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Alignment Efficiency of Nickel-Free Niobium–Titanium–Tantalum–Zirconium Compared to Nickel–Titanium Orthodontic Archwires during Initial Treatment Phase: A Randomized Controlled Trial

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Abstract

Objective This randomized controlled trial investigated the efficiency of nickel–titanium (NiTi) and nickel-free archwires during the initial leveling and alignment stage.
Materials and Methods A total of 30 patients (mean age, 17.81 ± 1.96 years) were randomly grouped to receive either single-strand or niobium–titanium–tantalum–zirconium (nickel-free Gummetal), or multistrand NiTi archwires. All the patients had moderate anterior crowding and were treated via a nonextraction approach. Three-dimensional digital models were taken at baseline (T0) and 4-week intervals for three months (T1, T2, and T3). The amount and percentage variations in Little's Irregularity Index (LII) scores during the 3-month observation period were used to estimate alignment efficiency and rate.
Statistical Analysis The Analysis of variance (ANOVA) and Kruskall–Wallis tests were used to test the differences between the three archwire groups. The difference between variables within each group at different measurement intervals was assessed using paired *t*-test.
Results The LII scores were reduced in all the three archwire groups; however, there were insignificant differences in the scores between the tested archwire groups ($p < 0.05$). For the single-strand NiTi group, the LII scores reduced by 2.15 mm (28.38%) after 4 weeks (T1) by 3.79 mm (47.93%) after 8 weeks (T2), and by 5.61 mm (73.98%) after 12 weeks (T3). The LII scores decreased by 1.90 mm (26.93%) after 4 weeks, 3.59 mm (50.84%) after 8 weeks, and 5.28 mm (74.85%) after 12 weeks with Gummetal archwire. Similar to the other groups, the LII scores for multistrand archwire reduced by 1.82 (27.83%), 3.34 (51.07%), and 4.54 mm (69.38%) at T1, T2, and T3, respectively. There was nonsignificant differences in the alignment rates (mm) and percentage (%) of changes among the groups at all measurement intervals ($p > 0.05$).

Keywords
- orthodontic leveling and alignment
- Little's index
- nickel free
- NiTi archwires

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Conclusion All three tested archwires were equally effective for correcting moderate mandibular anterior crowding. Furthermore, all three archwires produced a comparable rate of alignment after 12 weeks of initiating orthodontic therapy.

Introduction

Dental crowding is the most frequent malocclusion with the highest prevalence in the mandibular anterior region. The most critical stage of fixed orthodontic therapy is leveling and alignment which involves relieving of crowding in addition to an improvement in both vertical and horizontal discrepancies that is accomplished by different types of archwires.[1–3]

Nickel–titanium (NiTi) archwires are generally used as initial wires during orthodontic therapy because of their advantageous properties such as higher elastic limit, good durability, and low elastic modulus.[4] However, these archwires cannot be used in patients allergic to nickel, necessitating the use of an alternate archwires in those cases.[5] Gummetal is a new niobium-based titanium archwire with a chemical description and formula of Niobium–Titanium–Tantalum–Zirconium and Ti-Nb-Ta-Zr, respectively.[6] This wire is shaped formable and produces light-continuous forces in addition to being nickel free. Despite the fact that the safety and hypersensitivity reactions of nickel-free alloys have been experimentally tested,[6,7], there is limited clinical evidence about the effectiveness of Gummetal archwire.[8]

Another limitation of conventional single-strand NiTi archwire is that there could be a difficult wire engagement without its permanent deformation in some cases. Multistranded archwires are currently recommended for mechanical benefits they provide such as improved flexibility and a lower load deflection rate. This has been attempted favorably with stainless steel archwires[9,10] and also other attempts have been made in the NiTi category, where multistrand, also referred to as supercable or coaxial NiTi, archwires have been introduced.

