Original Article

Comparison between effects of reverse curve of Spee nickel titanium archwire and stainless steel archwires with and without torque on the lower incisors in deep overbite treatment: a randomized control study

Farah Shakhtour[a]; Kazem Al-Nimri[b]

ABSTRACT

Objectives: To compare the effect between three different reverse curve of Spee (RCOS) archwires: 0.016 × 0.022-inch Nickel-Titanium and 0.019 × 0.025-inch stainless steel (SS) with and without crown labial torque (CLT) on lower incisors during deep overbite treatment.

Materials and Methods: Eighty subjects with deep overbite were randomly divided into three groups: the first group (mean age: 20.5 years) received SS RCOS with CLT, the second group (mean age: 19.4 years) was treated with 0.019 × 0.025-inch SS RCOS with zero CLT, the third group (mean age: 18.2 years) was treated with rocking-chair nickel-titanium (NiTi) 0.016 × 0.022-inch with RCOS. Two lateral cephalometric images were taken for each patient, one after alignment and the second after deep bite correction. These images were superimposed using the corpus axis to study the lower incisor horizontal and vertical changes.

Results: The lower incisor angular change was significantly smaller in Group II (−0.3°) compared to Group I (4.8°) and Group III (6.0°, $P \leq .001$). Lower incisor anterior movement was reduced in Group II compared to Group I ($P = .014$) and Group III ($P = .008$). Group III showed significantly more downward movement of the lower Incisors ($P \leq .001$). The three groups showed comparable amounts of true intrusion (1 mm, $P = .536$).

Conclusions: 0.016 × 0.022-inch NiTi and 0.019 × 0.025-inch SS with crown labial torque RCOS archwires resulted in similar proclination and forward movement of the lower incisors. Removal of anterior crown labial torque from the 0.019 × 0.025-inch SS RCOS archwire prevents lower incisor proclination and forward movement. (*Angle Orthod*. 2025;95:27–34.)

KEY WORDS: Deep overbite treatment; Curve of Spee; Lower incisor proclination

INTRODUCTION

Deep overbite correction can be accomplished by many methods. These include labial inclination and intrusion of lower and/or upper anterior segments, downward backward mandibular rotation, and posterior segment extrusion.[1] Posterior extrusion can be achieved by different mechanics; one of these methods is using reverse curve of Spee archwire (RCOS).

[a] Postgraduate Student, Jordan University of Science and Technology, Irbid, Jordan.
[b] Professor of Orthodontics, Jordan University of Science and Technology, Irbid, Jordan.
Corresponding author: Dr Kazem Al-Nimri, Orthodontics, Jordan University of Science and Technology, P.O. Box 3030, Irbid, Jordan (e-mail: ksnimri@just.edu.jo)

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RCOS wires may be either rectangular or round, stainless steel (SS), or nickel titanium (NiTi). This technique of overbite correction produces mainly extrusion of molars and premolars and minimal intrusion of the anterior segment.[2] It has been advocated with criticism that this method causes flaring of the lower anterior segment, while some believe that this side effect is influenced by many factors other than having a RCOS in the archwire.[3] One way to overcome this labial inclination side effect is applying crown lingual torque to the wire to cancel the flaring effect.[4]

The shape and size of the RCOS wire could affect the degree of lower incisor proclination during overbite correction. However, AlQabandi et al.[5] observed similar labial flaring with 0.016 × 0.022-inch rectangular wires in a 0.018-inch slot compared with round wires.

It could be assumed that using a larger rectangular wire with RCOS during leveling will have better control over the inclination of the lower incisors, resulting in less incisor proclination. Additionally, it would be expected that removal of the crown labial torque resulting from adding RCOS to the wire would reduce proclination of the lower incisors. However, there is no clinical study to support these assumptions.

The primary objective of this study was to compare changes in lower incisor inclination and anterior movement during deep overbite treatment using RCOS 0.019 × 0.025-inch SS with crown labial torque and with zero torque and RCOS 0.016 × 0.022-inch NiTi archwires. The secondary objectives were to evaluate the changes in vertical intrusive movement and true intrusion of the lower incisors during deep overbite treatment using RCOS.

The null hypothesis was that there would be no significant difference in the change in inclination and horizontal linear and vertical movement of the lower incisors when SS with and without torque or NiTi RCOS archwires were used to correct deep overbite.

