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Labial bone thickness and root volume changes after alignment with two different types of Ni Ti wire.

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ABSTRACT

Objectives: To Compare between two types of nickel titanium arch wires during initial orthodontic alignment as regards bone thickness change and root volume change.

Methods: This randomized clinical trial included patients aged 13 and 23 years, selected from the orthodontic outpatient clinics at Al-Azhar University, Assiut. Patients with Class I malocclusion, Little's irregularity index 4-6 mm and non-extraction treatment of the maxillary arch were randomly assigned to receive two types of alignment arch after randomly grouping to conventional NiTi group and Cu-NiTi group. Four sizes of wire (14,16,18,16*22) were used in present study, every wire change after 28 days and place the next archwire. before initial (T0) and final (T1) archwire cone beam CT was taken to evaluate the change regarding bone thickness and root volume.

Results: Comparison between the two groups revealed no significant statistical differences in bone thickness across all root levels, nor in root volume alterations after alignment.

Conclusion: These two types of Ni Ti archwires produced comparable effects on bone thickness at various root levels as well as on root volume changes.

Keywords: *Orthodontics wires, Nickel titanium, copper Nickel titanium, alignment, bone thickness and root volume*

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1. INTRODUCTION

Dental crowding is considered one of the types of malocclusion and ranks as the third most prevalent oral disease worldwide. [1]. For a proper orthodontic diagnosis and treatment plan, it is essential to accurately assess dental crowding and the space needed to relieve it. There are several methods for assessing dental crowding. This can be done clinically by visual assessment or by specific measurements that can be done in the dental study models[2].

The choice of treatment for crowding malocclusion is influenced by several factors, including age of the patients, the jaw involved, and the degree of crowding. For optimal outcomes, careful consideration is required in determining the appropriate management strategy for each case. Treatment options generally include either an extraction or a non-extraction approach[3].

Non-extraction approach to treatment gained popularity with the start of the Angle era in the early 20th century. Angle believed that extraction reduced the chance of achieving the best occlusion and aesthetics. Although the cases that were treated with non-extraction approach as Angle advocated provided ideal aesthetic and occlusion, these cases showed high rate of relapse and the treatment was unstable[4].

The leveling and alignment phase represents the initial step in orthodontic treatment and is regarded as the most critical preliminary stage when using fixed appliances. Leveling is the process of arranging the incisal edges anteriorly and the buccal cusps posteriorly on a common horizontal plane. Alignment, on the other hand, refers to arranging the teeth within an arch to establish proper contact point relationships[5-7].

Early-phase apical root resorption observed during orthodontic tooth movement has been suggested to predict the extent of overall root length loss throughout treatment. [8, 9] . While mild apical root resorption is a common finding in orthodontic patients [10], severe loss of root length is relatively rare. Previous study [8] reported that resorption exceeding half the original root length occurred in only 1% of examined teeth, whereas another study [11] observed root length loss greater than 4 mm in 2.3% of treated teeth.

Orthodontic forces applied during leveling and alignment result in alterations in anterior bone thickness, with resorption occurring on the compression side as the tooth moves away from the alveolar bone and apposition occurring on the tension side as the tooth shifts toward the bone.[12]

Understanding the properties of arch-wires is a must before making the decision to use which one so that the decision could be justified and optimum predictable treatment results can be accomplished. Some of the important parameters in the selection of a wire are the modulus of elasticity (stiffness, load deflection rate); range (maximum elastic strain), which is the distance the wire deflect elastically before permanent deformation occurs; spring-back (the amount, in length units, a wire will return beyond its yield point), which is the difference between a given deflection (activation) and the residual deformation after unloading to 0 g-mm[13].

Nickel–titanium (NiTi) alloys were first introduced into orthodontic practice in the 1970s by Andreasen and colleagues. The material was originally developed by W. F. Buehler at the Naval Ordnance Laboratory for the U.S. space program and was later commercialized under the name “Nitinol,” an acronym derived from Nickel, Titanium, and Naval Ordnance Laboratory. Andreasen was the first to recognize its orthodontic applications and highlighted several advantages over stainless steel wires, including reduced wire changes, shorter chair time, more efficient tooth movement, and reduced patient discomfort [14].