It was suggested that these wires could be advantageous because of greater spring back, high resistance to deformation, and sparse force delivery. Furthermore, compared with other aligning archwires, multistrand NiTi archwires have been shown to engage a comparably large distance at the beginning of treatment, allowing for better degrees of uprighting, leveling, and rotation control.[11] Few clinical studies[1,8,12,13] are available that have investigated the efficiency of the NiTi archwires during the initial leveling and alignment stage. Nevertheless, to the current knowledge, no studies have compared the single- and multistrand NiTi archwires with the nickel-free Gummetal archwire.

Accordingly, it appeared valuable to assess the clinical efficiency of these archwires during the orthodontic leveling and alignment stage. Therefore, this clinical study investigated the efficiency of single- and multistrand NiTi archwires with the nickel-free Gummetal archwire during leveling and alignment of initial orthodontic stage. The study's primary outcome was to evaluate and compare the alignment efficiency among the three archwires. The secondary outcome was evaluating the monthly alignment rate of the archwires during the clinical observation period.

Materials and Methods

Study Design and Ethical Approval

This study was an examiner-blinded, single-centered, three-group randomized clinical trial (RCT) registered at ClinicalTrials.gov (ID: NCT04387578) and following the Consolidated Standards of Reporting Trials (CONSORT) guidelines. The study protocol was in accordance with the World Medical Association (WMA) Declaration of Helsinki (as revised in 2013) and Good Clinical Practice recommendations. The study was performed during September 2018 to September 2019 after obtaining necessary approval from the Institutional Review Board and the Ethical Research Committee of Faculty of Dental Medicine (Boys), Al-Azhar University, Egypt with approval number (xxxxxxxx). The study enrolled 30 patients with a mean age of 17.81 ± 1.96 years (►**Table 1**) from the Outpatient Clinic, Department of Orthodontics,

Table 1 Baseline patient characteristics comparison among the treatment groups

		Total	Single-strand NiTi	Gummetal	Multistrand NiTi	*p*-Value	Sig.
		($n=28$)	($n=10$)	($n=8$)	($n=10$)		
Gender	Females	15 (55.6%)	5 (50.0%)	4 (50.0%)	6 (60.0%)	0.92[a]	NS
	Males	13 (44.4%)	5 (50.0%)	4 (50.0%)	4 (40.0%)		
Age (y)	Mean ± SD	17.81 ± 1.96	17.27 ± 1.95	17.33 ± 2.42	18.70 ± 1.49	0.20[b]	NS
	Range	15–20					

Abbreviations: NiTi, nickel–titanium; NS, nonsignificant; SD, standard deviation; Sig., significance.
[a]Chi-square test.
[b]One way analysis of variance. ($p > 0.05$).

(**2072018**). The patients and/or their parents were informed about the study aim and protocol and later signed an informed consent form.

Sample Size Estimation

In accordance with a previous study,[3] the sample size calculation was accomplished with G*power version 3.1 software. Assuming 80% power and α value (two-tailed) of 0.05, it was required to have a total of 27 patients (nine per group) to detect a tooth movement difference of 1 mm. A difference of 1.0 mm was chosen because any tooth movement <1.0 mm could not be clinically justified. However, it was decided to increase the sample size to 30 patients to compensate for any possible dropouts or missed patients during the study period.

Eligibility Criteria

The sample patients in the age group of 15 to 20 years were included if they presented with moderate mandibular anterior crowding to be treated without extractions in complete permanent dentition excluding third molars, absence of tooth anomalies as evident from radiographs, no blocked, or impacted tooth that posed an obstruction for bracket placement. The patients were excluded if they had undergone orthodontic treatment, anomalies and syndromes, atypical vertical and anteroposterior relationships, cleft lip and palate, periodontal diseases, periapical lesions, and bone resorption in mandibular region as evident from radiographs, and any routine patient medications that could impede orthodontic tooth movement.

