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Original Article

Alleviation of Lower Anterior Crowding with Super-Elastic and Heat-Activated NiTi Wires: A Prospective Clinical Trial

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Main Points

- Both heat-activated and super-elastic archwires showed similar alleviation of lower anterior crowding in initial leveling and aligning stages.
- Heat-activated archwires can be used to engage grossly malpositioned teeth to obtain greater control at the initial stages of treatment.
- Intercanine width, intermolar width, and arch depth were increased with use of heat-activated archwires.

ABSTRACT

Objective: To compare the amount of alleviation of lower anterior crowding and changes in intercanine width (ICW), intermolar width (IMW), and arch depth (AD) dimensions using 2 different types of nickel-titanium (NiTi) archwires.

Methods: Thirty participants were randomly allocated to 2 treatment groups, using heat-activated NiTi (HANT) or super-elastic (SE-NiTi) round (0.014″) archwires. The inclusion criteria were a Little's Irregularity Index (LII) greater than 4, malocclusion requiring non-extraction therapy, all teeth erupted to the second molars in the lower arch, and Angle's Class I malocclusion. The primary aim was to measure alleviation in mandibular crowding over 12 weeks; the secondary aim was to measure changes in ICW, IMW, and AD during those 12 weeks. Simple randomization was performed. The measurements were made on dental stone casts using a coordinate measuring machine at 4-week intervals.

Results: LII at 0, 4, 8, and 12 weeks was 8.59 ± 1.44, 6.17 ± 1.65, 4.65 ± 1.63, and 3.28 ± 1.57 mm in the HANT; 8.87 ± 1.29, 6.92 ± 1.49, 5.25 ± 1.32, and 3.63 ± 1.32 mm in the SE-NiTi group, respectively. ICW increased from 25.43 ± 1.39 to 27.41 ± 1.29 mm in the HANT and from 25.81 ± 1.78 to 27.27 ± 1.83 mm in the SE-NiTi groups over a period of 12 weeks, at $P < .05$. There was a statistically significant increase in IMW, CAD (canine arch depth), and MAD (molar arch depth), favoring the HANT group ($P < .05$). No significant differences in LII between the 2 groups were noted ($P > .05$).

Conclusions: The amount of alleviation of lower anterior crowding was similar with both archwires. ICW, IMW, and AD increased with HANT archwires.

Keywords: Orthodontic wire, nitinol, crowding, arch dimensions, coordinate measuring machine, tooth movement

INTRODUCTION

Fixed appliance therapy is a pillar of contemporary orthodontic treatment, in which archwires are used for force application. The aim of using aligning archwires at treatment initiation is primarily to alleviate crowding. Aligning archwires use light forces to move teeth, thereby reducing root resorption.[1] The dimensional and physical–chemical properties of an archwire determine the amount of force delivered clinically. Ideal properties of aligning archwires include a large range of activation, flexibility, low modulus of elasticity with reduced friction, low cost, and ease of manufacture.[2]

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Stainless steel (SS) archwires were the clinicians' first choice before the introduction of nickel-titanium (NiTi) archwires.[3] Subsequent developments led to the production of stabilized NiTi alloys by "Unitek Corporation" under the trade name Nitinol (Nickel Titanium Naval Ordinance Laboratory), for clinical use. This archwire soon replaced SS wires. Further searches for a better archwire for orthodontic use led to the development of super-elastic NiTi (SE-NiTi) alloys in 1978. Many modifications in archwire properties were made to obtain an ideal archwire with definite clinical advantages. One was the addition of copper (Cu) to NiTi wires, called Copper-NiTi (CuNiTi) wire or heat-activated archwires. These archwires demonstrated true shape-memory effects above the transition temperature range.

Adding Cu to the NiTi alloy improves shape-memory properties, thermal stability, and fatigue endurance; mitigates hysteresis and loading stress; and helps regulate transition temperature range.[4,5] These effects help in accelerating tooth movement.[6] Different compositions of NiTi alloy archwires with varied mechanical properties have shown various advantages in the literature.[6,7] However, most studies have been in vitro and require validation by in vivo studies. The findings obtained from in vitro[6,7] conditions are ambiguous compared to in vivo studies.[8-10] Two studies[11,12] showed contrasting results of alignment efficiency, where no significant difference was noted between Cu-NiTi and NiTi archwires. Conversely, another study[13] found that heat-activated NiTi (HANT) was more efficient in aligning teeth. Weiland et al.[14] demonstrated greater efficiency with SE-NiTi wires but with higher root resorption. These conflicting findings from multiple investigators make it difficult to gauge which archwire is better in terms of performance or alignment.[15]

The purpose of the present study was to investigate differences in the degree of alleviation of lower anterior crowding using SE-NiTi and HANT round archwires for alignment. It also aimed to assess intermandibular arch dimensional changes over 12 weeks using a coordinate measuring machine (CMM). The authors hypothesized that no difference would be observed between SE-NiTi and HANT archwires in the alleviation of lower anterior crowding over 12 weeks. The second hypothesis was that no difference would exist between SE-NiTi and HANT archwires in intermandibular arch dimensional changes in the same period.

