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DEEP BITE CORRECTION USING AUXILIARY INTRUSION CANTILEVERS WITH INITIAL ARCH WIRES IN ADOLESCENTS

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Abstract:

Deep overbite is a challenging malocclusion facing orthodontists and numerous treatment options were proposed to correct it. The intrusion of lower incisors is found to be particularly practical in patients with adequate upper incisor display.

Aim of the study: *The purpose of this study is to compare deep overbite correction using auxiliary cantilever springs to relative intrusion during initial stages of orthodontic treatment.*

Materials and methods: *Thirty patients exhibiting deep overbite malocclusion were divided into test and control groups. Test group received auxiliary cantilever springs on top of leveling arches to intrude lower incisors. Control group received sequential leveling arch wires. Treatment effect was evaluated after six months by using lateral cephalometric radiographs to assess incisors, molars and premolars changes. Comparison between T0 (preoperative) and T1 (6 months postoperative) within each group was done using paired samples T-test, while comparison of mean difference of different parameters between both groups was done using Mann-Whitney U test.* ***Results:*** *A mean overbite reduction of 3.2 mm was found in the experimental group. Incisor intrusion was found to be significant in the test group with a mean of -1.33 and -1.31 when measured from center of resistance and apex. Distal tipping of lower 1st molars was significant in the experimental group (P<0.001) while premolar extrusion was more significant in the control one.*

Conclusion: *Deep bite correction can be achieved during the leveling and alignment phase using cantilever springs with lower incisors intrusion without significant difference in labial tipping other than that created by relative intrusion with continuous sequential archwires.*

Introduction:

Deep overbite is one of the most widespread and challenging problems facing orthodontists [1,2]. It was found to be presented in 65.5% of the Egyptian orthodontic patients [3].

The sequelae of untreated deep overbite include incisal wear, gingival recession, palatal impingement, generalized compromised esthetics [1,4] as well as muscle imbalance leading to improper functional occlusion [5].

Non-surgical treatment options for deep over bites are either; molar extrusion, incisor intrusion, incisor proclination or a combination between any of the previously mentioned [4,6] .When selecting between these options some factors should be considered first; as where the occlusal plane should be placed, the amount of mandibular growth anticipated and the vertical dimension desired at the end of the treatment [7].

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Upper incisor intrusion has been classically used for the correction of deep overbite. However, the amount of upper incisal show during rest decides where should the occlusal plane be placed [8]. Hence, lower incisor intrusion is considered a viable treatment option in patients with optimal upper incisal show [4,9].

Many designs of intrusion arches were introduced in the literature. Ricketts and Burstone pioneered in this field as they were able to introduce the utility arches [10] and segmented intrusion arches [7], respectively. Other mechanical methods used are the reverse curve of Spee archwires and the Connecticut Intrusion Arches [11].

The mechanics of deep overbite correction by intrusion arches has been an argumentative subject. Early studies [12,13] showed that deep bite correction was mainly achieved by the extrusion of posterior teeth with little contribution of incisor intrusion. It was then suggested that the use of light constant forces ranging from 10-15 g per tooth [14] enables incisors intrusion and allows the occlusal forces to minimize posterior vertical anchorage loss manifested in posterior extrusion [15,16].

It is believed that deep overbite correction is necessary to properly reduce overjet, especially in Class II, division 1 extraction cases; where the palatal aspects of the maxillary incisors could interfere with the mandibular incisors, causing lingual tipping and loss of anchorage [17]. In conventional orthodontic treatments this would be achieved following the leveling and alignment phase.

The procedure of orthodontic intrusion is usually associated with periodontal changes. Various studies investigated the correlation between incisor intrusion and the periodontal changes [18–20].

In animals with healthy periodontium, relatively low intrusive loads led to minor decrease in the height of alveolar bone [21]. Whereas in humans; a study by Erkan *et al.*[19] found that the gingival margin moved in the same direction with teeth creating no change in the pocket depths and no change in keratinized gingiva. Other studies found that orthodontic intrusion could be a potent method in improving the periodontal condition if associated with proper periodontal treatment[18,22]. Thus, when signs of periodontal breakdown appears in orthodontically treated patients, it is presumably due to inflammation and plaque accumulation [23].

In an attempt to decrease the prolonged orthodontic procedure, it was suggested that auxiliary intrusion arches or cantilever springs are combined with resilient archwires during initial stage of treatment. [24].

Literature is abundant in ways to optimize the antroposterior correction time while there is scarcely any evidence regarding the optimization of vertical dimension correction. The aim of this study is to evaluate the treatment effect of using the assembly of auxiliary intrusion cantilevers and initial resilient archwires in adolescents in deep overbite correction and the leveling of the curve of Spee in the initial stages of treatment. Effects of this assembly on periodontal parameters have also been investigated.

The null hypothesis designates no difference in deep overbite correction, either in the positions of lower incisors or molars using cantilever springs on top of resilient wires when compared to relative intrusion using resilient sequential archwires alone.

