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Original Research Article

Evaluation of pain, alignment efficiency, and post alignment anterior torque between I –Archwires and superelastic NiTi wires: A comparative study

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ABSTRACT

Objective: to compare the aligning efficiency, pain experienced by the patient during alignment and the post alignment third order values of anterior teeth in I arch (study) group and conventional NiTi (control) wire group.
Design: A prospective clinical study.
Materials and Methods: A total of 40 dental arches (maxilla/mandible) were divided into 2 study groups with 20 dental arches (maxilla/mandible) in each group based on the selection criteria. Group I. Twenty dental arches (maxillary/mandibular) having 0.018" preadjusted appliance (MBT) brackets (ORMCO), aligned with I –arch 0.016"x0.014" copper NiTi wires. Group II. Twenty dental arches (maxillary/mandibular) having 0.018" preadjusted appliance (MBT) brackets by ORMCO aligned with round super elastic NiTi archwires.
Results: I -arch copper NiTi (study group) was more efficient in alignment compared to the superelastic NiTi (control group) in the lower arch and the values are statistically significant. There was torque expression in the I-arch group as compared to the superelastic NiTi group. The subjects in the I-arch (study group) experienced lesser pain compared to the superelastic NiTi (control group) and the pain values are statistically significant.

1. Introduction

An orthodontist strives to achieve the best possible treatment outcome within the least possible time frame causing minimum pain and discomfort to the patient. Raymond Begg[1] defined three stages in Comprehensive Orthodontic treatment which are alignment and leveling, correction of molar relationship, space closure, finishing and detailing. The aligning and leveling of teeth comprises of the first phase of orthodontic treatment. Alignment is the lining up of teeth of an arch in order to achieve normal contact relationship. Leveling is the process in which the incisal edges of the anterior teeth and the buccal cusps of the posterior teeth are placed on the same horizontal plane.[2]

The forces delivered by the arch wires depend largely on the physical properties of wire material and dimension of the wire. By changing the mechanical properties of a material, hence, the content of an alloy, we could possibly obtain ideal archwire characteristics required at each stage of fixed orthodontic treatment.[3] NiTi wires were introduced in orthodontics by Andreasen and Hilleman.[4] Burstone[5] reported use of chinese NiTi in 1985 which had 1.4 times spring back of Nitinol wire and 4.6 times the springback of stainless steel wire. Nickel titanium (NiTi) wires are preferred by clinicians because compared to stainless

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steel wires, they have a wider working range and higher springback properties. Nitinol which is categorized in the M_{stab} group, contains 55% nickel and 45% titanium, and is also known as “M-NiTi”. This material has high springback values, despite having neither superelasticity nor a shape memory effect. Miura[6] reported superelasticity of Japanese NiTi in 1986. In 1994, Ormco Corporation introduced a new orthodontic wire alloy “Copper NiTi”, developed by Rohit Sachdeva[7] and is available in three temperature variants of 27°C,35°C, and 40°C, corresponding to the austenite-finish temperatures for the completion of the martensite-to-austenite transformation. In CuNiTi wires, the addition of copper into the alloy reduces hysteresis and helps control the transition temperature range. The copper content of Cu NiTi archwires also enables these wires to exert more homogenous forces from one side of the wire to the other, thereby providing faster and more efficient tooth movement.[7]

Pain and discomfort are recognized side effects of orthodontic treatment. Pain starts about 4 hours after insertion of the appliance, peaks between 12 hours and 3 days after insertion and then decreases for up to 7 days. Almost all patients (95%) report and suffer pain or discomfort 24 hours after insertion of fixed appliances, and fixed appliances may produce higher pain responses than removable appliances[8] A study[9] comparing the alignment with stainless steel, multistranded stainless steel and superelastic NiTi archwires concluded that NiTi wires had greater tendency towards incisor proclination followed by stainless steel and multistranded stainless steel. In an attempt to overcome the problem of incisor proclination, SIA orthodontic manufacturer, Italy introduced a new copper NiTi in ribbon arch mode i.e.0.016” x 0.014”.These wires are meant to be used in 0.018inch slot brackets which ensures early torque delivery in the aligning phase of treatment. This may reduce excessive flaring of anterior segment and thinning of marginal cortical bone. These wires exert very light forces (23gm) especially during the initial phase of treatment. This implies lesser pain to the patient and lesser trauma to tissues involved.[10] Very few in vitro randomized controlled studies have evaluated and compared the clinical performance of round archwires and rectangular Copper NiTi wires at the initial stage of orthodontic treatment.

