ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

# Comparison of the Treatment Effects of Two Intrusive Mechanics: Connecticut Intrusion Arch and Mini-Implant

## İki İntruzyon Mekaniğinin Tedavi Etkilerinin Karşılaştırılması: Connecticut İntruzyon Arkı ve Mini-İmplant

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**ABSTRACT Objective:** The aim of this study was to compare the treatment efficiencies and root resorption amounts of two different incisor intrusion mechanics. **Material and Methods:** Thirty-two patients with deep bite and elongated maxillary incisors were randomly allocated two treatment groups: Connecticut intrusion arch group (CG) or Mini-implant group (MG). In both groups approximately 60 g of force applied between central and lateral incisors. Dentoalveolar effects were studied via cephalograms taken before and after 5 months of intrusion while root resorption was assessed using periapical roentgens. Paired t-test was used to evaluate differences within groups. The changes observed in both groups were compared by using independent t-test. **Results:** While the overbite reduced significantly in both groups ($p<0.001$), this amount was greater in MG ($p<0.01$). The center of resistance (CR) of incisors showed significant apical movement ($p<0.001$) in both groups with greater values observed in MG ($P<0.05$). The labial tipping and sagittal advancement of the incisor edge was significant in the treatment groups ($p<0.001$); these changes were greater in MG. Apex of the central incisor displayed significant backwards movement ($p<0.05$) with no intergroup difference ($p>0.05$). Incisors in both groups showed significant root resorption ($P<0.000$) which was significantly greater in MG compared to CG ($P<0.05$). **Conclusion:** Mini-implants were more efficient in bite-opening. However they also led to more root resorption and labial tipping compared with the Connecticut intrusion arch.

**Key Words:** Tooth movement; Connecticut; orthodontic anchorage procedures

**ÖZET Amaç:** Bu çalışmanın amacı farklı iki keser intruzyon mekaniğinin tedavi etkinliği ve kök rezorpsiyonu miktarı yönünden karşılaştırılmasıdır. **Gereç ve Yöntemler:** Derin kapanış ve uzamış maksiller kesicilere sahip 32 hasta rastgele iki tedavi grubuna ayrıldı: Connecticut intrüzyon arkı grubu (CG) veya mini-implant grubu (MG). Her iki grupta santral ve lateral kesiciler arasından yaklaşık 60 g kuvvet uygulandı. Dentoalveolar etkiler keser intruzyonundan önce ve 5 ay sonra alınan sefalometriler ile değerlendirilirken kök rezorpsiyonu periapikal filmlerle değerlendirildi. Eşleştirilmiş t-testi ile grup içindeki farklar analiz edildi. Her iki gruptaki değişimler bağımsız t-testi ile karşılaştırıldı. **Bulgular:** Her iki grupta overbite anlamlı miktarda düşerken ($p<0.001$), bu miktar mini-implant grubunda daha fazla idi ($p<0.01$). Keserlerin direnç merkezi (CR) miniimplant grubunda daha fazla değerde olmakla birlikte her iki grupta da önemli düzeyde apikale yer değiştirdi ($p<0.001$). Labial devrilme ve kesici kenarının sagittal ilerlemesi tedavi gruplarında önemli bulunurken ($p<0.001$), bu değişiklikler miniimplant grubunda daha fazla idi. Santral kesicilerin apeksleri gruplar arası fark olmaksızın ($p>0.05$) her iki grupta geri yönde hareket etti ($p<0.05$). Her iki grupta da kesicilerde önemli kök rezorpsiyonu görülürken ($p<0.000$), miniimplant grubunda Connecticut grubuna göre daha fazla bulundu. **Sonuç:** Kapanışı açmada miniimplantlar daha etkilidir. Ancak Connecticut intruzyon arka göre daha fazla kök rezorpsiyonuna ve labial devrilmeye sebep olmaktadırlar.