Randomization and Allocation Concealment

The sample grouping was performed using a controlled randomization technique via an online software (*https://www.graphpad.com*). A blinded investigator (A.M.A.), who was unaware of the study process accomplished the randomization and patient allocation-concealment process. The computer-generated numbers were assigned to each patient on the day of bracket bonding, and the patients were informed not to disclose their numbers to the clinician performing the treatment. Accordingly, the patients were randomly allocated to one of the three groups as listed below:

- Single-strand NiTi archwire group: 10 patients (five males and five females; mean age: 17.27 ± 1.95 years) were treated with round super elastic single-strand NiTi archwires (Henry Schein Orthodontics, California, United States) in an order of 0.012, 0.014, and 0.016 inches.
- Gummetal archwire group: 10 patients (six males and four females; mean age: 17.33 ± 2.42 years) were treated with round nickel-free (Gummetal) archwires (Rocky Mountain Morita Corporation, Tokyo, Japan) in an order of 0.014, 0.016, and 0.018 inches according to manufacturer's recommendations.
- Multi-strand NiTi archwires: 10 patients (four males and six females; mean age: 18.70 ± 1.49 years) were treated with round multistrand NiTi archwires (Speed System Orthodontics, Ontario, Canada) in an order of 0.016, 0.018, and 0.020 inches according to manufacturer's recommendations.

Roth preadjusted metal orthodontic brackets (0.022 inch × 0.028 inch, 3M Unitek, Monrovia, United States) were bonded to all the patients by a single orthodontist (A.T.H) who was blinded to the randomization and patient allocation. In each group, the archwires were utilized for leveling and alignment of the teeth as part of the complete orthodontic treatment plan. The archwire was engaged to the teeth wherever clinically possible and ligated with figure-of-eight elastomeric modules (Oromo Corporation, California, United States). All patients were examined before treatment (T0), and after week 4 (T1), week 8 (T2), and week 12 (T3) of treatment.

Study Measurements and Data Collection

Basic orthodontic records were obtained for all the patients before treatment. An alginate impression of the mandibular arch was made and poured immediately with white extrahard dental stone for all the patients. The obtained study casts were scanned using a three-dimensional (3D) digital scanner (Einscan, Shining 3D Tech Co., Hangzhou, China) and uploaded to 3D software (Maestro 3D Orthodontics Design, Shining 3D Tech Co., Hangzhou, China) to obtain 3D models for all patients.

The alignment efficiency of the archwires was evaluated by measuring the Little Irregularity Index (LII) scores[14] during the 3-month observation period in accordance with previous studies.[3,8,12,15–17]The LII scores was calculated by measuring the linear displacement of anatomic contact points of each mandibular incisor from the adjacent tooth's anatomic contact point where the sum of the five displacements represented the relative degree of anterior irregularity. Scoring of LII scores (mm) was determined on a scale of 0 to 10 as following: 0 is perfect alignment, 1 to 3 is minimal irregularity, 4 to 6 is moderate irregularity, 7 to 9 is severe irregularity, and 10 implies very severe irregularity.[14] The scores were measured using the 3D design software (as in ►**Fig. 1**) by a single clinician who was blinded to the study design and groups. The measurement was assessed for each patient in all the groups at T0, T1, T2, and T3 intervals. The alignment rate of the mandibular anterior region at different observation period was calculated by dividing the change in LII score (mm) on time elapsed during the study period.[17]

Reliability Measurements

To assess intrarater reliability of the measurements, a total of 36 random 3D models were selected and LII scores was remeasured by the same clinician (A.M.A) after 4 weeks from the first measurement. Reliability was described as the degree to which a measurement of the randomly selected 3D models could be reproduced under similar testing conditions. For assessing the interrater reliability, one randomly chosen measurement of the primary investigator (A.M.A) was independently repeated by a second investigator (F.A.H).