METHODS

This study was a single-center prospective trial conducted in the Department of Orthodontics and Dentofacial Orthopaedics. Before recruitment, the research protocol was accepted by the ethical committee of the Institute (ACDS/IEC/32/Oct 2018). All participants were given a research participant information sheet, which detailed why the research was being conducted, what it would involve, and what was expected of them as participants. The participants completed a questionnaire about past dental and medical history and were subsequently evaluated intraorally to assess Angle's classification of molar relation and Little's Irregularity Index (LII).

The inclusion criteria were (a) requiring fixed orthodontic treatment, (b) lower anterior crowding with LII greater than 4, (c) all teeth erupted to the second molars in the lower arch, (d) malocclusion requiring only non-extraction therapy, (e) Angle's Class I malocclusion, and (f) maximum contact point displacement of 2.5 mm. Patients using medication, or with spacing in the lower anterior segment, or a blocked-out tooth that would not permit bonding in initial alignment, missing lower incisors and/or canines, periodontally compromised dentition, or previous history of orthodontic treatment were excluded. Those eligible to participate in the study signed a consent form.

The 30 included participants were allocated randomly in a 1 : 1 ratio to either of the 2 archwire groups, namely group 1: 0.014″ HANT (3M Unitek, Monrovia, USA) or group 2: 0.014″ Super-Elastic NiTi (3M Unitek, Monrovia, USA). A CMM was used to measure mandibular anterior irregularity (LII), intercanine width (ICW), intermolar widths (IMW), and arch depth (AD) on the lower cast, at 0, 4, 8, and 12 weeks. A monitoring committee was established to evaluate participant criteria and protocols. No changes were made to established protocols. Simple randomization using a computer-generated table at the beginning of the study allocated the archwires to participants. The allocated archwires were concealed in opaque envelopes, ensuring that both the investigator and participants were blind to the intervention. One author was responsible for the randomization. Both participants and investigators were blinded to the allocation of the archwire group, because the wires were provided in an opaque envelope to the clinician at the time of archwire placement. The investigators were also blinded to outcome measurements because each retrieved dental cast was assigned a number to innominate the data. A single operator treated all enrolled participants using 0.022″ × 0.028″ slot MBT prescription brackets (Mini-Twin™, Ormco Corp, Orange, CA, USA). The archwires used in the study were (a) 0.014″ HANT (3M Unitek, Monrovia, USA) and (b) 0.014″ Super-Elastic NiTi (3M Unitek, Monrovia, USA) with ovoid arch form. Teeth were etched with etching gel for 15 seconds. Ortho Solo™ (Ormco Corp, Orange, CA, USA) universal sealant and bond enhancer and Enlight light cure adhesive (Ormco Corp, Orange, CA, USA) were used for bracket bonding. After placement of brackets, an impression of the lower arch was made with alginate for each participant. The assigned archwire was then removed from the sealed envelope and ligated using elastomeric modules. The wire was removed at the next appointment and an impression with alginate was made again. This impression was poured in dental stone Type III. The same archwires were placed again using fresh elastomeric modules. Digital photographs of the lower arch were also obtained at each 4-week interval (Figure 1). At 8 and 12 weeks, the same process was replicated. The dental stone models were adjusted to be precisely positioned in the CMM (Figure 2). Specific points for each tooth were noted in 3 dimensions for all 6 lower anteriors. The central fossa of first molars, cusp tips of canines, and incisal edges of incisors were considered. Measurements of LII, ICW, IMW, and AD were made in the lower arch. ICW was assessed from cusp tips of bilateral lower

