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Overbite Correction and Smile Esthetics

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OVERBITE CORRECTION AND SMILE ESTHETICS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

by

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Abstract

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The purpose of this prospective clinical study was to investigate differences in outcomes from two common treatment modalities used to reduce deep overbite: maxillary incisor intrusion using an intrusion arch and posterior tooth eruption using an anterior bite plate. Pre-treatment, post-overbite correction and post-treatment records were gathered from 32 patients who presented with deep overbite malocclusions to the Virginia Commonwealth University orthodontic clinic. Both groups of patients experienced reductions in overbite and maxillary incisor display as well as maxillary and mandibular incisor proclination and mandibular incisor occlusal movement during treatment. In the intrusion arch group, the center of resistance of the maxillary incisor was significantly intruded during overbite correction. The maxillary incisor incisal edge was significantly more intruded at the end of treatment in the

intrusion arch group. Both groups experienced flattening of the smile arc in agreement with previous studies showing similar changes in orthodontically treated individuals.

Introduction

One of the primary goals of orthodontics is to establish occlusal harmony between the maxillary and mandibular dentition while maintaining or enhancing facial esthetics.[1] The desire for improved facial appearance is a motivating factor for patients seeking orthodontic treatment. Physical attractiveness is highly valued in most cultures and an attractive smile is considered to be one of the most important attributes of facial esthetics.[2] Esthetic considerations in the selection of orthodontic treatment goals have become increasingly important to orthodontists.[3] Attempts have been made to define and quantify the smile characteristics that are considered to be ideal. Defining these characteristics has helped practitioners to establish individualized treatment goals based on achieving ideal smile architecture. Vertical positioning of the upper incisors and configuration of the smile arc are two significant factors that have been found to influence smile attractiveness. Some suggestions have been made regarding treatment strategies that should be used to maintain or produce ideal smile esthetics, but no evidence has been presented to substantiate these approaches.

In the later part of the 19th century, Kinglsey[4] emphasized the esthetic objectives of orthodontic treatment. In his view the articulation of the teeth was secondary to facial appearance. Early in the 20th century, Case[5] continued to advocate the paramount importance of esthetics in orthodontic treatment planning. Angle,[6] however, believed that if the teeth were put in proper occlusion then optimal facial esthetics would be produced. With the influence of Angle's teachings on occlusion and with the advances in orthodontic technology, especially radiographic cephalometry, orthodontists became increasingly focused on hard tissue goals.

Burstone[7] revisited the importance of esthetic soft tissue evaluation in diagnosis and orthodontic treatment planning. He believed that facial esthetics, perioral function and stability were influenced by the soft tissues. Burstone[7] also demonstrated a technique for obtaining a reproducible relaxed lip position and advocated using the relaxed lip posture to aid in proper positioning of the incisors. He defined anterior tooth display or "lip-to-tooth" as the vertical length of the maxillary incisors showing below the lip at rest when both lips were unstrained and the teeth were together. According to Peck et al.,[8] maxillary incisor exposure at age 15 averages 5.3 mm for females and 4.7 mm for males. The measurements of relaxed lip-to-tooth relationships have subsequently been used for the purpose of planning vertical goals for the incisors during orthodontics and orthognathic surgery.

In 1992, Peck et al.[8] introduced the concept that smile esthetics could actually be studied scientifically and sought to examine the nature of the gingival smile line. Ackerman et al[6] offered the "smile mesh" as a tool for measuring smile esthetics and popularized the term "smile arc", previously described by Hulsey[10] and Frush and Fisher[11] as the "smile line", to describe the relationship between the upper anterior teeth and the contour of the lower lip. Hulsey,[10] Rigsbee[12] and later Ackerman[9] all found that an unstrained posed smile could be reproduced consistently.

Sarver[13] described the smile arc as "the relationship of the curvature of the incisal edges of the maxillary incisors and canines to the curvature of the lower lip in the posed smile." The ideal smile arc has the maxillary incisal edges parallel to the curve of the lower lip upon smile, and is referred to as *consonant.* A smile is considered *flat* if the incisal edges are straight and *reverse* if the incisal edges are aligned in an arc opposite to the contour of the lower lip. A consonant smile is considered to be more youthful and attractive in appearance.[10,14]

Hulsey[10] evaluated the "smile line" and determined whether there was a measurable component that might permit an objective evaluation of the smile. Hulsey had a panel of laypersons evaluate the smiles of 40 subjects. Twenty of the subjects comprised an untreated group with "normal occlusions" with the remaining 20 subjects having undergone orthodontic treatment. The results showed that harmony between an arc of curvature connecting the incisal edges of the upper incisors and the upper border of the lower lip was an important characteristic of an attractive smile. The most attractive smiles also displayed symmetry with the upper lip at the height of the gingival margin of the upper central incisor on smile. Somewhat surprisingly, the orthodontically treated smiles were judged to be less attractive than their untreated counterparts. Hulsey, however, did not compare the changes in smiles of the same patients before and after treatment.

Mackley[15] expanded on Hulsey's work by attempting to determine the effects of orthodontics on the smile by evaluating four criteria: the attractiveness of the smile, maxillary incisor torque, dental protrusion, and profile. A panel of five orthodontists and six parents evaluated the pre and post-treatment photographs of 168 patients and found that the average scores improved for all four categories. The most attractive smiles had a smiling lip line close to the gingival margin of the upper incisors. The patients that showed the greatest improvements in smile appearance had a decreased vertical lip-to-tooth relationship with an increase in maxillary incisor torque. Mackley concluded that proper vertical positioning of the maxillary incisors must be included in the treatment planning process for clinicians to maximize their potential for improving the patient's smile.

Ackerman et al.[16] evaluated the posed smiles of 30 orthodontically treated individuals before and after treatment and 30 untreated individuals over a 2.5-year period. A statistically significant decrease in lip drape, increase in smile width and increase in maxillary inter-canine width occurred in treated individuals. They found that only 13% of the untreated sample displayed any change in smile arc during the observation period, whereas 40% of the treated patients exhibited discernable changes in the smile arc. In the treated group, six out of the nineteen patients whose initial smile arcs were consonant became flat with treatment. In the untreated group, only one patient out of twenty whose smile arc was consonant became flat over time.

In order to better control and improve the smile arc during treatment, several authors have suggested that careful bracket positioning is important.[17,18] A vertical difference of anywhere from 0.5 to 1.5 mm in bracket placement between the maxillary central and lateral incisors has been advocated. In a case report, Sarver and Ackerman[17] showed that careful leveling without intrusion of the maxillary incisors was important to preserve a favorable smile arc. To control overbite and maintain smile esthetics, intrusion of mandibular incisors, rather than maxillary incisors was suggested by Sarver[17] and Zachrisson.[18] Vertical steepening of the occlusal plane, either by growth modification or by surgery, has also been advocated by Sarver and Ackerman[17] and Sarver [13] as a means for altering the relationship of the maxillary anterior curvature relative to the lower lip for improvement of the smile arc.

Some authors speculated that various mechanical interventions employed by orthodontists may cause a patient's smile arc to flatten during treatment. It was suggested that broadening the maxillary arch may flatten the appearance of the smile arc.[9,17] Sarver[13] stated that "maxillary intrusion arches or maxillary arch wires with accentuated curve could result in a flattening of the smile arc." Ackerman and Ackerman[9] said they found that "the segmented-arch technique using cantilever springs offers better control of leveling" and that "leveling with a continuous arch wire will intrude the maxillary central and lateral incisors and thus flatten the smile arc." Zachrisson[18] also cautioned against over intrusion of maxillary incisors in patients with low lip lines because it decreased the lip to tooth relationship. He did advocate such intrusion, however, for patients with high lip lines. Despite these recommendations, there have been few published studies of the effects of specific orthodontic mechanical interventions on the esthetics of the smile.

The purpose of the present study was to examine and compare the effects of two commonly used treatment interventions for correcting excessive overbite: maxillary incisor intrusion and posterior tooth eruption, on two factors influencing smile esthetics:

the lip to tooth relationship and the smile arc. The design was a prospective clinical trial in which patients underwent one of the two procedures for correction of deep overbite. Various measures of tooth movement and esthetic changes were made and compared between the two groups.

