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THREE-DIMENSIONAL APPRAISAL OF MARGINAL ALVEOLAR BONE AND ROOT LENGTH OF MANDIBULAR INCISORS FOLLOWING ORTHODONTIC ALIGNMENT WITH MULTISTRAND VERSUS CONVENTIONAL NITI ARCHWIRES

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ABSTRACT

Objective: The present study was designed to evaluate and compare the changes in labial alveolar bone (LAB) and root length (RL) of mandibular incisors following orthodontic leveling and alignment with multistrand versus conventional single stranded NiTi archwires using Cone Beam Computed Tomography (CBCT).

Patients and methods: Twenty patients, 18 females and 2 males, with a mean age of 16 ± 2.1years were randomly selected and allocated into two equal groups: group I, where coaxial multistrand NiTi archwires were used for leveling and alignment; whereas group II conventional single stranded NiTi archwires were utilized. Mandiblular CBCT scans were obtained before treatment (T1) and immediately following complete leveling and alignment (T2) and analyzed for changes in LAB level and RL of mandibular incisors. Comparisons between both groups were performed using Mann-Whitney test and Friedman's test. Level of significance was set at $p \leq 0.05$.

Results: Overall changes in LAB (T1-T2) of multistrand archwire group were -2.18 ± 1.55 mm; whereas it was -2.13 ± 1.39 mm for conventional one. Additionally, changes in RL of mandibular incisors in both groups were as - 0.26 ± 0.23 mm and -0.29 ± 0.27 mm; respectively. Moreover, appraisal of magnitude of LAB loss and root resorption of mandibular incisors within each archwire group revealed no statistically significant differences ($p> 0.05$).

Conclusion: Both coaxial multistrand and conventional NiTi archwires produced comparable minimal degrees of LAB loss and root resorption of mandibular incisors. In addition, no archwire was superior in reducing the incidence of either LAB loss or root resorption during leveling and alignment stage.

Keywords Marginal Alveolar Bone; Root Resorption, Orthodontic Leveling and Alignment; Mandibular Incisors; Multistrand Superelastic NiTi Archwires; CBCT

INTRODUCTION

Leveling and alignment correspond to the first and the most important phase of orthodontic treatment, since it improves the facial appearance and enhances patient's satisfaction. Approximating any other medical interventions, there is no orthodontic treatment without complications. During this phase, several biological reactions might occur, among which labial alveolar bone and root length reductions. [1, 2] These reactions most commonly take place during non extraction or expansion protocol, and are greatly depends upon

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many factors, the most important of which are the type and force level delivered by aligning arch wires and the nature of biological response of the periodontal tissues.[(2-4)]

Moreover, tendency for apical root resorption during this early phase has been shown to be indicative of the final root length loss during the entire orthodontic treatment.[3,4] The literature poses a correlation between root resorption at an early stage of treatment and the occurrence of severe resorption at the end of treatment. Patients with detectable root resorption during the first 6 months of active treatment have also been reported to be more likely to experience resorption during the following 6-month period.[(5-7)]

In order to optimize the biological environment for tooth movement and minimize patient discomfort, the principle requirements are the minimum stiffness and maximum range of the aligning archwires. The success of the orthodontic treatment may depend upon, among other factors, the careful selection of the aligning archwires.[2] Mechanotherapy during leveling and alignment phase is performed using arch wires that falls into two large categories: stainless steel and Nickel-Titanium (NiTi) with superelastic properties. Due to the convenience of the clinical use, superelastic arch wires rapidly gained popularity among orthodontists, particularly during the leveling phase.[(2,8)]

Multistranding of archwires has been successfully attempted with the use of stainless steel alloys to gain mechanical advantages such as increased flexibility and a reduced load deflection rate. Afterward, multistranding of NiTi arch wires has been performed to produce what is called the seven strands superelastic or Supercable NiTi wire.[(8-12)]

Two-dimensional (2D) radiographs, were originally used to evaluate the periodontium and any dental deleterious effect during orthodontic treatment. Although, alterations of the interproximal crestal bone could be determined; however, facial and lingual aspects of the alveolus could not be evaluated. The 2D radiographs are limited because they produce 2D images of a 3-dimensional (3D) structure, leading to labiolingual superimposition of the whole root structure. [(13,14)]

Currently, Cone Beam Computed Tomography (CBCT) has permitted complete visualization of the bony components of the alveolus. This 3D representation of the alveolus has allowed detection of facial and lingual bony defects or any root resorption.[13,14] In addition, CBCT technique, in combination with multiplanar reconstructions, has the advantage of optimal visualization of each tooth despite the changes in tooth position that occur during orthodontic treatment, thus enhancing reproducibility.[(5,13,14)]

A systematic review on clinical trials of aligning arch wires advocated that there is insufficient data to make clear recommendations regarding the most effective arch wire for alignment. [15] In another Cohrane review, some additional factors, including the amount of root resorption along with tooth movement during initial alignment, was evaluated. It was concluded that there is some evidence to suggest that there is no difference between the speed of tooth alignment or pain experienced by patients when using one initial aligning arch wire over another. However, root resorption had not been investigated by only a few randomized clinical trials, even though it is one of the most serious side effects of orthodontic treatment. It was suggested that further evaluation of the aligning arch wires should consider this potentially serious side effect of orthodontic treatment.[(16)]