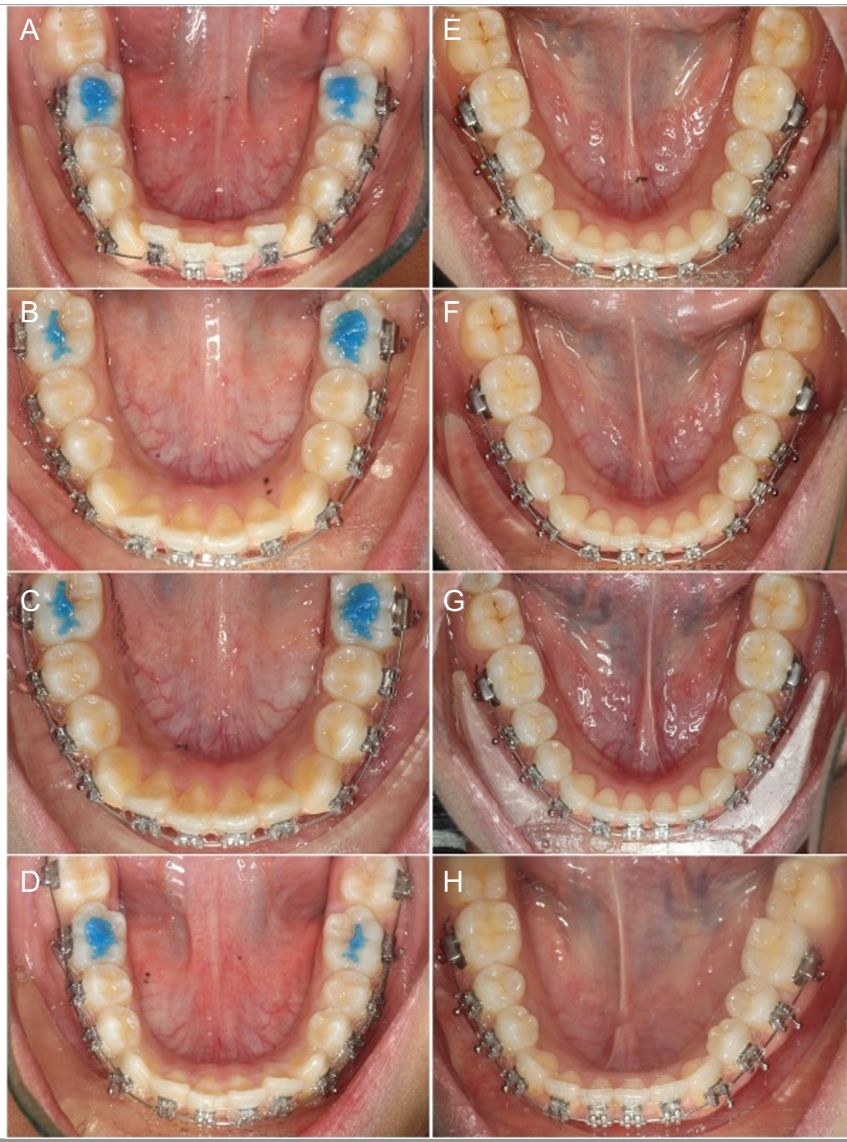

Figure 1. (A-D) Alignment at every 4-week interval using heat-activated NiTi; (E-H) Alignment at every 4-week interval using super-elastic NiTi.

canines and IMW was measured from central fossae of bilateral first molars. AD was assessed at 2 sites: intermolar depth and intercanine depth as the perpendicular distance from the most prominent lower central incisor to the respective IMW and ICW lines (Figure 3). All measurements were made using a CMM (Explorer Performance, Hexagon Manufacturing Intelligence, Stockholm, Sweden) by one author, who was unaware of the archwire being tested (Figure 4). The measurements were then repeated by another author to assess the reproducibility of measurements. LII, ICW, IMW and AD were noted at all stages. To reflect overall tooth movement, data recorded for intertooth distances (3-2, 2-1, 1-1, 1-2, 2-3) at all 4-week intervals were summed. Thus, the mean alignment value for the lower anterior segment at each phase was attained. The primary outcome was to assess the amount of alleviation of lower anterior crowding with 0.014″ SE-NiTi and 0.014″ HANT archwires over 12 weeks in non-extraction therapy. A secondary outcome was to assess changes in ICW, IMW, and AD using these archwires for the same duration. No modifications in result assessments were made after the start of the trial.

Statistical Analysis

Sample size estimation was performed according to the study by Sebastian.[16] The sample size was estimated using G Power software 3.1 using analysis of variance (ANOVA): repeated measures within-between interaction design. Effect size (partial eta squared) (n^2) [effect size measure for interaction between the within and between-subject variables, i.e., between wire and time] was calculated assuming medium (n^2 = 0.06) partial eta squared conversion, and thus effect size determined was 0.2526. Keeping alpha error at 5% or 0.05, statistical power at 90%, assuming correlation among repeated measures 0.5 and non sphericity correction (ε=1), the sample size estimated was 15 per group.

The Statistical Package for Social Sciences version 22.0 software (IBM Corp.; Armonk, NY, USA) was used to perform statistical analyses. Descriptive analysis of all the explanatory and outcome parameters was performed using mean and standard deviation for quantitative variables and frequency and proportions for categorical variables. Independent Student's *t*-test was used to compare LII values, ICW, IMW, CAD, and MAD between the 2 groups at