MATERIALS AND METHODS

Trial Design and Any Changes After Trial Commencement

This single-center study was a two-arm parallel randomized clinical trial with a 1:1:1 allocation. The methods were not changed after trial initiation.

Participants, Eligibility Criteria, and Settings

This trial was conducted at the Postgraduate Dental Teaching Clinics at Jordan University of Science and Technology (JUST). The study was approved by the Institutional Review Board Committee at King Abdullah University Hospital/(JUST) in Irbid, Jordan, (#106/118/2018).

Inclusion Criteria

Inclusion criteria were: (1) patients with increased overbite (more than half of the lower incisors), (2) mild skeletal discrepancy assessed by patient profile, (3) no missing or extracted teeth in the lower arch except for third molars, (4) patients whose treatment plan did not include extraction of lower teeth and/or any extrusive mechanics (headgear, functional appliance, expansion appliance), (5) subjects with a brachyfacial facial pattern (mandibular plane angle less than 25°). Exclusion criteria were: (1) partially erupted or unerupted lower permanent second molars, (2) previous orthodontic treatment, (3) poor oral hygiene, (4) patients with severe skeletal discrepancy requiring orthognathic surgery. Informed consent was signed by patients who agreed to participate or their parent if the patient was under 18 years of age.

Interventions

The same orthodontist (F. S.) carried out the orthodontic treatment using fixed appliances with 0.022 × 0.028-inch slot brackets (Victory series, Roth prescription; 3M Unitek, Monrovia, CA, USA). Treatment was started by bonding the upper and lower arches, except for patients in which lower incisor bonding was not possible due to increased overbite and minimal overjet. In those patients, treatment in the lower arch was postponed until the amount of overjet was increased.

After alignment, the patients were divided into three groups and assigned to one of the following treatment protocols:

Group I. For this group, deep overbite was treated by 0.019 × 0.025-inch SS archwire with RCOS. The archwire was placed in all lower brackets and cinched distal to the lower second permanent molars. To ensure that the same depth of RCOS was used for all patients, a customized mold was used to fabricate the RCOS (Figure 1a). The crown labial torque (CLT) that resulted from adding the RCOS was kept in the anterior segment and removed in the posterior segment using two Tweed rectangular pliers (Figure 1c). At each subsequent visit, the wire was checked and restored to its initial depth if flattened.

Group II. For this group, the deep overbite was treated by the same method as Group I except that the CLT resulting from adding the RCOS in the anterior segment was removed using two Tweed rectangular pliers. The torque was considered zero when the Tweed plier holding the anterior wire segment was horizontal (Figure 1b).

Group III. For this group, the deep overbite was treated with RCOS 0.016 × 0.022-inch NiTi archwire (G & H Orthodontics, Franklin, IN, USA). The depth of the curve of Spee in the archwire was similar to that added to the stainless steel wires in Group I and Group II.

Sample Size Calculation

Based on the study of AlQabandi et al,[5] who reported 6.1 ± 3.85° of lower incisor proclination using RCOS, the sample size was calculated using the G*power 3.1.9.4 program. It was determined that a total sample size of 63 subjects should be recruited to achieve a conventional alpha level of (0.05) and desired power (1 − β) of 0.80. To make up for dropouts, 17 additional patients were enrolled (attrition rate of 20%).

