COMPARISON OF SURFACE ROUGHNESS AND BENDING BEHAVIOR OF ESTHETIC COATED CONVENTIONAL AND NICKEL TITANIUM AND ARCHWIRES

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Abstract:

Aim: The aim of this study is to assess the surface roughness and bonding behavior of esthetic coated archwire compared to a Niti archwire.
Method: A 3 point bend test was performed to determine the bending behavior of wire samples and Atomic Force Microscopy was used to check the surface roughness of the esthetic coated NiTi wires.
Results: This study shows that esthetic coated archwire has better bending behavior and less surface roughness compared to conventional Niti archwire.
Conclusion: In conclusion, Niti archwire was found to have more surface roughness when compared to Esthetic coated archwire while Esthetic coated archwire showed more bending behavior when compared to Niti archwire.

Keywords: Surface roughness, Bonding behavior, Esthetic coated archwire

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1. Introduction:

In orthodontics, an archwire is used in conjunction with brackets as a source of force to correct tooth positioning anomalies. An archwire can also be utilized to keep teeth in their current locations. Nickel Titanium (NiTi) wires, known for their superelasticity and shape memory are the most commonly used initial stage arch wires. However, the high nickel concentration of NiTi alloys (Ni: 47–50%) and their incredibly rough surface topography causes problems in orthodontics like generation of frictional forces during initial alignment and leveling (1).

Esthetics is a significant consideration for most people choosing to undergo an orthodontic treatment in recent times. Esthetic brackets have been introduced as a result of the dramatically rising demand for aesthetics during fixed appliance therapy. Tooth-colored ceramic and plastic brackets have been employed in patients in an effort to improve the aesthetic appearance of metallic orthodontic appliances.(2, 3, 4, 5).

Orthodontic aesthetic archwires became necessary with the introduction of aesthetic brackets(6). There are three primary categories of aesthetic archwires: coated, coated with composite polymers, and optiflex archwires(7). Effectiveness of archwire-guided tooth movement is significantly influenced by the archwire's surface roughness(8). Materials(9),coatings(5),manufacturers(10),and manufacturing methods(9),(8),(11)have all been found to have an impact on the surface structure of archwires. This study aims to assess the surface roughness and bending behavior of esthetic archwires compared to the conventional NiTi arch wires.

2. Materials and Methods:

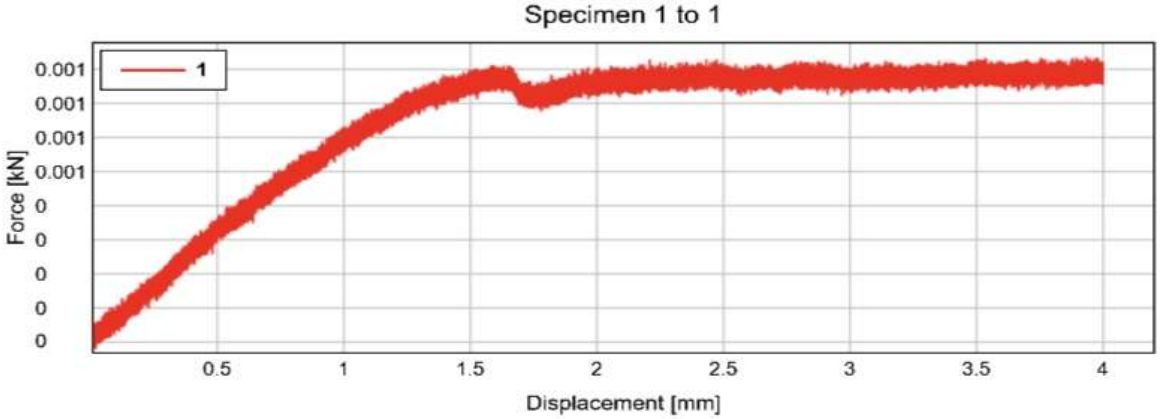
Group 1: Conventional NiTi
Group 2: Esthetic coated NiTi
Tests done:
Three Point Bend test:
The wires from both the groups were cut into 30mm segments and the samples underwent a three point bending test in a universal testing machine (Instron Electropuls E3000).
The fixture of the universal testing machine was made of two supports, had a 12 mm distance, thus creating a 6mm inter-point distance. Each sample was placed directly on the supports so that the center of each sample was on the center of the inter support distance. The load was applied using an Electromechanical Universal testing machine (Instron Electropuls E3000) with a crosshead speed of 1 mm/min to the center of each sample. The maximum deflection for each sample was 1.5 mm

Atomic Force Microscopy (AFM):
The samples were placed in Nanosurf Nanite AFM and the samples were measured in a 5x5 and 10x10 micron range and 128 points/line under Contact Mode. The roughness values were calculated by the Nanosurf C3000 software.