Materials and Methods

Overview

Institutional Review Board (IRB) approval was granted to conduct a study comparing the effects of two treatment interventions to correct deep overbite: maxillary incisor intrusion using an intrusion arch and posterior tooth eruption using an anterior bite plate. Patients presenting to the Virginia Commonwealth University Orthodontic Clinic were asked to participate in the study if they had at least 50% overbite at the start of treatment and were over 10 years of age. Patients with Sella-Nasion to Mandibular Plane angles of greater than 40° and patients with extractions planned as part of treatment were excluded from the study. The treatment method for each patient, intrusion arch or bite plate, was determined by the orthodontic resident and attending to be the best treatment to reduce overbite for that particular patient. However, the procedure used was largely dependent on the day of the week the patient chose to be treated because different attending orthodontists tended to implement their own preferred overbite correction method consistently.

Intra-Examiner Reliability for Cephalometric Measurements

To test for intra-examiner reliability for the angular and linear measurements, 10 radiographs were selected from the original sample using a random number generator. These radiographs were retraced and re-measured, with the two measurements at least 4 weeks apart. The original and repeated measurements were compared using correlation analysis.

Intra- and Inter-Examiner Reliability of Smile Arc Assessment

Intra- and Inter-examiner reliability of the smile arc assessment was evaluated using the kappa statistic[24] to determine the subjectivity of the assessment. The smile photographs were randomized and placed in a database. Two examiners independently rated the smiles as being consonant, flat, or reverse in relation to the vermillion border of the lower lip. Ten of the smile photographs were repeated in the database to evaluate intra-examiner reliability.

Subjects and Measurements

A total of 60 patients agreed to participate in the study: 31 in the intrusion arch group and 29 in the bite plate group. Of those patients, 40 had data collected at the pre-treatment and post-overbite correction stages: 20 intrusion arch and 20 bite plate patients. Seventeen of remaining patients never received the planned treatment, two patients moved during treatment, and one patient had incomplete records. Of the 40 patients that had post-overbite correction records, 32 patients had their data collected for the final analysis. Six patients received other means of overbite correction during the course of treatment and were excluded, one patient had incomplete records, and one patient had not yet completed treatment at the time of final data collection. Extra-oral posed smile photographs and cephalometric radiographs were taken before and after overbite correction and again at the conclusion of treatment. The cephalometric landmarks and the cephalometric measurements used in this study are described in Figure 1 and Table 1, respectively. In addition, a clinically-determined lip to tooth measurement to the nearest 0.5 mm was made for all patients at each timepoint. The center of the right central incisor incisal edge was used for consistency. The smile arc assessments (consonant, flat, or reverse) were made as recommended by Sarver and Ackerman [20] by the same examiner clinically before and after overbite correction and at the conclusion of treatment.

For the intrusion arch patients, the techniques employed were either that advocated by Burstone[21] or Isaacson et al.[22] and were used in the maxillary arch only. Bite plate patients received either a removable or fixed maxillary acrylic bite plate that contacted the lower incisors to prevent posterior occlusal contact. In both groups, aligning arch wires in addition to the overbite correction appliance were placed in most patients during the overbite correction phase of treatment.

Both skeletal and dental variables were measured on the individual cephalograms at T1 (pre-treatment), T2 (post-overbite correction), and T3 (post-treatment). Maxillary and mandibular superimpositions were used to evaluate the vertical position of the incisors. Superimpositions were accomplished using Bjork’s structural method.[23] For each patient, a maxillary and mandibular incisor center of resistance was defined as one half of the root length in the alveolar process on the pre-treatment cephalometric film and carried forward to the post-overbite correction incisors. An incisor template was used to standardize this process. The pre-treatment functional occlusal plane and mandibular plane were transferred to the post-overbite correction and post-treatment radiographs to serve as a stable reference plane for describing tooth movements. Linear measurements were made perpendicular to the functional occlusal plane. Linear measurements made inferior to the functional occlusal plane were assigned negative values.

Statistics

Intra-examiner reliability of the cephalometric and clinical measurements was assessed using correlation analysis. The kappa coefficient was used to evaluate inter-examiner reliability of the smile arc assessment. Cephalometric and clinical measurement changes as a result of overbite correction and treatment were evaluated within and between groups using repeated measures ANOVA and significance was set at $P = 0.05$. Smile arc changes within and between groups were evaluated using Chi Square analysis with a threshold for significance set at $P=0.05$.

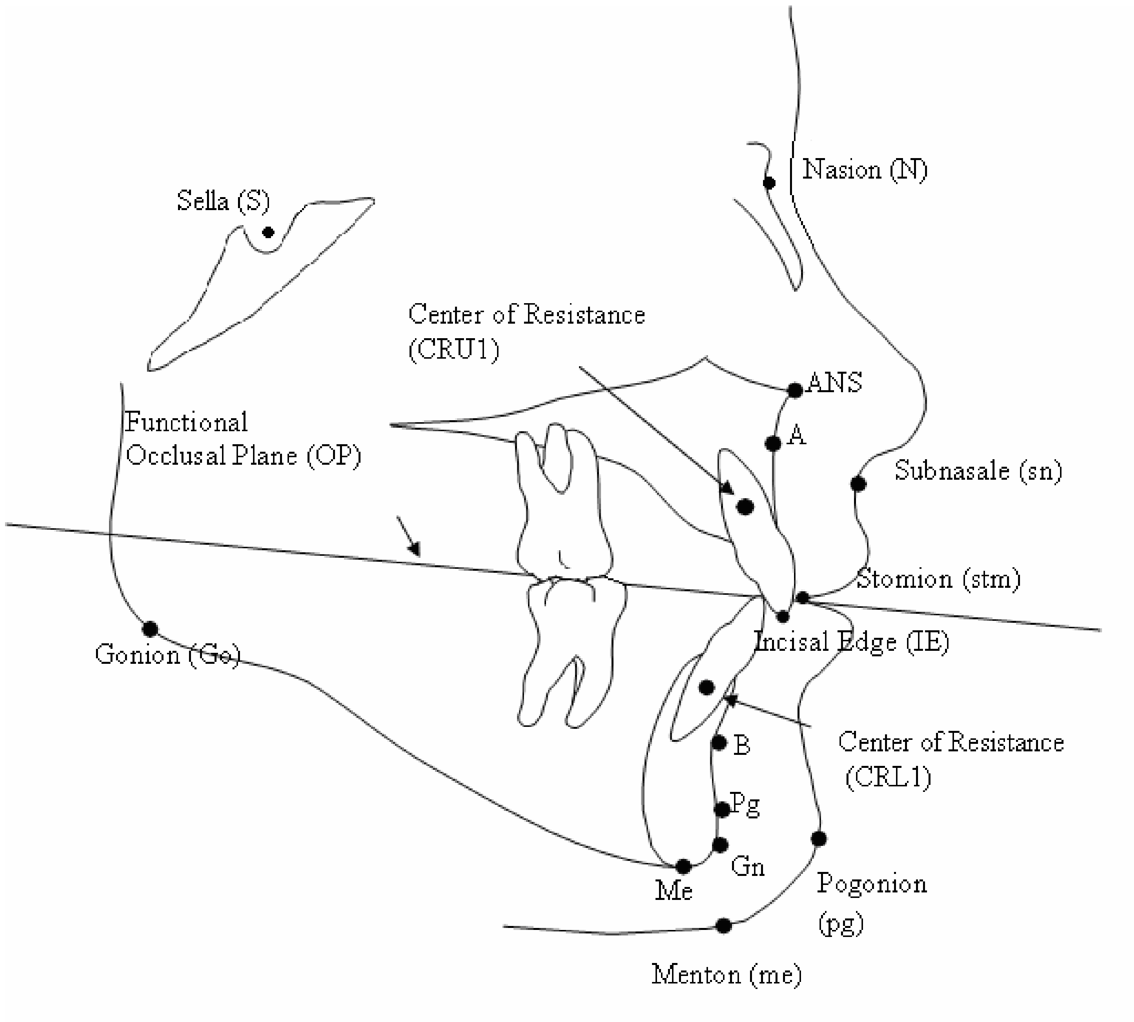


Figure 1. Cephalometric landmarks

Table 1. Description of cephalometric measurements.