Hence, the aim of the present study was to compare the aligning efficiency, pain experienced by the patient during alignment and the post alignment third order values of anterior teeth in I arch (study)group and conventional NiTi (control) wire group.

2. Aim and Objectives

1. To clinically evaluate the effectiveness of two aligning archwires (I-arch wires and superelastic NiTi wires).
2. Compare the post alignment torque values of anterior teeth in I-arch group and superelastic NiTi group.
3. Analyse and compare the pain experienced by the patients in I-arch wire group and superelastic NiTi wire group.

3. Materials and Mathods

3.1. Study type and study site

The present study was a prospective clinical study conducted in the department of Orthodontics and Dentofacial Orthopaedics at Swami Devi Dyal Hospital and Dental College, Barwala, Panchkula, Haryana.

3.2. Institutional Ethical clearance

The ethical clearance for this study has been obtained from the institutional ethical committee at Swami Devi Dyal Hospital and Dental College

3.3. Study population

Forty dental arches of the subjects in the age range of 12-25 years bonded with 0.018” slot preadjusted edgewise appliance (MBT) prescription were included in this study based on the selection criteria. Randomization process was employed for allocation of arches in each group. Subjects in the age range of 12-25 years undergoing fixed mechanotherapy with 0.18” MBT slot prescription with similar amount of crowding (according to the anterior crowding assessment[11] done on the pretreatment study cast) were selected for the study. Subjects who had undergone previous orthodontic treatment, with a blocked out tooth that did not allow placement of the bracket, whose treatment plan included extraction of an incisor and subjects with poor oral hygiene or periodontically compromised teeth were excluded in the study. Subjects with relevant medical history such as neuralgia, migraine, or any condition requiring daily intake of analgesics were also excluded in our study. Prior to the study an informed consent was obtained from each participant or their parents if the participant was a child.

3.4. Grouping of subjects

1. **Group 1 (Study group)**- Twenty dental arches (maxillary/mandibular) having 0.018” preadjusted appliance (MBT) brackets (ORMCO), aligned with I –arch 0.016”x0.014” copper NiTi wires. This comprised of arches of 2 males and 18 females in the age range between 12 to 25 years.
2. **Group 2 (Control group)-** Twenty dental arches (maxillary/mandibular) having 0.018” p readjusted appliance (MBT) brackets by ORMCO aligned with round super elastic NiTi archwires. This comprised of arches of 12 males and 8 females in the age range between 12 to 25 years.

Armamentarium (Figure 1)

1. Inclinometer
2. Round superelastic NiTi wires (0.014” or 0.016”)
3. I-Arch wires (0.016” x 0.014” copper NiTi)
4. Digital Vernier Caliper
5. Metallic Scale
6. Lacron Carver
7. Glass Slab
8. Pencil
9. Impression Trays
10. Alginate Impression material

Fig. 1: Armamentarium

3.5. Methodology

Bonding with 0.018” Pre adjusted appliance (MBT) ORMCO brackets were done for all the participants in both the groups. In study group, the initial arch wire used was 0.016”x0.014” Cu- NiTi (I-Arch) with stainless steel ligatures. In the control group, 0.014 or 0.016” Superelastic NiTi was engaged as the initial arch wire with stainless steel ligatures.

3.6. Data collection

Alginate records were made and study models were obtained for all the participants in both the groups at the beginning of the treatment and the same were repeated at 8 weeks (T5) after engagement of initial arch wires.