Materials and Methods:

Trial design:

The study is a single centered, two-arm controlled clinical trial. The review board and ethics committee's approval of the faculty of dentistry in Alexandria university was granted with a serial number of (0049-08/2019).

Participants, eligibility criteria and settings:

Patients were selected from the waiting lists of the Department of Orthodontics at Alexandria university. Fifty candidates were investigated at first where only 30 were found to meet the study's inclusion criteria and accepted to join. Written consents were obtained from guardians after explaining the method of treatment and its implications.

Inclusion criteria

- Class I or II skeletal patterns.

- Overbite exceeding 3 mm.

- Full set of permanent dentitions.

- Minimal or no crowding in lower anterior teeth (< 3mm).

- Age range of 12-17 years.

Exclusion criteria

- Patients requiring lower extractions.
- Patients with previous orthodontic treatment.
- Syndromic manifestations or skeletal asymmetries.
- Patients with any periodontal involvement, developmental anomalies, or previous root canal treatment of lower anteriors.

Intervention:

Thirty deep bite patients were randomly allocated to either test or control group, where all of them needed lower incisor intrusion. Before treatment (T0), cephalometric radiographs, along with study casts, periodontal charts of the pocket depths of lower incisors and measurements of the width of the keratinized gingivae were obtained for all patients. Patients in the test group received intrusion springs instantly in the first visit (Figure 3).

Orthodontic procedure:

All patients received a full set of 0.022" slot brackets (Mini 2000, Ormco®.USA) with Roth prescription in upper and lower arches. Lower first molars received double tubed bands with 0.022" slots (Ormco®.USA) while lower 2nd molars received single bondable tubes with the same gauge (Ormco®.USA). Upper arches were treated in a way convenient to each case whether upper extractions were needed or not.

In the study group, patients received their lower leveling arches which were engaged in all brackets and cinched behind 2nd molars. The sequence of used wires in lower arch was altered according to the needs of each patient, only one patient started leveling phase with 0.012" NiTi, while the rest started with 0.014" NiTi wires, then were leveled up to 0.016"

NiTi or 0.018” NiTi and ending with 0.016” x 0.022” NiTi archwire (Ormco®.USA).

The leveling arches were piggy backed with auxiliary cantilever springs that were customized from an 0.017” x 0.025” TMA archwire (Ormco®.USA) and inserted into the auxiliary tubes on 1st molars with tip back bends. Springs were then attached distal to the lower laterals with the aid of preformed hooks from the same wire delivering an intrusive force of 20-40 g per side (Figure 1).

Patients in the control group obtained the regular lower leveling arches to create relative intrusion starting with 0.014” NiTi wires.

Follow up:

For six consecutive months, each patient was checked every three to four weeks for routine changes in the wires. In the test group, intrusion forces were checked with force gauge and the basal leveling arches were changed accordingly.

Lateral cephalometric x-rays, dental casts and periodontal charts were repeated after six months of treatment (T1).

Outcome measures:

Primary outcomes were all obtained from cephalometric radiographs where 5 linear and 2 angular measurements were obtained (Table 1) and (Figure 2).

Secondary outcomes comprised of measuring the depth of curve of Spee, depth of gingival sulcus and keratinized gingiva.

The curve of Spee was measured on dental casts by calculating the mean of the right and left side maximum depths from a flat plane formed by the tips of the mandibular incisors anteriorly and the distal cusp tips of the second molars posteriorly.

Gingival sulcus depths were measured with the aid of a Michigan O periodontal probe (ProDent ® USA); where three points were measured around each lower incisor (mesial, distal and mid-labial). A total of 12 readings was obtained from each patient, and an average mean was calculated to detect the amount of change in pocket depths.

Width of keratinized gingiva from free gingival margin to the mucogingival junction was measured at mid-labial point of each lower incisor and again an average mean was calculated for each patient.

Sample size estimation:

Sample size was calculated assuming 80% study power and 5% alpha error. Varlık *et al.* [9] reported mean (SD) increase in lower incisor intrusion= 2.6 (1.4) after applying an intrusion protocol, while Weiland *et al.* [13] reported mean (SD) increase in lower incisor intrusion= 1.03 (1.55) after continuous leveling and alignment. Based on comparison of means, the minimum sample size was calculated [25,26] to be 14 per group, increased to 15 to make up for cases lost to follow-up. The total sample size= number of groups × number per group= 2 × 15= 30 patients.