The development of heat-activated NiTi archwires aimed to combine favorable clinical features, including shape memory, reduced rigidity, enhanced spring-back, and the superelasticity associated with earlier generations of NiTi archwires[15]. From a biomechanical perspective, thermo-active archwires delivering dynamic forces are believed to induce more favorable tissue responses compared to wires applying constant static forces.

The null hypotheses of this study stated that no significant differences would be observed between the two types of NiTi archwires regarding bone thickness and root volume changes during maxillary anterior alignment efficiency.

2. MATERIALS AND METHODS

Participants

Participants were selected from Al-Azhar University's Orthodontic Clinic, faculty of dental medicine (Assiut branch). Eligibility was based on strict inclusion and exclusion criteria.

Inclusion Criteria:

1. Patients presenting with Class I malocclusion and moderate anterior crowding.
2. Age range between 13 and 23 years, with a fully permanent dentition.
3. Candidates for treatment of the maxillary arch with non-extraction approach.
4. Little’s Irregularity Index (LII) ranging from 4 to 6 mm.
5. Absence of any periodontal disease.

Exclusion Criteria:

1. Severe crowding.
2. Poor oral hygiene.
3. Present or history of periodontal diseases.
4. Systemic diseases that would affect the rate of tooth movement.
5. Extraction case.

Study Design and sample size:

Based on previous study[16] and sample size calculation using the G*Power statistical power analysis software (version 3.1.9.4), a total sample of 16 participants, divided equally into two groups of eight, was determined to be adequate to detect a large effect size (f = 1.6932) with a statistical power of 0.80 (90%) at a significance level of 0.05 (5%) for a two-tailed hypothesis test. The sample size was increased by 25% to compensate for possible patient drop-out, giving a total of n=20 (10 for each group).

Grouping and randomization:

we randomly divided the samples into two groups.

Group I: 10 patients who were treated with superelastic Ni Ti arch wires, and

Group II: 10 patients who were treated with Cu Ni Ti arch wires.

Intervention:

Every patient enrolled in the present study; routine orthodontic records were taken before the treatment (T0). All patients received orthodontic treatment with fixed appliances, Patients were treated by 0.022×0.028 metal bracket system Roth prescription and buccal tubes. Patients in group I received superelastic Ni Ti arch wires while group II received Cu Ni Ti arch wires.

All patients in group I received superelastic Ni Ti arch wires in the same manner and schedule for group II that received Cu Ni Ti arch wires as the following orders.

1. After bonding patients received wire 14 for 28 days.
2. Received wire 16 for 28 days.
3. Received wire 18 for 28 days.
4. Received wire 16*22 for 28 days (T1)

Measurements:

Bone thickness evaluation:

Alveolar bone thickness was measured by the distance between the maxillary anterior teeth roots and labial alveolar bone at three levels at both (T0) and (T1). The distances at the levels were categorized as A1, A2, and A3 according to 3-, 6-, and 9-mm distance from the cementoenamel junction as documented previous study.[17] (Figure 1). Bone thickness was evaluated for anterior teeth from right canine to left canine for all patients at (T0) and (T1).

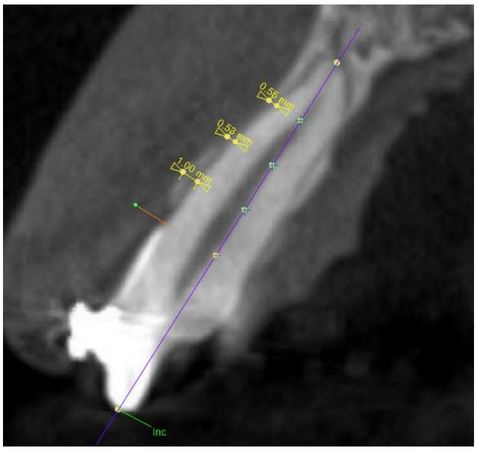

Fig (1): Alveolar bone thickness measurements at different levels

Root volume evaluation:

