Original Article

Arch Expansion Efficiency of Coaxial Tubular Superelastic Nickel-Titanium in Comparison to Single-Stranded Superelastic Nickel-Titanium While Relieving Mandibular Anterior Crowding: A Randomized Controlled Study

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Abstract

Aim: The aim of the study is to compare the efficiency of six-stranded coaxial tubular superelastic nickel–titanium (NiTi) archwire and a single-stranded wire in relieving anterior mandibular crowding.

Materials and Methods: This double-blind randomized study included 40 patients, categorized into two groups: Sentalloy round group and Speed tubular supercable group (20 each). After taking alginate impressions, the allocated archwire was engaged. With a digital caliper, intercanine, interpremolar, and intermolar width were recorded on the study models, immediately and at 4, 8, and 12 weeks stages. The Statistical Package for the Social Sciences (SPSS) version 20 was used for analysis.

Results: The measured parameters were increased in both the groups, with the difference being insignificant statistically.

Conclusion: Superelastic coaxial NiTi wires show better efficiency in relieving anterior crowding than single-stranded NiTi wire.

Keywords: *Anterior crowding, digital caliper, intercanine width, nickel–titanium wire, superelastic coaxial nickel–titanium wire*

Introduction

Inadequate arch width or arch perimeter is one of the major causes for crowding of teeth. The intermolar width and intercanine width are considered as clinical indicators for measuring arch expansion and can be easily measured.[1] To achieve arch expansion, either of conventional fixed appliances or rapid maxillary expansion appliances are usually employed. In a few cases, archwires are used for expansion.[2] The properties that influence the clinical performance of wires are low modulus of elasticity, flexibility, resilience, high spring back, corrosion resistance, ease of bracket engagement, and biocompatibility.

Many varieties of archwires are available, each having their own pros and cons when compared to the other. They are available in different configurations, solid, multistranded, looped, or tubular. Each one imparts a distinctive force level, due to variation in elastic modulus. Studies have shown that for initial stages of treatment, nickel–titanium (NiTi) wires are ideal, due to their low stiffness, which produces low-intensity forces. They can be employed as single-stranded archwires or as multistranded archwires, the later showing increased flexibility and reduced load deflection rate.[3,4]

Recently, speed six-stranded coaxial tubular superelastic NiTi is introduced into the market. It has advantage over single-stranded superelastic NiTi in many ways such

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as shortening of treatment time, increased spring back, deformation resistance, and low-force delivery.[3-5]

Our study aims to clinically assess the expansion effectiveness of six-stranded coaxial tubular superelastic NiTi-speed tubular super (STS) cable and single-stranded superelastic NiTi Sentalloy by measuring the change in intermolar width and intercanine width at 4-, 8-, and 12-week interval.

Materials and Methods

This double-blind study included 40 patients, between 12 and 18 years reported to the Department of Orthodontics and Dentofacial Orthopaedics, Pushpagiri College of Dental Sciences, Thiruvalla, Kerala. Ethical committee clearance was attained from the institution (Ethical Committee No: PCDS/IEC/S20/12/14) and informed consent was obtained from the participants. Sample size was determined from similar studies using the formula: $n=[(z \propto + z\beta)]$. With a confidence interval of 95% and power of 95% for the study, a sample size of 40 was obtained. The mandibular anterior crowding was assessed based on Little's Irregularity Index.[6]

The selected patients were divided into two groups, that is, Sentalloy round (SR) group (Light Archform, Dentsply-GAC, International) and STS cable group (Speed System Orthodontics, Ontario, Canada), 20 in each group. The allocation of archwire was randomized by means of computer software created numbers. Envelops were used to assign archwire for the two groups, thus concealing both the investigator and the participant. Bracket bonding and archwire placement were done by the same orthodontist. No other archwires were used.