3.6.1. Pain assessment

The subjects and their parents were explained about the Verbal rating scale (VRS) and Numeric rating scale (NRS) for evaluating the level of discomfort and pain experienced after bonding.[12,13] (Table 1)

Table 1: Time interval for recording Verbal rating scale (VRS) and Numeric Rating Scale (NRS)

Interval	Definition
T0	Pretreatment
T1	24 hours after bonding
T2	4 days after bonding
T3	7 days after bonding
T4	4 weeks after bonding

3.6.2. Crowding assessment

The methods used for crowding assessment are as follows;

1. Anterior crowding assessment method
2. Littles’ irregularity Index
3. Maxillary irregularity Index

3.6.2.1. Anterior crowding assessment[11]. The lower anterior crowding was calculated by the difference between the available and the required arch lengths.

3.6.2.2. Littles irregularity Index. The technique involves measuring the linear distance from anatomic contact point to adjacent anatomic contact point of mandibular and maxillary anterior teeth (i.e. from left canine to right canine). The sum of these five linear measurements represents the irregularity index.[14] (Table 2)

Table 2: Scoring of irregularity on dental cast

Score	Interpretations
0	Perfect alignment
1-3	Minimal irregularity
4-6	Moderate irregularity
7-9	Severe irregularity
10	Very severe irregularity

3.6.2.3. Maxillary irregularity Index. In maxillary arch another variant of Little’s irregularity index was used that is known as Maxillary irregularity index.[15] The cast was viewed from above, sighting down onto the incisal edges of the anterior teeth, the caliper was held parallel to the occlusal plane while the beaks were lined up with the contact points to be measured. (Figure 2)

3.6.3. Torque assessment

3.6.3.1. Design and the use of inclinometer. The inclinometer used in this study was custom made. It consisted of a wooden table with a centric slot**.** A freely moveable metallic scale was attached to this wooden table.

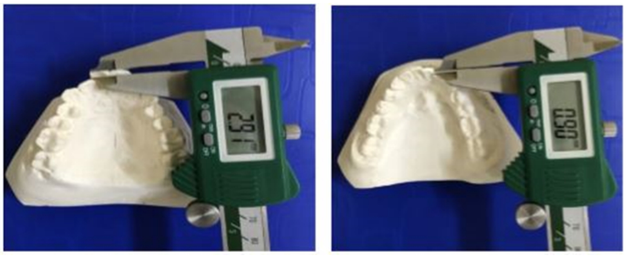

Fig. 2: Measurement of irregularity on upper and lower cast using Digital Vernier caliper

This was aligned parallel to the long axis of the tooth. The extension of the metallic scale on the 180 degree protractor determined the angulation of a particular tooth having an extension to measure the angulations of the tooth placed on the glass slab, while maintaining the reference of occlusal plane[16] (Figure 3 ; 1 = wooden table with a centric slot, 2 = glass slab, 3 = metallic scale used as an extension to measure the angulations of the tooth, 4 =180 degree protractor).

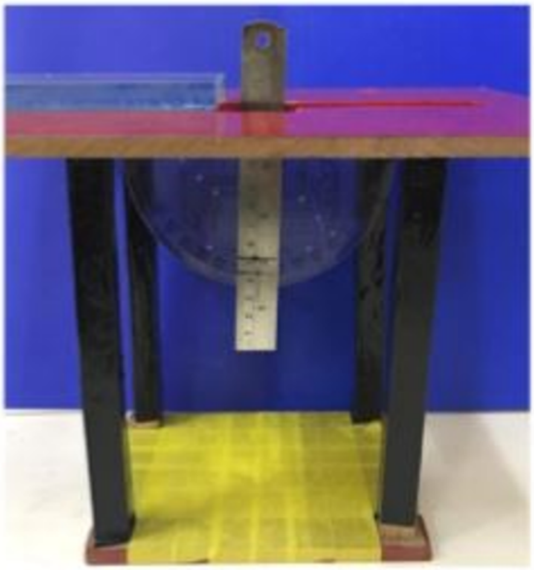

Fig. 3: Inclinometer (1 = wooden table with a centric slot, 2 = glass slab, 3 = metallic scale used as an extension to measure the angulations of the tooth, 4 =180 degree protractor)