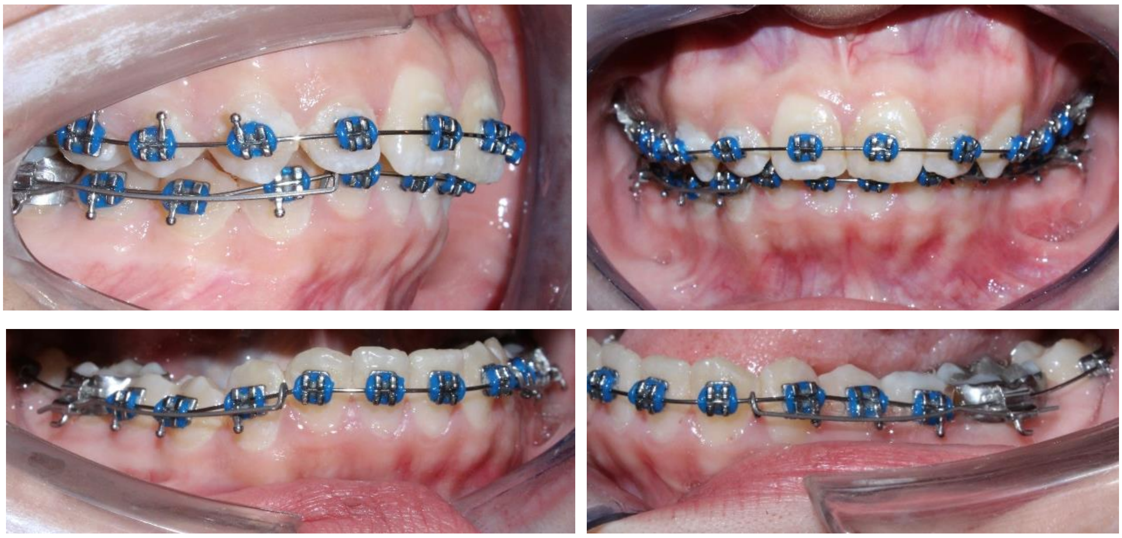


Figure 1: 0.017” x 0.025” TMA cantilever spring on top of the leveling archwire.

Figure 3.2: 1- Overbite: Perpendicular distance between incisal edges of maxillary and mandibular central incisors, perpendicular to occlusal plane.
2- L1 to MP: Angle formed by the long axis of mandibular central incisor and mandibular plane.
3- L1CR to MP: Perpendicular distance from mandibular plane to center of resistance.
4- L1 inc. to MP: Perpendicular distance from mandibular plane to incisal edge
5- L1 apex to MP**:** Perpendicular distance from mandibular plane to apex of lower incisor.
6- L6 tip to MP: Perpendicular distance from mandibular plane to mesio-buccal cusp tip of the lower first molars.
7- L6 to MP : Angle formed between the long axis of lower 1st molar and mandibular plane

Table 1: Outcome measures obtained from cephalometric radiographs.

Parameter	Description
1. Overbite	Distance between incisal edges of maxillary and mandibular central incisors, perpendicular to occlusal plane.
2. L1 to MP (◦)	Angle formed by the long axis of mandibular central incisor and MP*
3. L1CR to MP (mm)	Perpendicular distance between the CR** of mandibular central incisor and MP
4. L1 inc. to MP (mm)	Perpendicular distance between the incisal edge of the lower central incisor and MP
5. L1 apex to MP (mm)	Perpendicular distance between the apex of the lower central incisor and MP
6. L6 tip to MP (mm)	Perpendicular distance between the mesio-buccal cusp tip of the lower first molars and MP
7. L6 to MP (◦)	Angle formed between the long axis of lower 1st molar and MP
8. L5 Cusp tip-MP (mm)	Perpendicular distance between the buccal cusp tip of the lower 2nd premolar and MP
9. L5 MP (°)	Angle formed between the long axis of lower 2nd premolar and MP

*MP: Mandibular plane created by line joining the center of Gonion (Go) and Menton (Me).
**CR: Center of resistance located 1/3 distance of the root length of lower incisor apical to alveolar crest.