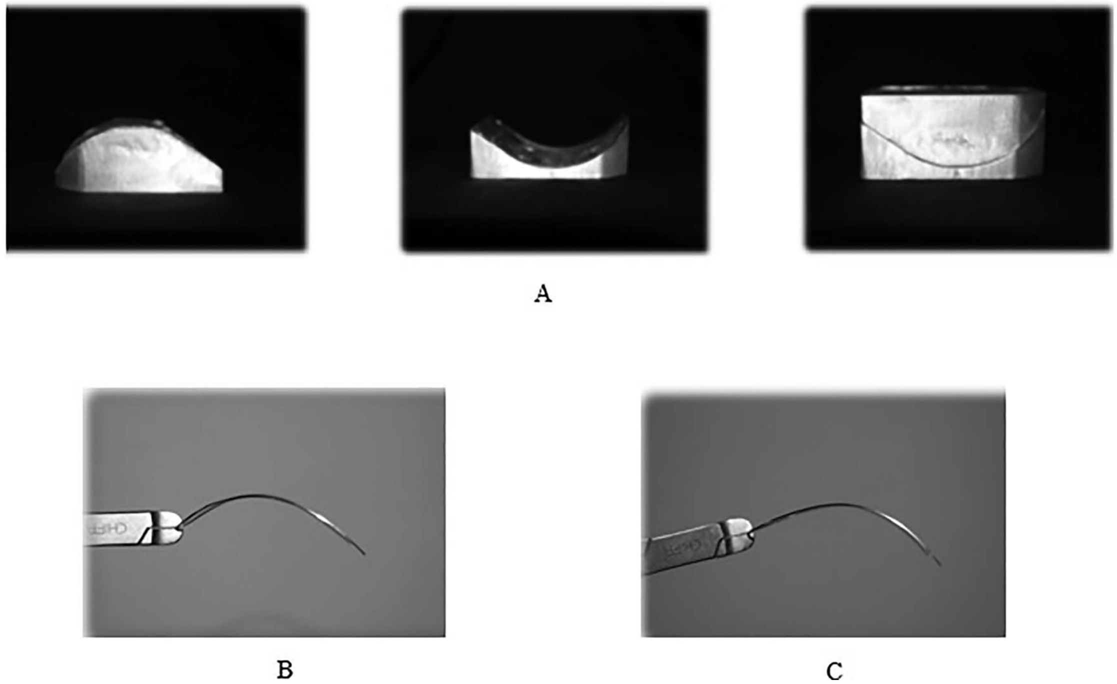

Figure 1. (A) Customized mold used for RCOS standardization. (B) Nontorqued archwire. (C) Torqued archwire. RCOS indicates reverse curve of Spee.

Outcomes (Primary and Secondary)

Lateral cephalograms were taken for all patients after the alignment stage (T1) and after overbite correction (T2). All cephalograms were taken using the same machine (ORTHOPHOS XGPLUS, Dentsply Sirona Company, Charlotte, NC, USA). The cephalometric radiographs in JPEG format were imported to FACAD Orthodontic tracing software (version 3.11.2.1616, Ilexis AB Co., Link « oping, Sweden) to perform cephalometric analysis. Calibration was achieved based on measurement of the x-ray system ruler. Landmark identification was carried out manually on digital images using a mouse-driven cursor.

Primary Outcomes

Twenty-three hard tissue and dental landmarks were identified on each cephalogram (Figure 2). From these landmarks, six planes were constructed (Table 1). To assess mandibular tooth linear dental changes, a horizontal reference line (HRL) was drawn from Protuberance menti, (PM) 30° below the corpus axis and a perpendicular line to the corpus axis passing through PM formed the vertical reference line (VRL) (Figure 3). To measure mandibular dentition changes, T1 and T2 lateral cephalometric radiographs were superimposed on the corpus axis at PM. The horizontal change of the lower incisor tip position was determined by measuring the linear distance between two perpendicular lines drawn from the lower incisor tips at T1 and T2 to HRL (Figure 4). The degree of lower incisor proclination was determined by calculating the change of the lower incisor angle to the corpus axis.

Secondary Outcomes

Vertical change of the lower incisor was the linear distance between two perpendicular lines drawn from the lower incisor tips at T1 and T2 to VRL (Figure 4). By measuring the length of the lower central incisor at

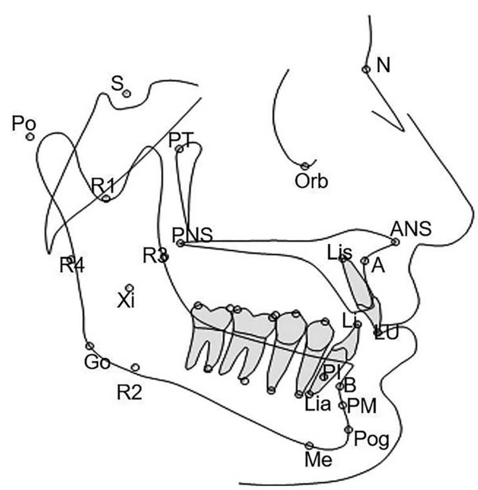

Figure 2. Cephalometric landmarks.