Regarding the marginal alveolar bone loss, a number of authers evaluated patients requiring retraction of the maxillary incisors to close extraction spaces and found that the lingual alveolar bone thickness decreased significantly in 11 of 19 patients. [17] Others, also showed that 84% of the lingual surfaces of the mandibular central incisors demonstrated bone height decreases of more than 2 mm.[(18)]

On the other hand, experimental data suggests that alveolar bone loss can also take place when mandibular incisors are proclined. In monkeys, it was found that, moving the mandibular incisors labially by 3.05 mm caused 5.48 mm of marginal bone loss.[(19)] Also, others reported 7 mm of bone loss associated with 6 mm of incisor proclination.[(20)] However, little human support is available for such experimental reports.[(1)] Using 2D radiographs to evaluate posterior interdental vertical bone height, 0.5 mm and 0.13 mm of bone loss has been reported in orthodontically treated patients compared.[(21-23)]

As derived from the literature, there seems to be little human researches have been performed to 3-dimensionally judge the effects of aligning NiTi arch wires on the periodontium a result of labial movement of incisors, especially in comparison with the multistrand NiTi one.[1,5,1824] Therefore, the rationale of the current study was directed to evaluate and compare the changes in marginal labial alveolar bone (LAB) and root length (RL) of mandibular incisors following leveling and alignment with multistrand versus conventional single stranded NiTi archwires using CBCT.

PATIENTS AND METHODS

The study protocol was reviewed and approved by Institutional Review Board and the Ethical Research Committee of Al-Azhar University, Egypt. This prospective study was carried out from September 2015 to March 2016 on a total sample of 20 patients, 18 females and 2 males, with mean initial age was 16±2.1 years old (range 13 to 19 years) who were randomly selected from the outpatient clinic, Department of Orthodontics, Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo, Egypt. All participants and/or their parents who accepted to participate in this study signed an informed consent form before treatment initiation that allowed their data to be used for scientific purposes.

Based on a previous studies, a power analysis using G*Power software (version 3.1.9.2; Universitat Dusseldorf, Dusseldorf, Germany) showed that the sample size of 20 patients ensured more than 80% power to detect significant differences at a 0.05 significance level.[(1,2,8)] The sample included patients who fulfilled the following criteria: complete permanent dentition (third molars not included); moderate mandibular anterior crowding with Little's irregularity index greater than 2 mm treated without extractions in the mandibular arch; no tooth size, shape or root abnormalities visible on the patient's radiographic records; no spaces in the mandibular arch; no blocked out tooth that did not allow for placement of the bracket at the initial bonding appointment; and no treatment with intermaxillary elastics, interproximal stripping, open NiTi springs, and removable or extraoral appliances.

The following exclusion criteria were applied: severe dental crowding treatment that requires an extraction approach, abnormal antero-posterior and vertical relationships, patients with cleft lip and palate, anomalies, and syndromes; previous orthodontic treatment; radiographic signs of periodontal diseases or periapical lesions and resorption; history of trauma or periodontal problems that required massive periodontal therapy which could affect the labial and/or lingual bone support of the mandibular anterior teeth; and regular medication intake that could interfere with orthodontic tooth movement.

All patients received Roth preadjusted metallic brackets (3M Unitek, Monrovia, Calif)) with a 0.022×0.028 inch slot and had treatment by the same researcher (A.A.E). The sample was randomly divided into two equal groups, according to the type of initial wires that used for leveling and alignment. The process of randomization and group allocation was undertaken with an allocation ratio of 1:1 and clinical assistants arbitrarily allocated patients into two experimental groups with 10 patients each, using a computerized simple generated randomization plan using online software (http://www.graphpad.com/quickcalcs/randomize2/).

One group of patients (n=10) were treated with conventional single stranded superelastic NiTi archwires (Ortho Organizer Super Elastic Nitanium® Archwiress, USA) in a sequence of 0.012, 0.014 and 0.016 inch. On the other hand, in the second group, patients received coaxial multistrand superelastic NiTi archwires (Speed System Orthodontics, Ontario, Canada) commercially available as supercable wires. It was used according the manufacturer's recommendations in a sequence of 0.016, 0.018, 0.020 inch. In both groups, the archwires were inserted for leveling and alignment of the lower anterior segment as a part of their comprehensive orthodontic treatment plan. Each archwire type was ligated, without modifications to the wire, with figure-of-eight elastomeric modules (Oramco Corporation, CA) to achieve complete engagement wherever clinically possible.

All patients were examined at two predetermined points of treatment: before treatment start (T1) and at the end of the leveling phase (T2), approximately 3 to 4 months after initiation of treatment and subsequently followed up every 3 weeks until the crowding was alleviated.[2] After that, all patients completed their comprehensive treatment and orthodontic objectives were achieved.

