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Miniscrews for upper incisor intrusion

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SUMMARY The aim of this study was to investigate if true incisor intrusion can be achieved using miniscrews. Eleven patients (three males and eight females; mean age: 19.8 ± 4.8 years) with normal vertical dimension showing a pre-treatment deep bite of 5.9 ± 0.9 mm and a 'gummy' smile were enrolled in the study. After levelling of the maxillary central and lateral incisors with a segmental arch, an intrusive force of 80 g using closed coil springs was applied from two miniscrews placed between the roots of the lateral and canine teeth. The amount of incisor intrusion was evaluated on lateral cephalometric headfilms taken at the end of levelling (T1) and at the end of intrusion (T2). Statistical analysis of the data was performed using a paired *t* and Wilcoxon signed rank tests. A significance level of $P < 0.05$ was predetermined.

The mean upper incisor intrusion was 1.92 mm and the mean overbite decrease 2.25 ± 1.73 mm in 4.55 months. Upper incisor angulation resulted in a 1.81 ± 3.84 degree change in U1-PP angle and a 1.22 ± 3.64 degree change in U1-NA angle. However, these were not statistically significant ($P > 0.05$).

True intrusion can be achieved by application of intrusive forces close to the centre of resistance using miniscrews. However, studies with a larger number of subjects and long-term follow-up are necessary.

Introduction

A deep bite is a complex orthodontic problem that is a common feature of many malocclusions (Al-Buraiki *et al.*, 2005). A decrease in vertical skeletal growth, axial inclinations of the upper and lower anterior teeth, vertical positions of the anterior (Wolfson, 1938; Dermaut and Vanden Buckle, 1976; Karlsen, 1994) and posterior (Schudy, 1968; Karlsen, 1994) teeth, and loss of periodontal support (Melsen *et al.*, 1989) are among the factors that contribute to the development of deepening of the bite. Correction of a deep bite is an important part of orthodontic treatment due to the potential deleterious effects on the temporomandibular joint (Alexander *et al.*, 1984) and periodontal health and facial aesthetics (Janzen, 1989; Lindauer *et al.*, 2005).

Non-surgical correction of a deep bite involves extrusion of posterior teeth, intrusion of the incisors, or both (Burstone, 1977; Otto *et al.*, 1980; Hans *et al.*, 1994; Davidovitch and Rebellato, 1995; Weiland *et al.*, 1996; Nanda, 1997). The treatment of choice depends on a variety of factors such as smile line, upper lip length, incisor display, and vertical dimension (Lindauer *et al.*, 2005). For instance, in subjects with a normal vertical dimension, intrusion of the anterior teeth is recommended. Conventional methods for incisor intrusion usually involve 2 × 4 appliances or reverse curved arches. Labial tipping of anterior teeth is commonly the outcome of these arches that gives the impression of deep bite correction due to the change in vertical incisal edge position (Barton, 1972; Engel *et al.*, 1980; Otto *et al.*, 1980; Hans *et al.*, 1994; Davidovitch and Rebellato, 1995; Weiland *et al.*, 1996). Only a few studies that show true incisor intrusion can be found in the orthodontic literature (Hans *et al.*, 1994; Weiland *et al.*, 1996; Kinzel *et al.*, 2002).

Miniscrews are used in orthodontics as a stable anchorage unit. Due to their small dimensions, they can be placed in interdental areas where traditional implants cannot be inserted (Carillo *et al.*, 2007). The orthodontic literature is lacking controlled studies on the effects of miniscrew-supported incisor intrusion. This study aimed to investigate the effects of incisor intrusion obtained with the aid of miniscrews. The null hypothesis investigated is that true incisor intrusion can be achieved using miniscrews.

Subjects and methods

This study was approved by the Medical Scientific Ethics Committee of Baskent University. Informed consent was obtained from the patients and/or parents. The patients were selected according to the following criteria:

1. A deep bite of at least 4 mm.
2. Excessive gingival display on smiling.
3. Normal vertical dimensions, represented by a GoGnSN angle of 32 ± 6 degrees.