**Anahtar Kelimeler:** Diş hareketi; Connecticut; ortodontik ankoraj işlemleri

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Deep overbite can be part of various skeletal and dental malocclusions. Therefore several treatment alternatives are present depending on the patients remaining growth potential, vertical growth pattern and esthetical concerns such as the smile line and incisor display.[1,2]

The most invasive solution, namely orthognathic surgery, is the choice of treatment in adult patients who present with maxillary vertical alveolar excess that cannot be compensated with conservative options.[3,4] Molar extrusion can be a solution for deep overbite cases, if the patient has a hypodivergent growth pattern with plenty of growth remaining, and is presenting an acceptable gingival and incisal display.[5] On the contrary, if the patient has a normal or hyperdivergent growth pattern, excessive gingival display upon smiling, and elongated incisors beyond the occlusal line, incisor intrusion is indicated for the optimal esthetical and functional outcomes.[5,6]

Various methods of intruding incisors have been reported: Base arch, utility arch, reverse curve arches, J-hook headgear and recently mini-implant anchorage. However efficiency of the intrusion, duration of the intrusion process and magnitude of the possible side effects such as extrusion of the posterior teeth and root resorption of the intruded teeth may vary according to the utilized method. Recently mini-implant assisted orthodontics is the treatment of choice due to the elimination of the possible side effects together with providing the advantages of skeletal anchorage systems.

Polat Ozsoy et al. compared the effects of utility arches and mini-implants, Senisik and Turkkahraman weighed the effects of Connecticut intrusion arch and the mini-implant intrusion while Deguchi et al. studied the intrusive effects of J-hook headgear and mini-implants.[7-9] However in those studies either the root resorption was not evaluated, or the intrusion was not assessed from center of resistance or the observation time was not standardized in groups with the final records taken when the overbite is eliminated.[7-9] Thus this study was undertaken to evaluate the intrusion achieved via mini-implants and Connecticut intrusion arches in predesignated time duration with a standardized method of evaluating resorption using paralleling extension cone method.

The objective of this parallel-arm, randomized study was to compare the outcomes of maxillary incisor intrusion obtained with Connecticut intrusion arch (CIA), and mini-implant (MI) orthodontics regarding positional changes in maxillary dentition and amount of root resorption of maxillary incisors.

## MATERIAL AND METHODS

The study protocol was approved by the Ethics Committee of the School of Medicine, Ege University, and written consent was obtained from the patients.

Thirty patients (16 female, 16 male) fulfilling the following requirements were included in this study: (1) Normal or increased vertical dimensions, represented by a SNGoGn angle raging between 30°-36° (2) A deep bite of at least 5 mm (3) Increased display of incisors without flaring (4) mild or no crowding. Stratified randomization (based on sex) with blocking (block sizes of 4) were used.[10] A web-based randomization method was used (www.sealedenvelope.com). Treatment of the patients was provided by 1 experienced clinician (I.A.) working in orthodontic clinic of the same university, with a standardized protocol. An 0.018-inch Roth straight-wire appliance was bonded to the maxillary incisors. After leveling of the maxillary central and lateral incisors with a segmental arch, they were consolidated by figure-eight ligature ties and 0.017x0.025-inch of stainless (SS) steel wires were inserted to incisor brackets. In the mini-implant group (MG), 1.4 mm-diameter, 7 mm-length ORLUS MIs (Ortholution, Seoul, South Korea) were inserted between the central and lateral incisors at the mucogingival border. 30 g of force was exerted from each MI to the 0.017x0.025-in SS wire via elastic power chain (3M Unitek/ESPE, St Paul, Minn) (Figure 1). In the CIA group (CG), a 0.017x0.025-inch prefabricated nickel titanium alloy intrusion arch (Ortho Organizers, Carlsbad, Calif) was used to obtain the advantages of shape memory, light and con-

**FIGURE 1:** Application of the mini-implant supported intrusive mechanics.

**FIGURE 2:** Application of the Connecticut Intrusion arch.

tinuous force distribution. The CIA was ligated distal to the central incisors and was calibrated to deliver approximately a total of 60 g (Figure 2). Force was re-checked and re-adjusted every visit until the end of the designated intrusion period which was 5 months. The intrusion phase was followed by comprehensive fixed appliance therapy.