The middle facial axis of incisor clinical crown (FACC) i.e. on the centre of the clinical crown was marked on the respective anterior tooth (Figure 4) and the measurement was performed using an incisor inclination gauge i.e. Inclinometer. An inclinometer is a device for measuring the angle of inclination, especially from the horizontal. A custom made inclinometer was used to measure the angle of inclination of anterior teeth. The values were defined as positive if the gingival portion of the facial tangent as marked by the protractors extension was lingual to the incisal portion and negative, if the incisal portion was lingual. (Figure 5) The change in inclination was recorded by calculating the difference in 3^{rd} order values at T0 to T5 for each participant.

Fig. 4: Teeth marked with FACC point

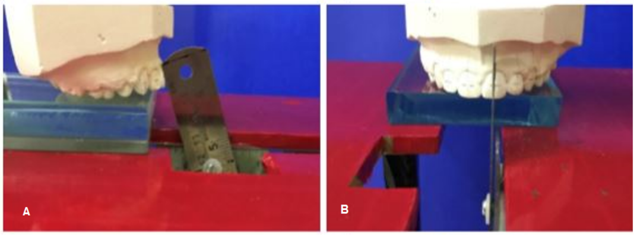

Fig. 5: Torque measurement using inclinometer in maxillary cast A) lateral view and B) frontal view

3.6.3.2. Time intervals for data recording. A patient particular form was maintained for each patient in order to ensure timely recording of parameters (pain assessment, crowding and torque assessment) at six regular pre-determined intervals**.** Pain was recorded at all six different times i.e. T0, T1, T2, T3, T4 and T5 intervals while crowding and torque assessment was assessed on the study models at T0 (i.e. Pretreatment) and T5 (i.e. 8 weeks after initial arch wire placement).

To determine the errors associated with the measurement, 10 casts were randomly selected and the measurements were repeated after 4weeks of the first measurments initially by the principal observer followed by another observer. Kappa test and chronbachs alpha were applied to find inter and intra examiner error. Kappa value was found to be 0.86 indicating good agreement between the observers. Criterion and construct validity of the questionnarie was assured by using spearman's correlation coefficient (p<0.001).

4. Observation and Results

4.1. Assessment and comparison of alignment efficiency in I-arch (study group) and superelastic (control group). (Table 3)

On comparison between the two groups, the I-arch (study group) exhibited greater alignment efficiency than superelastic NiTi (control group) within 8 weeks of the study. The maximum change towards alignment was observed between right lateral and canine which was statistically significant (p =0.04). The alignment efficiency was observed in this order2-3> 1-1>3-2>1-2. Interestingly, it was found that I-arch exhibited greater alignment efficiency especially in the lower arch, which has lesser interbracket span. These results are statistically significant in four out of six contacts.

4.2. Assessment and comparison of torque change in I-Arch (study group) and Superelastic NiTi (control group). (Table 4)

There was a significant change in the third order values between I-arch (study group) and superelastic NiTi (control group), especially between right canines (p value =0.01), right central incisors (p value=0.03), and left canines (p value= 0.006).

4.3. Determination and comparison of pain between I-arch (study group) and Superelastic NiTi (control group) (Tables 5 and 6)

The pain level was graded, in each patient, using numeric scale and verbal scale respectively. The mean for each group was analyzed and it showed that the pain experienced in the study group was lesser than that in the control group. These results were statistically significant.

5. Discussion

In the present study, the change in irregularity index was greater in the I-arch (copper NiTi 0.016"x0.014") group as compared to the control group (0.016" superelastic NiTi group but was not statistically significant. However, at one contact point between the canine and lateral incisor on the right side, the displacement is more in the copper NiTi group than the superelastic NiTi group and is statistically significant(p value = 0.04).