Routine orthodontic records were obtained for each patient before treatment. Additionally, mandibular CBCT images were taken before treatment (T1) and immediately following complete leveling and alignment (T2) for both groups. All CBCT images were taken with the same machine (Planmeca Promax machine, Finland) and the following exposure parameters were applied: 668×668×668–cm field of view (FOV), 90kVp, 12 mA, 15-second scan time, 0.2 mm slice thickness and 150-μm isotropic voxel size. The same subject's posture and the same settings were used for all the scans.

Analysis of CBCT images

All CBCT images were saved as Digital Imaging and Communication in Medicine (DICOM) format. The CBCT images of each patient were imported into medical imaging software (Planmeca Romexis 4.4.0) to construct a 3D computer model and analyzed for the measurements of the LAB level and RL. All pretreatment (T1) and post-alignment CBCT (T2) images were measured by the same researcher (M.M.H) who was blinded regarding the origin of the radiographs. An identification number was given to each CBCT image; thereby the examiner was blinded to patient's name, patients' allocated group, and time point. The images were rematched to the patient and archwire group after data collection was completed. [25]

A three-dimensional (3D) superimposition of CBCT images was performed for the mandibular central incisors and mandibular lateral incisors in both sides.[1,24,26] To ensure a consistent procedure, pre- and post-alignment scans of the target tooth were superimposed and oriented along the long axis (a line bisecting the root canal) and anatomical crown of a target incisor tooth on every view (sagittal, transverse, and coronal) as follows: First, the long axis of each incisor tooth was adjusted on axial, sagittal, and coronal planes of pre-treatment scan (T1). Next, 3D superimposition was performed by the best-fit method, where the T2 scan was superimposed on the T1 scan using two sets of homologous landmarks in each CBCT image. Then, a manual refinement process was undertaken to adjust the T2 on T1 image using the same coordinate axis (Figs.1-3).[24,26]

The following CBCT landmarks were used for linear assessment of LAB and RL:

ACL2 T1	Alveolar bone crest of mandibular left lateral incisor before leveling and alignment
ACL2 T2	Alveolar bone crest of mandibular left lateral incisor after leveling and alignment
ACL1 T1	Alveolar bone crest of mandibular left central incisor beforeleveling and alignment
ACL1 T2	Alveolar bone crest of mandibular left central incisor after leveling and alignment
ACR1 T1	Alveolar bonecrest of mandibular right central incisor before leveling and alignment
ACR1 T2	Alveolar bone crest of mandibular right central incisor after leveling and alignment
ACR2 T1	Alveolar bone crest of mandibular right lateral incisor before leveling and alignment
ACR2 T2	Alveolar bone crest of mandibular right lateral incisor after leveling and alignment
RA L2 T1	Root apex of mandibular lateral incisor before leveling and alignment.
RA L2 T2	Root apex of mandibular lateral incisor after leveling and alignment.
RA L1 T1	Root apex of mandibular central incisor before leveling and alignment.
RA L1 T2	Root apex of mandibular central incisor after leveling and alignment.
RA R1 T1	Root apex of mandibular right central incisor before leveling and alignment.
RA R1 T2	Root apex of mandibular right central incisor after leveling and alignment.
RA R2 T1	Root apex of mandibular right lateral incisor before leveling and alignment.
RA R2 T2	Root apex of mandibular lateral incisor right after leveling and alignment.

The following CBCT linear measurements were used (Fig.3): first, changes in marginal LAB level (mm) were assessed by measuring the distance between the pre-treatment labial alveolar bone crest (AC T1) and post-alignment labial alveolar bone crest (AC T2). Second, changes in RL (mm) were assessed by measuring the distance between the pre-treatment root apex (RA T1) and post-alignment root apex (RA T2). The utilized software was used to obtain linear measurements in all scans and all measurements were performed twice on the sagittal CBCT view and the mean value was recorded.

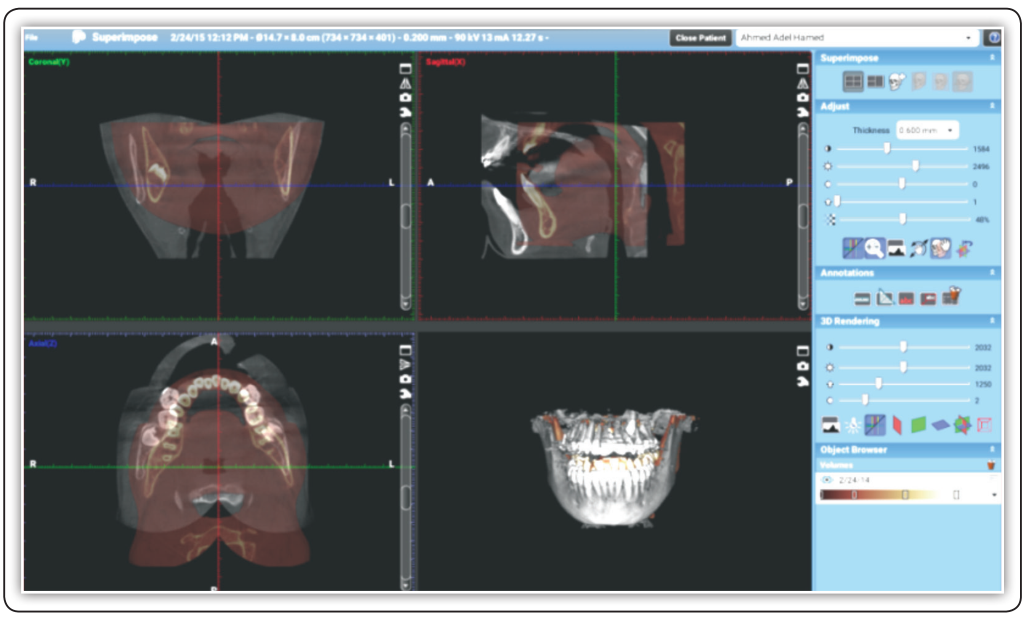

FIG (1) T1 and T2 CBCT images before 3D superimposition and manual refinement process.