The study was conducted using periapical roentgens and lateral cephalometric radiographs that were acquired before (T1) and 4 months following the initiation of the intrusion (T2). Pre- and post-intrusion periapical images were obtained in a standardized paralleling extension cone method as described by Costopoulus and Nanda.[11] All cephalometric radiographs were taken on the same cephalostat. An individual center of resistance ($C_R$) of the maxillary central incisor was determined for each patient as the point one-third of the root length measured apically to the alveolar crest rather than the $C_R$ of the anterior segment because of its ease of location and high reproducibility and the point determined on the pre-intrusion images was replicated onto the post-intrusion images along the long axis of the tooth as the same distance from the incisor edge.[12,13] Blinding was done for cephalometric measurements: when measuring the cephalograms and periapical roentgens, the examiner (S.Ö.) was unaware of the group to which the patient had been allocated. Five angular and 9 linear measurements were made using Dolphin Imagining 11.0 Software (Dolphin Imaging and Management Solutions, Chatsworth, Calif) and ImageJ open-source image-analysis software (Version 1.46r, National Institutes of Health, Bethesda, Md) (Figures 3 and 4). According to the power analysis at the 0.05 level and 80% power (based on a 0.56-mm standard deviation and a 0.6-mm detectable group difference regarding intrusion rates[9]), the minimum sample size needed for each group was 14. Sixteen subjects were recruited for each group accounting for the possible dropouts.

## STATISTICAL ANALYSIS

For the assessment of method error, 20 randomly selected cephalograms were retraced and remeasured in 2-weeks interval. Dahlberg formula was used to assess measurement repeatability: √ Σ:

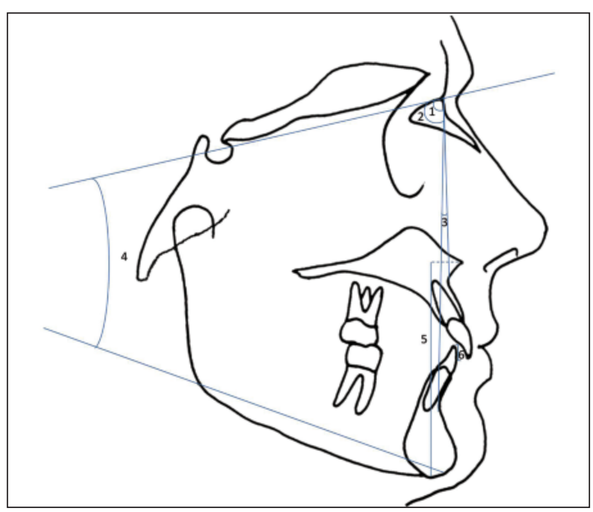


**FIGURE 3:** Skeletal and dentoalveolar cephalometric measurements: 1, SNA; 2, SNB; 3, ANB; 4, SN-GoGn; 5, ANS-Me; 6, Overbite.

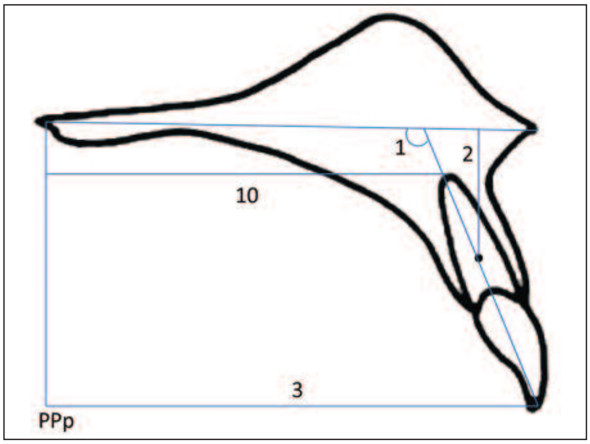


**FIGURE 4:** Maxillary cephalometric measurements: 1, U1- PP; 2, CR- PP; 3, 1i-PPp (mm); 4, 1a-PPp (mm); PPp, a line drawn at PNS and is perpendicular to the palatal plane (PP).

