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Research Article

Comparison of arch width and depth changes and pain/discomfort with conventional and copper Ni-Ti archwires for mandibular arch alignment

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ABSTRACT

Objective: The aim of this study was to compare conventional nickel-titanium (Ni-Ti) and copper Ni-Ti archwires in the leveling of mandibular anterior teeth.
Materials and Methods: Study models of 32 patients who received full fixed appliance treatment with 0.022 × 0.028-inch slot self-ligating brackets were analyzed. The copper Ni-Ti group had ligated 0.014-inch Cu-Ni-Ti at T0 (pretreatment) followed by 0.016-inch Cu-Ni-Ti at T1 (2-month interval). In the conventional Ni-Ti group, the archwire sequence involved a conventional 0.014-inch Ni-Ti at T0 and 0.016-inch Ni-Ti at T1. Pretreatment (T0) and posttreatment (4 months after initial treatment) characteristics were recorded from dental casts and included irregularity index, intercanine width, interpremolar width, intermolar width, and canine depth, premolar depth, and molar depth. Each subject was given a specially designed visual analog scale diary, and was asked to complete it over the first month following the first and second arch wires.
Results: There were no significant differences between the copper Ni-Ti and conventional Ni-Ti groups at 16 weeks in Little's irregularity score changes ($P > 0.05$). Also, there were no significant differences in intercanine widths, interpremolar width, intermolar width, and depth changes between the copper Ni-Ti and Ni-Ti groups ($P > 0.05$). Pain score changes between different treatment periods were the same between the copper Ni-Ti and Ni-Ti groups ($P > 0.05$).
Conclusions: Copper Ni-Ti archwires were no more efficient than Ni-Ti archwires in leveling of the mandibular anterior teeth changes in arch dimensions in patients with moderate dental irregularity. Changes in mandibular arch dimensions were similar in the copper Ni-Ti and Ni-Ti groups.

1. Introduction

Leveling and alignment form the first stage of orthodontic treatment. The ideal archwire for this phase should be able to provide light and continuous force over a period of months, providing patient comfort, and reducing periodontal ligament necrosis and root resorption risk [1,2]. Nickel-titanium (Ni-Ti) wires with their optimal mechanical properties along with super elasticity and shape memory provide a large portion of these properties. The evolutionary trends in Ni-Ti alloy archwires have provided them with superior features. The first-produced Ni-Ti archwires, developed and presented by Andreasen et al. [3], have been noted for their high elastic limit and resilience, along with low elastic modulus and stiffness. Although Ni-Ti archwires have an excellent property of elastic recovery, they did not have, by that time, the superelastic or shape memory feature because of the effect of cold working during the manufacturing process. Thus, these wires were passive and were considered as a martensitic-stabilized alloy [4].

In 1985, Burstone et al. [5] showed the high spring-back characteristic of Chinese Ni-Ti, followed by Miura et al. [6], who published the superelastic feature exhibited by Japanese Ni-Ti. These alloys provided the ability to maintain a mild, light, and constant force over a wide range of activation-deactivation [7,8]. In 1963, Buehler et al., observed the shape memory property of Ni-Ti alloy, which exhibited low-temperature deformation in the martensitic phase at room temperature, and its ability to reestablish its original configuration when heated above the transition temperature in the austenitic phase [9,10]. In the 1990s, this feature was used in orthodontic archwires with the addition of copper to Ni-Ti

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alloy and was named heat-activated Ni-Ti (HANT) or copper (Cu) Ni-Ti [11]. Although the initial Ni-Ti archwires had this feature, the inability to manipulate with the transition temperatures did not allow this property to be used for orthodontic purposes [12]. Adding copper to nickel and titanium led to better-defined transition temperatures [11]. Thus, the benefit of Ni-Ti alloy archwires exhibiting different characteristics at room temperature and mouth temperature was used in orthodontic alignment and leveling stages. In the martensitic phase at room temperature, archwire is ductile and can be deformed and more easily inserted into the brackets, increasing patient comfort [13]. In the austenitic phase at mouth temperature, the wire improves the efficiency of the tooth movement by applying constant, light, and continuous force while the original configuration of the archwire is reestablished [14].

The aim of this study was to compare the effectiveness of conventional Ni-Ti and copper Ni-Ti in the leveling of the mandibular anterior teeth and the effects it produces on changes in arch dimensions in patients with moderate dental irregularity. In addition, we investigated whether there were any significant differences in terms of pain/discomfort in these two different types of archwires.

2. Materials and methods

A power analysis using G*Power Software (version 3.1.9.2; Universität Düsseldorf, Düsseldorf, Germany) showed that the sample size of 32 patients ensured more than 80% power to detect significant differences at a 0.05 significance level. Ethical approval was obtained from the Research Ethics Committee of Ordu University, Turkey (2016/35). Informed consent allowing their data to be used for scientific purposes was obtained from patients and their parents.