Eleven patients (three males and eight females; mean age: 19.79 ± 4.79 years; mean overbite: 5.9 ± 0.9 mm) who met the selection criteria and agreed to the placement of miniscrews participated in the study. Prior to insertion of the miniscrews, brackets were bonded to the four maxillary incisor teeth only and the teeth were levelled with 0.016 and 0.016 × 0.016 nickel titanium (NiTi) segmental wires. After completion of levelling, a 0.016 × 0.022 stainless steel wire was bent to the maxillary anterior segment with small hooks at the distal ends of the wire for intrusion.

Two miniscrews (Absoanchor; Dentos, Taegu, Korea), 1.2 mm in diameter and 6 mm in length, were placed distal to the maxillary lateral incisors under local anaesthesia. The implants were inserted at the mucogingival junction into the bone without drilling. Placement of the implants was carried out by an oral surgeon.

One week after insertion, the screws were loaded with medium superelastic NiTi closed coil springs and an intrusion force of 80 g was applied. The patients were recalled every 4 weeks and the screws were checked for signs of mobility or infection.

In five patients, brackets (Victory series; 3M Unitek, Monrovia, California, USA) were bonded to teeth in the lower arch.

Records and measurements

Two lateral cephalometric headfilms of the patients, one at the end of levelling (T1) and the other at the end of intrusion (T2), were obtained. All cephalograms were traced by the same investigator (OPO) over a negatoscope in a dark room using a 0.3 mm lead pencil. Fifteen landmarks were located and 16 measurements (seven angular and nine linear) were made on the cephalometric tracings (Figure 1). The centre of resistance (CR) of the maxillary central incisor was determined for each patient rather than the CR of the anterior segment due to its ease of location and high reproducibility (Van Steenbergen *et al.*, 2005). The CR of the maxillary central incisor was taken as a point located at one-third of the distance of the root length apical to the alveolar crest (Burstone, 1962). A horizontal reference plane (palatal plane) and a vertical reference plane (a line perpendicular to palatal plane from point A) were used.

Periapical radiographs were obtained for each patient at T2 to determine any signs of root resorption.

Statistical analysis

One week after the initial evaluation, six radiographs were retraced by the same investigator to determine the method error. Spearman rho correlation coefficients were calculated for repeatability, and the coefficients were found to be close to 1.00.

Descriptive statistics for age, duration of treatment, mean differences, standard deviations, and minimum and maximum values were calculated between T2 and T1. After checking for normal distribution of the data, a paired *t* or a Wilcoxon signed rank test was performed for the assessment of treatment changes. A significance value of 0.05 was predetermined.

Results

A total of 22 screws were inserted. One screw was replaced due to close proximity to one of the lateral roots, and two due to post-operative infection and mobility.

Upper intrusion was achieved in 4.55 ± 2.64 months. The mean rate of intrusion was 0.42 mm/month.

The mean overbite at T1 was 5.54 ± 1.38 mm. The mean intrusion of the upper anterior segment was 1.92 ± 1.19 mm (CR-PP distance) and the mean change in overbite 2.25 ± 1.73 mm (Table 1). Vertical movement and overbite change were statistically significant ($P < 0.05$).

The sagittal position of the upper incisors showed minimal changes (U1-NA angle 1.22 ± 3.64 degrees; U1-NA