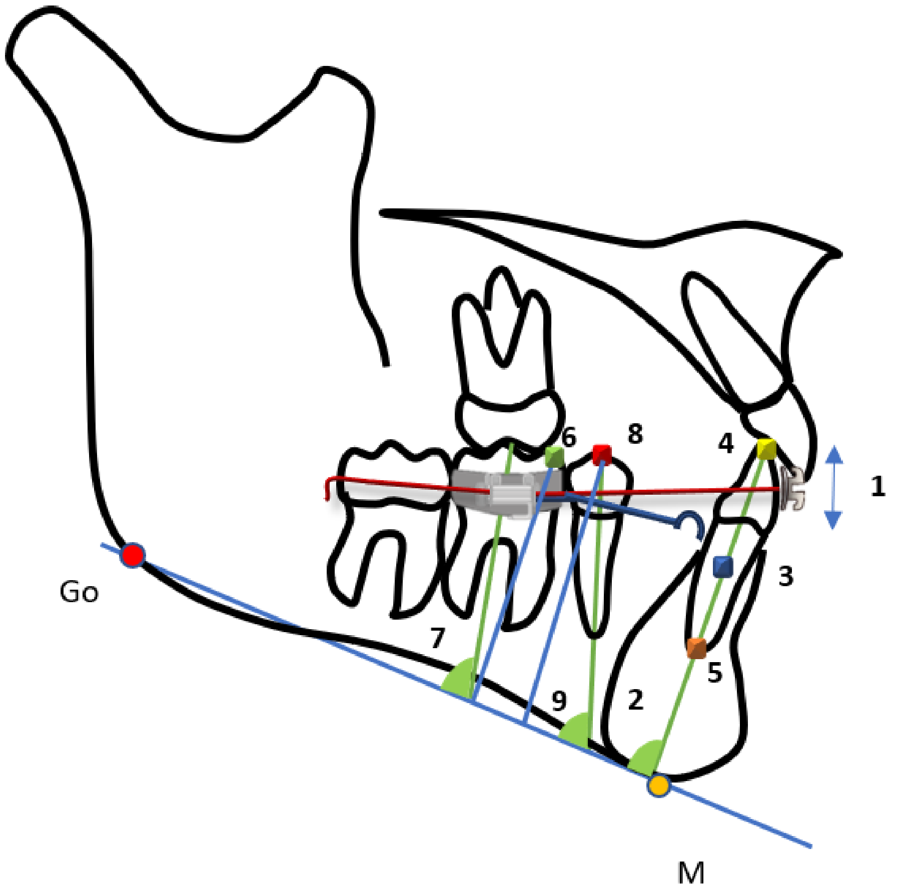


Figure 2: 1- Overbite: Perpendicular distance between incisal edges of maxillary and mandibular central incisors, perpendicular to occlusal plane.
2- L1 to MP: Angle formed by the long axis of mandibular central incisor and mandibular plane.
3- L1CR to MP: Perpendicular distance from mandibular plane to center of resistance.
4- L1 inc. to MP: Perpendicular distance from mandibular plane to incisal edge
5- L1 apex to MP**:** Perpendicular distance from mandibular plane to apex of lower incisor.
6- L6 tip to MP: Perpendicular distance from mandibular plane to mesio-buccal cusp tip of the lower first molars.
7- L6 to MP: Angle formed between the long axis of lower 1st molar and mandibular plane.
8- L5 Cusp tip-MP: Perpendicular distance between the buccal cusp tip of the lower 2nd premolar and MP
9- L5 MP: Angle formed between the long axis of lower 2nd premolar and MP

Statistical analysis:

Normality was tested for all variables using descriptive statistics, plots (Q-Q plots and histogram), and normality tests. All variables showed normal distribution, so means and standard deviation (SD) were calculated, and parametric tests were used. Comparisons between test and control groups were done using independent samples t-test with calculation of mean difference and 95% confidence intervals (CI). Comparisons between T0 and T1 within each group were done using paired samples t-test. Comparison of mean difference of different parameters between both groups were done using Mann-Whitney U test. Significance was set at p value <0.05. Data were analyzed using IBM SPSS for Windows (Version 23.0).

Error of method and assessment of reliability:

To test for reliability, both investigators traced and measured ten randomly selected radiographs. Measurements by the first investigator were done at least 2 weeks after the first measurement. Paired sample t tests showed no significant difference between the 1st and 2nd sets of measurements of the first and second investigator. Intra- and inter-examiner reliability was calculated, and the Intraclass Correlation Coefficient (ICC) ranged from 0.785 to 0.999, indicating good to excellent agreement between the examiners and over time.

Results:

Fifty patients were initially examined to participate in the study. Twenty subjects were excluded as they either did not satisfy the inclusion criteria (n = 19) or declined to participate (n = 1). Baseline data were reported in (Table 2). Both test and control groups at the launch of the study showed no statistically significant difference in terms of age, gender distribution or malocclusion.

Cephalometric measurements (Table 3)

A statistically significant reduction in overbite was found in both test and control groups with mean difference of (-3.20 0± 1.72) mm for the test group (P < 0.001). While the control group showed a mean reduction of (-1.11 ±1.55) mm (P = 0.02). The P value of the difference between both groups at (T1-T0) was also found significant in favor to the test group (P < 0.001).

The amount of incisor proclination following intrusion in test group was found to be increased with a mean of (7.13 ± 5.78) degrees which led to a high significance of < 0.001. The mean amount of proclination in the control group was also significant (5.50 ±6.81) degrees. Difference between test and control groups at T1 was found to be significant (0.02) with more proclination in favor of the former. However, the difference in incisor inclination between both groups at T1-T0 was not statistically significant.

Three different cephalometric parameters were used to investigate incisor intrusion; which are the distance between mandibular plane to each of the following; the center of resistance (L1 Cr: MP), incisal edge (L1 Inc.: MP), and apex of the lower incisor (L1 Apx.: MP). All three parameters showed statistically significant reduction (P≤ 0.001) in the test group with means of (- 1.33± 1.01) mm, (-1.37±1.22) mm and (-1.31 ± 1.06) mm respectively.

Although control group showed some incisor intrusion; yet, none of the parameters were significantly different. The means for intrusion parameters were as follows; -0.14± 1.26 mm decrease in the distance between center of resistance and mandibular plane, -0.29 ± 1.50 mm difference in the distance between incisal edges and mandibular plane, and an increase with 0.14 ± 1.75 mm in the distance between apices to mandibular plane.