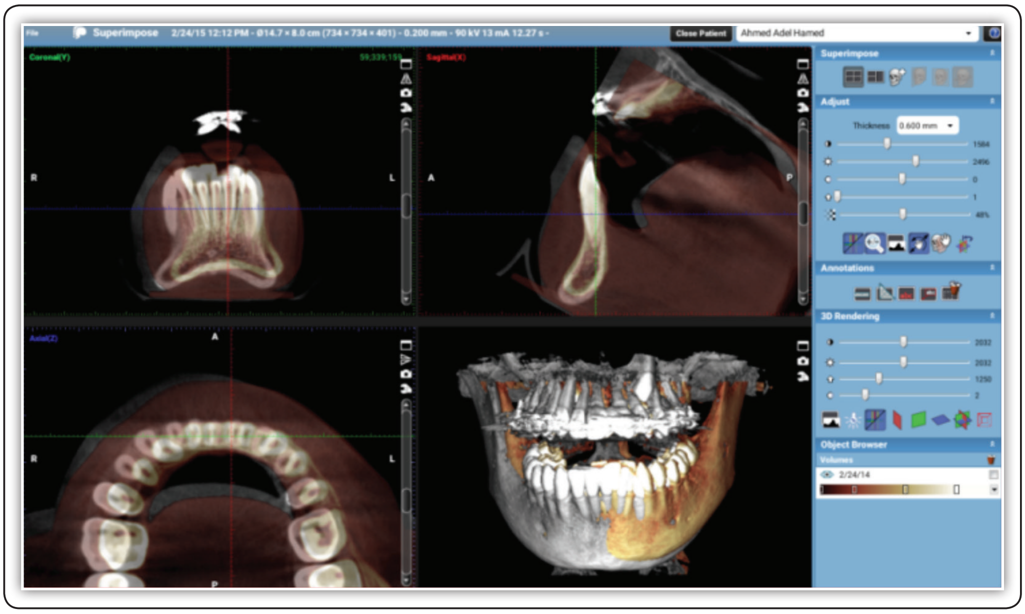

FIG (2) 3D superimposition and manual refinement process of T1 and T2 CBCT images by targeting one mamdibular incisor based on its long axis and anatomical crown, that adjusted on axial, sagittal, and coronal planes.