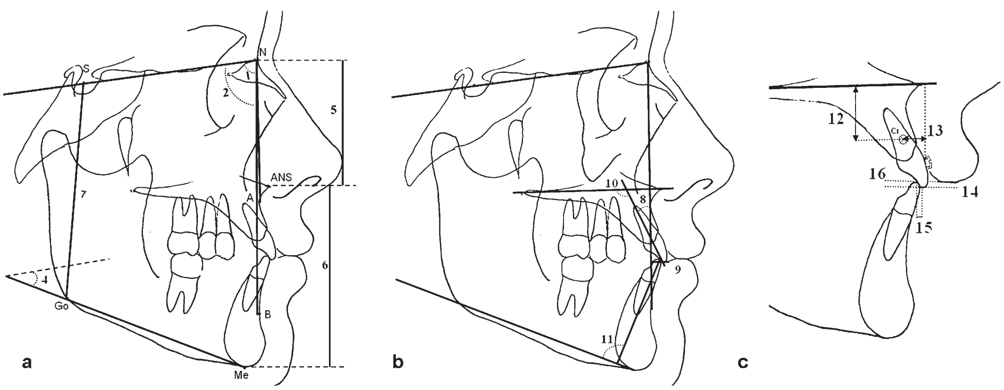

Figure 1 (a–c) Skeletal and dental measurements used in the study. (1) SNA (degree), angle formed between sella nasion and nasion point A planes; (2) SNB (degree), angle formed between sella nasion and nasion point B planes; (3) ANB (degree), angle formed between nasion point A and nasion point B planes; (4) GoMe-SN (degree), angle between the mandibular and sella nasion planes; (5) N-ANS (mm), distance between nasion and anterior nasal spine; (6) ANS-Me (mm), distance between anterior nasal spine and menton points; (7) S-Go (mm), distance between sella and gonion points; (8) 1-NA (degree), angle formed between the upper incisor axis and nasion point A plane; (9) 1-NA (mm), distance between the labial point of the upper incisor and nasion point A plane; (10) 1-PP (degree), angle formed between the upper incisor axis and the palatal plane; (11) IMPA (degree), angle formed between the lower incisor axis and the mandibular plane; (12) Cr-PP (mm), vertical distance between the centre of resistance (CR) of the upper incisor and the palatal plane; (13) Cr-PFA (mm), horizontal distance between the CR of the upper incisor and the point of force application on the upper incisor where the bracket is bonded; (14) 1-Ls (mm), vertical distance between the upper incisor tip and upper lip stomion; (15) overjet (mm), horizontal distance between the tips of the upper and lower central incisors; and (16) overbite (mm), vertical distance between the tips of the upper and lower central incisors.

Table 1 Pre-treatment (T1) and post-treatment (T2) cephalometric values and results of the statistical evaluation.

	T1	T2	T2 − T1	*P* value
	82.81 ± 3.51	81.63 ± 3.09	−3.00 ± −1.18	0.029
SNB (°)	75.68 ± 1.40	76.40 ± 1.95	−0.72 ± 1.00	0.039
ANB (°)	6.31 ± 1.90	5.95 ± 1.63	−0.36 ± 0.97	NS
GoGnSN (°)	32.80 ± 4.20	33.00 ± 4.56	0.20 ± 1.15	NS
N-ANS (mm)	55.77 ± 3.93	55.93 ± 3.37	0.16 ± 1.01	NS
ANS-Me (mm)	67.13 ± 5.44	67.48 ± 6.20	0.34 ± 1.88	NS
S-Go (mm)	84.63 ± 5.12	85.00 ± 5.31	0.36 ± 1.34	NS
1-NA (°)	11.31 ± 8.71	12.54 ± 9.42	1.22 ± 3.64	NS
1-NA (mm)	0.50 ± 3.79	1.36 ± 3.82	0.86 ± 1.28	NS
1-PP (°)	101.50 ± 9.19	103.31 ± 8.95	1.81 ± 3.84	NS
Cr-PP (mm)	15.42 ± 2.85	13.51 ± 2.73	−1.92 ± 1.19	0.007
Cr-PFA (mm)	5.13 ± 1.50	5.27 ± 1.61	0.13 ± 1.05	NS
1-Ls (mm)	4.54 ± 1.98	3.38 ± 2.28	−1.16 ± 1.01	NS
Overjet (mm)	4.54 ± 1.98	3.38 ± 2.28	−0.27 ± 1.21	0.004
Overbite (mm)	5.54 ± 1.38	3.29 ± 1.44	−2.25 ± 1.73	0.002
IMPA (°)	96.95 ± 5.85	95.54 ± 4.86	1.40 ± 3.61	NS