Root volume was evaluated following a previously reported study[18] Image reorientation was performed to ensure that the tooth's longitudinal axis corresponded with the sagittal and coronal planes. Manual segmentation was carried out using the "Annotation" tool to generate discrete layers between the CEJ and the root apex at 600 µm intervals. The outer tooth contours were traced on each layer and connected to form a closed boundary, after which the volume was determined by multiplying the surface area of each section by its thickness. (Figure 2). Root volume was evaluated for anterior teeth from right canine to left canine for all patients at (T0) and (T1).

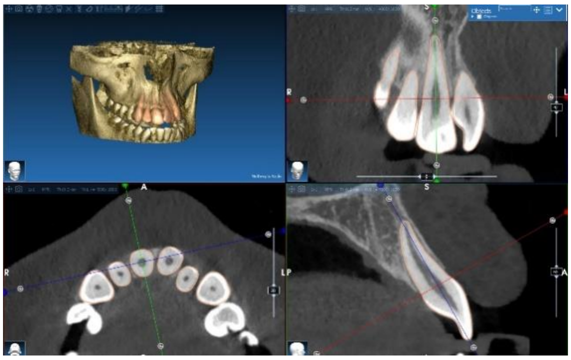

Fig (2): Root volume measurement

Statistical Analysis

Data analysis was conducted using IBM SPSS Statistics (version 22.0; IBM, Armonk, NY). Normality of the data was evaluated using graphical methods and the Shapiro–Wilk test. For the assessed outcomes, which were normally distributed, descriptive statistics were given mean ± SD. Independent Samples T test was used to compare between mean changes of the two groups.

Results:

As regarding bone thickness at A1, A2 and A3, there were non-statistically significant differences between the two groups for all measurements. Therefor the null hypnosis states that no significant difference among two groups is accepted (Table 1). As regarding root volume changes for anterior teeth, there were non-statistically significant differences between the two groups for all teeth. Therefor the null hypnosis states that no significant difference among two groups is accepted (Table 2).

Table (1): comparison of the bone thickness changes at A1, A2 and A3 between groups of the study:

Variables		Ni Ti		Cu Ni Ti		Mean diff	Independent sample T test			
		Mean	SD	Mean	SD		t	df	P value	sig
A1	RT1	.084	.405	.172	.344	.088	.370	16	.721	NS
	RT2	.062	.186	.132	.175	.07	.610	16	.559	NS
	RT3	.056	.101	.282	.184	.338	3.58	16	.07	NS
	LT1	.318	.204	.112	.184	.206	1.67	16	.133	NS
	LT2	.308	.258	.164	.065	.144	1.21	16	.261	NS
	LT3	.144	.062	.034	.281	.178	1.38	16	.204	NS
A2	RT1	.100	.173	.074	.259	.026	.186	16	.857	NS
	RT2	.126	.273	.044	.194	.170	1.13	16	.291	NS
	RT3	.074	.061	.096	.143	.022	-.315	16	.761	NS
	LT1	.070	.118	.008	.141	.078	.946	16	.372	NS
	LT2	.330	.579	.122	.186	.452	1.65	16	.136	NS
	LT3	.088	.112	.106	.257	.018	-.143	16	.889	NS
	RT1	.220	.131	.156	.219	.064	-.558	16	.592	NS
	RT2	.188	1.09	.032	.196	.220	.441	16	.671	NS

A3	**RT3**	.210	.349	.032	.111	.242	1.47	16	.179 NS
	LT1	.102	.515	.070	.224	.032	-.127	16	.902 NS
	LT2	.410	.945	.274	.266	.684	1.55	16	.158 NS
	LT3	.122	.293	.140	.288	.262	1.42	16	.192 NS

SD; standard deviation, not significant when P>0.05, significant when P value< 0.05 NS; not significant.