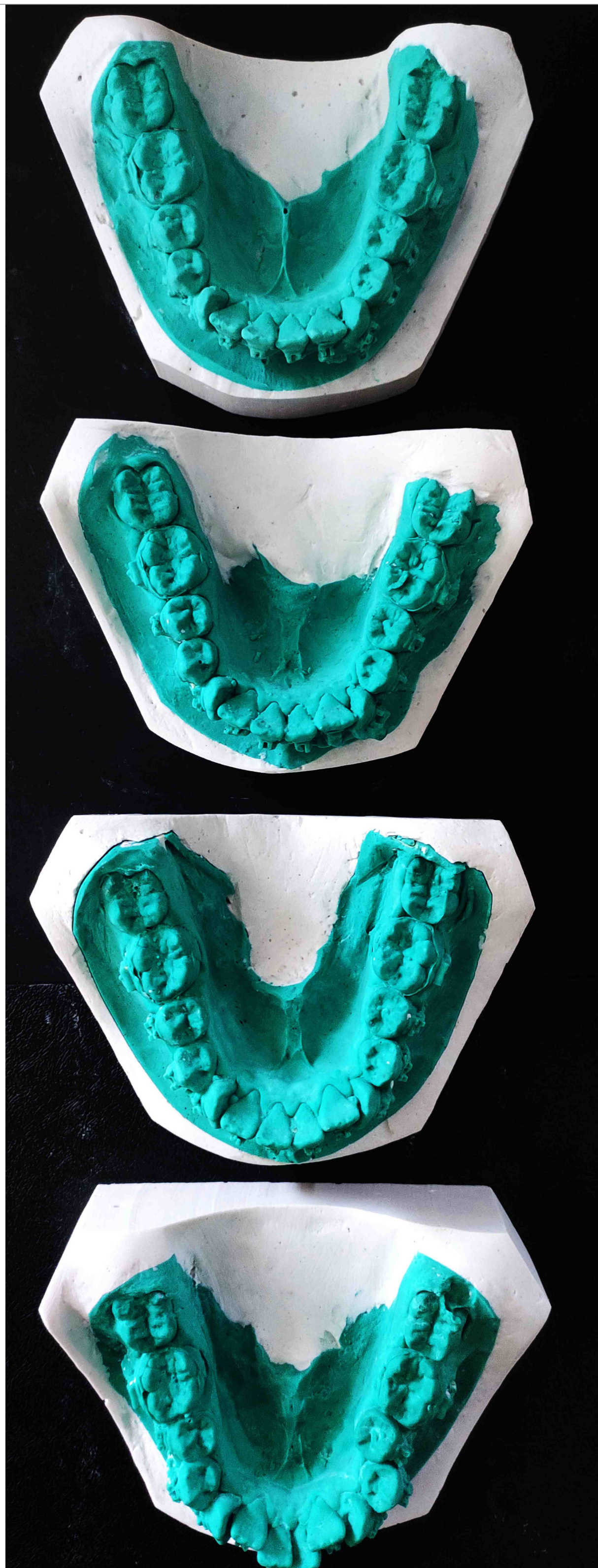

Figure 2. Dental stone models obtained at every 4-week interval.

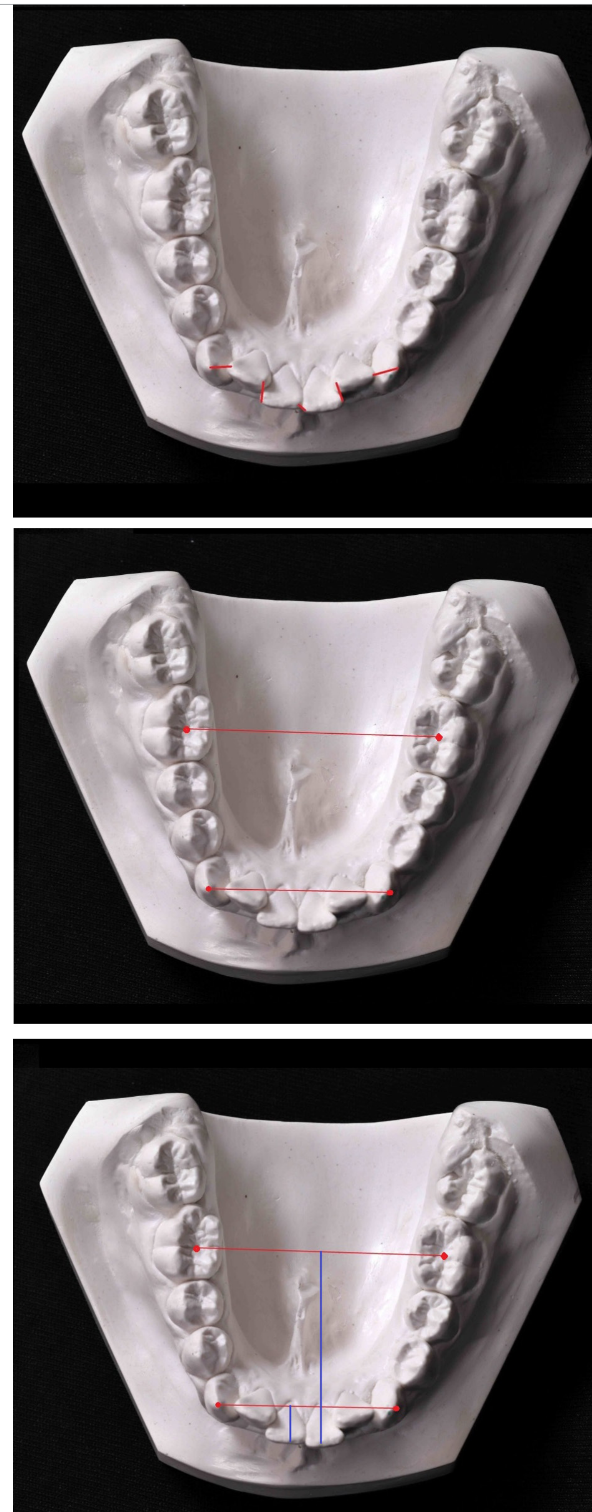

Figure 3. Mandibular measurements: Little's irregularity index, intercanine width, and intermolar width and arch depth.