**TABLE 1:** Demographic variables of the groups.

| Groups | Female | Male | Mean Age | Min. Age | Max. Age |
|---|---|---|---|---|---|
| CG | 8 | 8 | 14 y 6 m | 12 y 5 m | 16 y |
| MG | 8 | 8 | 14 y 10 m | 12 y 6 m | 16 y 5 m |

Where d is the difference between 2 measurements of a pair, and n is the number of double measurements.

Normal distribution of pre- and post-intrusion differences was observed by means of the Shapiro-Wilks test. Thus, paired t-test was used for significance of mean changes in both groups, and comparisons of mean changes between in both groups were performed using independent t-test. The data were analyzed using SPSS software (version 16.0, SPSS Inc, Chicago, Ill). Statistical significance was set at $p<0.05$.

## RESULTS

8 female and 8 male patients were included in both groups with mean ages of 14 years, 6 months and 14 years 10 months, in CG and MG, respectively (Table 1). Thirty-two implants that were inserted in the mini-implant group between lateral and central incisors were successfully used until the end of the intrusion process. The overall success rate was 100% showing sufficient anchorage for the maxillary incisor intrusion. The method error for cephalometric landmark identification and digitizing did not exceed 0.46 mm and 0.78° for any cephalometric variables investigated.

Pre-intrusion and post-intrusion cephalometric and periapical measurements are presented in Table 2. Intragroup changes and intergroup differences are presented in Table 3. Overbite decreased significantly in both groups ($P<0.001$) with greater bite opening in MG ($P<0.01$). The $C_R$ of incisors showed significant apical movement in both groups ($P<0.001$) with greater values observed in MG

**TABLE 2:** Preintrusion (T1) and postintrusion (T2) cephalometric and periapical measurements of the groups.

| | Mini-Implant Group | | Connecticut Intrusion Arch Group | |
|---|---|---|---|---|
| | T1 (mean±SD) | T2 (mean±SD) | T1 (mean±SD) | T2 (mean±SD) |
| SNA (o) | 82.38±2.66 | 82.14±2.52 | 82.69±3.02 | 82.58±3.00 |
| SNB (o) | 78.65±1.92 | 78.75±1.68 | 78.75±1.84 | 78.55±1.76 |
| ANB (o) | 3.73±2.02 | 3.39±1.94 | 4.11±1.91 | 4.03±2.02 |
| SNGoGn (o) | 35.52±3.87 | 35.86±3.33 | 35.41±3.45 | 36.21±3.98 |
| ANS-Me (mm) | 65.28±5.65 | 65.54±5.70 | 66.07±6.02 | 66.89±6.39 |
| Overbite (mm) | 5.82±1.12 | 2.55±1.00 | 5.70±1.30 | 3.65±1.18 |
| Cr-PP (mm) | 16.07±2.93 | 13.62±2.68 | 15.84±2.85 | 14.35±2.31 |
| U1-PP (o) | 96.58±3.08 | 106.23±4.22 | 98.13±4.02 | 104.75±3.51 |
| 1i-PPp (mm) | 46.23±2.80 | 50.26±3.69 | 47.04±3.36 | 49.99±3.01 |
| 1a-PPp (mm) | 44.58±2.03 | 43.46±2.17 | 45.26±2.47 | 44.25±2.06 |
| LC-TL (mm) | 24.36±2.31 | 23.38±2.09 | 24.17±2.64 | 23.58±2.60 |
| LL-TL (mm) | 22.61±2.13 | 21.80±1.92 | 22.28±1.96 | 21.73±2.23 |
| RC-TL (mm) | 24.09±2.01 | 22.96±2.2.08 | 24.39±2.27 | 23.68±2.02 |
| RL-TL (mm) | 22.46±1.80 | 21.81±1.62 | 23.00±2.01 | 22.6±1.88 |

LC: Indicates left central incisor; LL: Left lateral incisor; RC: Right central incisor; RL: Right lateral incisor; TL: Tooth length.

