groups |
|-----------------|-----------------|-----------------|
| Gender         | CIA             | Miniscrew       |
| Female         | 12              | 13              |
| Male           | 8               | 7               |
| Mean Age       | 17,9±4.54       | 18,9±3.42       |

In the first group, a 0.016 × 0.022 in CIA (Intranol, GAC, USA) was used. First, a three-tube molar band was placed on the upper right and left first molars. Roth brackets (Omni-Roth, GAC, USA) with 0.018 × 0.025 in slots were attached to the upper four incisors, which were then connected with a 0.010 in ligature wire to form a block. The transpalatal arch was used to improve molar anchorage. Next, 0.016 × 0.022 in stainless steel wire was placed on the incisors, and the intrusion arch was placed in the auxiliary tubes. The front part of the intrusion arch was connected to a 0.016 × 0.022 in steel wire from the area between the central and lateral teeth (Fig. 1a, b). The CIA applied an average of 35-40 g of intrusion force. In cases of the application of insufficient force by the CIA, the force was increased to the desired level (70-80 g) by increasing the bends in the molar region. The patients were recalled for control at 4-week intervals.

For the Miniscrew group, two 1.6 mm wide × 8 mm long miniscrews (DualTop Anchor System, Jeil Medical, South Korea) were selected. They were placed bilaterally between the maxillary central and lateral incisors with a long hand driver. After the induction of local anesthesia, a screwdriver was used to insert the miniscrews at a 45° angle to the occlusal plane without removing the flap. For standardization, the miniscrews...
Upper incisor intrusion were inserted by the same dentist (DST). Roth brackets (Omni-Roth, GAC, USA) with 0.018 × 0.025 in slots were placed in the upper four incisors, which were connected as a block with a 0.010 in ligature wire. After the placement of 0.016 × 0.022 in stainless steel wire, 70-80 g of force was applied between the central and lateral incisors with a closed coil spring (Closed Coil Spring, GAC, USA) (Figure 2a, b).

To determine the effect of intrusion during deep bite treatment, no orthodontic mechanics were applied to the posterior region or lower jaw. After the application of force to the two groups for 6 months, the intraoral and extraoral photographs and cephalometric radiographs were retaken. The patients were checked every 4 weeks for signs of mobility or infection around the screws.

Figure 1 a,b. Intraoral views of intrusion mechanics with the CIA: (a) Frontal view and (b) Upper occlusal view

Figure 2. Intraoral views of intrusion mechanics with the Miniscrew: (a) Frontal view and (b) Upper occlusal view

Statistical analysis

Descriptive statistics, such as the mean, standard deviation, and minimum and maximum values, were calculated. The suitability of continuous variables for normal distribution was assessed with the Kolmogorov-Smirnov test, and homogeneity was determined by Levene’s test. The paired Student’s t-test was used for the in-group comparisons of the pre-intrusion [T1] and post-intrusion [T2] values. The differences between the two groups were assessed with the independent Student’s t-test. The chi-square test was used to measure frequencies. Systematic errors were not detected in the analysis (p > 0.05). A systematic error analysis performed with the Dahlberg formula yielded an acceptable level (0.018-0710) in the cephalometric measurements (Table 2). The data were found to be homogenous and normally distributed. The tests were performed with IBM SPSS Statistics. A 95% confidence interval was used, and significance was set at p < 0.05.

Results

Lateral cephalometric radiographs were obtained at T1 and T2 from the 40 participants in the CIA and Miniscrew groups. A total of 84 measurements, including skeletal, dental, and soft tissue, were made (Fig. 3-7).
Table 2. Dahlberg values related to cephalometric measurements used in the study