different time intervals. Repeated Measures of ANOVA followed by Bonferroni's post hoc analysis was used to compare the mean values of different study parameters between time intervals in each study group. Intra-class correlation (ICC) statistics were used to assess the reproducibility of study measurements between 2 observers at baseline and 12 weeks. The level of significance was set at $P < .05$.

RESULTS

Participants were recruited over 1 year (July 2018 to July 2019). Sixty-three prospective participants were reviewed for enrolment;

Figure 4. Coordinate measuring machine (Explorer Performance, Hexagon Manufacturing Intelligence, Stockholm, Sweden).

30 were disqualified because they did not meet the inclusion criteria. Three refused to take part. Thirty participants were randomly assigned to either group 1: HANT (n = 15) with a mean age of 17.4 ± 1.12 or group 2: SE-NiTi (*n* = 15) with a mean age of 17.13 ± 0.92 at the start. A CONSORT diagram (Figure 5) illustrates participant flow throughout the analysis. Table 1 and Table 2 display no significant disparities in statistical or preliminary information between the groups in terms of age, gender or initial amount of crowding.

Participants were examined at every follow-up for any bracket breakages, though none were reported. The LII, ICW, IMW, and AD of all 120 casts retrieved during this 12-week study were determined using a CMM, and values were rounded off to the nearest 0.1 mm.

A mean reduction in LII was noted from 8.59 to 3.28 mm for Group 1, and from 8.87 mm to 3.63 mm for Group 2, over a period of 12 weeks. The Student's *t*-test comparing the means between both the HANT (mean reduction of 5.31 mm) and SE-NiTi groups (mean reduction of 5.24 mm) indicated that LII was not statistically significant at the 5% level (Table 1) over a period of 12 weeks.

However, Table 3 shows that the amount of ICW, IMW, CAD, and MAD increased over a period of 12 weeks, favoring the HANT group. Table 3 portrays the pattern of decline in crowding as assessed with repeated measures ANOVA. LII at 0, 4, 8, and 12 weeks was 8.59 ± 1.44, 6.17 ± 1.65, 4.65 ± 1.63, and 3.28 ± 1.57 in HANT, and 8.87 ± 1.29, 6.92 ± 1.49, 5.25 ± 1.32, and 3.63 ± 1.32 in SE-NiTi group, respectively. ICW increased from 25.43 ± 1.39 to 27.41 ± 1.29 in the HANT and from 25.81 ± 1.78 to 27.27 ± 1.83 in the SE-NiTi groups over a period of 12 weeks. IMW increased from 37.13-38.54 to 40.18-41.32, respectively, in the HANT and the SE-NiTi groups at 12 weeks.

Canine AD and molar AD also significantly increased in both groups, favoring the HANT group, from 6.35 ± 0.63-7.02 ± 0.64 (mean increase of 0.67 mm) to 24.32 ± 0.93-24.94 ± 0.97 (mean increase of 0.62 mm), respectively, over 12 weeks. The repeated measure factor "time" showed statistical significance ($P < .001$). Bonferroni's post hoc analysis of mean differences in LII, ICW, IMW, and AD between different time intervals (0 week * 4 week, 0 week * 8 week, 0 week *12 week) showed statistically significant differences at $P < .001$ (Table 3).

To check the reproducibility of measurements, all measurements were analyzed twice, by both authors, for all 120 casts retrieved in this study. The reproducibility of repeated measurements was estimated by ICC at 0 and 12 weeks. It demonstrated good reliability, ranging from 0.75 to 0.90 (Table 4).

DISCUSSION

The first phase of fixed orthodontic treatment is leveling and alignment of the arches.[17] Besides biological influences that are beyond the orthodontist's influence, the choice of bracket system and archwires also has a significant impact on overall tooth movement.[10]

Several clinical trials have been performed to determine the efficiency of aligning archwires. Some have tried and failed to show one archwire's superior efficacy in alignment over another,[8,9,18,19] also others have reported no difference.[3,16] Systematic analyses by Riley et al.[20] and Jian et al.[21] found that clinical studies had provided inadequate evidence for the most efficient alignment archwire. Additionally, the authors reported that more well-designed randomized clinical trials were needed.