**TABLE 3:** Preintrusion (T1) and postintrusion (T2) cephalometric and periapical measurement changes and intergroup comparisons

| | Mini-implant Group | | | Connecticut Intrusion Arch Group | | | Intergroup Difference |
|---|---|---|---|---|---|---|---|
| | X | SD | P | X | SD | P | P |
| SNA (o) | -0.24 | 0.66 | 0.181 | -0.11 | 0.57 | 0.467 | 0.556 |
| SNB (o) | 0.10 | 0.30 | 0.115 | -0.20 | 0.53 | 0.056 | 0.061 |
| ANB (o) | -0.34 | 0.74 | 0.073 | 0.09 | 0.66 | 0.066 | 0.093 |
| SNGoGn (o) | 0.31 | 0.98 | 0.241 | 0.80 | 1.46 | 0.052 | 0.275 |
| ANS-Me (mm) | 0.26 | 0.94 | 0.302 | 0.82 | 1.51 | 0.054 | 0.220 |
| Overbite (mm) | -3.27 | 0.86 | 0.000*** | -2.05 | 1.09 | 0.000*** | 0.002** |
| CR-PP (mm) | -2.45 | 0.59 | 0.000*** | -1.49 | 0.98 | 0.000*** | 0.003** |
| U1-PP (o) | 9.38 | 3.51 | 0.000*** | 6.62 | 3.36 | 0.000*** | 0.031* |
| 1i-PPp (mm) | 4.03 | 1.51 | 0.000*** | 2.95 | 1.12 | 0.000*** | 0.035* |
| 1a-PPp (mm) | -1.12 | 1.69 | 0.022* | -1.01 | 1.34 | 0.011* | 0.840 |
| LC-TL (mm) | -0.98 | 0.57 | 0.000*** | -0.59 | 0.45 | 0.000*** | 0.041* |
| LL-TL (mm) | -0.81 | 0.42 | 0.000*** | -0.55 | 0.30 | 0.000*** | 0.054 |
| RC-TL (mm) | -1.13 | 0.62 | 0.000*** | -0.71 | 0.42 | 0.000*** | 0.034* |
| RL-TL (mm) | -0.65 | 0.39 | 0.000*** | -0.40 | 0.32 | 0.002** | 0.057 |

LC: Indicates left central incisor; LL: Left lateral incisor; RC: Right central incisor; RL: Right lateral incisor; TL: Tooth length.
*,p<0.05; **, p<0.01; ***, p<0.001.

(P<0.01). The labial tipping of the incisors were significant in both groups (P<0.001) with more flaring detected in MG (P<0.05). Similarly, while the incisal edge of the incisors showed significant forward movement in both groups (P<0.001), this amount was greater in MG (p<0.05). Apex of the incisors moved towards palatal plane perpendicular significantly (P<0.05) with no intergroup difference.

Central and lateral incisor in both groups showed significant root resorptions (P<0.001) and reductions in central incisor lengths were significantly greater in MG compared to CG (P<0.05) with no intergroup difference among lateral incisors (P>0.05).

## DISCUSSION

While deep bite causes functional, psychological and esthetic consequences the treatment of deep bite itself has drawbacks on dentition such as root resorption, tipping and extrusion of the anchor teeth.[14-17] Therefore its treatment is constantly facing modifications. Thus the aim of this study was to compare the long-established mechanics of bite opening using last generation wires with recently developed skeletal-anchorage mechanics.