Table (2): comparison of the root volume changes at the teeth between for the two groups:

Variables	Ni Ti		Cu Ni Ti		Mean diff	Independent sample T test			
	Mean	SD	Mean	SD		t	df	P value	sig
Right central	9.28	2.37	13.06	11.13	-3.78	-.742	16	.479	NS
Right lateral	8.58	1.71	9.24	5.08	-.662	-.276	16	.790	NS
Right canine	10.81	5.18	11.81	4.84	-1.00	-.315	16	.761	NS
Left central	8.25	3.56	13.64	8.10	-5.38	-1.36	16	.211	NS
Left lateral	6.39	2.11	8.73	1.02	-2.34	-2.22	16	.057	NS
Left canine	11.47	3.63	12.38	5.84	-.904	-.294	16	.776	NS

SD; standard deviation, not significant when P>0.05, significant when P value< 0.05 NS; not significant.

3. DISCUSSION:

Copper-nickel-titanium (CuNiTi) archwires represent a relatively recent addition to the orthodontic treatment arsenal. First introduced by Ormco in 1994, these wires are engineered to transition between a flexible martensitic phase and a shape-retentive austenitic phase at specific transformation temperatures (27 °C, 35 °C, and 40 °C). As a result, they are heat-activated by body temperature, allowing easier engagement at room temperature and becoming fully functional within the oral environment[15, 19].

Currently, cone-beam computed tomography (CBCT) is employed to evaluate alveolar bone height and thickness with a high degree of accuracy and precision.[20] Thus, we used CBCT in our study to assure the accurate result between the two groups of the study.

In present study, we divided the root into three third to compare the change at bone thickness of each tooth at different level of bone support as recommended by previous study ,[21] we were found that there non-statistically significant change between two groups at any level of the bone support although that bone thickness at different level was decreased after leveling and alignment at all teeth of the study, but this change was non-statistically significant. These findings were agreement with previous study [22] showed that orthodontic treatment produces a reduction in bone thickness of incisors.

We accepted the null hypothesis at present study regarding bone thickness change after period of the study that stated that there no statistically significant differences between group (I) that treated with (CuNiTi) archwires and group (II) that treated with conventional Ni Ti archwires.

During first phase of orthodontic treatment (leveling and alignment), the anterior bone thickness undergoes changes due to the forces applied to the teeth. Bone resorption occurs on the side where the tooth is moving away from the bone (tension side), and bone formation occurs on the side where the tooth is moving into (compression side).[12] These processes result in continuous remodeling of the bone, which can vary in intensity depending on the amount of force applied, the duration of treatment, and the patient's age. Younger patients tend to experience more robust bone remodeling, while older patients may experience slower responses [12, 23]. This concept in line with our results regarding bone thickness changes following tooth movement with different changes at labial and lingual bone.

According to **Yee et al**. [24, 25], maintaining minimal and light orthodontic forces does not negatively impact the alveolar bone, as such forces result in simultaneous displacement of the tooth, alveolar bone, and cortical bone. Therefore, light force application is regarded as a core principle of tooth movement regardless of direction.

As regarding the changes in root volume at both groups, we accept the null hypothesis that stated that there are no statistically significant differences between group (1) that treated with (Cu NiTi) archwires and group (II) that treated with conventional Ni Ti archwires.

Shubhangi Jain[26] conducted A comparative clinical assessment of 0.016-inch superelastic versus heat-activated nickel–titanium archwires focusing on alignment efficiency, root resorption, and pain perception. Although root resorption was assessed using root length rather than root volume, the study found no statistically significant differences between the two groups, a finding that is consistent with the results of the present study.

4. CONCLUSION:

Within the limits of this study, although copper NiTi archwires have shown advantages over conventional NiTi in vitro during the initial alignment phase, such findings require clinical validation. The present study demonstrated no statistically significant differences between conventional and copper NiTi archwires in terms of bone thickness changes and root volumes changes

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