Measure	**Definition**
OB	Overbite measured perpendicular to the functional occlusal plane.
Lip-Tooth	Vertical distance from the upper incisor incisal edge to Stomion perpendicular to the functional occlusal plane.
OP-U1IE	Vertical distance from the upper incisor incisal edge to the functional occlusal plane.
OP-CRU1	Vertical distance from the upper incisor constructed center of resistance to the functional occlusal plane.
OP-CRL1	Vertical distance from the lower incisor constructed center of resistance to the functional occlusal plane.
SN-U1	Angulation of the upper incisor relative to Sella-Nasion.
MP-L1	Angulation of the lower incisor relative to the Mandibular Plane.
SN-MP	Mandibular Plane angle.

Results

Intra-Examiner Reliability for Cephalometric Measurements

There was a significant correlation (P<.0001) between the original and repeated cephalometric measurements. Correlation values ranged from r=.94 for upper incisor angulation (SN-U1) to r=.99 for occlusal plane to upper incisor incisal edge (OP-U1IE). The greatest mean difference (1.01º) between the initial and repeated measurements occurred for the measure of upper incisor angulation (SN-U1).

Smile Arc Assessment

The percentage agreement for smile arc assessment between the two raters was 77%. A kappa coefficient of .44 indicated a moderate level[24] of agreement between the two raters. For intra-examiner reliability, 9 of the 10 repeated photos received the same assessment.

Characteristics of Treated Groups

There were no significant differences between the groups in mean age at the start of treatment (P=.45) or total treatment time as shown in Table 2. However, there was a small, but significant difference in time for overbite correction between the groups (P=.05) with the bite plate group 1.6 months shorter on average.

Table 2. Characteristics of treated groups

Groups	N	Gender (M/F)	Mean Age (T1) in years (± SD)	Mean Time for Overbite Correction in months (± SD) (T1-T2)	Mean Time for Total Treatment in years (± SD) (T1-T3)
IA	18	7/11	14.7 (± 9.3)	5.3 (± 2.5)*	2.4 (± 1.0)
BP	14	3/11	13.6 (± 1.8)	3.7 (± 1.5)	2.1 (± 0.8)

* P-value denotes a significant difference between groups P<.05

Clinical and Cephalometric Measurements

There was a significant correlation between the clinical and cephalometric lip to tooth measurements (r=.67, P=.0001). Therefore, only clinical lip-to-tooth values are reported. There were no significant pre-treatment differences between the groups for any of the clinical or cephalometric characteristics measured except for the mandibular plane angle (MP-SN) (P=.04). The pre-treatment mandibular plane angle was 32.7° ± 4.8° for the intrusion arch group and 29.3° ± 4.5° for the bite plate group. Pre-treatment, post-overbite correction and post-treatment averages for clinical and cephalometric measurements for the intrusion arch and bite plate groups are shown in Tables 3 and 4, respectively. A comparison of the mean values between the groups at each time point is presented in Table 5. Mean treatment changes are compared between the intrusion arch and bite plate groups in Table 6.

Table 3. Mean values (SD) for the intrusion arch group

Intrusion Arch Group

Measure	T1	T2	T3	P-value (T1-T2)	P-value (T2-T3)	P-value (T1-T3)
OB (mm)	4.3 (±1.2)	1.8 (±0.6)	1.5 (±0.6)	.0001	.28	.0001
Lip-Tooth (mm)	6.0 (±1.7)	3.9 (±1.9)	4.0 (±2.0)	.0001	.61	.0001
OP-U1IE (mm)	-1.8 (±1.5)	0.0 (±1.3)	0.2 (±1.5)	.0001	.42	.0001
OP-CRU1 (mm)	10.4 (±0.9)	11.6 (±1.1)	11.0 (±1.2)	.0001	.052	.10
SN-U1(°)	102.0 (±9.9)	105.5 (±5.8)	110.2 (±5.8)	.089	.0001	.003
OP-CRL1 (mm)	-10.1 (±1.1)	-9.3 (±1.3)	-8.9 (±1.7)	.009	.18	.003
MP-L1(°)	92.8 (±6.2)	94.6 (±7.1)	96.6 (±4.9)	.17	.12	.005
SN-MP(°)	32.7 (±4.8)	32.6 (±4.6)	32.3 (±4.9)	.84	.38	.45

P-value denotes significance of difference between timepoints within the group.

Table 4. Mean values (SD) for the bite plate group

Bite Plate Group

Measure	T1	T2	T3	P-value (T1-T2)	P-value (T2-T3)	P-value (T1-T3)
OB (mm)	4.1 (±1.0)	1.9 (±0.5)	1.6 (±0.7)	.0001	.25	.0001
Lip-Tooth (mm)	5.4 (±1.2)	4.6 (±1.3)	4.0 (±1.0)	.004	.09	.002
OP-U1IE (mm)	-1.8 (±1.4)	-1.0 (±1.6)	-0.9 (±1.6)	.004	.87	.03
OP-CRU1 (mm)	10.5 (±1.1)	10.7 (±1.4)	10.6 (±1.3)	.58	.78	.84
SN-U1(°)	102.6 (±10.4)	107.8 (±7.8)	110.2 (±6.8)	.0006	.18	.001
OP-CRL1 (mm)	-10.2 (±1.3)	-9.1 (±1.2)	-9.4 (±1.8)	.003	.42	.14
MP-L1(°)	94.9 (±5.2)	97.1 (±6.2)	98.6 (±3.9)	.03	.25	.005
SN-MP(°)	29.3 (±4.5)	30.0 (±4.8)	29.4 (±5.1)	.07	.32	.79

P-value denotes significance of difference between timepoints within the group.

Table 5. Comparison of mean values (SD) between groups

Measure	T1 IA	T1 BP	T1 P-value	T2 IA	T2 BP	T2 P-value	T3 IA	T3 BP	T3 P-value
OB (mm)	4.3 (±1.2)	4.1 (±1.0)	.74	1.8 (±0.6)	1.9 (±0.5)	.63	1.5 (±0.6)	1.6 (±0.7)	.87
Lip-Tooth (mm)	6.0 (±1.7)	5.4 (±1.2)	.24	3.9 (±1.9)	4.6 (±1.3)	.21	4.0 (±2.0)	4.0 (±1.0)	.91
OP-U1IE (mm)	-1.8 (±1.5)	-1.8 (±1.4)	.98	0.0 (±1.3)	-1.0 (±1.6)	.06	0.2 (±1.5)	-0.9 (±1.6)	.04
OP-CRU1 (mm)	10.4 (±0.9)	10.5 (±1.1)	.76	11.6 (±1.1)	10.7 (±1.4)	.03	11.0 (±1.2)	10.6 (±1.3)	.38
SN-U1(°)	102.0 (±9.9)	102.6 (±10.4)	.87	105.5 (±5.8)	107.8 (±7.8)	.34	110.2 (±5.8)	110.2 (±6.8)	.99
OP-CRL1 (mm)	-10.1 (±1.1)	-10.2 (±1.3)	.80	-9.3 (±1.3)	-9.1 (±1.2)	.67	-8.9 (±1.7)	-9.4 (±1.8)	.39
MP-L1(°)	92.8 (±6.2)	94.9 (±5.2)	.32	94.6 (±7.1)	97.1 (±6.2)	.30	96.6 (±4.9)	98.6 (±3.9)	.21
SN-MP(°)	32.7 (±4.8)	29.3 (±4.5)	.04	32.6 (±4.6)	30.0 (±4.8)	.12	32.3 (±4.9)	29.4 (±5.1)	.12

P-value denotes significance of difference between the groups at each timepoint.