Statistical Analysis

The collected data were analyzed using SPSS (IBM SPSS, v.23, Chicago, Illinois, United States) software. Data were statistically presented in terms of means, standard deviations, standard error, mean difference, and percentage (%) of changes in variables. One-way analysis of variance (ANOVA) followed by

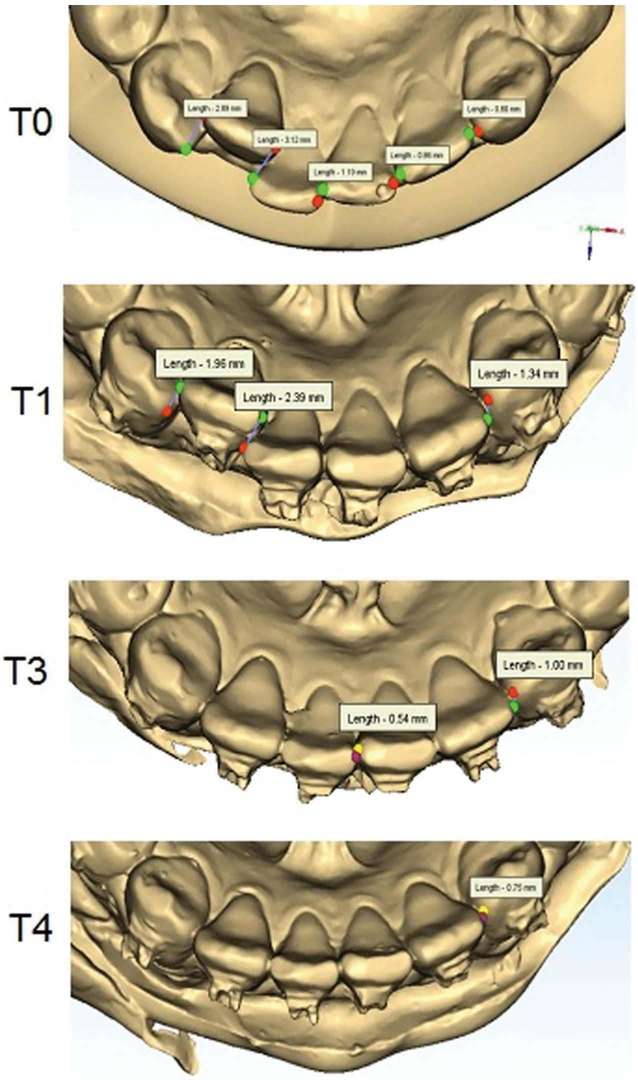

Fig. 1 Measurement of Little's irregularity index on a 3D scanned digital model using Maestro 3D software. T0 (before treatment), T1 (after 4 weeks), T2 (after 8 weeks), T3 (after 12 weeks). 3D, three-dimensional.

Kruskall–Wallis test was used to appraise the difference among the three groups. The difference between variables within each group at different observation period was analyzed using paired *t*-test. Intraexaminer reliability measurements of the 3D models was assessed using a paired *t*-test. Intraclass correlations coefficient (ICC) with 95% confidence interval (CI) were used to assess the interrater reliability for the measurements. Pearson's correlation analysis was performed to assess the improvement in alignment efficiency of the archwire groups with an increase in initial irregularity index values. The significance level was set at $p \leq 0.05$.

Results

Patient Follow-up and Drop Outs

In total, 45 patients were assessed for eligibility and 15 of those were excluded. Nine of the excluded participants did not match the inclusion requirements and six declined to