<table>
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<tr>
<th>Measurements</th>
<th>Dahlberg</th>
<th>Measurements</th>
<th>Dahlberg</th>
<th>Measurements</th>
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<td>U1-HRP(cr)</td>
<td>0.329</td>
<td>U6MxP(cr)</td>
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<td>Pog-HRP</td>
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<td>Pr-VRP</td>
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<td>Pog'-VRP</td>
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<td>L1-MnP</td>
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<td>L1-NB</td>
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<td>E'-LLA</td>
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<td>U6-HRP</td>
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<td>L6m.k HRP</td>
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<td>Nasolabial angle</td>
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<td>L6m.k VRP</td>
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<td>U1-L1</td>
<td>0.111</td>
<td>U1-MxP(cr)</td>
<td>0.204</td>
<td>Sn-Me'</td>
<td>0.145</td>
</tr>
</tbody>
</table>
1. SNA: Angle formed between sella nasion and nasion point A planes.  
2. SNB: Angle formed between sella nasion and nasion point B planes.  
3. ANB: Angle formed between nasion point A and nasion point B planes.  
4. SN-GoMe: Angle between the mandibular and sella nasion planes.  
5. N-S-Ar: Angle between the anterior cranial base plane and the Articulare point.  
6. HRP-MxP: The angle between the horizontal reference plane and the maxillary plane.  
7. HRP-MnP: Angle between the horizontal reference plane and the mandibular plane.  
8. Gonial Angle: The angle between the mandibular plane and the tangent drawn to the posterior edge of the ramus.  
10. SN-Pog: Angle between the anterior cranial base plane and the Pogonion

Figure 5: Angular dental measurements used in the study


Figure 6: Linear Dental Measurements Used in the Study

**Skeletal Measurements**

Statistically significant differences were found in the comparisons of the ANB angles (p < 0.01) and HRP-MnP values (p < 0.01) measurements in the CIA group. The ANB values decreased statistically, and the HRP-MnP values increased. The linear measurements such as Wits (p < 0.01), HRP-A (p < 0.05), HRP-B (p < 0.05), and Pog-HRP (p < 0.05) indicated statistically significant increases. No statistically significant change was detected in the other skeletal measurements at T1 and T2 in the CIA group (Table 3). The within-group comparison indicated statistically significantly lower ANB angles (p < 0.01). It also indicated that there was no statistically significant change in the other skeletal measurements in the Miniscrew group (Table 4). A between-group comparison indicated a statistically significant difference in the SNA (p < 0.05) in the skeletal measurements at T2 (Table 5).

**Dental Measurements**

In the CIA group, the following angles were found to be statistically increased: U1-MnP (p < 0.001), U1-HRP (p < 0.001), U1-NA (p < 0.001), L1-NB (p < 0.05), and L1-MnP (p < 0.05). The interincisal angle (p < 0.001) decreased significantly. The measurements indicated significant decreases in the U1-HRP (cr) (p < 0.001), U1-HRP (tip) (p < 0.05), U1-VRP (cr) (p < 0.001), overbite (p < 0.001), Pr-HRP (p < 0.001), and U1-MnP (cr) (p < 0.01). The linear measurements indicated statistically significant increases in the U1-VRP (tip) (p < 0.01), U6-VRP (cr) (p < 0.001), U6-HRP (tip) (p < 0.001), U1-APog (p < 0.01), overjet (p < 0.01), U1-NA (p < 0.05), L1-NB (p < 0.001), L6 mk-VRP (p < 0.001), and U6-MnP (cr) (p < 0.001) (Table 6).

In the Miniscrew group, there were indicated significant increases in the following dental angular measurements: U1-MnP (p < 0.001), U1-HRP (p < 0.001), U1-NA (p < 0.001), L1-NB (p < 0.05), L1-MnP (p < 0.05), U6-VRP (p < 0.001), and U6-MnP (p < 0.001). However, there was a significant decrease in U1` L1 (interincisal angle) (p < 0.001). The within-group comparisons indicated significant decreases in the following linear measurements in the Miniscrew group: U1-HRP (cr) (p < 0.001), U1-HRP (tip) (p < 0.001), Pr-HRP (p < 0.001), overbite (p < 0.001), and U1-MnP (cr) (p < 0.001). There were significant increases in the following values: U1-VRP (tip) (p < 0.001), U6-VRP (tip) (p < 0.05), L1-VRP (p < 0.001), U1-APog (p < 0.01), overjet (p < 0.001), Pr-VRP (p < 0.05), U1-NA (p < 0.001), L1-NB (p < 0.001), and L6 mk-VRP (p < 0.05). The other dental
measurements in the Miniscrew group at T1 and T2 indicated that there was no statistically significant change (Table 7).