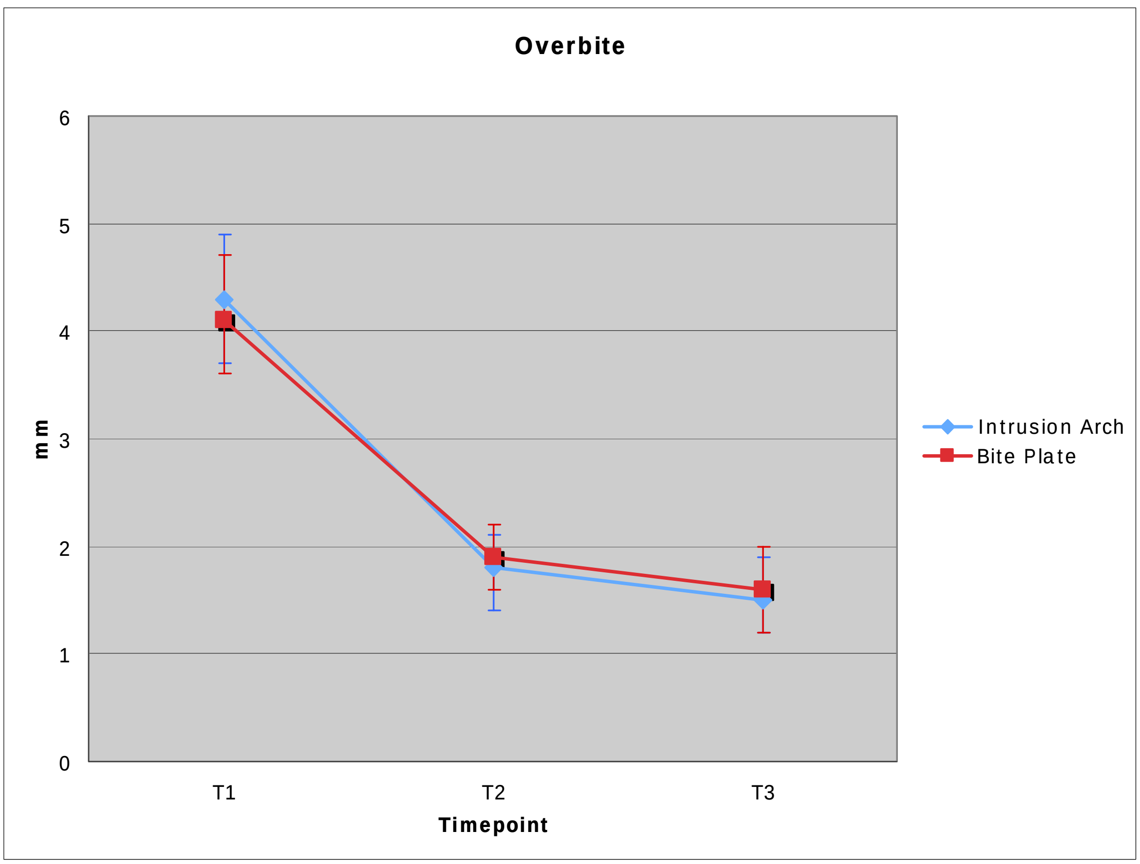
Table 6. Comparison of mean changes (SD) between groups

Measure	T1-T2 IA	T1-T2 BP	T1-T2 P-value	T2-T3 IA	T2-T3 BP	T2-T3 P-value	T1-T3 IA	T1-T3 BP	T1-T3 P-value
OB (mm)	-2.5 (±1.2)	-2.3 (±1.2)	.60	-0.2 (±0.8)	-0.3 (±0.9)	.84	-2.7 (±1.4)	-2.6 (±1.3)	.73
Lip-Tooth (mm)	-2.1 (±1.1)	-0.8 (±0.8)	.0005	0.2 (±1.4)	-0.7 (±1.3)	.09	-2.0 (±1.6)	-1.4 (±1.3)	.28
OP-U1IE (mm)	1.8 (±1.4)	0.8 (±0.9)	.02	0.2 (±1.0)	0.1 (±1.1)	.69	2.0 (±1.6)	0.9 (±1.3)	.03
OP-CRU1 (mm)	-1.2 (±0.9)	-0.2 (±1.0)	.003	0.6 (±1.3)	0.1 (±1.0)	.20	-0.6 (±1.4)	-0.1 (±1.4)	.32
SN-U1(°)	3.5 (±8.3)	5.3 (±4.4)	.48	4.7 (±4.1)	2.4 (±6.3)	.21	8.3 (±10.3)	7.7 (±7.1)	.85
OP-CRL1 (mm)	0.7 (±1.0)	1.0 (±1.1)	.44	0.5 (±1.4)	-0.3 (±1.2)	.13	1.2 (±1.5)	0.8 (±1.8)	.46
MP-L1(°)	1.8 (±5.4)	2.3 (±3.5)	.80	2.0 (±5.2)	1.5 (±4.7)	.80	3.8 (±5.1)	3.8 (±4.2)	.98
SN-MP(°)	-0.1 (±1.7)	0.7 (±1.4)	.15	-0.4 (±1.7)	-0.6 (±2.2)	.72	-0.4 (±2.5)	-0.1 (±1.9)	.48

P-value denotes significance of differences in changes between the groups

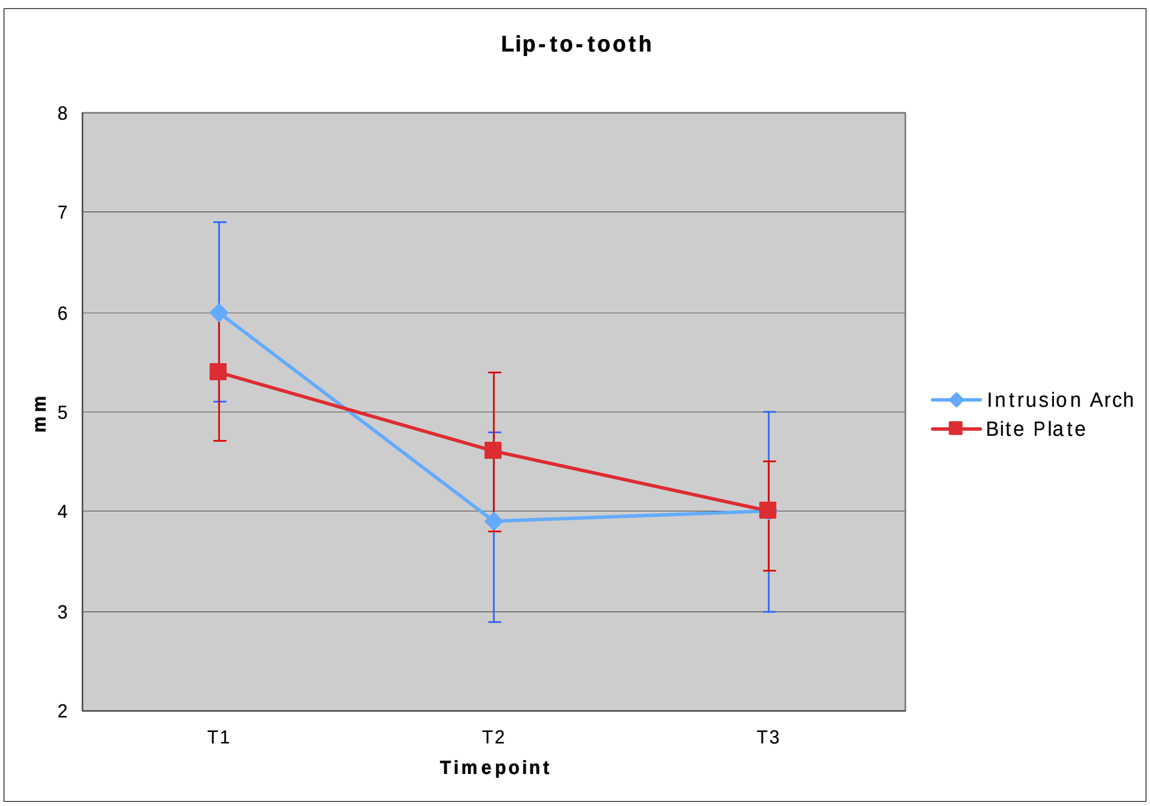
For overbite (Fig. 2), the intrusion arch and bite plate groups were not significantly different in their response to the treatment over time (P=.85). Both the intrusion arch and bite plate groups experienced significant decreases in overbite from T1 to T2 (P=.0001) and from T1 to T3 (P=.0001). There were no significant differences between groups in overbite at T1, T2 or T3. There were no significant differences between the groups for change in overbite.