Inclusion criteria

1. Patients between 12 and 18 years with lower anterior crowding and with mandibular irregularity index more than 6
2. Class I skeletal pattern
3. Extraction treatment with two first premolars in mandibular arch
4. Eruption of all mandibular teeth excluding third molars with no spacing between them
5. Normal medical history
6. No recent history of intake of drugs such as nonsteroidal anti-inflammatory drugs
7. No previous active orthodontic treatment.

Exclusion criteria

1. Developmental anomalies in the dentition
2. Abnormal root morphology in lower arch
3. Patients with periodontal disease and loss of attachment.

Sample size determination

Number of participants was calculated to select sample for the present study using the formula: $n=[(z \propto + z\beta)]$.[2] A sample of 36 was obtained with a confidence interval of 95% and power of 95% for the study. It was decided to select 40 participants, with the expectation of dropouts.

Data collection

For each patient, a high-quality alginate impression of the lower dental arch was obtained at the preexpansion phase after placing bonded attachment and bands. The allocated archwire which came in a sterilized opaque cover was taken and then engaged as fully as possible into the bracket using elastomeric modules. At routine follow-up appointment after 4 weeks, participants were recalled, archwires removed, and alginate impressions were taken and poured immediately with stone, to obtain the study models. The archwires were ligated and activated with elastomeric modules or steel ties. Entire process was replicated another time after 8 and 12 weeks, by a single operator.

Measurement of study cast

With a fine tip digital caliper (Digimatic 0–6 inch, Mitutoyo, Japan), measurements were recorded on the study models [Figure 1]. Individual points were noted for molar width and intercanine width [Figures 2 and 3]. All the readings were recorded by a single expert operator in a double-blind manner immediately, at 4, 8, and 12 weeks [Figure 4].

Duplicate readings were taken on the cast at the commencement and at the end of the study in ten cases to assess intraoperator reliability to get an idea of measurement error in the study. Statistical Package for the Social Sciences (SPSS) version 20 for Windows software was used for analysis.

Results

On Statistical evaluation, the median values of the intercanine, interpremolar, and intermolar width demonstrated a rise with the progression of time from the 1st week to the 12th week. This was consistently seen in all observations except for the intermolar width

Figure 1: Digital caliper for recording measurements

in the speed tubular group which showed a decrease [Tables 1 and 2].

Figure 2: Measuring intercanine width

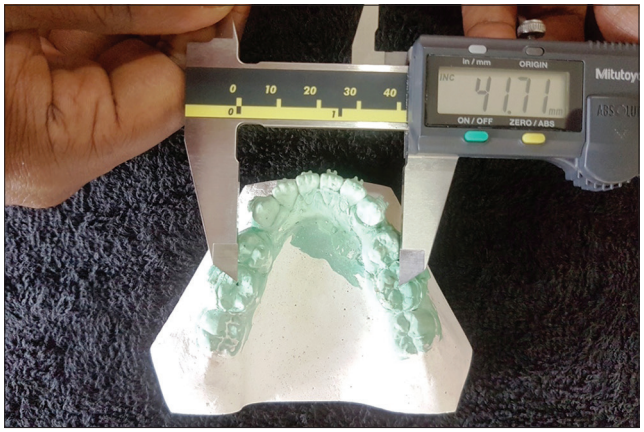

Figure 3: Measuring intermolar width

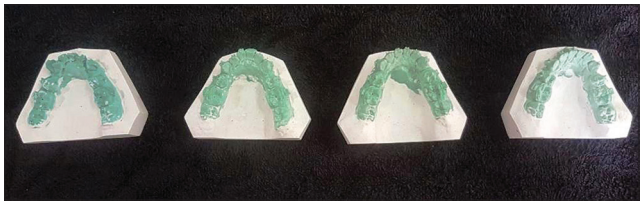

Figure 4: Four aligning stages

In SR group, a highly significant increase was seen in the intercanine width over the 12-week period ($P < 0.001$). The transverse expansion in the premolar and the molar regions was not statistically significant [Friedman Test: Table 3].