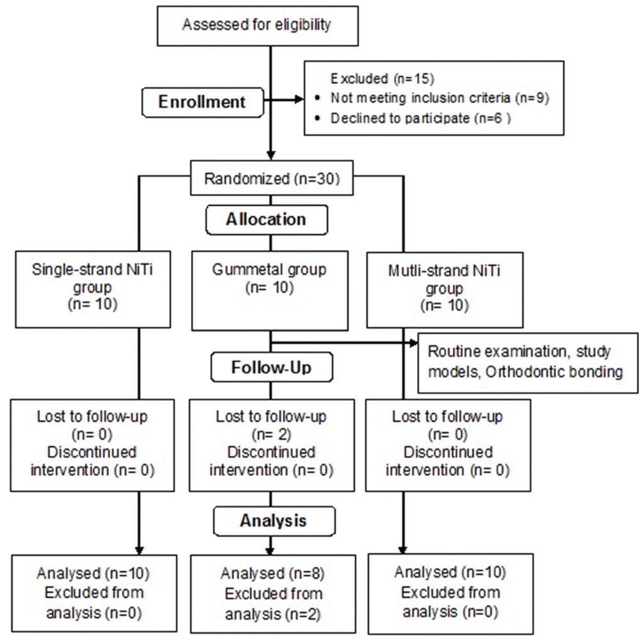

Fig. 2 CONSORT flow diagram of the study process. CONSORT, Consolidated Standards of Reporting Trials.

participate in the study. The 30 patients enrolled in the current study were randomly allocated into three groups. However, two male patients in the Gummetal archwire group were lost to follow-up due to missed appointments and lack of reasonable cooperation. The remaining 28 patients completed their 3 months' follow-up in accordance with the study objective and the data obtained were included in the analysis. ►**Fig. 2** presents the flow chart outlining patient's enrolment and measurements in accordance with CONSORT guidelines.

Reliability of Measurements

The repeated measurements demonstrated no significant differences from the first measurements ($p > 0.05$, paired *t*-test), indicating very strong intraexaminer reliability. ICC with 95% CI among the archwires groups at different measurement intervals are presented in ►**Table 2**. The ICC for the interrater measurements ranged from 0.963 to 0.999 indicating excellent reliability.

Study Outcomes

There was insignificant difference in LII scores (mm) of mandibular anterior teeth before treatment (T0) among the three archwire groups ($p > 0.05$). The LII scores for single-strand NiTi archwire were 7.59 ± 1.44, Gummetal archwire was 7.06 ± 1.66, and multistrand NiTi archwire was 6.55 ± 1.55 (►**Table 3**). These results show that pretreatment mandibular anterior crowding was comparable among the groups.

Descriptive statistics and comparison of variations in LII scores (amount [mm] and %) at different observation period within the three archwires groups using paired *t*-test is presented in ►**Table 2**. In the single-strand group, there

Table 2 ICC with 95% CI among the archwire groups at different measurement intervals

	ICC (95% CI)			
	T0	T1	T2	T3
Single strand NiTi	0.999 (0.994–0.999)	0.997 (0.983–0.999)	0.992 (0.944–0.998)	0.999 (0.9934–0.999)
Gummetal	0.963 (0.763–0.994)	0.999 (0.9936–0.999)	0.998 (0.985–0.999)	0.999 (0.996–0.999)
Multi strand NiTi	0.998 (0.990–0.999)	0.995 (0.970–0.999)	0.993 (0.951–0.999)	0.998 (0.991–0.999)

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient; NiTi, nickel–titanium.
Note: T0, before treatment; T1, after four weeks; T2, after eight weeks; and T3, after 12 weeks.

Table 3 Descriptive statistics and comparison of amount (mm) and % changes in LII scores among the archwire groups from baseline to different measurement intervals