3. Result:

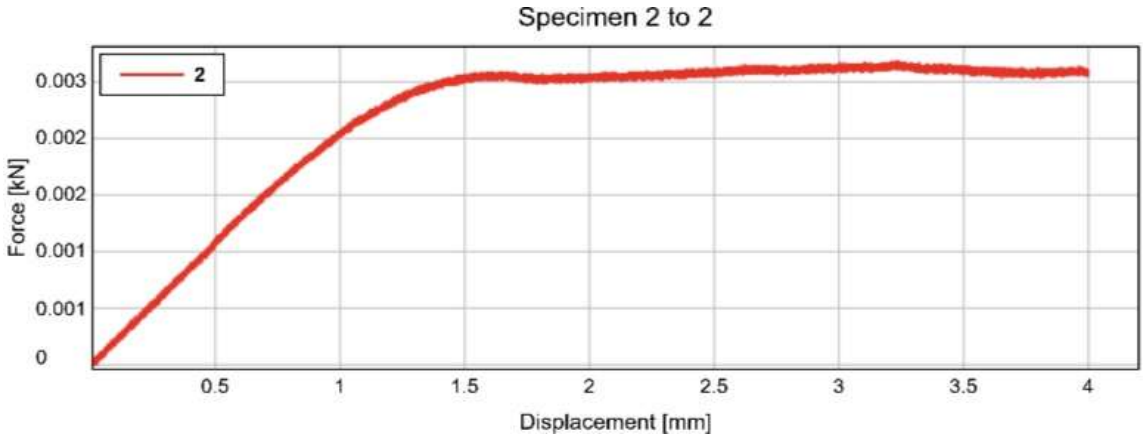
3 Point bend test:

Graph 1: Represents the bending behavior of Conventional Niti wire



The above graph 1 shows that the X-axis represents displacement and Y-axis represents force. So it depicts that at the displacement of 3.93mm, the force of the Niti wire is 0.84N.

Graph 2: Represents the bending behavior of Esthetic coated arch wire



The above graph 2 shows that the X-axis represents displacement and Y-axis represents force. So it depicts that at the displacement of 3.24mm, the force of the Niti wire is 2.68N.

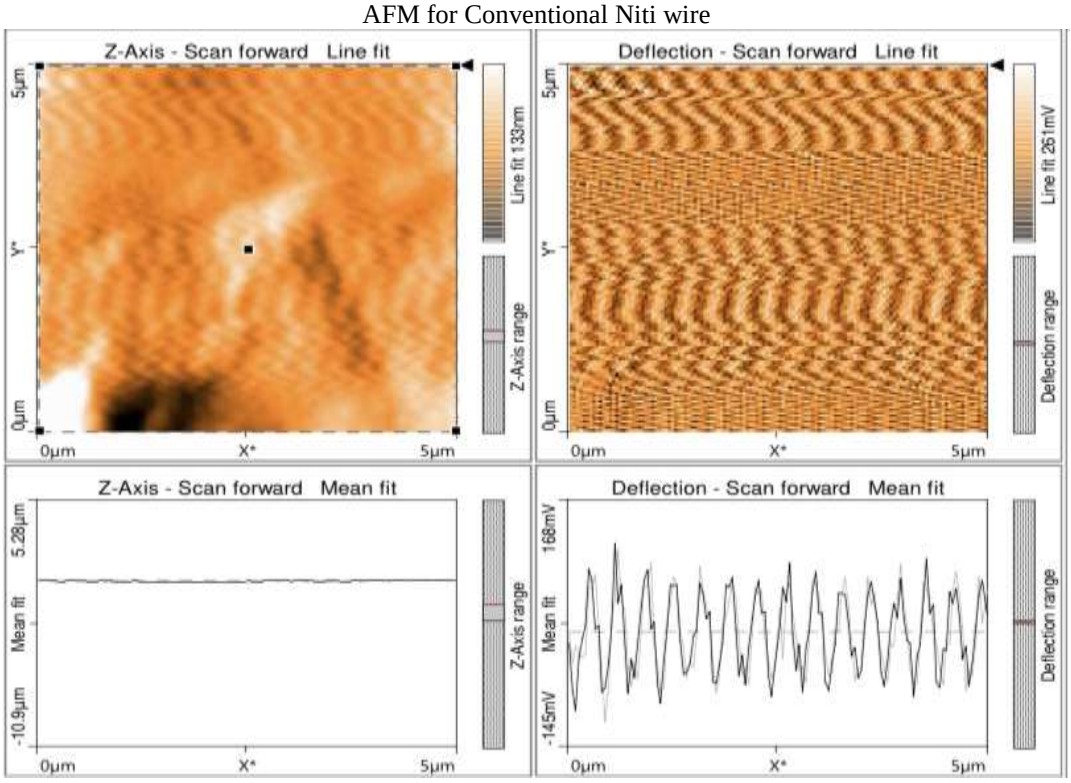
Table 1: Comparing both Niti and Esthetic coated archwire based on its Surface Roughness and bending Behaviour.