In the second group (STS cable), a significant increase in the intercanine and the interpremolar widths ($P \leq 0.001$) was recorded, while the intermolar width increased, which was insignificant [Table 4]. Although the wires did demonstrate transverse expansion individually, when the two groups were compared using the Mann–Whitney test, there was no significant variation among two wires in relation to the expansion achieved.

Discussion

It has been shown that archwires that give light continuous forces over long areas are most effectual in orthodontics.[7] To decrease the load deflection ratio, many attempts were made which lead to the introduction of multistranded steel wires such as superelastic or austenitic active NiTi wires, true shape memory or martensitic active wires, and nonsuperelastic or martensitic stabilized NiTi wires for initial alignment. Studies did not reveal any significant benefit of these wires but showed multiple advantages such as increased flexibility and a reduced load deflection rate.[8-10] Berger used a supercable, a seven-stranded round coaxial superelastic NiTi archwire and found this wire exerts only 36%–70% of the force of solid NiTi wires.[5]

In our study, we noticed that with time, there was an increase in intertooth distance, but the variation among the groups was statistically insignificant. Our findings are similar to Biju Sebastian *et al.*, who found a significant difference ($P < 0.05$) in mean tooth movement between the coaxial superelastic NiTi wire and single-stranded superelastic NiTi in lessening lower anterior crowding.[3]

Serafim *et al*. and Mahmoudzadeh *et al*. compared the time required to relieve lower anterior crowding using two types of archwires, conventional NiTi and conventional and NiTi heat-activated wires. They

Table 1: Mean and standard deviation

Wire type	ICWP	ICW4	ICW8	ICW12	IPMWP	IPMW4	IPMW8	IPMW12	IMWP	IMW4	IMW8	IMW12
SR												
Mean	26.07800	27.10850	27.58842	27.78187	36.54842	37.03368	37.55411	36.40533	39.15150	39.00350	38.37263	39.24687
SD	2.727166	2.282494	2.11256	2.244715	3.435046	3.317604	3.134033	3.077619	2.638381	2.666798	3.492311	2.83331
STS												
Mean	27.16650	28.05842	28.45722	27.29277	34.12555	34.68647	35.09666	35.03933	39.43842	39.09388	38.90117	38.96125
SD	4.426094	4.27176	4.268998	8.105666	7.202044	6.098916	6.249233	6.065972	5.380239	5.272335	5.383479	5.689839

SR=Sentalloy round, STS=Speed tubular supercable, ICWP=Intercanine width pretreatment, ICW4=Intercanine width after 4 weeks, ICW8=Intercanine width after 8 weeks, ICW12=Intercanine width after 12 weeks, IPMWP=Interpremolar width pretreatment, IPMW4=Interpremolar width after 4 weeks, IPMW8=Interpremolar width after 8 weeks, IPMW12=Interpremolar width after 12 weeks, IMWP=Intermolar width pretreatment, IMW4=Intermolar width after 4 weeks, IMW8=Intermolar width after 8 weeks, IMW12=Intermolar width after 12 weeks, SD=Standard deviation

Table 2: Median values

Wire type	ICWP	ICW4	ICW8	ICW12	IPMWP	IPMW4	IPMW8	IPMW12	IMWP	IMW4	IMW8	IMW12
SR												
Median	26.555	27.270	27.080	27.055	36.10	36.91	37.69	36.27	39.16	39.27	38.76	39.435
n	20	20	19	16	19	19	17	15	20	20	19	16
STS												
Median	26.450	26.980	27.680	28.060	35.53	36.11	36.74	36.36	41.05	40.45	39.44	39.985
n	20	19	18	18	18	17	15	15	19	18	17	16