SE-NiTi and HANT archwires were compared in the present study to evaluate the amount of alleviation of lower anterior crowding as a primary outcome. The secondary outcome was to assess changes in ICW, IMW, and AD over 12 weeks. Other factors which may affect the outcome were standardized, such as bracket slot dimensions, play between archwire and slot (same diameter archwires), and interbracket span (only in the mandibular arch) between both groups. Ages of the participants recruited were similar; the mean was 17.4 years for group 1 and 17.1 years for group 2.

NiTi archwires must be deformed by 50-70 degrees to properly utilize their super-elastic properties. This deformation is clinically possible due to the extent of crowding and shortened interbracket span in lower anterior crowding situations.[22] In the

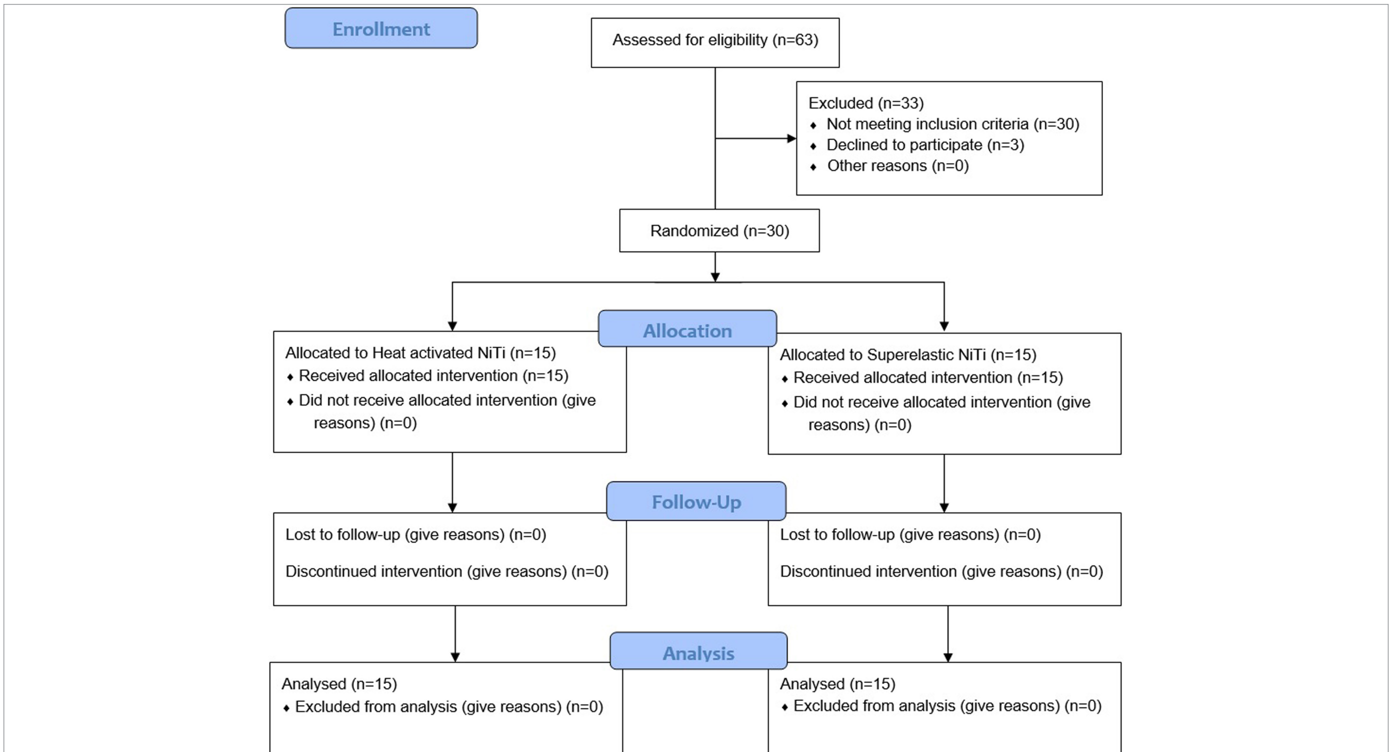

Figure 5. CONSORT flow diagram.

analysis, an LII > 4 was considered to optimize the archwires' super-elastic properties.

No relevant differences were noted in gender distribution between the groups, also helping in establishing unbiased results.

The key outcome variable was the amount of mandibular decrowding observed over 12 weeks for both wires. The group treated with HANT wires had a mean LII of 3.28 (± 1.57) at 12 weeks, while it was 3.63 (± 1.32) for the group treated with SE-NiTi archwires. The null hypothesis was not rejected. This agrees with studies published previously.[23,24]

Experiments conducted in vitro have demonstrated that SE-NiTi wires produce light forces that increase tooth movement and reduce discomfort,[1,25] though individual responses could act as confounding factors. Although these laboratory studies have shown the effectiveness of NiTi alloys characterized by superelasticity and shape-memory, the literature provides little clinical evidence supporting the benefits associated with these mechanical properties.[26]

West et al.[3] reported greater alignment using SE-NiTi when compared to multistranded SS in the lower anterior region, which was attributed to reduced interbracket span. In their analysis, the amount of alleviation of lower anterior crowding was 1.20 mm compared to the 1.95 mm noted in this study. This minor variance may be due to differences in initial crowding in participants, differences in ligation methods, or archwires being sourced from different manufacturers.