Table 1. Cephalometric Lines and Planes and Their Definition

Dental Landmarks	Definitions
Anterior cranial base (S–N) Plane	Line extending from point sella (S) to point nasion (N).
Frankfort Horizontal (FH) Plane	Line extending from porion (Po) to orbitale (Or).
Mandibular (Mn) Plane	Line extending from gonion (Go) menton (Me).
Maxillary (Mx) Plane	Line extending from the anterior nasal spine (ANS) to the posterior nasal spine (PNS).
Functional Occlusal Plane (FOP)	Line extending from the intersection between the upper and lower first molars posteriorly and between the premolars anteriorly
Corpus Axis (C.A)	Line extending from Protuberance Menti (PM) to (Xi).

(T1) and multiplying this length by 0.66, it was possible to calculate the true vertical movement of the lower incisor. Point I was located two-thirds of the tooth length from the incisal edge along the long axis.[6] Subsequently, the point was moved on the T2 lateral cephalogram and this measurement was repeated on the T1 lateral cephalogram using a transfer line of equal length. The change in Point I was the distance between two perpendicular lines drawn from T1 Point I and T2 point I to VRL.

Measurement Error

To calculate the measurement error, measurement of 10 lateral cephalograms was repeated 2 weeks after the initial tracing. For angular cephalometric measurements, the intraclass correlation coefficient ranged from 0.928° to 0.993° and, for linear measurements, ranged from 0.931 mm to 0.979 mm, indicating that the measurements were reproducible.

Randomization

Participants were randomly allocated into three groups. The allocation sequence was concealed in sequentially numbered, opaque, and sealed envelopes from the investigator (F. S.) responsible for assigning participants into the intervention groups. Each patient was asked to pick a sealed envelope to assign the leveling method.

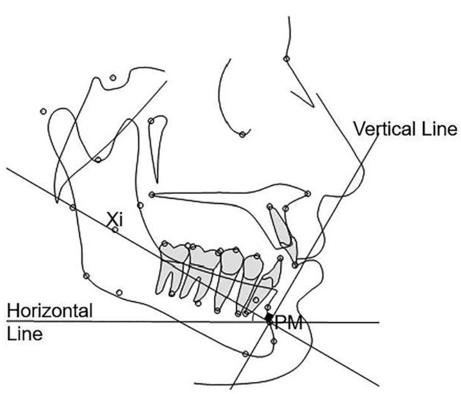

Figure 3. Vertical and horizontal reference lines.

Blinding

Blinding was not possible during intervention and was only applied during data collection and analysis.

Statistical Analysis

Descriptive and analytic statistics were obtained using Statistical Package for the Social Sciences software, version 25.0 (Chicago, Ill). All cephalometric measurements were tested for normality using the Shapiro-Wilk test.

Analysis of variance (ANOVA) test was used to compare the three groups for age, post-leveling overbite, and skeletal and dental measurements. Chi-square test was used to compare the three groups for gender and two-way ANOVA was used to test the significance of age by gender and group.

The comparison of changes that occurred during levelling among the three groups was accomplished

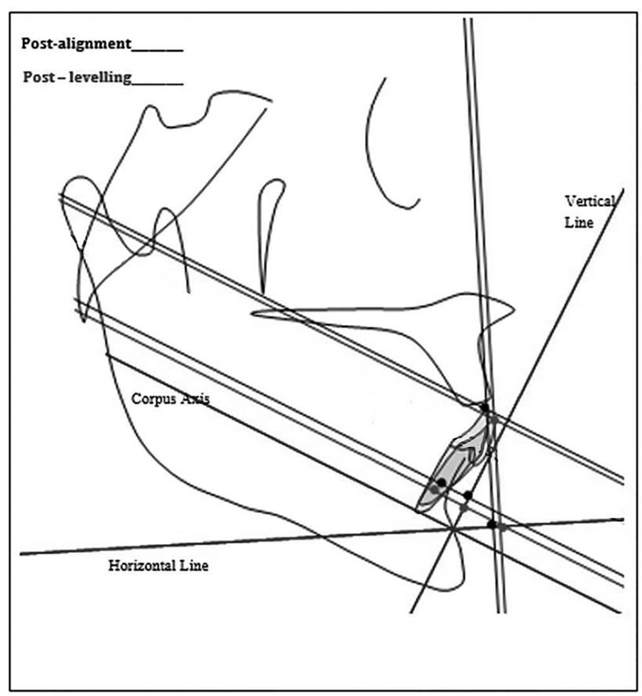

Figure 4. Changes in horizontal and vertical positions of the mandibular teeth.