Archwire groups	Measurement interval	Mean ± SD	SE	Mean ± SD	SE	Mean changes (mm)	SE	Mean changes (%)	*p*-Value
Single strand NiTi ($n=10$)	T0–T1	7.59 ± 1.44	0.43	5.43 ± 1.84	0.56	2.16	0.70	−28.38	0.001[a]
	T0–T2	7.59 ± 1.44	0.43	3.80 ± 2.34	0.71	3.79	0.72	−49.93	0.000[a]
	T0–T3	7.59 ± 1.44	0.43	1.97 ± 1.70	0.51	5.61	0.42	−73.98	0.000[a]
Gummetal ($n=8$)	T0–T1	7.06 ± 1.66	0.68	5.16 ± 2.29	0.93	1.90	0.19	−26.93	0.030[a]
	T0–T2	7.06 ± 1.66	0.68	3.47 ± 1.90	0.78	3.59	0.37	−50.84	0.003[a]
	T0–T3	7.06 ± 1.66	0.68	1.78 ± 2.30	0.94	5.28	0.43	−74.85	0.002[a]
Multistrand NiTi ($n=10$)	T0–T1	6.55 ± 1.55	0.49	4.73 ± 1.71	0.54	1.82	0.57	−27.83	0.000[a]
	T0–T2	6.55 ± 1.55	0.49	3.20 ± 2.21	0.70	3.34	0.34	−51.07	0.000[a]
	T0–T3	6.55 ± 1.55	0.49	2.01 ± 1.14	0.36	4.54	0.27	−69.38	0.000[a]

Abbreviations: LII, Little's irregularity index; NiTi, nickel–titanium; SD, standard deviation; SE, standard error; T0, before treatment; T1, after 4 weeks; T2, after 8 weeks; T3, after 12 weeks.
[a]Statistically significant values ($p \leq 0.05$).

was a significant decrease ($p \leq 0.001$) in LII scores by 2.15 (28.38%), 3.79 (49.93%), and 5.61 mm (73.98%), during T0 to T1, T0 to T2, and T0 to T3 intervals, respectively.

In the Gummetal archwire group, we observed a significant decrease in LII scores by 1.90 (26.93%), 3.59 (50.84%), and 5.28 mm (74.85%) during T0 to T1, T0 to T2, and T0 to T3 intervals, respectively ($p \leq 0.001$). Similarly, in the multistrand NiTi archwire group, there was a significant decrease ($p \leq 0.001$) in LII scores by 1.82 mm (27.83%) at T0 to T1, 3.34 mm (51.07%) at T0 to T2, and 4.54 mm (69.38%) at T0 to T3 intervals.

The comparison of changes (mm and %) in LII scores among the three groups using the one-way ANOVA test demonstrated nonsignificant differences ($p > 0.05$) in the alignment scores (mm) and percentage (%) of changes at all observation intervals (►**Table 3**).

►**Table 4** shows the alignment rate (mm/month) comparison during T0 to T1, T0 to T2, and T0 to T3 intervals using the one-way ANOVA test. There were nonsignificant differences ($p > 0.05$) in the monthly alignment rate among the tested archwire groups at all observation intervals.

Pearson's correlation showed a moderate nonsignificant correlation ($r = -0.714$, $p = 0.286$) between the alignment efficiency improvement and an increase in initial LII during the 12 weeks treatment period.

Discussion

Leveling and alignment correspond to the most crucial orthodontic phase, since they dramatically improve the facial appearance and enhance patient satisfaction. Different archwires forms and alloys have been utilized for this phase. Although NiTi archwires are frequently used as initial wires, they have some limitations, such as in patients with nickel sensitivity, where an alternative archwire was proposed such as nickel-free Gummetal archwire.[4,8,18] In addition, multistrand NiTi archwires were developed to offer lower force compared with conventional single-strand wires.[11] These archwires were tested to some extent in several laboratory experiments.[6,7,10,19,20] Unfortunately, there is limited clinical data regarding the effectiveness of these archwires during initial orthodontic stage, particularly lacking comparison with the Gummetal wires.[1,8,11,13] Consequently, this study aimed to investigate the efficiency of these archwires for alleviating moderately crowded mandibular cases.