The between-group dental measurements indicated significant differences in the overjet (p < 0.05), overbite (p < 0.05), and U1-NA (p < 0.001) values (Table 8).

**Soft Tissue Measurements**

In the CIA group, the soft tissue measurements indicated significant decreases in the following values: upper lip length (p < 0.05), upper lip thickness (p < 0.05), and Pog′-VRP (p < 0.05). There were significant increases in the following: B′-HRP (p < 0.05), LS-VRP (p < 0.001), Li-VRP (p < 0.01), Li-HRP (p < 0.05), Sn-HRP (p < 0.01), Pog′-HRP (p < 0.05), and Sn-NA (p < 0.01). However, there were significant decreases in the E-ULA (p < 0.05) and E-ULA (p < 0.05) values. The within-group comparisons of the T1 and T2 values for the CIA group indicated that there was no statistically significant change in the other soft tissue measurements (Table 9).

In the Miniscrew group, the soft tissue measurements indicated a significant reduction in the following values: upper lip thickness (p < 0.05), nasolabial angle (p < 0.001), labiomental angle (p < 0.05). A significant increase was found in A′-VRP (p < 0.05), and B′-VRP (p < 0.05), Ls-VRP (p < 0.001), and Li-VRP (p < 0.01) values. There was a significant decrease in the E-ULA (p < 0.001) and E-ULA (p < 0.01). In the Miniscrew group, the within-group comparisons indicated that there was no statistically significant change in the other soft tissues (Table 10).

The T2 between-group comparisons indicated that there was a significant difference in the nasolabial angle (p < 0.01). The between-group comparisons at T1 and T2 also showed that there was no significant difference in the soft tissue measurements (Table 11).

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**Table 3.** Descriptive statistics of skeletal measurements of the CIA group and comparison within group

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<tr>
<th>Parameter</th>
<th>n</th>
<th>T1 Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>S.D.</th>
<th>T2 Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>S.D.</th>
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<td>72.00</td>
<td>61.95</td>
<td>5.28</td>
<td>57.00</td>
<td>80.00</td>
<td>66.50</td>
<td>6.28</td>
<td>0.001 *</td>
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<td>70.00</td>
<td>57.50</td>
<td>5.08</td>
<td>42.00</td>
<td>75.00</td>
<td>54.50</td>
<td>4.66</td>
<td>0.001 **</td>
</tr>
<tr>
<td>ANB</td>
<td>20</td>
<td>35.50</td>
<td>60.00</td>
<td>48.50</td>
<td>6.06</td>
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<td>65.00</td>
<td>39.50</td>
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<td>31.00</td>
<td>5.52</td>
<td>17.00</td>
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<td>1.00</td>
<td>0.50</td>
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Table 7. Descriptive statistics of dental measurements of Miniscrew group and comparison within group

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Table 9. Descriptive statistics of soft tissue measurements of the CIA group and comparison within group

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Table 10. Descriptive statistics of soft tissue measurements of the Miniscrew group and comparison within group

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However, it is also seen in CI II division 2 anomalies (22). Dermaut and Vanden Bulcke (22) reported that deep bites resulted from excessive eruption of the upper incisors. Lewis (24) associated deep bites with excessive eruption of the upper and lower incisors. Schudy (25) indicated that the vertical development of the upper and lower molars may be a factor in deep bites.