Figure 2. Mean values and 95% confidence intervals for overbite correction



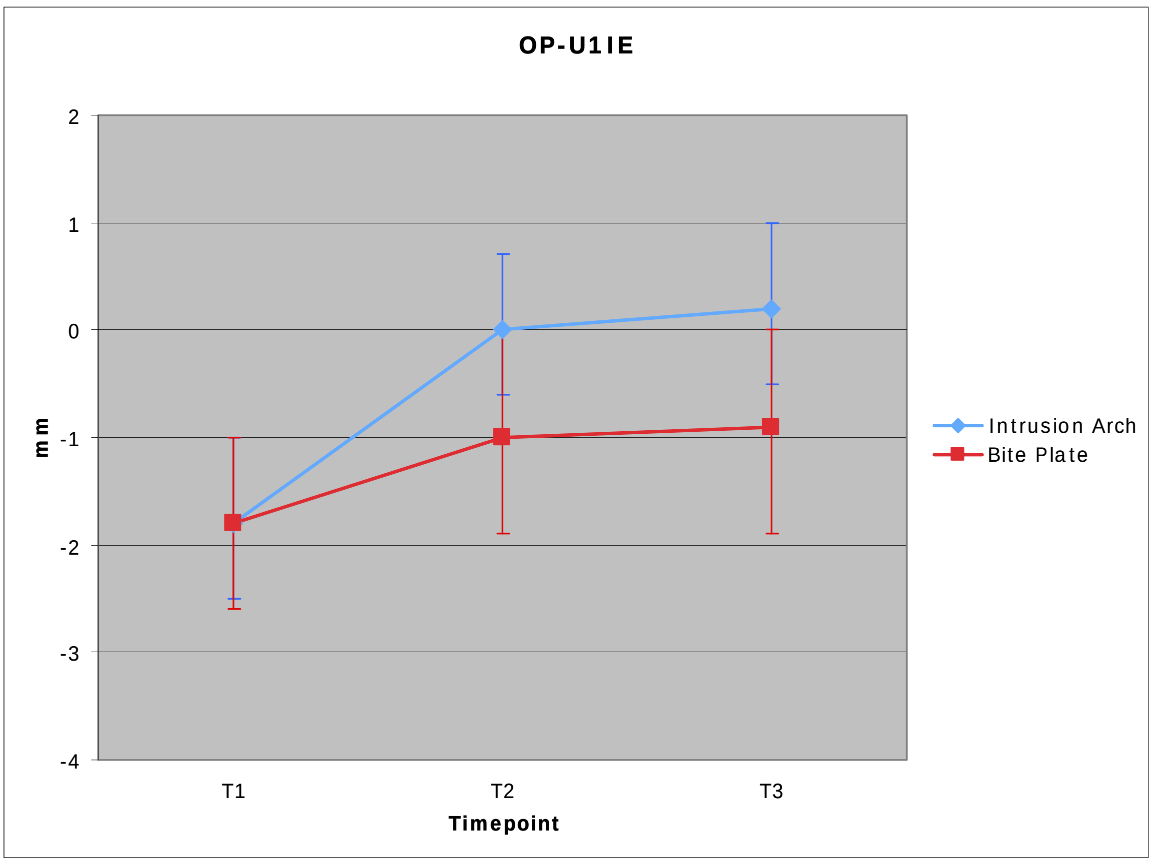
Changes in lip-to-tooth during treatment (Fig. 3) were significantly different between the groups (P=.01). Both the intrusion arch and bite plate groups experienced significant decreases in lip-to-tooth from T1 to T2 (P=.0001, P=.004, respectively) and from T1 to T3 (P=.0001, P=.002 respectively) with the intrusion arch group experiencing a significantly greater decrease than the bite plate group from T1 to T2 (P=.0005). There were no differences between groups for lip-to-tooth at T1, T2 or T3. There were no significant differences between the groups for change in lip-to-tooth from T2 to T3 or from T1 to T3.

Figure 3. Mean values and 95% confidence intervals for lip-to-tooth



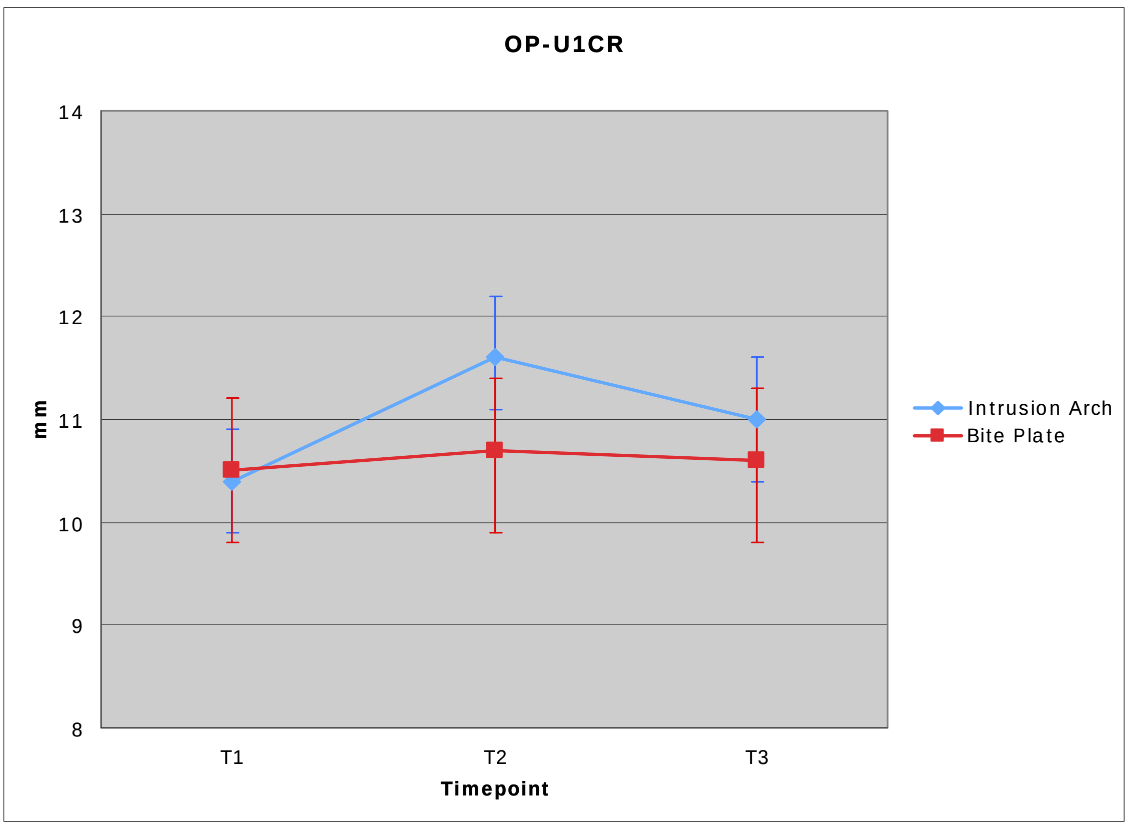
The movement of the incisal edge of the upper incisor (Fig. 4) was significantly different between the groups in response to treatment (P=.02). Both the intrusion arch and bite plate groups experienced significant apical movement of the incisal edge of the upper incisor from T1 to T2 (P=.0001, P=.004, respectively) and from T1 to T3 (P=.0001, P=.003, respectively) with the intrusion arch group experiencing significantly greater apical movement than the bite plate group from T1 to T2 (P=.02) and from T1 to T3 (P=.03). The incisal edge of the upper incisor of the intrusion arch group also was significantly more apically positioned than in the bite plate group at T3 (P=.04).