Table 4 Comparison of alignment rate (mm/month) among the archwire groups at different measurement intervals

Measurement interval	Single strand NiTi ($n = 10$)		Gummetal ($n = 8$)		Multistrand NiTi ($n = 10$)		Test value	*p*-Value
	Mean ± SD	SE	Mean ± SD	SE	Mean ± SD	SE		
T0--T1	2.15 ± 0.56	0.76	1.90 ± 0.54	0.59	1.82 ± 0.11	0.79	0.164	0.850
T0–T2	1.89 ± 0.14	0.41	1.79 ± 0.84	0.52	1.68 ± 0.81	0.36	0.123	0.884
T0–T3	1.87 ± 0.73	0.33	1.76 ± 0.74	0.74	1.51 ± 0.45	0.43	0.830	0.448

Abbreviations: LII, Little's irregularity index; NiTi, nickel–titanium; SD, standard deviation; SE, standard error; T0, before treatment; T1, after 4 weeks; T2, after 8 weeks; T3, after 12 weeks.

Patients of the current sample were selected with a narrow age range to obtain, as much as possible, the same biological response. In addition, adolescents and young adults were included to negate the aging effects on the periodontium as possible.[1] According to the previous studies, the study groups were matched up as possible in terms of demographic characteristics and the amount of initial crowding.[1,3,8,11,13]

In accordance with previous clinical reports, the efficiency of the current aligning archwires was evaluated based on an assessment of changes in scores of LII which address the sum of the five-contact point displacement for the mandibular anterior teeth.[3,8,11–13,15–17] Previous studies have employed index of tooth alignment approach which evaluates contact-point displacements over the entire dental arch.[10] This may be more effective when deviations are found in the dental arch's posterior region. The current experiment was confined to the mandibular anterior because the alignment of the posterior segment with the initial aligning wires would be nominal.[3,8,17]

In the current investigation, Maestro 3D software was used to analyze the changes of LII scores per other studies.[8,16] Currently, two standard methods are used for the assessment of changes in LII scores; direct and manual measurement with a vernier caliper[12,17] and indirect (digital) measurement using 3D scanned digital models.[8] The later approach is determined to be more accurate and accessible compared with manual approach.[21–23]

A follow-up period of 12 weeks in this study to evaluate the aligning efficiency is consistent with other studies[1,8,11] because of the unpredictable outcome awaiting the completion of alignment stage. Furthermore, it would not be acceptable to unduly extend the leveling and aligning stage and comprehensive treatment period, if there is any prior alignment by any particular archwire.[13] The tested archwires in this study had round configurations that were utilized for alignment because the use of closely fitting resilient rectangular archwires creates back-and-forth movement of root apices as the teeth aligned.[24] The efficacy of the initial stage of fixed appliance therapy, which is focused with tooth alignment, is dependent on various factors. In addition to biological aspects, such as periodontal conditions and cellular and connective tissue response, that are beyond the control of the orthodontist, the selected bracket system and orthodontic archwires have a direct impact on the outcome of orthodontic treatment.[1] The main of the current study was to compare the three archwires, it was crucial to standardize all the relative factors that could influence the alignment rate such as bracket type and the associated inter bracket span.

The archwire order used followed the manufacturer's instructions, especially in the nickel-free Gummetal and multistrand categories. Ong et al[9] evaluated the effectiveness of three archwire sequences from initial alignment to working archwire placement in the mandibular arch. The authors found no significant variations in efficiency among archwire sequences as related to the time it took to start the working archwire and patient discomfort. They came to the conclusion that archwire selection is influenced by the clinician's therapeutic philosophy and expertise.

Regarding the force level of multistrand NiTi wires, Berger and Waram[25] reported that multistrand superelastic NiTi wires could profoundly reduce the force delivered by the initial archwire. A 55 g of force considered by 0.016-inch multistrand NiTi archwire was the lowest force, and force produced by 0.020-inch multistrand NiTi archwires was only 105 g. Also, the unloading force calculated for the smallest copper NiTi archwire of 0.013 inches was about three times larger than that of the smallest multistrand NiTi archwire of 0.016 inches. Furthermore, at 3-mm deflection, 0.012-inch nitinol produces greater forces than 0.020-inch multistrand NiTi wires.[25]

The current findings demonstrated that LII scores were reduced in all patients with same amounts and rates when single, multistrand NiTi, and nickel-free Gummetal archwires were used for alignment. This was manifested as alleviating crowded mandibular arches of all patients included in the present sample (►**Fig. 3**). However, there are currently no relevant clinical studies that address this issue in relation to these archwires, making comparisons with existing results difficult.