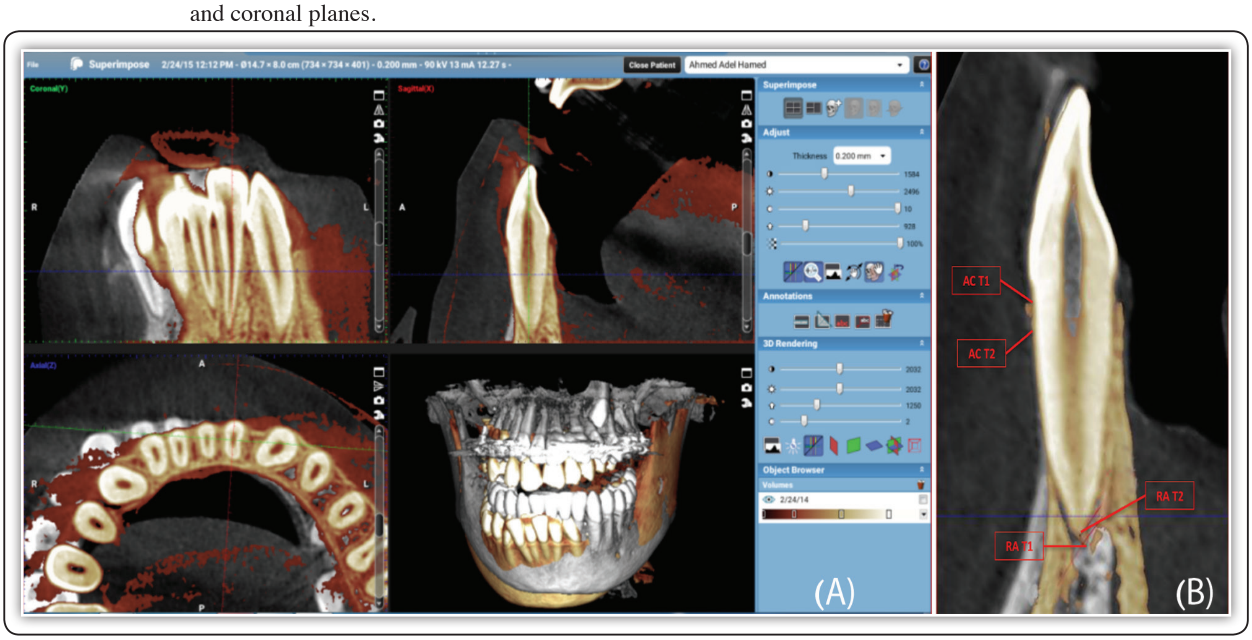

FIG (3) (A) Completed 3D superimposition of bothT1and T2 CBCT scans by the best-fit method between two sets of homologous landmarks. (B) CBCT image of a lower incisor tooth after manual refinement process based on its long axis and anatomical crown with linear measurements in sagittal view of superimposed T1 and T2 images.

Statistical analysis

The data were submitted to statistical analysis using Statistical Package for Social Science (SPSS) software for Windows (version 20, Inc., IBM Company, Chicago, III, USA). Data were presented as mean, standard deviation, minimum, maximum and 95% confidence interval (95% CI) the changes in labial alveolar bone level and root length of mandibular incisors for each group of archwire.

To verify the normal distribution of the variables, Kolmogorov-Smirnov and Shapiro-Wilk tests were used. All data were not normally distributed, so non-parametric tests were deemed appropriate. Comparison of between both groups was performed by Mann-Whitney U test whereas Friedman's test was used to compare between different teeth in each group. Level of significance was set at $p \leq 0.05$.

RESULTS

Error of the method

The reproducibility of the measurements was assessed by analyzing the difference between 2 replicate CBCT measurements by the same examiner taken 4 weeks apart. CBCT measurements for both LAB level and RL were repeated for randomly selected 8 patients 4 for each group. Intra- examiner reliability was assessed by comparing the 1st and 2nd sets of measurements via Cranach's alpha reliability coefficient and Intra-class Correlation Coefficient (ICC). Regarding the LAB level there was very good intra-observer agreement with Cronbach's alpha values ranging from 0.950 to 0.988. Concerning RL, there was good to very good intra-observer agreement with Cronbach's alpha values ranging from 0.747 to 0.805.

1) Effects of the tested archwires on the labial alveolar bone (LAB) level:

Table 1 shows comparison of CBCT measurements of LAB changes (mm) of mandibular incisors between the two groups of archwires using Mann-Whitney U test. The mean changes in LAB level in the multistrand group are -1.66±1.47mm for lower left central incisors (LL1), -2.53±1.92 for the lower left lateral incisors (LL2), -1.68±1.38mm for the lower right central incisors (LR1), and -2.85 ±2.36 for the lower right lateral incisors (LR2). However, in single strand group, the mean LAB changes are (-1.97± 1.59 mm) for the LL1 and (-2.08± 1.38 mm) for LL2 and -2.32±1.66 mm for LR1 and -2.17±1.65mm for LR2.

The LAB changes of LL1, LL2, LR1, and LR2 are not significantly different between the two groups (*p*-value = 0.597, 0.791, 0.307 and 0.910, respectively). Additionally, the overall changes in LAB level, demonstrate no statistically significant difference between the two groups (*p*-value= 0.940).

Table 2 shows comparison of changes in LAB level (mm) among mandibular incisors within each group using Friedman's test. Neither the multistrand wire group nor the single strand one demonstrates any significant difference (*p*-value= 0.120 and 0.377, respectively) among different mandibular incisors.

2) Effects of the tested archwires on the root length (RL):

Table 3 shows comparison of CBCT measurements of RL changes (mm) of mandibular incisors between the two groups by using Mann-Whitney U test. In the multistrand group, the mean RL changes of LL1, LL2, LR1, and LR2 were -0.21± 0.19 mm, -0.23 ± 0.20 mm, -0.31± 0.29 mm, and -0.31±0.28 mm, respectively. On the other hand, in single strand group, the mean RL changes of LL1, LL2, LR1, and LR2 were -0.28± 0.24 mm, -0.21± 0.19 mm, -0.27±0.23 mm, -0.39 ±0.32mm, respectively. The overall change in RL of mandibular incisors is -0.26 mm ± 0.23 in multistrand group and - 0.29 mm ± 0.27 in single strand one. The mean RL changes of LL1, LL2, LR1, and LR2 are not significantly different between the two groups (*p*-value= 0.562, 0.939, 0.642, and 0.877, respectively). Furthermore, the overall changes of RL shows no statistically significant difference between the two groups (*p*-value= 0.940).

Table 4 shows comparison of changes in RL among mandibular incisors within each group using Friedman's test. Neither the multistrand wire group nor the single strand one demonstrate any significant difference (*p*-value= 0.360 and 1.000, respectively) among different mandibular incisors.

TABLE (1) Comparison of labial alveolar bone (LAB) changes (mm) between the two groups using Mann-Whitney U test.