	Maximum Force [N]	Specimen label	Flexure displacement at Maximum Force [mm]
1	0.84	Ni Ti	3.93
2	2.68	Ni Ti colour coated	3.24

The above table 1 depicts that for a displacement of 3.93mm the force which acquired was 0.84N for Conventional NiTi and and for the displacement of 3.24mm the force attained was 2.68N for esthetic coated NiTi.

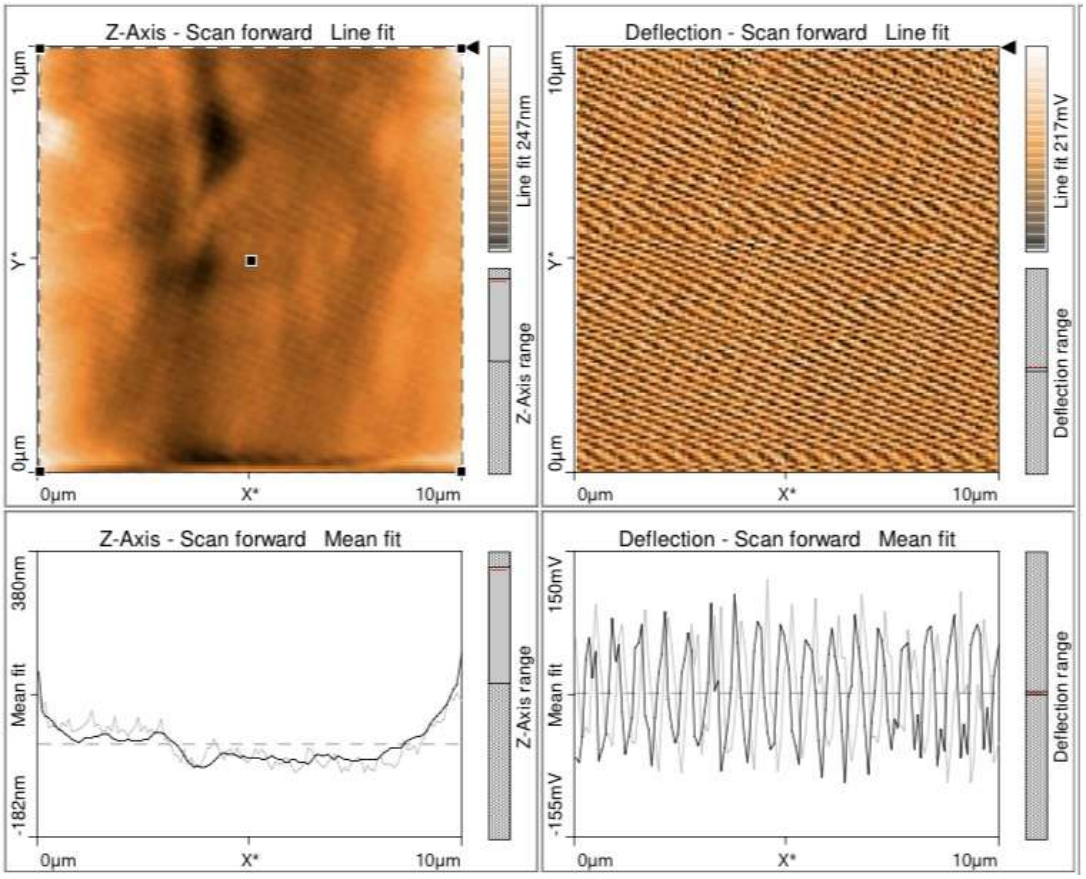
AFM:

AFM for Conventional Niti wire



The above AFM procedure is done at 5µm. At 5µm the roughness average is 14.61nm and the root mean square value is 22.613nm for Niti archwire.

AFM performed for Esthetic coated arch wire in the below image.



The above AFM procedure is done at 5µm. At 5µm the roughness average is 28.247nm and the root mean square value is 35.98nm for Esthetic coated archwire.

4. Discussion:

There is an increasing demand for esthetics in patients not only after treatment but during treatment as well. To meet their demands, research in material science has progressed in dentistry particularly in orthodontics(13). Ceramic brackets were introduced long ago, but archwires remained unchanged which has become an aesthetic concern. Coated archwires were thought to be one of the acceptable solutions for this problem(14). Metallic archwires are coated with tooth-colored polymers such as Teflon or epoxy resin by different manufacturers to meet the demand of esthetics from patients(15).