The current findings are inconsistent to those of Nordstrom et al[8] who found no significant difference between single-strand NiTi and Gummetal archwires regarding changes in LII scores for a somewhat more extended period of 12 to 16 weeks. However, the authors concluded that Gummetal wires having added advantages over conventional single-strand NiTi in terms of formability and use in nickel allergy patients. Moreover, the present investigation supports findings of Suzuki et al,[7] in experimental animals that

Fig. 3 Intra-oral photographs of the representative patients treated using the arch wires (**A**) pretreatment right side view, (**B**) pretreatment occlusal view, (**C**) pretreatment left side view, (**D**) posttreatment right side view, (**E**) posttreatment occlusal view, (**F**) posttreatment left side view

used nickel-free and NiTi archwires to deliver buccal tooth movement that reported no difference between the two archwires. In addition, the present outcomes are in general agreement with laboratory studies which showed that the clinical performance of Gummetal archwires could be comparable to NiTi, as they generate forces and have low stiffness and Young's modulus.[26,27]

Nevertheless, Abdelrahman et al[1] reported somewhat different results regarding NiTi archwires and mandibular anterior crowding after 8 weeks. They observed that 0.014-inch NiTi, 0.014-inch thermal NiTi, and 0.014-inch Nitinol, all reduced irregularity by 4.76, 4.86, and 4.75 mm, respectively. Due to differences in initial irregularity scores and the type and dimension of their NiTi archwires, their patient sample witnessed a more significant decrease in irregularity than the current study. Concerning multistrand NiTi arch, the present results oppose the study outcomes of the Sebastian[11] who found that these archwires were more efficient than single-strand NiTi one to relieve crowded mandibular arches after 12 weeks. The mean tooth movements in the former study produced by multistrand NiTi archwire were 4.93, 7.40, and 9.87 mm, whereas for single-strand NiTi archwire, they were 1.55, 2.33, and 3.10 mm at 4, 8, and 12 weeks, respectively.

However, it is essential to note that the author selected a sample with moderate to extreme crowding of the lower anterior segment and used the same diameter of 0.016 inches for both archwires at the start of treatment that differed in their modulus elasticity. According to the author, the complex engagement of single-strand NiTi was more evident than the multistrand NiTi one. This could explain why the variation in alignment efficiency between the two archwires in the previous investigation was so substantial. Another reason for dissimilarity could be that he utilized different assessment methods of alignment via coordinate measuring machine.[11]

Limitations

One limitation of this study could be the sample size adjusted to the minimum sufficient size based on the previous study.[3] Perhaps, a larger sample size could be able to detect a difference among these aligning archwires. Furthermore, including patients with extreme crowding might demonstrate a difference in their clinical performance.

Unfortunately, no published studies utilized Gummetal or multistrand NiTi archwires in extraction cases with limited information about their friction aspects. Future studies of these archwires with different sequences or configurations over a longer duration with another bracket's variety could demonstrate clinical differences. It is suggested to perform additional clinical trials to explore further the clinical efficiency of Gummetal archwire relative to incidence of root resorption and confirm its advantage of being nickel free.

Conclusion

Single-strand NiTi, multistrand NiTi, and nickel-free Gummetal archwires are equally effective for correcting moderate mandibular anterior crowding, as evident by reducing Little's index. Furthermore, all three archwires produced a comparable rate of alignment after a 12-week period of an initial stage of orthodontic therapy.

Conflict of Interest
None declared.

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