There are three basic approaches to deep bite correction: posterior teeth extrusion, incisor intrusion, and a combination of these two methods. Attaining pure intrusion in incisors is difficult; however, miniscrews are often used to achieve true intrusion. Studies (26,27) have discussed the mechanics that provide pure intrusion. However, true intrusion in incisors can be achieved only by using implants or bone screws (28). Experimental and clinical studies have found that miniscrews provide effective and stable anchorage for orthodontic treatment (13-18,20).

Burstone (29) suggested that the vertical dimension should not be increased in most class II cases. The increase in the vertical facial dimensions has negative effects on the class II relationship. It results in a long face, with adverse effects on the aesthetics. Especially in individuals with long faces and severe skeletal class II relationships, Burstone also found that molar extrusion causes downward and backward rotation of the mandible. Therefore, he suggested that deep bites be corrected by incisor intrusion. Fayeda et al. (30) examined buccolingual bone thickness in cone beam computed tomography performed on 100 patients aged 13-18 and 19-27 years. They found that the most suitable anterior regions for miniscrew insertion were between the central and lateral incisors in the maxilla and between the canine and lateral incisors in the mandible.

In the present study, the decrease in the ANB angle (p < 0.01) was statistically significant in both the CIA and Miniscrew groups. In a similar study, the ANB angle decreased after incisor intrusion (31). As a result of the protrusion that occurs during incisor intrusion, the root tip moves backward, and the incisal edge moves forward. As the root tip moves backward, the vestibule bone follows the tooth root. Thus, point A moves backward as a result of remodeling after intrusion, and the SNA angle increases (32-34). In the present study, the SNA angle decreased in both groups; however, the decrease was not statistically significant. In the present study, there was a significant increase in the HRP-MnP angle in the CIA group as a result of molar extrusion. The significant increase in

### Table 11. Comparison of the soft tissue measurements between CIA and Miniscrew groups

<table>
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<tr>
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<th>CIA and Miniscrew</th>
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<tr>
<td>Labiomental angle</td>
<td>20</td>
<td>3.80</td>
<td>5.02</td>
<td>0.454 ns</td>
<td>-6.96</td>
</tr>
<tr>
<td>Sn-MnP</td>
<td>20</td>
<td>0.52</td>
<td>1.86</td>
<td>0.779 ns</td>
<td>-0.07</td>
</tr>
</tbody>
</table>
the HRP-B and Pog-HRP measurements also supports molar extrusion and posterior rotation of the mandible in the CIA group. In related studies (12,31), the mandible was rotated posteriorly because of molar extrusion in the CIA group. In the Miniscrew group, there was no extrusion, as no application was made to the molar teeth. A meta-analysis by Sosly et al. found that miniscrews were more effective for correcting deep bites and providing true intrusion. In addition, there was no occurrence of molar extrusion (20,35). Al-Nimri et al. (33) investigated the relationship between the protrusion of the upper incisors and the position of the A point in CI-II division 2 patients. They stated that point A moved downward and backward as a result of the protrusion of the incisors. In the present study, point A moved downward in both groups.

Using the utility and CIA arches to apply incisor intrusion, Amasyalı et al. (12) found a statistically significant increase in the ANS-Me, N-Me, and S-Go height. Otto et al. (36), Schudy (25), and Dake and Sinclair (37) also found an increase in front face height; however, Çakırer (38) found no increase in face height. In the present study, there was no statistically significant difference in the ANS-Me, N-Me, and S-Go measurements in either group. In the present study, a statistically significant difference in the lower anterior and posterior face height was not observed in the CIA group because the transpalatal arch was used to increase molar anchorage. The results in the Miniscrew group were similar to those of studies in which incisor intrusion was performed with bone anchoring (34,39).

In both groups, there was a significant difference in the reduction in the distance of the resistance center (U1-HRP [cr]) of the upper incisor to the horizontal reference plane. The U1-HRP (cr) decreased by 1.90 mm in the CIA group and an average of 3.70 mm in the Miniscrew group. These results, which were consistent with those of previous studies (12,34,38,40), were an indication of successful intrusion. However, in the present study, the resistance center of the upper incisor in the miniscrew group moved more. This indicates that more intrusion was achieved with miniscrew anchorage.