In the present study, rigid rectangular SS arch wires were inserted in incisor brackets before initiation of the intrusion to eliminate the side effects such as undesired further protrusion and uncontrolled tipping of the incisors as suggested by Burstone.[6] The $C_R$ of the incisors was reported lie between lateral incisors and canines, which is the choice of force application point if minimum flaring is aimed.[18,19] However, our study groups had upright incisors and the labial movements of the incisal edges were needed. Thus the force was applied more anteriorly and no cinch back was incorporated to the CIA, distal to the molar tubes. Coherently, in the study of Şenışık and Türkkahraman where force was applied between lateral incisor and canine teeth, the flaring amounts were approximately 5° and 8° in CG and MG groups even though round wires were used during intrusion which permitted greater degrees of labial tipping whereas our corresponding values were 6.6° and 9.4° in rigid rectangular wires.[8] Similarly, while the incisor edges of the centrals moved 0.90 and 1.83 mm forward in the fore mentioned study, in the current research these values were 2.95 mm in the CG and 4.03 mm in the MG. The authors of the current article believe that the lesser flaring amounts observed in the CG group was due to the anchorage of the posterior segment that prevented excess flaring, when compared to the MG group which no posterior tooth were incorporated. The restrictive effect of posterior teeth on flaring of the anterior segment is also seen in Senisik and Turkkahraman study.[8] When the sagittal apical movement of the incisors was studied, both groups showed approximately 1 mm of lingual root torque motion with no intergroup difference. Thus it can be deduced that sagittal positional changes of the incisor positions were largely due to the movement of the incisal edge rather than torqueing of the apex into the spongiosa.

While the overbite was significantly reduced in both groups, this reduction was greater in the MG. Similarly, the apical movements of $C_R$ in both groups were significant, while there was significantly more intrusion in the MG. The intrusion rates in the present study were 0.49 mm/month and 0.29 mm/month in MG and CG, respectively. These findings are in accordance with Polat-Ozsoy et al.'s study reporting intrusion rates of 0.27 mm/month and 0.44 mm/month with utility arches and mini-implants, respectively, and also with Deguchi et al. who investigated the differential intrusion effects of J-hook headgear (0.15 mm/month) and mini-implants (0.55 mm/month) with reference to the incisal edge.[7,9] Deguchi et al. reasoned out that the lack of patient cooperation resulting in headgear removal that led to significant difference between groups.[9] Conversely, Senisik and Turkkahraman did not find any intergroup difference at the end of the 7-month period with intrusion rates of 0.31 and 0.34 mm/month in their Connecticut arch and mini-implant groups, respectively.[8] It has long been pointed out in the literature that increased forces lead to hyalinization which in turn arrests tooth movement in initial phases of orthodontic treatment. Recently, it has been shown that even at the later stages of tooth movement small hyalinized patches were present.[20] Concerning the force levels in intrusion, the consensus of applying a total of 40-60 g is present in the literature, whereas Senısık and Turkkahraman used 70-90 g in their MG while they applied a 60 g in their CG.[8,10,21,22] Thus according to the dose-response relationship, forces resulting in pressures beyond the advocated levels would result in slower tooth movement because of extensive hyalinization of the PDL, which could have bias the attainable rate of intrusion in MG.[23,24]

Even though the mandibular plane angle did not show any significant intragroup changes and intergroup differences, the *P* value in CG was on the verge of reaching the significance level. This is probably due to the tip-back moment exerted on the molars by the intrusion arch, thus emphasizes the efficiency of palatal arch in reinforcing the anchorage of the 1st molars. The non-significant differences found in and among groups were in accordance with the previous studies.[7-9]

The incisors showed significant root resorptions in both groups. Though there was no difference among groups concerning the resorption amounts of lateral incisors, an inclination was present towards more shortening in MG whereas central incisors actually did show significantly greater reduction values in length. This outcome was probably due to greater apical movement of the $C_R$ in the MG, which is a known risk factor for resorption. This finding is supported by the significant correlation between the amount of root resorption and achieved intrusion in previous studies.[25,26]

**Limitations:** The exact amount of resorption can only be assessed by scanning electron microscope and micro-computed tomography which cannot be utilized in clinical conditions.[27-29] The best alternative to the forementioned methods is cone-beam computed tomography which predisposes the patient to greater amounts of radiation compared to conventional periapical roentgens. Hence, within the limitations of this study, a relative comparison of two methods was carried out regarding root resorption rather than the exact loss of root material.

## CONCLUSION

Though both methods were efficient in opening the bite, the rate of intrusion and amount of overbite reduction were higher with mini-implant mechanics. On the other hand, intrusion via Connecticut intrusion arches led to less root resorption and smaller degrees of flaring.

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