NS, not significant.

distance 0.86 ± 1.28 degrees; and U1-PP angle 1.81 ± 3.84 degrees); however, these changes were not significant ($P > 0.05$). A change in the distance between the point of intrusive force application and the CR of the maxillary central incisor was also found not to be statistically significant (0.13 ± 1.05 mm, $P > 0.05$).

The lower incisors were slightly protruded but the extent of the protrusion was not significant (1.40 ± 3.61 degrees, $P > 0.05$). A significant decrease in overjet was observed (0.27 ± 1.21 mm, $P < 0.05$).

Skeletal measurements showed significant changes in SNA and SNB ($P < 0.05$); however, all vertical measurements remained unchanged ($P > 0.05$).

When periapical radiographs were examined for signs of resorption, slight blunting of only one central incisor root was seen. Figure 2a,b shows the intraoral records of a patient with incisor intrusion.

Discussion

Correction of a deep overbite is one of the primary goals of orthodontic treatment. In patients with an excessive gingival display and a normal vertical dimension, maxillary incisor intrusion is the treatment of choice. Conventional intrusion mechanics frequently cause labial tipping of incisors, a situation which does not always give favourable treatment outcomes (Barton, 1972; Engel *et al.*, 1980; Otto *et al.*, 1980). Melsen *et al.* (1989) indicated that the segmented arch technique is the treatment of choice for patients with elongated incisors or periodontal bone loss. However, since conventional arches are connected to the posterior teeth during intrusion, the presence of counteracting moments is frequently inevitable (Burstone, 2001). Direct application of intrusive forces from miniscrews offers an efficient alternative to 2 × 4 arches and true intrusion can be achieved. However, to date, no clinical studies have evaluated the effects of miniscrews used for incisor intrusion. The aim of this study was to investigate whether true incisor intrusion can be achieved with the use of miniscrews.

Recently, the focus of the orthodontic literature has been on the evaluation of the smile and the effect of incisor display during smiling (Janzen, 1989; Lindauer *et al.*, 2005; Sarver and Ackerman, 2005). It has been speculated that overbite correction with maxillary incisor intrusion will lead to a flattening of the smile arc and a reduction in smile attractiveness (Lindauer *et al.*, 2005). The patients selected for this study

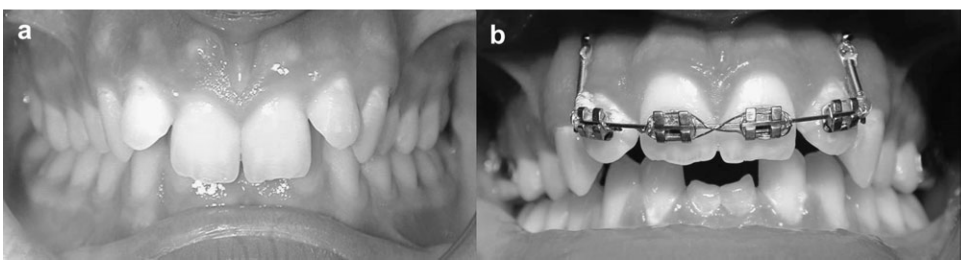

Figure 2 Frontal intraoral views of a patient treated with miniscrews: (a) pre-intrusion and (b) post-intrusion.

showed a gummy smile and incisor intrusion was the preferred choice of treatment. However, no overcorrection was carried out and bite opening was to be achieved by intrusion not only of the maxillary but also of the mandibular incisors.