Tooth	Multistrand Group(n=10)		Single strand group(n=10)		Mean difference	*p*-value
	Mean	SD	Mean	SD		
LL1	1.66	1.47	1.97	1.59	-0.31	0.597 NS
LL2	2.53	1.92	2.08	1.38	0.45	0.791 NS
LR1	1.68	1.38	2.32	1.66	-0.64	0.307 NS
LR2	2.85	2.36	2.17	1.65	0.69	0.910 NS
Overall	2.18	1.55	2.13	1.39	0.05	0.940 NS

n= number; LL1= mandibular left central incisor, LL2= mandibular left lateral incisor, LR1= mandibular right central incisor, LR2 = mandibular right lateral incisor, SD = standard deviation, NS=non significant where p> 0.05

TABLE (2) Comparison of labial alveolar bone (LAB) changes (mm) among mandibular incisors within each group using Friedman's test.

Group	LL1		LL2		LR1		LR2		*p*-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Multistrand (n=10)	1.66	1.47	2.53	1.92	1.68	1.38	2.85	2.36	0.120 NS
Single strand (n=10)	1.97	1.59	2.08	1.38	2.32	1.66	2.17	1.65	0.377 NS

n= nimber; LL1= mandibular left central incisor, LL2= mandibular left lateral incisor, LR1= mandibular right central incisor, LR2 = mandibular right lateral incisor, SD = standard deviation, NS=non significant where p> 0.05.

TABLE (3): Inter-group comparison of root length (RL) changes (mm) of mandibular incisors using Mann-Whitney U test.

Tooth	Multistrand Group(n=10)		Single strand group(n=10)		Mean difference	*p*-value
	Mean	SD	Mean	SD		
LL1	0.21	0.19	0.28	0.24	-0.06	0.562 NS
LL2	0.23	0.20	0.21	0.19	0.02	0.939 NS
LR1	0.31	0.29	0.27	0.23	0.04	0.642 NS
LR2	0.31	0.28	0.39	0.32	-0.09	0.877 NS
Overall	0.26	0.23	0.29	0.27	-0.02	0.940 NS

n= nimber; LL1= mandibular left central incisor, LL2= mandibular left lateral incisor, LR1= mandibular right central incisor, LR2 = mandibular right lateral incisor, SD = standard deviation, NS=non significant where p> 0.05.

TABLE (4): Comparison of root length (RL) changes (mm) among mandibular incisors within each group using Friedman's test.

Group	LL1		LL2		LR1		LR2		*p*-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Multistrand (n=10)	0.21	0.19	0.23	0.20	0.31	0.29	0.31	0.28	0.360 NS
Single strand (n=10)	0.28	0.24	0.21	0.19	0.27	0.23	0.39	0.32	1.000 NS

LL1= mandibular left central incisor, LL2= mandibular left lateral incisor, LR1= mandibular right central incisor, LR2 = mandibular right lateral incisor, SD = standard deviation, NS=non significant where p> 0.05

DISCUSSION

Alignment and leveling of teeth generally characterize the most imperative preliminary clinical stage of any of orthodontic fixed therapy. Among the adverse biological reactions to tooth movement, are the tendency for marginal alveolar bone loss and apical root resorption.[2-7]

The present study compared the changes in LAB level and RL of mandibular incisors with multistrand versus conventional NiTi archwires using CBCT. Finishing the leveling phase has been considered as the end point for evaluation of the two dissimilar aligning archwires, because it was suggested that the possible amount of root reduction in earlier phases of treatment is of high predictive value for severity of RR after the completion of treatment.[3,5,7]

Mandibular incisors were selected for this study because they are the most prone to alveolar bone loss and root resorption, since they have slender roots covered by a thin plate of alveolar bone. In addition, a small reduction of their roots length is easily detected by radiographic methods.[2] Moreover, the position of the mandibular incisors and its relation to the supporting bone that surround them has great importance on orthodontic diagnosis and treatment planning. Before initiating treatment, orthodontists should be aware of the existing bony support around the mandibular incisors in order not to violate the relatively small buccolingual dimensions of the alveolar process in this region. [27]

In the current study, the selected cases had a mild to moderate amount of crowding, therefore, they could be successfully treated by dentoalveolar expansion, although, the level of LAB may be affected by such intervention.[19-23] There has been an augmented concern in the orthodontic community for judgment of alveolar bone heights and thicknesses before, during, and after orthodontic intervention. The CBCT have made such estimation possible under situation where direct observation is not possible. [18,24,26,28]

With the advent of CBCT method, teeth and their supporting bone can be evaluated with low radiation doses as compared to other diagnostic medical imaging techniques, such as computed tomography scanning. Because of the high spatial resolution and relative affordability, it has gained widespread acceptance in dentistry and in orthodontics. In addition, CBCT assessment of RL and alveolar bone level during orthodontic treatment has many advantages over intraoral radiography. It makes it possible to create scenes similar to previous ones despite changes that may have occurred during treatment. The ability to provide distortion-free slice images of single roots provides excellent possibilities to study root resorption.[13,14,28]

As regards the reliability of CBCT measurements of the present study, Lund et al and Leung et al accomplished that despite changes in tooth positions, the CBCT technique yields a high level of reproducibility, enhancing its usefulness in orthodontic research. Besides, they concluded that it provides accurate and precise method for assessment of root shortening and bone level changes during orthodontic treatment.[14,28]