Thirty-two patients were randomly divided into two groups according to ligated archwire: copper Ni-Ti (16 subjects) and Ni-Ti (16 subjects) groups were selected (7 male and 25 female; mean age 16.15 $\pm$ 2.37 years). The patients were bonded with 0.022 $\times$ 0.028-inch slot self-ligating brackets (Empower; American Orthodontics, Sheboygan, WI) at the Department of Orthodontics, Faculty of Dentistry, Ordu University, Turkey. Patients were selected based on characteristics such as moderate mandibular irregularity, orthodontic treatment with no extraction on the mandibular arch, all mandibular teeth erupted except third molars, and no spaces in the mandibular arch. The following exclusion criteria were applied: use of analgesics; treatment with extractions; impacted or unerupted permanent teeth; treatment with intraoral or extraoral appliances, including rapid palatal expansion appliances, removable appliances, or headgear; or patients with cleft lip and palate, anomalies, and syndromes.

The copper Ni-Ti group received 0.014-inch Cu-Ni-Ti (Tanzo; American Orthodontics) at T0 (pretreatment) followed by 0.016-inch Cu-Ni-Ti (Tanzo; American Orthodontics) at T1 (2-month interval), and the conventional Ni-Ti group received 0.014-inch Ni-Ti (G4; G&H Orthodontics, Franklin, IN) at T0 and 0.016-inch Ni-Ti (G4; G&H Orthodontics) at T1. Each subject was provided with a specially designed visual analog scale (VAS) diary and requested to mark pain intensity in a 10-cm VAS at 4 hours, 24 hours, 3 days, 1 week, and 1 month, using the terms no pain (0) and the highest pain (100) perceived over the first month following the first archwire insertion (0.014-inch Cu-Ni-Ti and 0.014-inch Ni-Ti) and the second month after 0.016-inch Cu-Ni-Ti and 0.016-inch Ni-Ti archwire insertion.

Pretreatment (T0) and posttreatment (T2) characteristics were recorded from dental casts, including irregularity index, intercanine width, interpremolar width, and intermolar width and canine depth, premolar depth, and molar depth. Alignment of six mandibular anterior teeth was evaluated by using Little's irregularity index from all study models. Intercanine widths were measured from the cusp tips of the canines, interpremolar widths from buccal cusp tips of the first premolars, and intermolar widths from the central fossa of the mandibular first molars. Arch depths were measured as the horizontal linear distance from the most anterior point of the central incisor to the line drawn between the tip of the canines, tip of the premolar buccal cusps, and the mesial contact point of the first molars (Fig. 1). An identification number was given to each dental cast model, thereby the researcher was blinded to patient name and time point. Measurements were made by using digital calipers with a sharpened fine edge with accuracy to 0.01 mm (Mitutoyo, Tokyo, Japan). All models were measured by the same researcher (F.G.).

Assessment of intraexaminer reliability was made by remeasuring all characteristics of 16 randomly selected dental cast models. To investigate reproducibility of measurement, paired *t* tests were performed for each variable and no statistical significance was shown between the first and second measurements ($P > 0.860$).

All VAS and study model measurements were statistically analyzed using the SPSS program (SPSS for Windows version 20.0; SPSS Inc, Chicago, IL). After performing the normal distribution test, parametric tests were performed to the parameters having a normal distribution, whereas nonparametric tests were done to the parameters with non-normal distributions. The data were analyzed by using independent *t* test, Mann-Whitney *U* test, Wilcoxon test, and Friedman test.

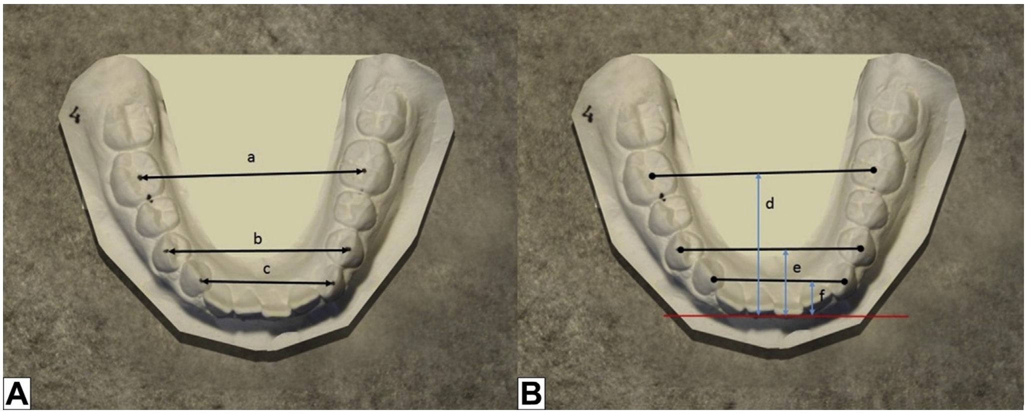

Fig. 1. Mandibular measurements. (A)-(a) Intermolar width, (b) inter-premolar width, (c) intercanine width. (B)-(d) Molar depth, (e) premolar depth, (f) canine depth.