The difference between test and control groups when measuring the distance between center of resistance and mandibular plane was significant both at T1(P = 0.04) and at T1-T0 (P = 0.04). Additionally, the distance between incisal edges and mandibular plane was significant between the two groups at T1 (P = 0.03) and at T1-T0 (P = 0.04). Distance between apices and mandibular plane showed significant difference between two groups at T1 (P= 0.04) and T1-T0 (0.03) with more intrusion accompanying test group.

Experimental group resulted in more molar extrusion with a mean of (1.27 ±1.57) mm and the results were significant with a P value of 0.007. On the other hand, control group showed difference of (0.21 ±1.58) mm and a P value that was not significant. Difference between two groups at (T1- T0) was not statistically significant.

Distal tipping of first molars as an outcome of the anterior intrusive forces was detected with the angle created between their long axes and the mandibular plane. Test group showed a significant distal molar tipping with a mean of (11.00 ± 5.13) degrees and P value of <0.001, while control one showed an insignificant amount of tipping (1.64 ± 3.25) degrees (P = 0.08). The difference between both groups at T1 and at (T1-T0) was significant (P<0.001).

The distance between buccal cusps of lower 2nd premolars and mandibular plane was increased significantly in both test and control groups (0.045 and 0.004). However, control group showed more premolar extrusion which led to a significance in the difference between two groups at T1 (P=0.01) and at (T1-T0) (P < 0.001). No change was found in the axial inclination of 2nd premolars in both groups.

Flattening of the curve of Spee (Table 4):

The leveling of curve of Spee was significant in both study arms, with a higher significance in in favor of the test group (P < 0.001) both at T1 and T1-T0.

Periodontal parameters (Table 5, Figures 4&5)

There was a statistically significant increase in pocket depths in both test and control groups. The average increase was (0.48 ± 0.43) mm for the test arm and (0.27 ± 0.18 mm for the control one. P values were significant for both arms with values of (0.006) and (0.003) respectively. However, the difference between the groups was not statistically significant. The within- and between-group comparisons of the width of keratinized gingiva showed no statistically significant difference, where the change in test group was (-0.15 ± 0.34) mm and the control group was (0.00 ± 0.53) mm. The difference between the two groups (T1-T0) was also not significant.

Table 2: Baseline characteristics of the two study groups.

<table>
<tr><th colspan="2"></th><th>Test (n=15)</th><th>Control (n=15)</th><th>P value</th></tr>
<tr><td colspan="2">Age (mean (SD)</td><td>14.79 (1.65)</td><td>15.14 (1.23)</td><td>0.52</td></tr>
<tr><td rowspan="2">Gender: n (%)</td><td>Male</td><td>6 (40%)</td><td>7 (46.7%)</td><td rowspan="2">0.71</td></tr>
<tr><td>Female</td><td>9 (60%)</td><td>8 (53.3%)</td></tr>
<tr><td rowspan="2">Malocclusion: n (%)</td><td>Class I</td><td>4 (26.7%)</td><td>8 (53.3%)</td><td rowspan="2">0.25</td></tr>
<tr><td>Class II</td><td>11 (73.3%)</td><td>7 (46.7 %)</td></tr>
<tr><td colspan="2">Bite gauge in mm (mean (SD)</td><td>6.07 (1.79)</td><td>5.32 (1.05)</td><td>0.19</td></tr>
</table>