SR=Sentalloy round, STS=Speed tubular supercable, ICWP=Intercanine width pretreatment, ICW4=Intercanine width after 4 weeks, ICW8=Intercanine width after 8 weeks, ICW12=Intercanine width after 12 weeks, IPMWP=Interpremolar width pretreatment, IPMW4=Interpremolar width after 4 weeks, IPMW8=Interpremolar width after 8 weeks, IPMW12=Interpremolar width after 12 weeks, IMWP=Intermolar width pretreatment, IMW4=Intermolar width after 4 weeks, IMW8=Intermolar width after 8 weeks, IMW12=Intermolar width after 12 weeks

Table 3: Readings recorded in Neo Sentalloy

Intercanine width			Interpremolar width			Intermolar width		
Parameter	Mean rank	Level of significance	Parameter	Mean rank	Level of significance	Parameter	Mean rank	Level of significance
ICWP	1.59	0.000	IPMWP	1.71	0.018	IMWP	2.34	0.85
ICW4	2.16		IPMW4	2.29		IMW4	2.53	
ICW8	2.84		IPMW8	2.86		IMW8	2.41	
ICW12	3.41		IPMW12	3.14		IMW12	2.72	

ICWP=Intercanine width pretreatment, ICW4=Intercanine width after 4 weeks, ICW8=Intercanine width after 8 weeks, ICW12=Intercanine width after 12 weeks, IPMWP=Interpremolar width pretreatment, IPMW4=Interpremolar width after 4 weeks, IPMW8=Interpremolar width after 8 weeks, IPMW12=Interpremolar width after 12 weeks, IMWP=Intermolar width pretreatment, IMW4=Intermolar width after 4 weeks, IMW8=Intermolar width after 8 weeks, IMW12=Intermolar width after 12 weeks

Table 4: Readings recorded in Speed tubular supercable

Intercanine width			Interpremolar width			Intermolar width		
Parameter	Mean rank	Level of significance	Parameter	Mean rank	Level of significance	Parameter	Mean rank	Level of significance
ICWP	1.22	0.000	IPMWP	1.57	0.001	IMWP	2.81	0.707
ICW4	2.22		IPMW4	2.21		IMW4	2.47	
ICW8	2.94		IPMW8	2.89		IMW8	2.34	
ICW12	3.61		IPMW12	3.32		IMW12	2.38	

ICWP=Intercanine width pretreatment, ICW4=Intercanine width after 4 weeks, ICW8=Intercanine width after 8 weeks, ICW12=Intercanine width after 12 weeks, IPMWP=Interpremolar width pretreatment, IPMW4=Interpremolar width after 4 weeks, IPMW8=Interpremolar width after 8 weeks, IPMW12=Interpremolar width after 12 weeks, IMWP=Intermolar width pretreatment, IMW4=Intermolar width after 4 weeks, IMW8=Intermolar width after 8 weeks, IMW12=Intermolar width after 12 weeks

found that heat-activated wires relieved crowding in significantly less time than the conventional one.[11,12]

Pandis *et al*. did not notice any difference in lessening of lower anterior crowding with copper-NiTi and superelastic NiTi wires.[8] Evans *et al*. also did not observe any significant variation in alignment capability of medium force active martensitic rectangular NiTi wire, multistranded stainless steel wire, and graded force active martensitic NiTi wire.[13] West *et al*. after comparing superelastic NiTi and multistranded stainless steel found a significantly better alignment with the former one.[14] Jones *et al*. found a superior mean enhancement in incisal alignment with superelastic NiTi than coaxial stainless steel one.[15]

Thus, all the studies including ours support the view that lower anterior alignment is superior and quicker with coaxial tubular superelastic NiTi archwire than single-stranded wire. The main advantage of the former archwire is better engagement into the bracket, and furthermore, it engages a fairly large archwire with low-force delivery.

Limitations

The limitation of the study is smaller sample size.

Conclusion

Coaxial tubular superelastic NiTi wires showed significant effectiveness than single-stranded NiTi in reducing lower anterior crowding after 4, 8, and 12 weeks. The obtained knowledge regarding the preference of archwire can be utilized for better orthodontic treatment.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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