Figure 4. Mean values and 95% confidence intervals for OP-U1IE



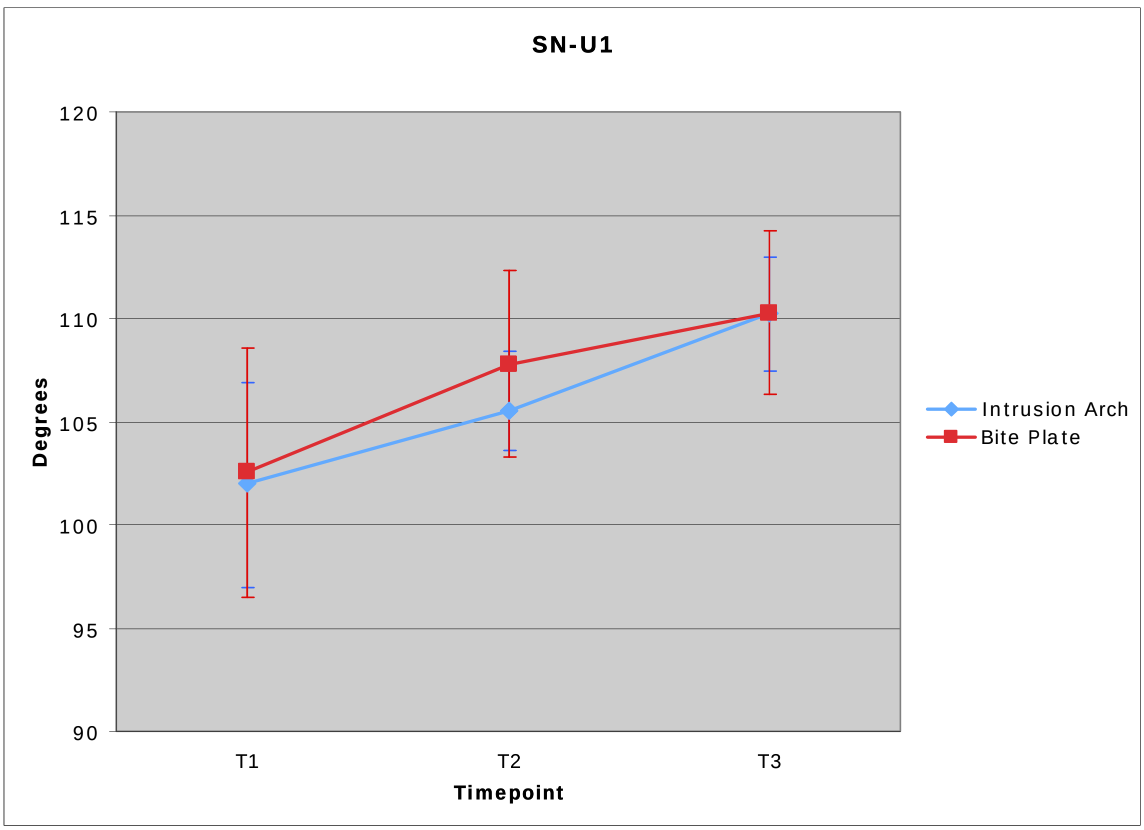
The movement of the center of resistance of the upper incisor (Fig. 5) was significantly different between the groups in response to treatment over time (P=.05). The intrusion arch group experienced significantly greater intrusion of the upper incisor center of resistance from T1 to T2 (P=.003) with the incisor being intruded significantly from T1 to T2 (P=.0001). At T2 in the intrusion arch group the incisor was significantly more intruded (P=.03) than in the bite plate group. The intrusion arch group experienced significant extrusion of the upper incisor from T2 to T3 (P=.05). There was no significant change in the position of the center of resistance of the upper incisor for the bite plate group and no significant differences between the groups by the end of treatment (T3).

Figure 5. Mean values and 95% confidence intervals for OP-U1CR



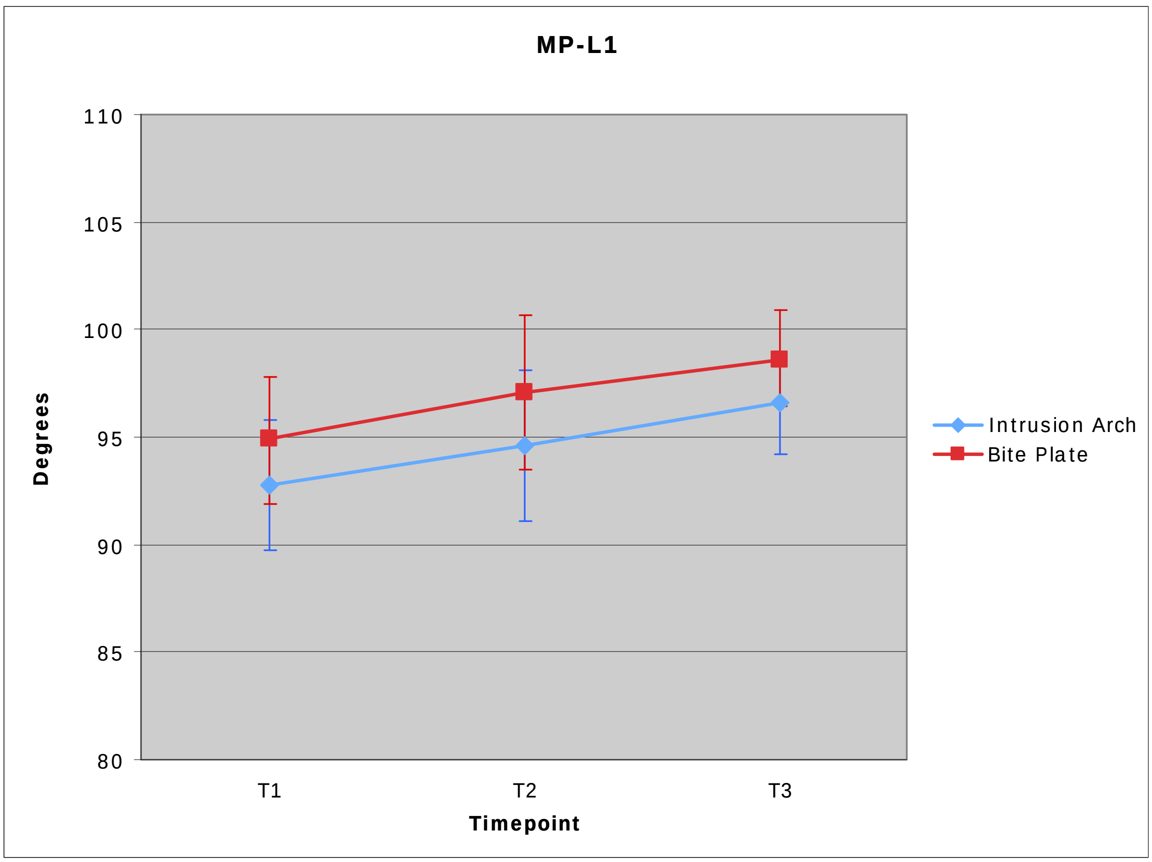
For upper incisor angulation (Fig. 6), the intrusion arch and bite plate groups were not significantly different in their response to treatment over time (P=.64). Significant flaring was observed in the bite plate group from T1 to T2 (P=.0006) and in the intrusion arch group from T2 to T3 (P=.0001). Both groups had significant increases in upper incisor angulation from T1 to T3 (P=.001 for the bite plate group and P=.003 for the intrusion arch group). There were no significant differences between groups for upper incisor angulation at T1, T2 or T3. There was no difference between the groups for changes in SN-U1.