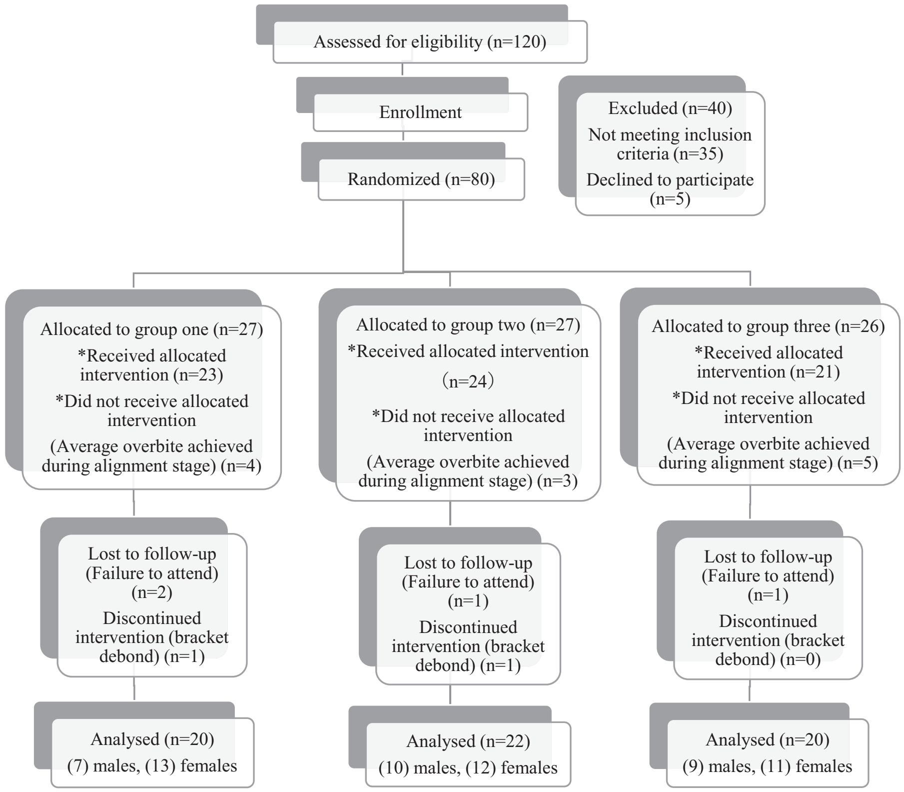

Figure 5. CONSORT flowchart illustrating patient flow during the trial.

by ANOVA and Tukey post-hoc analysis. Significance was set at $P \leq .05$

RESULTS

Subjects

The study involved recruitment of 80 patients and 18 were excluded during treatment, so final analysis was performed for 62 subjects. Four patients were dropped because they failed to show up for their scheduled appointments, two patients were excluded because their brackets debonded and were not rebonded within 24 hours, and 12 patients were excluded because their deep overbite was corrected during the alignment stage (Figure 5).

Demographic Characteristics

There were no significant differences among the three groups regarding gender ($P = .725$) and age ($P = .138$). The mean ages were 20.5 years, 19.4 years, and 18.2 years for Groups I, II, and III, respectively. There was no significant difference among the three groups in gender with regard to age ($P = .73$).

Baseline Data

The three groups were matched in postalignment skeletal and dental measurements (Table 2)

Lateral Cephalometric Changes

Primary outcome. The angular change of lower incisors was significantly smaller in group II (−0.3°) compared to Group I (4.8°) and Group III (6.0°, $P \leq .001$). There was a significant difference in the anterior movement between Group II and Group I ($P = .014$) and Group III ($P = .008$, Table 3). There was no significant difference in lower incisor proclination and forward movement between Group I and Group III (Table 4).

Secondary outcome. Table 3 shows the magnitude of lower incisor downward movement and true intrusion. The lower incisors in group III showed significantly more downward movement (1.945 mm) in comparison to group I (1.01 mm) and II (0.97 mm, $P \leq .001$, Table 4). No significant differences were detected among the three groups in relation to the intrusion of point I ($P = .536$, Table 4).