*Statistically significant at p value <0.05

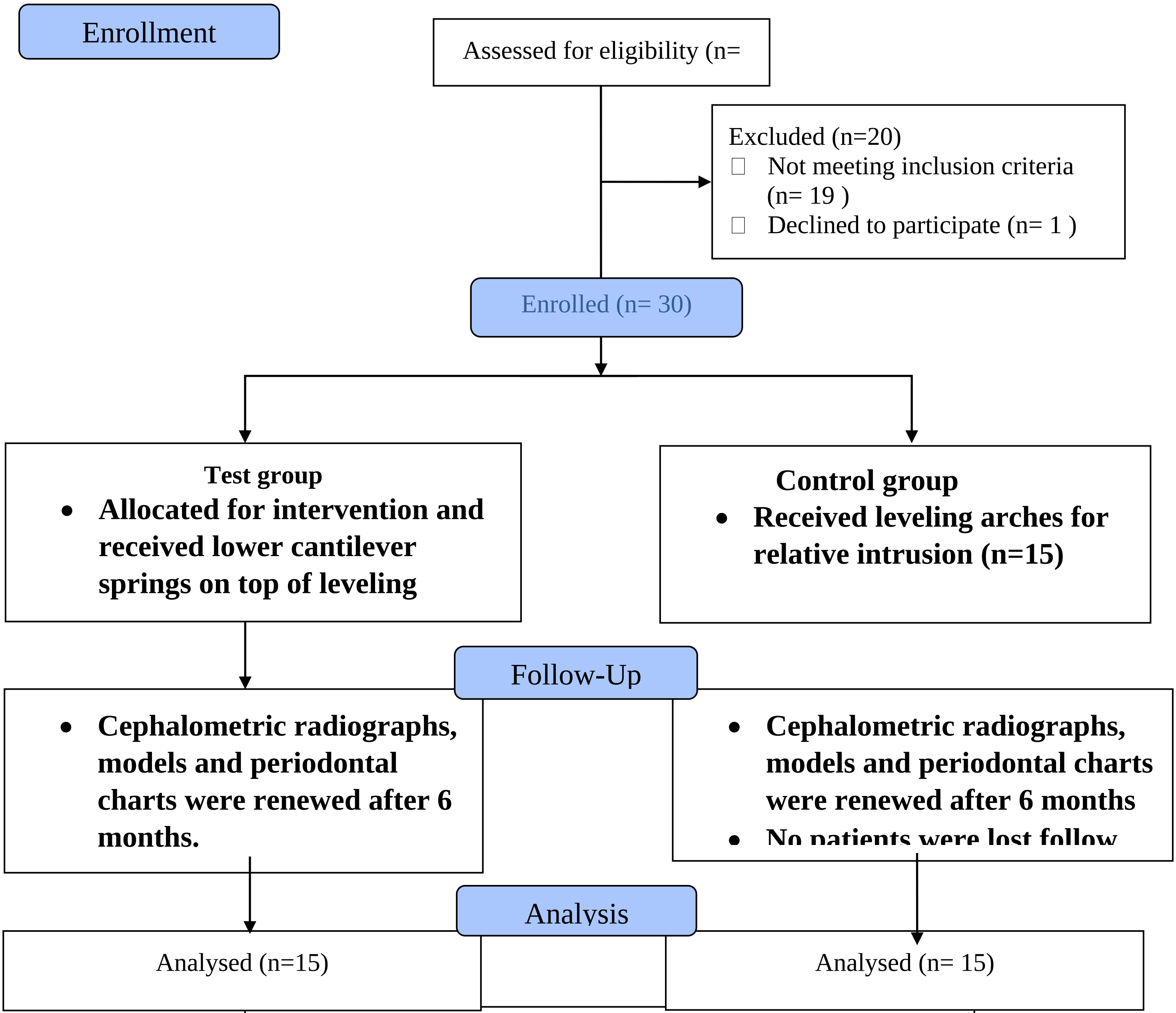


Figure 3: CONSORT flow chart showing patient flow during the trial.

Table 3: Cephalometric results.

		Test	Control	Difference Test-Control	95% CI	P value
		Mean (SD)				
Overbite	**T0**	6.07 (1.79)	5.32 (1.05)	0.75	-0.38, 1.87	0.19
	T1	2.87 (1.71)	4.21 (1.44)	-1.35	-2.55, -0.14	***0.03****
	Difference	-3.20 (1.72)	-1.11 (1.55)	-2.09	-3.34, -0.84	***<0.001****
	P value	***<0.001****	***0.02****			
L1 MP°	**T0**	96.80 (6.75)	92.79 (6.12)	4.01	-0.91, 8.94	0.11
	T1	103.93 (5.73)	98.29 (5.00)	5.05	1.02, 9.07	***0.02****
	Difference	7.13 (5.78)	5.50 (6.81)	1.03	-3.56, 5.63	0.65
	P value	***<0.001****	***0.01****			
L1 Cr: MP (mm)	**T0**	25.40 (3.23)	26.39 (2.80)	-0.99	-3.30, 1.32	0.39
	T1	24.07 (3.03)	26.25 (2.71)	-2.18	-4.38, -0.01	***0.04****
	Difference	-1.33 (1.01)	-0.14 (1.26)	-1.19	-2.06, -0.32	***0.04****
	P value	***<0.001****	0.68			
L1 Inc.: MP (mm)	**T0**	38.00 (3.77)	39.54 (3.14)	-1.54	-4.19, 1.12	0.24
	T1	36.63 (3.40)	39.25 (2.88)	-2.62	-5.03, -0.21	***0.03****
	Difference	-1.37 (1.22)	-0.29 (1.50)	-1.08	-2.12, -0.04	***0.04****
	P value	***0.001****	0.49			
L1 Apx Mp (mm)	**T0**	16.58 (2.83)	17.25 (2.69)	-0.67	-2.54, 1.83	0.58
	T1	15.27 (2.79)	17.39 (2.47)	-2.13	-4.14, -0.11	***0.04****
	Difference	-1.31 (1.06)	0.14 (1.75)	-1.41	-2.68, -0.43	***0.02****
	P value	***<0.001****	0.77			
L6 Cusp Tip-MP (mm)	**T0**	27.27 (3.23)	28.71 (3.06)	-1.45	-3.85, 0.95	0.23
	T1	28.53 (3.07)	28.93 (2.19)	-0.40	-2.44, 1.65	0.70
	Difference	1.27 (1.57)	0.21 (1.58)	1.05	-0.15, 2.25	0.10
	P value	***0.007****	*0.62*			
L6 MP°	**T0**	86.00 (5.32)	86.43 (2.77)	-0.43	-3.69, 2.84	0.79
	T1	75.00 (5.84)	84.79 (4.15)	-9.79	-13.67, -5.90	***<0.001****
	Difference	-11.00 (5.13)	-1.64 (3.25)	-9.36	-12.66, -6.06	***<0.001****
	P value	***<0.001****	0.08			
L5 Cusp tip-MP (mm)	**T0**	28.00 (0.76)	28.79 (1.37)	-0.79	-1.65, 0.08	0.07
	T1	28.60 (1.24)	30.21 (1.88)	-1.61	-2.85, -0.38	***0.01****
	Difference	0.60 (1.06)	1.42 (1.93)	-1.33	-2.01, -0.65	***<0.001****
	P value	***0.045****	***0.004****			
L5 MP°	**T0**	79.53 (4.14)	80.00 (4.65)	-0.47	-3.95, 3.02	0.79
	T1	78.73 (2.58)	77.25 (5.64)	1.48	-1.88, 4.84	0.37
	Difference	-0.80 (1.66)	-2.75 (4.43)	1.95	-0.96, 4.86	0.17
	P value	0.08	0.06			