The interbracket span being lesser in the lower arch, influence the flexibility of the arch wire at the initial aligning phase of treatment. According to Drescher, last deflections (of 50-70degrees bending angle are necessary to reach the superelastic plateau of the wire. These findings are in concordance with that of West[17] who concluded that the improved physical properties of SE alloys are most potent where the inter bracket span is reduced as in the lower anterior segment. Interestingly it was found that in comparison to Superelastic NiTi control group, the I arch exhibited an even greater alignment efficiency in the lower arch. This promising finding is statistically significant in four out of 6 contacts studied in the lower anterior segment.

The results of the present work are in concordance with the findings of Damon[18] who proved efficiency of Cu NiTi 35°C wire on slight loadings during the initial tooth alignment phase. He recommended the sequential use of the following Cu NiTi35°C i.e 0.014", 0.014"x0.025", and 0.018" for x 0.025" for faster and efficient orthodontic treatment. He recommends these wires to be used in conjunction with self ligating brackets. In the present study, similar results were achieved with the use of I –arch 0.016" x 0.014" with conventional 0.018" slot PEA (MBT) brackets. Similarly, an in vitro comparison of Cu NiTi and superelastic NiTi by Gravina et al[2] showed that, the Cu NiTi 27°C had lower deactivation loadings. However, according to Pandis[19] 2009 there were no differences in the alignment efficiency between NiTi and Copper NiTi wires. This could be attributed to mechanical and biological reasons.

Many in vitro studies have been carried out to investigate the mechanical properties of NiTi and copper NiTi wires. Gravina et al.[2] stated that copper niti 27 degree presented better mechanical properties than SE NiTi. Additionally they did not find any statistically significant difference in deformation of superelastic NiTi and copper NiTi.

The pain experienced by the subjects in the I arch study group was much lesser to that experienced by subjects in the Superelastic NiTi control group. These results were found to be statistically significant and could be attributed to lesser force levels exerted by the I-arch copper NiTi.

Pain associated with initial archwire placement has been previously researched. Jones[8] (1984) has reported that pain is experienced by the majority of patients 4 hours after archwire placement, which will peak after 24 hours and then decline. Various authors, who performed the same research in other racial and ethnic group confirmed these findings.[20,21] Jones and Chan[8] stated that pain from archwire placement can be worse in some patients and could even be more than that experienced after tooth extraction. They observed a diurnal variation in pain experienced by patients – with evening and nights showing the highest scores. The pain will usually last for 2-3 days and will gradually decrease in its intensity by 5^{th} or 6^{th} day.[22] No difference in the intensity, prevalence, or duration of pain between different archwires was found.[23]

As claimed by the manufacturer the copper NiTi (I-arch) exerts only 23 gms force which is well below the force exerted by superelastic NiTi wires which is 50 gms (Proffit). The 0.016x0.014 copper Niti wire nearly fills 0.018x0.028 slot of the brackets at the onset of treatment. Hence, in the present study, early torque delivery was observed in the I-arch (study) group than the Superelastic NiTi (control)

Table 3: Intergroup comparison of change in irregularity index of studied groups

	Group	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	T Value	Value
3-2	Control group	20	.93745	1.074820	.240337	-.359550	-1.047	0.3**
	Study group	20	1.29700	1.096862	.245266			
2-1	Control group	20	1.05395	1.378124	.308158	-.353800	-.846	0.4**
	Study group	20	1.40775	1.264256	.282696			
1-1	Control group	20	.34240	.672085	.150283	-.317200	-1.145	0.26**
	Study group	20	.65960	1.041314	.232845			
1-2	Control group	20	.9950	1.26349	.28252	-.40700	-.851	0.4**
	Study group	20	1.4020	1.72464	.38564			
2-3	Control group	20	.5195	.93319	.20867	-.87035	-2.049	0.04**
	Study group	20	1.3899	1.65447	.36995			