DISCUSSION

The primary objective of this study was to assess lower incisor proclination and horizontal anterior movement using lower RCOS archwire. The secondary aim was to evaluate lower incisor vertical movement. 0.016 × 0.022 NiTi archwire was used instead of 0.019 × 0.025 NiTi to

Table 2. Comparison of Baseline Skeletal and Dental Measurements and Age Among Three Groups

Variable	Group I		Group II		Group III		*P* value
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	
Age	20.5	4.0197	19.409	3.4731	18.275	2.839	.138
SNA1	83.635	3.6612	81.750	2.3718	83.010	4.0652	.196
SNB1	78.365	3.0266	77.105	2.8961	76.605	3.7616	.216
ANB1	5.270	2.6933	4.655	2.6838	6.420	2.5122	.099
Mn-Mx 1	22.660	6.5155	23.695	7.7083	25.005	6.8212	.577
Interincisal 1	119.895	7.8717	121.136	7.0023	120.235	5.8995	.091
Overbite1	5.115	.4158	5.050	.6435	5.430	.5859	.235
Lower incisor inclination	100.41	4.818	99.577	5.13	96.76	6.179	.088

study the effect of archwire size on the primary and secondary outcomes.

To ensure a valid comparison of treatment outcomes, fundamental demographic characteristics like age, gender, postalignment overbite, and dental and skeletal measurements were assessed to check compatibility among the groups. This helped mitigate potential confounding effects from these factors.

To reduce radiation exposure, the initial lateral cephalometric radiographs were taken after the alignment stage to eliminate potential changes occurring during this stage, ensuring more accurate assessment of the effects of leveling. To assess the horizontal and vertical dental linear changes, the postalignment (T1) and postleveling (T2) lateral cephalograms were superimposed on the corpus axis at the protuberance menti (Pm) as recommended by Ricketts.[7]

Dental Cephalometric Changes

In Groups I and III, the lower incisors proclined and moved forward while, in Group II, despite the presence of about 10° of play between the bracket and the 0.019 $\times$ 0.025 archwire, the removal of crown torque in the anterior segment seemed to prevent these movements. This might have been due to the intrusive movement of the lower incisor, which made the wire tightly contact the upper surface of the bracket slot. There were significant differences in the angular change of lower incisors among the three groups ($P \leq .001$). Group II exhibited the least change in incisor proclination. Additionally, a significant difference in anterior movement of the lower incisors was observed between Group II and Groups I and III. This may have been due to torque removal in the leveling archwire used in Group II.

According to Table 5, the results that were attained in the current study for Groups I and III were comparable to outcomes reported by other studies[2,5,8–10] in terms of the amount of lower incisor proclination. Regarding horizontal movement of lower incisors, results reported by Alzu'bi and Al-Nimri[9] and Nasrawai et al.[8] were similar to changes observed in Group III. The rest of the studies listed in Table 5 reported greater amounts of forward movement. Discrepancies in the average proclination of lower incisors reported previous studies may have been due to various factors, first of which was the use of different archwire dimensions. Second, previous studies documented overall changes in lower incisor inclination, whereas the current study specifically measured the impact of arch leveling. Last, in the current study, all wires were cinched back. Dave and Sinclair[10] did not mention cinching wires, and Alqabandi et al.[5] and Nasrawai et al.[8] specifically stated that cinching was not performed. Elms et al.[11] reported no significant change in axial inclination of the lower incisors in 42 patients after tying back the archwire throughout most of the treatment. The current study was not consistent with the findings of Elms et al.,[11] but was in agreement with Alzu'bi and Al-Nimri[9] who reported 5.94° lower incisor proclination even though the archwire was cinched behind the last molar. Braun et al.[12] proposed that continuous RCOS archwires generated tipping forces on the lower incisors, potentially causing excessive proclination. This proclamation was supported by Clifford et al.,[13] who asserted that increasing the RCOS in the archwire would amplify the downward and forward pressure on the incisor brackets, resulting in greater proclination of the lower incisor crowns and an increase in arch length. Additionally,

Table 3. Mean and Standard Deviation of Horizontal and Vertical Changes in Lower Incisors Between T2 and T1

Variable	Group I	Group II	Group III
Degree of lower incisor proclination	4.83 ± 2.73	−0.31 ± 2.481	6.00 ± 2.56
Lower incisor horizontal movement (mm)	0.51 ± 0.96	−0.01 ± 0.81	0.77 ± 0.639
Lower incisor vertical movement (mm)	−0.97 ± 0.81	−1.01± 0.74	−1.94 ± 0.90
Vertical change in Point I (mm)	−0.78 ± 0.72	−1.03 ± 0.86	−1.01 ± 0.80

Table 4. Comparison of Lower Incisor Inclination and Horizontal and Vertical Changes Among Three Groups

Variable	Difference Between Group I and Group II (GII–GI)	Difference Between Group I and Group III (GIII–GI)	Difference Between Group II and Group III (GIII–GII)
Degree of lower incisor proclination (°)	−5.14***	1.77	6.31***
Lower incisor horizontal movement (mm)	−0.52*	0.27	0.79**
Lower incisor vertical movement (mm)	0.04	0.97***	0.94**
Vertical change in Point I (mm)	0.25	0.24	−0.02

* $P < .05$; ** $P < .01$; *** $P < .001$.