*Statistically significant at p value <0.05

Table 4: Depth of the curve of Spee.

Curve of Spee	**T0**	3.60 (0.74)	3.59 (0.49)	0.009	-0.52, 0.54	0.97
	T1	0.73 (0.94)	2.45 (1.04)	-1.72	-2.53, -0.92	***<0.001****
	Difference	-2.87 (0.72)	-1.14 (0.78)	-1.73	-2.34, -1.12	***<0.001****
	P value	***<0.001****	***0.001****			

*Statistically significant at p value <0.05

Table 5: Periodontal pocket depth and width of keratinized gingivae in the two groups.

		Test	**Control**	**Difference Test-Control**	**95% CI**	**P value**
		Mean (SD)				
Average pocket depths	**T0**	2.92 (0.47)	3.13 (0.21)	-0.21	-0.59, 0.18	0.28
	T1	3.40 (0.58)	3.40 (0.34)	0.004	-0.49, 0.50	0.99
	Difference	0.48 (0.43)	0.27 (0.18)	0.21	-0.13, 0.56	0.32
	P value	***0.006****	***0.003****			
Average width of keratinized gingivae	**T0**	2.80 (0.35)	2.63 (0.52)	0.18	-0.29, 0.64	0.43
	T1	2.65 (0.47)	2.63 (0.52)	0.03	-0.47, 0.52	0.92
	Difference	-0.15 (0.34)	0.00 (0.53)	-0.15	-0.59, 0.29	0.57
	P value	0.19	1.00			

*Statistically significant at p value <0.05

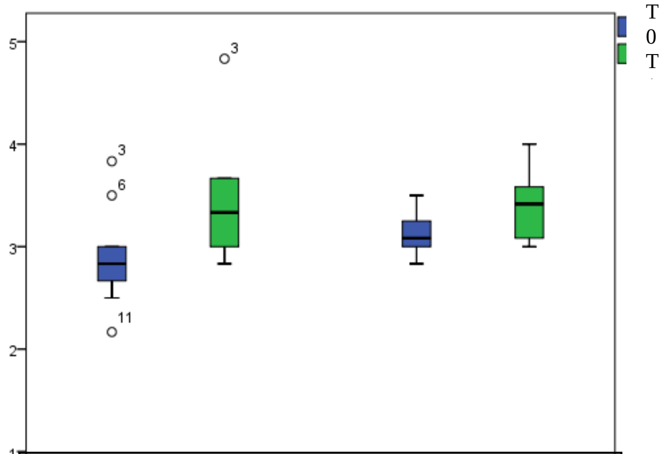
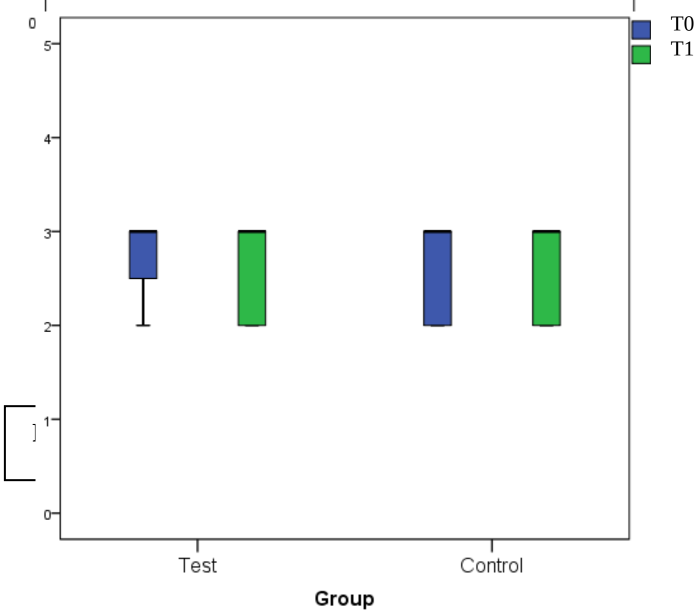


Figure 4: Average pocket depth at T0 and T1.