In vitro studies using different methods such as the laser reflection technique and holographic interferometry (Dermaut and Vanden Buckle, 1976), photoelastic stress analysis (Matsui *et al.*, 2000), and the finite element method (Reimann *et al.*, 2007) as well as *in vivo* studies have been performed to determine the CR of the incisors (Sia *et al.*, 2007). The results show that the CR of the four incisor teeth lies 8–10 mm apical and 5–7 mm distal to the lateral incisors (Dermaut and Vanden Buckle, 1976; Matsui *et al.*, 2000; Turk *et al.*, 2005; Reimann *et al.*, 2007; Sia *et al.*, 2007). Thus, application of intrusive forces mesial to the lateral incisors would result in their proclination. The miniscrews used in the present sample were placed between the incisor and canine roots in order to minimize forward movement of the incisors. The records were taken at the end of levelling and intrusion; therefore, any protrusion occurring during levelling was omitted from the measurements.

The use of the incisal edge or root apex for the evaluation of intrusion is not recommended because these points do not depend on any change in inclination (Ng *et al.*, 2005). Burstone (1962) reported that the CR of an upper incisor was located at one-third of the distance of the root length, apical to the alveolar crest. The CR of the central incisor was the reference point of choice in the present study due to the fact that it is easily identified and its reproducibility is high. Thus, it is unaffected by the change in tooth inclination.

The mean upper incisor intrusion in the present study was 1.92 mm. The amount of intrusion was determined not only by the extent of the overbite but also by the amount of the upper incisors displayed during smiling and the smile line. The amount of intrusion found was slightly higher than that reported by Weiland *et al.* (1996) and Kinzel *et al.* (2002) who evaluated the amount of true intrusion, using the CR or incisor centroid. However, those studies evaluated the effects of conventional segmented arches. There exists only one case report on the use of miniscrews for upper incisor intrusion. Kim *et al.* (2006) used one screw placed at anterior nasal spine in a Class II division 2 subject and although protrusion was favourable in that case, measurements for determining the amount of intrusion were not carried out.

The axial inclination of incisors in the present investigation showed a minimal increase during intrusion that was not significant. As stated above, the CR of the upper four incisors lies 8–10 mm apical and 5–7 mm distal to the lateral incisors (Dermaut and Vanden Buckle, 1976; Matsui *et al.*, 2000; Turk *et al.*, 2005; Reimann *et al.*, 2007; Sia *et al.*, 2007). The point of force application in this study was close to the CR and the amount of force applied was within recommended limits. The moments that would normally be produced with conventional intrusion arches did not occur since the segmented arch used did not extend to the posterior teeth.

In some of the patients, the lower arch was bonded for levelling during upper incisor intrusion. As a result, the lower incisors showed minimal, non-significant protrusion. The minimal increases in axial inclination of the upper and lower incisors resulted in a significant decrease in overjet.

Root resorption is one of the most serious consequences of orthodontic treatment and intrusion is one type of tooth movement that has been suggested as a possible cause of root resorption. DeShields (1969) and Kaley and Phillips (1991) found no correlation with upper incisor intrusion and root resorption. Conversely, McFadden *et al.* (1989) found 1.8 mm root shortening in patients treated with utility arches. Costipoulos and Nanda (1996) noted negligible amounts of resorption with intrusion and concluded that intrusion with low forces can be effective in reducing overbite without significant root resorption. In this study, any possible sign of root resorption was checked on the periapical radiographs and slight blunting of only one central incisor was detected. Intrusion was undertaken with continuous forces via closed coil springs and the use of continuous forces might have favoured root continuity. Thus, force levels were within the limits recommended by Burstone (2001). However, controlled studies on the effects of incisor intrusion using miniscrews on root resorption with a larger sample size should be performed.

Conclusions

1. True intrusion of upper incisors can be achieved using miniscrew anchorage.
2. During the application of intrusive force, the axial inclination of the upper incisors showed minimal change, which was considered to be clinically acceptable.
3. Root resorption was not seen as a consequence of incisor intrusion.

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