Bekler (39) performed upper incisor intrusion by placing miniscrews between the lateral and canine teeth in the upper jaw and applying 100 g of intrusion force. She reported the occurrence of protrusion and intrusion in the upper incisors. Amasyalı et al. (12) reported protrusion with intrusion in the upper incisors despite making the archwire cinch back in the posterior region in both groups in their study to correct deep bites with CIA and utility arches. In a comparison of the Ricketts and Burstone techniques for maxillary incisor intrusion, Çakırer (38) found a greater degree of labial tipping in the incisors in the Ricketts group. Parker et al. (41) reported a decrease in deep bites and the existence of protrusion in the incisors of individuals with deep bites treated with different mechanics. Similarly, McDowell and Baker (42) reported a high correlation between incisor protrusion and deep bite reduction.

In the present study, overjet significantly increased in both groups because of upper incisor protrusion and incisor inclination. Similar studies (31,37,38,43,44) on deep bite correction have reported a decrease in overbite and an increase in overjet. Jain et al. reported a decrease in overbite as a result of using the J-hook headgear, utility arch, and miniscrew techniques to perform maxillary incision intrusion (20). In the present study, there was a statistically significant decrease in the amount of overbite in both groups. The decrease was 2.55 mm in the CIA group and 3.67 mm in the Miniscrew group.

One of the treatment goals of deep bite treatment is to correct the interincisal angle. The reduction of this angle is necessary for treatment stability (24). Arvystas (45) suggested that the interincisal angle should be reduced for overbite correction and long-term stability. In the present study, the interincisal angle decreased by 16.61° in the CIA group and by 19.54° in the Miniscrew group.

In both groups, there was a significant decrease in upper lip thickness. Hor (31) reported a similar decrease. It was explained by the upward and backward movement of the area supporting the lip during the intrusion and protrusion of the upper incisors. In the present study, upper lip length decreased in both groups; however, this change was statistically significant in the CIA group. This decrease might be the result of intrusion-induced changes in the tooth and bone tissue, as well as the soft tissue. These findings are consistent with those of related studies (12,39).

The vertical distance from the upper and lower lip to the E plane (E-ULA and E-LLA) was significantly reduced in both groups. This shows that upper and lower incisor protrusion was followed by upper and lower lip protrusion (12,31). A statistically significant increase was detected in the LS-VRP and Li-VRP measurements in the CIA and Miniscrew groups. This indicates that the greater increase in lip support resulted from the protrusion accompanying the incisor intrusion in both groups. Hor (31) reported upper and lower lip protrusion in the utility arch group; the study found upper lip retraction and lower lip protrusion in the CIA group.

Posterior extrusion, a side effect of intrusion arches, was observed in the CIA group in the present study. The decrease in the Pog-VRP distance revealed downward and backward rotation

Conclusions

First, the CIA and miniscrew methods facilitated successful upper incisor intrusion and deep bite correction. In the treatment of deep bites with
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intrusion arches, anchorage-enhancing mechanics might be beneficial for preventing posterior extrusion.

Second, the miniscrew method is more clinically effective in deep bite treatment because it provides incisor intrusion without extrusion in the posterior region. In addition, it does not require patient compliance. Therefore, miniscrews are an ideal option as skeletal anchors in high-angle deep bite cases with an excessive incisor appearance.

Third, intrusion using CIA and miniscrews might lead to soft tissue changes because of incisor proclination. Both methods contribute positively to smiles and facial aesthetics in individuals with retrusive profiles.

Acknowledgments: This study was presented as a full-text oral presentation at the 1st International Dental Research and Health Sciences Congress held between 20-22 May 2021.

Ethical Approval: Ethics committee approval was received for this study from Dicle University Faculty of Dentistry in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2008/821

Peer-review: Externally peer-reviewed.


Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

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