Alqabandi et al.[5] highlighted that the intrusive forces exerted by these archwires, applied labial to the center of resistance of the lower incisors, led to their proclination. As the curve of Spee (COS) was leveled, arch length increased, contributing to further proclination of the incisors. In addition, Pandis et al.[14] proposed that, for every 1 mm of COS leveling, there would be a corresponding 4° of lower incisor proclination.

Using the incisal edges to assess intrusion is misleading, as the position of the incisal edge is influenced by tipping movement of the incisors[15]. In the current study, a point close to the center of resistance of the incisor, referred to as Point I, was selected for measuring absolute intrusion and omitting the effect of root resorption. This method was recommended by Greig.[6]

A significant difference among the groups was found regarding vertical movements caused by the combination of proclination and true intrusion. Group III exhibited the most significant downward movement vertically of the incisal edge compared to Groups I and II ($P \leq .001$). Mitchell and Stewart[16] and Robertson[17] reported a mean of 1.5 mm downward movement of the lower incisor incisal edge when using RCOS archwire. However, Nasrawi et al.[8] reported different vertical downward movement values for different wire types with reverse curve: 0.04 mm with 0.017 × 0.025-inch SS, 0.24 mm with 0.019 × 0.025-inch SS and 0.58 mm with 0.022 × 0.025-inch TMA.

No significant differences were detected among the three groups regarding intrusion measured at Point I ($P = .536$). This was in agreement with the findings of Roberston[17] and Al-Zoubi and Al-Nimri,[9] who found that, in cases treated with RCOS wires, the absolute intrusion of the lower incisor was 1 mm.

According to the results of this study, the null hypothesis was rejected since differences in proclination and movement of the lower incisor were observed among groups. The results of this study were obtained immediately after the leveling stage and it would be interesting to investigate whether these changes would persist through the duration of orthodontic treatment.

CONCLUSIONS

- In cases treated with RCOS 0.016 × 0.022-inch NiTi or 0.019 × 0.025-inch SS wires without removing the crown labial torque, the changes in lower incisor proclination were similar.
- 0.019 × 0.025-inch SS archwire with zero torque prevented proclination and anterior movement of the lower incisors.
- 0.016 × 0.022-inch RCOS NiTi archwire exhibited the highest degree of downward movement of the lower incisor incisal edge.

Table 5. Comparison Between Previous Studies and Current Study in Amount of Proclination and Forward Horizontal Movement of Lower Incisors

Study (Year)	Group	Arch Wire	Proclination (°)	Horizontal moment (mm)
Mitchell and Stewart (1973)	1	Arch wires of succeeding larger diameter	—	2.1
Dave and Sinclair (1989)	1	0.015*0.020 RCOS SS	1.3°	1.5 to A-Pog 0.4 to NB
Alqabandi et al. (1999)	G1	0.016 RCOS SS	6.75°	
	G2	0.016*0.022 NiTi RCOS then 0.016*0.022 RCOS SS	6.10°	
Bernstein et al. (2007)	1	0.016* RCOS then 0.016*.022 RCOS and ending with 0.017*0.025 RCOS SS	0.83°	1.5 L-APog
Nasrawai et al. (2022)	G1	0.017*0.025 SS RCOS	4°	0.78
	G2	0.019*0.025 SS RCOS	4°	1.05
	G3	0.021*0.025 RCOS TMA	4°	1.04
Alzu'bi et al. (2022)	1	0.016*0.022 RCOS NiTi	5.5°	0.761
Current study	G1	0.019*0.025 SS RCOS-T	4.8°	0.51
	G2	0.019*0.025 SS RCOS	0.3°	−0.014
	G3	0.016*0.022 RCOS NiTi	5.98°	0.77

- No significant difference in true intrusion of the lower incisors was detected among the groups.

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