*Significant, **non-significant

Table 4: Intergroup comparison of change in torque of studied groups

Tooth number	Group	N	Mean	Std. Deviation	Std. Error Mean	Mean difference	T Value	P Value
1-3	Control group	20	.10	4.471	1.000	4.250	2.532	0.01*
	Study group	20	-4.15	6.029	1.348			
1-2	Control group	20	- 1.50	4.466	.999	2.600	1.370	0. 1**
	Study group	20	-4.10	7.218	1.614			
1-1	Control group	20	-.90	6.390	1.429	2.700	1.375	0.03*
	Study group	20	-3.60	6.021	1.346			
2-1	Control group	20	-.45	5.49 1	1.228	1.400	.596	0.5**
	Study group	20	- 1.85	8.952	2.002			
2-2	Control group	20	.45	3.364	.752	-.100	-.060	0.9**
	Study group	20	.55	6.677	1.493			
2-3	Control group	20	1.75	3.892	.870	4.500	2.883	0.006*
	Study group	20	-2.75	5.794	1.295			

*Significant, **Non-significant

Table 5: Comparison of pain in I – arch (study group and superelastic NiTi (control group) at various study intervals using verbal scale

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean	Mean difference	T value	P value
T1	Control group	20	5.20	1.005	.225	3.20	.936	0.003**
	Study group	20	2.00	.52	.110			
T2	Control group	20	3.80	.616	.138	2.60	-1.000	0.01**
	Study group	20	1.20	.467	.056			
T3	Control group	20	.30	.979	.219	.000	.000	0.8*
	Study group	20	.30	.733	.164			
T4	Control group	20	.00	.000*	.000	—-	—–	——
	Study group	20	.00	.000*	.000			
T5	Control group	20	.00	.000*	.000	——	—–	—–
	Study group	20	.00	.000*	.000			

*Non-significant, *Significant

group. These results were statistically significant at three of the six teeths studied.

Similar results were obtained by Andresen and Amborn[24] in 1989 where they used 0.017”x0.025” thermal NiTi for 16 weeks in the upper arch and 0.016” twisted stainless steel in the lower arch. They demonstrated angular torque control in the maxillary incisors. Periapical radiographs does not show any signs of root resorption during the 6 week trial and only after a period of 1 year, one patient out of the four showed very slight maxillary anterior root resorption.

This ribbon arch rectangular Cu NiTi with lesser forces, expresses early torque delivery which has multiple benefits. The early torque delivery would reduce excessive flaring of the anterior segment. This would possibly prevent round tripping usually observed in extraction cases, further

Table 6: Comparison of pain in I – arch (study group and superelastic NiTi (control group) at various study intervals using numeric scale

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean	Mean difference	T Table	P value
T0	Control group	20	.20	.410	.092	.100	.872	0.008*
	Study group	20	.10	.308	.069			
T1	Control group	20	2.60	.503	.112	1.15	.936	0.002*
	Study group	20	1.45	.510	.114			
T2	Control group	20	1.90	.308	.069	0.70	-1.000	0.003*
	Study group	20	1.20	.452	.073			
T3	Control group	20	.15	.489	.109	.000	.000	0.8**
	Study group	20	.15	.366	.082			
T4	Control group	20	.00	.000*	.000	——	——	——
	Study group	20	.00	.000*	.000			
T5	Control group	20	.00	.000*	.000	—-	——	—-
	Study group	20	.00	.000*	.000			

*Significant, **Non-significant

reducing the overall treatment time. In this era, where, fuller smiles are considered aesthetically appealing, these I arch wires would be advantageous in borderline non extraction cases, especially, during the leveling and aligning phase. Moreover, the torque expression would also prevent resultant thinning of marginal cortical bone. This, would be especially beneficial in patients who have thin labial cortical plate and in such cases there is a greater demand for controlled root movement of anterior teeth.

6. Source of Funding

None.

7. Conflict of Interest

None.

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