Table 1. Comparison of Group 1 and 2 regarding age, initial crowding, reduction in crowding and changes in arch width and depths from week 0 to 12 by Independent Student t test

Variable	Group 1		Group 2		*P*
	Mean	SD	Mean	SD	
Age	17.4	1.12	17.13	0.92	.48[a]
Initial crowding	8.59	1.44	8.87	1.29	.59[a]
Reduction in LII	5.31	0.28	5.24	0.24	.442[a]
Change in ICW	-1.98	0.24	-1.46	0.22	.001*[a]
Change in IMW	-1.41	0.15	-1.14	0.15	.001*[a]
Change in CAD	-0.67	0.18	-0.49	0.13	.006*[a]
Change in MAD	-0.62	0.12	-0.52	0.08	.012*[a]

*Statistically significant at p≤0.05, a: Independent Student t Test, SD: Standard deviation, Group 1: Heat activated NiTi, Group 2: Superelastic NiTi; LII: Irregularity index; ICW: Intercanine width, IMW: Intermolar width, CAD: canine arch depth, MAD: molar arch depth.

Table 2. Gender distribution regarding Group 1 and Group 2

Variable	Category	Group 1		Group 2		*P*
		n	%	n	%	
Gender	Males	6	40.0%	7	46.7%	.71[b]
	Females	9	60.0%	8	53.3%	

b: Chi Square Test, n: number, Group 1: Heat activated NiTi, Group 2: Superelastic NiTi.

Table 3. Comparison of LII, ICW, IMW, Canine AD, and Molar AD values between time intervals in Group 1 and Group 2 using Repeated Measures of ANOVA Test

		Group 1		Group 2		Difference Between Weeks	
Parameter	Interval	Mean	SD	Mean	SD	Group 1	Group 2
LII	0 weeks	8.59	1.44	8.87	1.29	a = 0.001** b = 0.001** c = 0.001**	a = 0.001** b = 0.001** c = 0.001**
	4 weeks	6.17	1.65	6.92	1.49		
	8 weeks	4.65	1.63	5.25	1.32		
	12 weeks	3.28	1.57	3.63	1.32		
	P value	.001*		.001*			
ICW	0 weeks	25.43	1.39	25.81	1.78	a = 0.001** b = 0.001** c = 0.001**	a = 0.001** b = 0.001** c = 0.001**
	4 weeks	25.99	1.4	26.23	1.73		
	8 weeks	26.78	1.36	26.92	1.85		
	12 weeks	27.41	1.29	27.27	1.83		
	P value	.001*		.001*			
IMW	0 weeks	37.13	3.24	40.18	1.83	a = 0.010** b = 0.001** c = 0.001**	a = 0.001** b = 0.001** c = 0.001**
	4 weeks	37.43	3.16	40.53	1.74		
	8 weeks	38.08	3.16	40.91	1.83		
	12 weeks	38.54	3.19	41.32	1.82		
	P value	.001*		.001*			
Canine AD	0 weeks	6.35	0.63	7.11	0.80	a = 0.001** b = 0.001** c = 0.001**	a = 0.001** b = 0.001** c = 0.001**
	4 weeks	6.66	0.65	7.26	0.78		
	8 weeks	6.80	0.65	7.40	0.77		
	12 weeks	7.02	0.64	7.61	0.76		
	P value	.001*		.001*			
Molar AD	0 weeks	24.32	0.93	25.34	0.65	a = 0.001** b = 0.001** c = 0.001**	a = 0.001** b = 0.001** c = 0.001**
	4 weeks	24.56	0.96	25.56	0.63		
	8 weeks	24.79	0.98	25.72	0.63		
	12 weeks	24.94	0.97	25.86	0.62		
	P value	.001*		.001*			

*Statistically significant, group 1: heat-activated NiTi, group 2: super-elastic NiTi, a: 0 week * 4 week; b, 0 week * 8 week; c, 0 week * 12 week; ***P* < .05 adjusted Bonferroni correction.
SD, standard deviation; LII, irregularity index; ICW, intercanine width; IMW, intermolar width; AD, arch depth.