The forces delivered by the archwires, however, depend largely on the wire's material, mechanical and physical properties and dimensions of the wire, therefore, the initial aligning wires should apply light continuous force.[6] Conventionally, round wires are used for alignment because tightly fitting resilient rectangular archwires produce back-and forth movement of the root apices as the teeth move into alignment.[16] It was suggested that the need for alignment of posterior teeth with the initial aligning wire would be minimal, because the initial crowding usually minimal in the posterior segment.[6] Therefore, the present investigation was limited to the anterior segment.[25]

Concerning the effects of the investigated archwires on LAB level of mandibular incisors, the present results indicate that the mean changes in LAB level in the multistrand group are -1.66±1.47 mm for lower left central incisors (LL1), -2.53±1.92 for the lower left lateral incisors (LL2), -1.68±1.38mm for the lower right central incisors (LR1), and -2.85±2.36 for the lower right lateral incisors (LR2). Nevertheless, in single strand group, the mean LAB changes are (-1.97± 1.59 mm) for the LL1 and (-2.08± 1.38 mm) for LL2 and -2.32±1.66 mm for LR1 and -2.17±1.65 mm for LR2 (Table. 1).

It was reported that coaxial multistrand archwire offered the advantage of engaging a relatively large archwire at the start of treatment with low force delivery.[8] Furthermore, the alignment efficiency of 0.016-inch single-stranded NiTi versus 0.016-inch coaxial NiTi was compared in severe lower anterior crowding using Little's index. The degree of alignment with coaxial multistrand NiTi was significantly greater than with single-stranded NiTi.[8]

On the other hand, in the present invstigation LAB changes of LL1, LL2, LR1, and LR2 are not noticeably different between the two groups of archwires (p= 0.597, 0.791, 0.307 and 0.910, respectively). Moreover, the overall changes of LAB level, were not considerably diverse between both groups of archwires ($p = 0.940$). Additionally, there were no major differences in LAB changes of different mandibular incisors within each group (Table.2). Interestingly, both mandibular lateral incisors displayed more LAB loss than the mandibular centrals in both groups, however this difference was not statistically significant (p>0.05).

In the current study, the overall change in LAB level of the mandibular incisors segment was measured on 3D superimposition from alveolar crest of incisor on preoperative scan to the alveolar crest of incisor on postoperative scan. This indicates marginal alveolar bone reduction with both kinds of archwires that may be attributed to the expansion effect of the wires on incisor teeth with their consequent proclination. The available experimental information concurs with these findings where marginal LAB loss can occur when mandibular incisors were proclined. Steiner et al. showed that moving the mandibular incisors labially by 3.05 mm caused 5.48 mm of marginal labial bone loss in monkeys.[19] Moreover, Batenhorstet al. have moved mandibular incisors 6 mm labially that yielded 7 mm of labial bone loss compared with teeth that were not proclined.[20]

In harmony with the current study, 0.5 mm and 0.13 mm of posterior interdental bone loss has been reported in orthodontically treated patients compared with an untreated group using 2D radiographs.[21-23] Additionally, the current results are in accordance with the CBCT study of Garlock et al [1] who evaluated the marginal alveolar bone height of mandibular anterior region using conventional round NiTi 0.014 and 0.018 inch arch wires. They found average facial and lingual vertical bone loss of 1.16 ± 2.26 and 1.33 ± 2.50 mm, respectively. They concluded that orthodontic treatment produced changes in alveolar bone height and cortical bone thickness around the mandibular incisors.[1]

However, the mean vertical alveolar bone loss in the present work was greater than that reported by Garlock et al.(1) This may be attributed to the difference in treatment duration between the two studies, since the authors evaluated the alveolar bone changes after finishing stage with an average treatment duration of 22.7± 7.3 months. Therefore, resorption lacunae had enough time to be repaired, particularly; their patients were younger (average age 18.7 ± 10.8 years). Secondly, their investigation was conducted on a larger sample of 57 patients. Moreover, most of the current patients were females, and it has been reported that alveolar bone loss with fixed orthodontic therapy is larger in females.(18)

In premolar extractions cases, other human studies that assessed the changes in marginal alveolar bone due to retraction of anterior teeth indirectly support the present findings. Lund et al, who used CBCT in the anterior mandibular region found an average of 5.7 mm of bone loss on the lingual surface and increases of 0.8 mm on the buccal aspect of the same tooth.(1) Furthermore, Sarikaya et al found that the lingual alveolar bone of the mandible decreased significantly; in 11 of 19 patients over the central incisors, even though the labial bone maintained its thickness. This suggests that the bone thins as a tooth or root approaches cortical bone.(18)

It was supposed that multistrand superelastic NiTi wire, because of its reduced force level, would be capable to align the incisors with less adverse sequelae.(8) Unfortunately, no studies presented in literature that deal with the effect of superelastic coaxial NiTi wires on alveolar bone level, consequently, comparison seems to be currently not possible. As explained earlier, both tested NiTi archwires displayed no major difference in LAB changes of mandibular incisors (Table.1). Accordingly, this would provide us a clue that alveolar bone loss during treatment is multifactorial and other factors, rather than the wire behavior, may be responsible for this phenomenon.