Discussion:

The applicability of deep overbite correction with true intrusion has been a controversial research topic. Our current study aimed at evaluating the possibility of early incisor intrusion and deep bite correction during leveling and alignment phase with cantilever springs and comparing it to relative intrusion using sequential arches. Both groups were evaluated in terms of deep overbite correction, incisor intrusion, incisor flaring, premolar and molar extrusion along with periodontal changes. The null hypothesis in this study was that there was no difference in deep overbite correction, either in the positions of lower incisors or molars using cantilever springs on top of resilient wires when compared to relative intrusion using resilient sequential archwires alone. Based on the results the null hypotheisis was rejected.

The mean overbite reduction in the study was 3.20 mm in test group which is less than what was found by Varlik *et al.* [9] (3.9 mm) when using utility arches but more concurrent with what Weiland *et al.* [13] found which was 3.17

and 3.56 for continous and segmented mechanics, respectively. Results of the control group in this study showed an overbite reduction of 1.11 mm which although significant, yet the test group showed greater overbite correction.

Different reference points were used to assess true intrusion in previous studies; where some used the distance from the lower incisal edge to the mandibular plane [27,28], others used the center of resistance [13,29,30] but these points were found to be susceptible to greater incisor intrusion readings when incisors are more labially tipped [9,14]. In order to reduce these false readings, a third measurement was added, which is the distance between lower incisors apices and the mandibular plane. There are scarcely any previous trials that measured the amount of intrusion via the distance between lower incisors apices and mandibular plane.

In the current study the mean intrusion of incisors was (-1.33 ±1.01) mm when measuring from the center of resistance, (-1.37 ±1.22) mm when measuring from the incisal edge and (-1.31 ±1.02) mm when measuring from apices to mandibular plane. Comparing these results using cantilever springs to other results obtained when using different mechanics in literature, Weiland *et al.*[13] reported 1.72 mm incisal intrusion when using segmented Burstone's mechanics. Other authors, Aydoğdu and Őzsoy[29] Greig [30] and Dake and Sinclair [28] found a mean intrusion of less than 1mm, 1mm and 1.2 mm, respectively, using utility arches. On the other hand, Varlik *et al.* [9] noted a higher mean of intrusion of 2.66 ± 1.4 mm, which might be attributed to the retrospective study design where the included cases were not treated by the same operator.

The use of cantilever springs on top of resilient leveling arches in this study was found to create a significant amount of proclination with a mean of 7.13 degrees. Although cinching the wire behind 2nd molars did not hinder incisor proclination, yet, these findings where concurrent with Aydoğdu and Őzsoy[29] where mean incisor proclination was 8 degrees when using utility arches. On the contrary a mean of 5.3° was found by Dake and Sinclair[28], which is due to the lingual crown torque that is added at the anterior segment of utility arches.

Relative intrusion with sequential arches in the control group of this study created a lesser but significant amount of proclination with a mean of 5.50 degrees. Similarly ,Weiland *et al.* [13] found significant proclination when using continuous arch mechanics (5.71°) while there was more control upon anterior flaring when using Burstone's segmented arch mechanics (3.94°).

The contribution of molar extrusion in correction of deep overbite is debatable. In this study, significant molar extrusion was found in the experimental group with a mean of 1.27 mm. Greig [30] found a strong correlation between molar extrusion and correction of deep overbite, where molars significantly extruded with a mean of 2.3 mm, while Varlık *et al.*[9] correlated the correction of deep overbite to incisor intrusion rather than molar extrusion which showed a mean extrusion of 0.8 mm. However, deep overbite correction in this study can be attributed to both molar extrusion and incisor intrusion.

In a study by Rozzi *et al.* [27] the flattening of the curve of Spee was found to be secondary either to molar extrusion and uprightening or to incisor intrusion; which differs according to patients' facial patterns. Accordingly; in this study, leveling of the curve of Spee can be attributed to incisor intrusion in the test group and to premolar extrusion in the control one, where premolar extrusion was more significant.

Periodontal changes in the form of pocket depths were aggravated both in test and control groups, however; there was no significant difference between groups at (T1-T0). These conclusions are consistent with a systematic review published by Cerroni *et al.* [31] which found that there are no high score evidence that orthodontic mechanics influence the periodontal status, and when it happens it is rather due to improper oral hygiene measures. Also in a study by Erkan *et al.* [19] it was found that lower incisors intrusion had no deleterious effect on the gingival condition. In addition, width of keratinized gingiva was not changed in both groups.

Conclusion:

Deep bite correction can be achieved during the leveling and alignment phase using cantilever springs with lower incisors intrusion without significant difference in labial tipping other than that created by relative intrusion with continuous sequential archwires.

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