Figure 6. Mean values and 95% confidence intervals for SN-U1



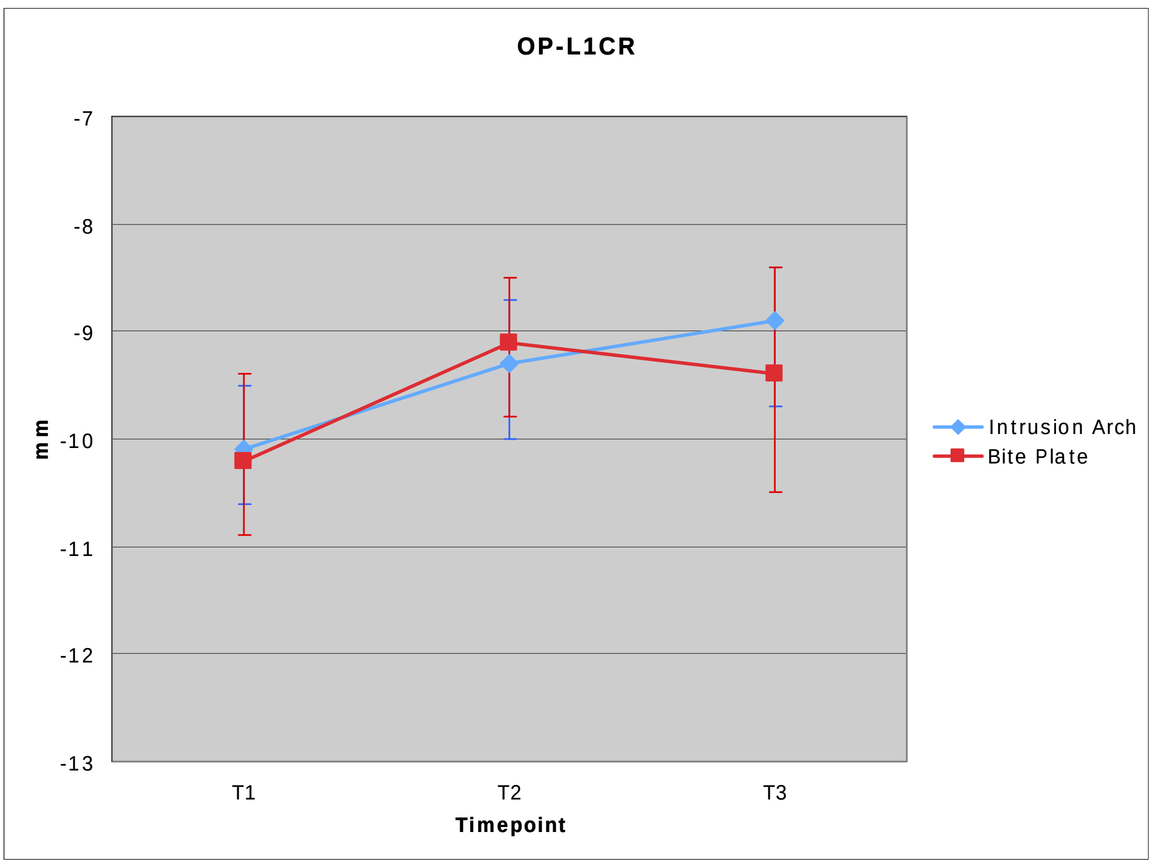
For lower incisor angulation (Fig. 7), the intrusion arch and bite plate groups were not significantly different in their response to the treatment over time (P=.96). Significant flaring was observed during initial overbite correction (T1-T2) in the bite plate group (P=.03) and in both groups from T1 to T3 (P=.005). There were no significant differences between the groups in lower incisor angulation at T1, T2 or T3. There was no difference between the groups for change in lower incisor angulation.

Figure 7. Mean values and 95% confidence intervals for MP-L1



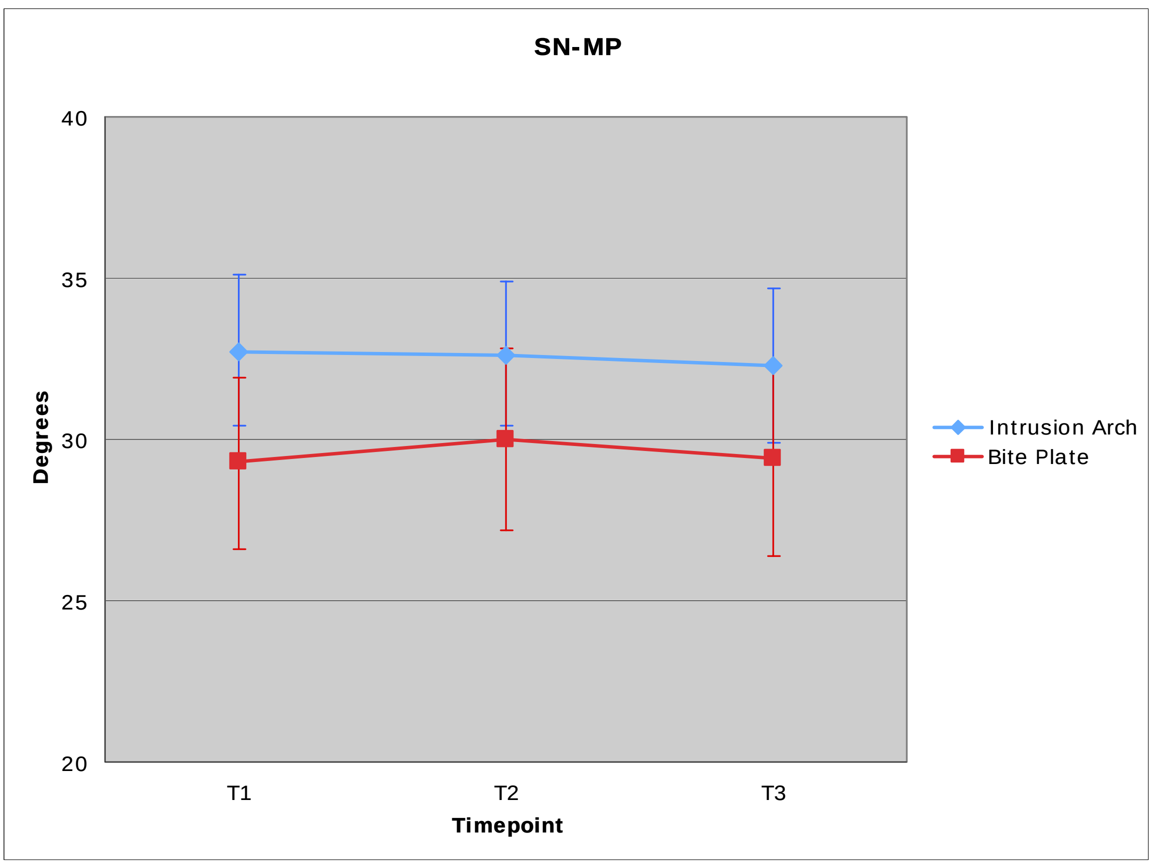
The movement of the lower incisor center of resistance (Fig. 8) was not significantly different between the groups in response to treatment over time (P=.32). Both the intrusion arch and bite plate groups experienced significant extrusion of the lower incisor from T1 to T2 (P=.009, P=.003, respectively) with the intrusion arch group also demonstrating significant extrusion from T1 to T3 (P=.003). There were no differences between groups for position of the lower incisor center of resistance relative to the occlusal plane at T1, T2 or T3. There were no significant differences between the groups for change in the lower incisor center of resistance.

Figure 8. Mean values and 95% confidence intervals for OP-L1CR



For mandibular plane angle (Fig. 9), the intrusion arch and bite plate groups were not significantly different in their response to treatment over time (P=.47). At T1 the intrusion arch group had a significantly greater mandibular plane angle (P=.04). There were no differences between groups for SN-MP at T2 or T3. A small increase in MP-SN was observed in the bite plate group from T1 to T2 but the increase was not statistically significant (P=.07). There were no significant differences between the groups for change in mandibular plane angle.

Figure 9. Mean values and 95% confidence intervals for SN-MP



Smile Arc Assessment

Smile arc assessments for each timepoint are shown in Table 7. One patient in each group was excluded from this portion of the analysis due to anterior tooth anomalies. Before treatment, 15 of the 17 patients in the intrusion arch group and 11 of the 13 patients in the bite plate group had a consonant smile. Both groups had one patient with a flat smile and one patient with a reverse smile before treatment. Following overbite correction, 10 of the 17 smiles in the intrusion arch group and 10 of the 13 smiles in the bite plate group were evaluated as being flat. No change in the smile arc was seen in 7 of the 17 intrusion arch patients and 4 of the 13 bite plate patients from T1 to T2. One patient's smile arc went from reverse to consonant in the intrusion arch group while none improved in the bite plate group. At the conclusion of treatment, 7 of the 17 smiles in the intrusion arch group and 7 of the 13 smiles in the bite plate group were evaluated as flat. No change in the smile arc was seen in 4 of the 17 intrusion arch patients and 3 of the 13 bite plate patients from T1 to T3. For the patients that experienced flattening of the smile arc during overbite correction, 5 of the 9 smiles in the intrusion arch group and 4 of the 9 smiles in the bite plate group improved back to consonant by the end of treatment. There were no statistically significant differences between groups at any time point. The overall patient population (P=.002) and the bite plate group (P=.01) experienced significant flattening of the smile arc during overbite correction. Although it was not a statistically significant difference from T1, 14 of the 30 patients evaluated had flat smiles at the conclusion of treatment.