Indeed, a number of authors have proposed that the pretreatment incisors' inclination, the architecture of LAB, and the facial variety are essential factors to estimate the marginal bone loss throughout treatment.(4,17,18) Nevertheless, there seems to be deficient human CBCT data concerning changes of the marginal LAB as a result of labial tooth movement or proclination of incisors. Yet, Garlock et al reported that incisor inclination was not correlated with alveolar bone height changes using CBCT.(1)

Regarding the effects of the investigated archwires on RL of mandibular incisors, the mean RL changes in the multistranded group for LL1, LL2, LR1, and LR2 were -0.21± 0.19 mm, -0.23 ± 0.20 mm, -0.31± 0.29mm, and -0.31±0.28 mm, respectively. On the other hand, in single strand group, the mean RL changes of LL1, LL2, LR1, and LR2 were -0.28± 0.24mm, -0.21± 0.19mm, -0.27±0.23mm, -0.39±0.32mm, respectively (Table.3).

The current results illustrate no significant difference (p>0.05) in RL changes of different mandibular incisors whichever within each group or between both groups of wires (Tables. 3&4). The overall RL change in the mandibular incisors segment as measured on 3D superimposition was - 0.26 mm ± 0.23 in multistrand group and - 0.29 mm ± 0.27 in single strand group (Table. 3). This indicates minimal non-significant RL reduction with both kinds of archwires.

Whereas, several laboratory and clinical studies have compared both aligning archwires in relation to their mechanical properties and clinical efficiency,[8-12] however, no CBCT studies are currently available that investigated changes of LAB and/or RR associated with the current tested archwires. Moreover, most of the available reports concerning RR and alveolar bone changes were performed with 2D radiographic methods associated with dissimilar orthodontic treatment modalities that made difficult comparisons with other studies.(14,22)

Comparison of RL changes between both groups of archwires has demonstrated no significant differences. Unfortunately, these results couldn't be directly compared to previous 2D radiographic studies and the literature is scarce in CBCT studies concerning the effect of increasing the lower incisors' angulations with superelastic wires on their RL.

Nevertheless, the present results indirectly coincide with those of Alzahawi et al.[2] who used periapical radiographs to compare root resorption after the orthodontic leveling phase, performed by either superelastic or multi-stranded stainless steel archwires. It was concluded that incisor root resorption after leveling did not differ significantly between patients treated with super-elastic and multi-stranded stainless steel archwires, except for the LL1 that revealed a more extensive resorption in the superelastic group. Furthermore, the present findings are in some way linked to those of Makedonas et al who recognized that root resorption after 6 months of orthodontic treatment was clinically considerable only for 4% of the patients by utlizing CBCT. [5]

In fact, there are three common radiographic methods to judge RR; direct measurement of root length from the radiograph [2], the use of ordinal scales to score the degree and severity of RR,[5,29] and 3D volumetric assessments.[30] In the present study, a modified method for assessment of the changes in the LAB and the RL was chosen via a CBCT 3D superimposition of individual teeth rather than direct measurements of tooth length to avoid as much as possible the errors associated with the routine methods.[14] In addition, volumetric analysis of root length was not used because of its problematical procedures.[1,28]

One shortcoming of this study could be the sample size that was accustomed to the least adequate size. Possibly, a larger sample size might be able to identify a significant difference between both aligning archwires and any possible gender differences. Additionally, longitudinal assessment of alveolar bone and RL changes might indicate to what level the osseous architecture is changed by treatment. It is recommended to carry out further clinical studies to analyze these changes subsequent to different orthodontic treatment modalities.

The morphology of the maxillary and mandibular alveolar cortex plays an important role in the planning of orthodontic treatment, especially in cases where there is a considerable discrepancy between the volume of teeth and the amount of space available in the dental arches. Unnecessary proclination of the anterior teeth possibly will result in iatrogenic sequelae such as facial alveolar bone loss, root resorption, fenestration and/or dehiscences, and gingival recession which is more common around mandibular incisors.[31,32] Hence, appraisal of the alveolar bone and roots of the anterior teeth after dental arch expansion could be helpful to elucidate the therapeutic limitation of orthodontic tooth movement.[3,6,7,17,31,32]

A pre-treatment CBCT assessment might help the planning for specific torque requirements or identifying bone levels that would preclude or limit certain types of orthodontic tooth movements. A disadvantage of CBCT judgment is that the radiation dose is higher than that of intraoral radiography. This leads to special considerations concerning treatment follow-ups and controls, especially in healthy young individuals, such as those undergoing orthodontic treatment. Efforts must be made to follow the ALARA (As Low As Reasonably Achievable) principle.[33]

CONCLUSION

1. Both superelastic coaxial multistrand and conventional single strand NiTi aligning archwires produce minimal degree of marginal LAB loss and root resorption of the mandibualr incisors during orthodontic leveling and alignment phase.
2. No wire is favored over the other in reducing the incidence for LAB loss or root resorption during the alignment stage.

3. Individual susceptibility and individual tooth type could be a risk factor in alveolar bone loss, since the lateral incisors are more affected in both groups of archwires.

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