Table 4. Intra-class correlation statistics to assess for the reproducibility of measurements between 2 observers at baseline and 12 weeks

		Group 1				Group 2			
			95% CI				95% CI		
Time	Variables	ICC	Lower	Upper	*P*	ICC	Lower	Upper	*P*
0 Weeks	LII	0.77	0.43	0.91	.002*	0.88	0.69	0.97	<.001*
	ICW	0.8	0.47	0.92	<.001*	0.84	0.33	0.97	<.001*
	IMW	0.8	0.47	0.92	<.001*	0.88	0.57	0.99	<.001*
	Canine AD	0.82	0.46	0.85	<.001*	0.87	0.53	0.97	<.001*
	Molar AD	0.81	0.43	0.87	<.001*	0.86	0.54	0.87	<.001*
12 Weeks	LII	0.85	0.78	0.99	<.001*	0.89	0.7	0.97	<.001*
	ICW	0.81	0.7	0.98	<.001*	0.88	0.7	0.98	<.001*
	IMW	0.79	0.46	0.98	.001*	0.85	0.73	0.98	<.001*
	Canine AD	0.87	0.51	0.89	<.001*	0.82	0.75	0.96	<.001*
	Molar AD	0.89	0.32	0.96	.001*	0.83	0.76	0.88	<.001*

*Statistically significant group 1: heat-activated NiTi, group 2: super-elastic NiTi.
ICC values < 0.50—Poor reliability; 0.50-0.75—moderate reliability; 0.75-0.90—good reliability; > 0.90—excellent reliability.
ICC, intra-class correlation coefficient; CI, class interval; LII, Little's irregularity index; ICW, intercanine width; IMW, Intermolar width; AD, arch depth.

A significant reduction in crowding was found with HANT in the initial period in the study. A mean reduction in LII of 2.42 mm was noted in the initial 4 weeks using HANT when compared to 1.95 mm using SE-NiTi. HANT provides the benefit of placing a large archwire with low force delivery at the start of treatment. Thus, at the outset of therapy, a better degree of rotational control and alignment was obtained relative to SE-NiTi wires, although the differences were not statistically significant.

Aydin et al.[11] compared conventional and CuNiTi archwires in relieving lower crowding and found no substantialdifferences between them in the alleviation of crowding. Contrary to the findings of the present and other studies,[9-12,24] Serafim et al.[13] found greater alignment with HANT. However, in their study, the archwire diameter was increased substantially. Changes in arch form (transverse) during the alignment process using rectangular archwires are required in non-extraction cases to reduce crowding.[27] The ICW changes were 1.46 mm with SE-NiTi and 1.98 mm with HANT. Previous studies have shown increases in ICW ranging from 0.54 to 1.96 mm.[28] However, lower arch form should remain in harmony with surrounding structures, to increase long-term stability.[29]

Both archwires caused an increase in ICW and AD in the study, favoring the HANT group at $P < .05$, similar to Aydin et al.[11] In this analysis, measurements of IMW in the SE-NiTi group were greater than HANT at the end of week 4, and this trend was reversed in the next 8 weeks. This is similar to findings by Aydin et al.,[11] who attributed it to an increase in the arch perimeter of the lower canines.

Mandibular crowding can be measured using LII. Previous studies have found this index to be a reliable indicator that could be used to standardize research.[30] The major drawback of LII is that it is not sensitive to rotations and axial inclinations. Two types of irregularity measurement methods exist: direct and indirect. Direct methods use Vernier calipers.[9] Measurements can also be done indirectly for three-dimensional calculations using advanced instruments such as a reflex metrograph,[8] reflection microscope,[3] or CMM.[16] The use of these specialized instruments provides a complete three-dimensional representation of movements of the contact point. Thus, a coordinate measuring system was used, which provided three-dimensional coordinates for each landmark on the dental casts, increasing the accuracy of measurements.

In clinical research, it is important to address the tendencies observed even when substantive differences are not found,[18] because the statistical mean does not always represent the clinical outcome. HANT wires showed a higher rate of reduction in irregularity in the initial 4 weeks from bonding, although the differences were not statistically significant. This may be due to variations in the in vivo transition temperature ranges, limiting the transformation of NiTi archwires, or the general irrelevance of the wires' mechanical behavior derived from the laboratory to clinical loading conditions. Additional variables influencing the clinical output of wires may include the effect of oral cavity conditions.

A limitation of the study is that it was relatively short-term. Elastomeric modules were used for ligation. A drawback of using these modules is that full engagement of the archwires is not always possible due to rotations and/or crowding. SS ligatures were intentionally not used in the study because using 2 different ligation methods can lead to confounding results. Another drawback is that the effects of periodontal ligament and bone in individual metabolic responses were not discussed.

CONCLUSION

HANT exhibited no superiority over SE-NiTi archwires in the alleviation of lower anterior crowding. However, the changes in ICW, IMW, and AD favored HANT wires.

Ethics Committee Approval: This study was approved by the Institutional Ethical Committee at Army College of Dental Sciences (ACDS/IEC/32/Oct 2018)

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer Review: Externally peer-reviewed

Author Contributions: Supervision – P.C.; Design – P.K.; Concept – P.K.; Resources – P.C., Materials – P.K.; Data collection/or processing – P.K.; Analysis and /or Interpretation – P.C.; Literature search – P.C.; Writing manuscript – P.K.; Critical review – P.C.

Conflict of Interest: The authors have no conflict of interest to declare.

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