Table 7. Smile arc assessment

	T1			T2			T3		
Assessment	Total	IA	BP	Total	IA	BP	Total	IA	BP
Consonant	26	15	11	9	7	2	16	10	6
Flat	2	1	1	20 *	10	10 **	14	7	7
Reverse	2	1	1	1	0	1	0	0	0

* Significant change recorded during treatment from T1 to T2 p= .002

** Significant change recorded during treatment from T1 to T2 p= .01

Discussion

The results of this study showed that both intrusion arches and bite plates were successful in correcting deep overbite. The mean overbite correction was 2.7 ± 1.4mm in the intrusion arch group and 2.6 ± 1.3 mm in the bite plate group. Previous studies[25-27] have reported similar reductions in overbite during orthodontic treatment with amounts from 1.5 mm to 2.7 mm.[25-27]

In the intrusion arch group the maxillary incisor center of resistance significantly intruded during overbite correction 1.2 ± 0.9 mm. This change was accompanied by a significant decrease in anterior tooth display and significant apical movement of the maxillary incisor incisal edge. Interestingly, the center of resistance of the maxillary central incisor moved occlusally significantly from T2 to T3 ($p=.05$). The occlusal movement of the upper incisor after initial overbite correction may have resulted from the use of continuous archwires subsequent to segmented intrusion. The amount of intrusion at the conclusion of treatment was similar to that reported in the results of earlier studies with similar patient demographics.[28,29] In untreated growing patients it is expected that the maxillary incisors will erupt 1 to 2 mm over a two year period .[28,29] Since some eruption of the maxillary incisor would have been expected without treatment, the small amount of actual incisor intrusion measured, along with the maxillary incisor flaring and growth that occurred, probably account for the overbite correction observed.

The bite plate group did not experience significant vertical movement of the maxillary incisor center of resistance during treatment. This group did however exhibit a significant decrease in lip to tooth and apical movement of the upper incisor incisal edge during overbite correction and at the conclusion of treatment. The decrease in anterior tooth display and the apical movement of the incisal edge in the bite plate group could be attributed, in part, to the significant proclination of the maxillary incisors that occurred during treatment.

In both groups, the mandibular incisor moved occlusally and flared during treatment. The small amount of lower incisor eruption that was observed is consistent with previous studies.[25,29,30,32] Parker et al.[32] in a retrospective study of 132 orthodontically treated patients with deep overbite, found that regardless of the Angle classification at the start of treatment or overbite mechanics used, there was substantial incisor flaring and small amounts of lower incisor occlusal movement that occurred during treatment.

There were no significant differences within groups or between groups for mandibular plane angle at the end of overbite correction or at the conclusion of treatment. There was a slight opening rotation observed in the bite plate group during overbite correction but it was not significant (p=.07). Previous studies observed an opening rotation of the mandible when molar extrusion occurred during treatment.[29,31,32] It was anticipated that molar extrusion secondary to posterior disclusion in the anterior bite plate group in this study would have resulted in an opening rotation of the mandible. The lack of opening rotation noted in the bite plate group may have been a result of vertical growth of the mandibular ramus that paralleled the rate of posterior tooth eruption.

There was a significant difference between groups for mean time for overbite correction (P = .05). Although the difference between the groups was statistically significant, the one month difference was probably of minor clinical significance.

Many authors have claimed that maxillary incisor intrusion can lead to an unesthetic flattening of the smile arc and have recommended other methods of overbite correction to avoid this deleterious outcome.[9,13,18] The purpose of the current study was to evaluate two different methods of overbite correction and compare the changes in anterior tooth display and the smile arc. The smile arc did flatten during treatment in 5 of 13 bite plate patients and 6 of 17 intrusion arch patients. Overall smile esthetics was not evaluated. It would be misleading to attribute this flattening to the specific process of maxillary incisor intrusion since some patients in both groups experienced flattening of the smile arc during overbite correction. It is possible that the flattening of the smile arc observed was the result of bracket placement and orthodontic alignment unrelated to the overbite reduction procedure.

According to Mackley,[15] one of the most important factors associated with improvement of the smile was a decrease in maxillary incisor show during treatment. This is in contrast to a recommendation by Zachrisson[18] to avoid excessively decreasing lip to tooth distance. Of course, the final determination of vertical anterior tooth positioning goals must be made on an individual basis. If decreasing lip to tooth is an objective of treatment then either method of overbite correction can produce a favorable outcome.

This was a prospective study designed to investigate differences in outcomes from two common treatment modalities used to reduce deep overbite: maxillary incisor intrusion using an intrusion arch and posterior tooth eruption using an anterior bite plate. This study was conducted over a four-year period at the Virginia Commonwealth University Orthodontic Clinic. Resident clinicians, with the aid of an attending faculty member, treated the patients in this study. Some difficulties in patient management were encountered during this study due to the transfer of patients from graduating residents and the changing of some attending faculty. Six patients in the bite plate group had to be excluded from the study because they received intrusion arch mechanics to achieve further overbite correction during the second phase of their treatment. In addition, four patients in the intrusion arch group, whose data were included in the study, received additional intrusion arch therapy for overbite correction during the second phase of their treatment.

With the prospective nature of this study, there may have been an inherent bias in the selection of the two groups that was not controlled. A significant difference in starting mandibular plane angle between groups suggets the treatment modality chosen may have been influenced by a patient’s mandibular plane angle. The intent of the study was to allow practitioners to use their preferred method of overbite correction. However, it is possible that different results from different methods of overbite correction were anticipated thus leading to a selection bias. For example, clinicians may have choosen to use the anterior bite plate in patients with a low mandibular plane angle. No other pre-treatment differences in any parameters were found between the intrusion arch and bite plate groups. Finally, the limited sample size and the attrition of eight patients may have influenced the outcome of this investigation.

In the patient population overall, the flattening of the smile arc that occurred during overbite correction decreased over time. This may have been the result of bracket repositioning and detailing bends that were placed during the finishing phase of treatment. Evaluation of these patients during retention may yield some interesting results. It is likely that changes will occur after active therapy resulting in changes in lip to tooth and smile arch consonance.

Conclusions

Both maxillary incisor intrusion mechanics and use of an anterior bite plate proved to be effective means of reducing overbite in a sample of patients presenting with deep overbite before orthodontic treatment. Both groups of patients experienced significant reductions in maxillary incisor display, increased maxillary and mandibular incisor proclination and mandibular incisor extrusion during treatment. In the intrusion arch group, the center of resistance of the maxillary incisor was significantly intruded during overbite correction. The maxillary incisor incisal edge was significantly more intruded at the end of treatment in the intrusion arch group than the bite plate group. Overall, the patient population experienced flattening of the smile arc during overbite correction but this was not significant by the end of treatment. There were no significant differences between the groups in the appearance of the smile arc at any time. The data from previous studies demonstrate that flattening of the smile arc occurs commonly during orthodontic treatment and the results of this study suggest that this is not necessarily related to the method of overbite correction utilized.

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Appendix A- Intrusion Arch Group

Pre-treatment Post-overbite Post-treatment

M.A.

L.B.

C.D.

L.D.

P.E.

B.G.

C.L

R.L

H.M.

J.M.

B.O.

P.O.

M.P.

K.P.

Appendix B- Bite Plate Group

Pre-treatment Post-overbite Post-treatment

I.C

L.C.

B.D.

L.J.

J.M.

L.L.


T.M.


M.M.


P.S.


N.T.


H.T.


C.W.


C.W.(2)

VITA

Kevin Kelleher was born in Rochester, NY in 1970. He received a Bachelor of Arts in Biology from the State University of New York at Buffalo in 2000. He attended the Medical University of South Carolina and graduated in 2005 with a Doctor of Dental Medicine. He is currently a postgraduate resident in the Orthodontics program at VCU and will receive a Certificate in Orthodontics and a Master of Science in Dentistry degree. Upon graduation, Kevin will enter private practice in Richmond, VA. He is married with one daughter.