Surface roughness is considered as one of the characteristics of orthodontic wires, influencing a variety of factors such as friction, amount of plaque build-up, wire corrosion, etc. Each of the above variables plays a role in orthodontic treatment. When comparing the bending behavior of both the wire we can evidently know that the Ni Ti wire has force of 0.84 N, where as in Esthetic coated archwire shows higher force of 2.68 N. Comparing the surface roughness, the esthetic coated NiTi showed a higher value compared to the conventional NiTi. Hence, conventional NiTi wire is more hygienic compared to esthetic coated NiTi as the reduced roughness attracts less plaque accumulation.

The vast range of orthodontic wires made of different alloys makes it increasingly difficult for orthodontists to judge them. Coated orthodontic wires form a group of innovative guiding archwires. An unequivocal correlation between the surface roughness and frictional forces of the wires could not be verified by atomic force microscopy. However increased surface roughness might contribute to more frictional forces during orthodontic tooth movement (18).

5. Conclusion:

The esthetic coated archwire has a higher bending force and more surface roughness when compared to conventional NiTi.

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Conflict Of Interest:

The authors would like to declare no conflict of interest in the present study.

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6. References:

Krishnan M, Seema S, Tiwari B, Sharma HS, Londhe S, Arora V. Surface characterization of nickel titanium orthodontic arch wires [Internet]. Vol. 71, Medical Journal Armed Forces India. 2015. p. S340–5.e5. Available from: http://dx.doi.org/10.1016/j.mjafi.2013.12.006

Morphological study on twisted NiTi wires for smart composite systems. Mater Lett. 2002 Dec 1;57(2):364–8.

Bending stiffness of two aesthetic orthodontic archwires: An in vitro comparative study. Clin Mater. 1994 Jan 1;16(2):63–71.

Doshi UH, Bhad-Patil WA. Static frictional force and surface roughness of various bracket and wire combinations. Am J Orthod Dentofacial Orthop. 2011 Jan;139(1):74–9.

The effect of surface treatment and clinical use on friction in NiTi orthodontic wires. Dent Mater. 2005 Oct 1;21(10):938–45.

Philip N, Sunny S, George LA, Antony PJ. Newer Orthodontic Archwires: Imparting Efficacy to Esthetics [Internet]. Vol. 2, International Journal of Oral Health Dentistry. 2016. p. 102. Available from: http://dx.doi.org/10.5958/2395-499x.2016.00018.6

Singh DP. Esthetic Archwires in Orthodontics- A Review [Internet]. Vol. 04, Journal of Oral Hygiene & Health. 2016. Available from: http://dx.doi.org/10.4172/2332-0702.1000194

Bourauel C, Fries T, Drescher D, Plietsch R. Surface roughness of orthodontic wires via atomic force microscopy, laser specular reflectance, and profilometry. Eur J Orthod. 1998 Feb;20(1):79–92.

A comparative study of frictional resistances between orthodontic bracket and arch wire. Am J Orthod. 1980 Dec 1;78(6):593–609.

Huang HH. Variation in surface topography of different NiTi orthodontic archwires in various commercial fluoride-containing environments. Dent Mater. 2007 Jan;23(1):24–33.

Daems J, Celis JP, Willems G. Morphological characterization of as-received and in vivo orthodontic stainless steel archwires. Eur J Orthod. 2009 Jun;31(3):260–5.

Elsaka S, Hassan A, Elnaghy A. Effect of gastric acids on surface topography and bending properties of esthetic coated nickel-titanium orthodontic archwires [Internet]. Vol. 25, Clinical Oral Investigations. 2021. p. 1319–26. Available from: http://dx.doi.org/10.1007/s00784-020-03438-7

Relationship Of Microbial Colonization To Surface Roughness And Orthodontic Wire Type (Esthetic Vs. Non Esthetic Orthodontic Wire) [Internet]. Vol. 3, Mansoura Journal of Dentistry. 2016. p. 52–4. Available from: http://dx.doi.org/10.21608/mjd.2016.201779

Taha M, El-Fallal A, Degla H. In vitro and in vivo biofilm adhesion to esthetic coated arch wires and its correlation with surface roughness [Internet]. Vol. 86, The Angle Orthodontist. 2016. p. 285–91. Available from: http://dx.doi.org/10.2319/122814-947.1

Ali MM, Ibrahim AF. Influence of machining parameters on surface roughness in wire EDM using zinc coated brass wire [Internet]. Vol. 61, Materials Today: Proceedings. 2022. p. 987–91. Available from: http://dx.doi.org/10.1016/j.matpr.2021.10.276

Thomas D, Kumar R, Singh GK, Sinha P, Mishra S. Modelling of Surface Roughness in Coated Wire Electric Discharge Machining through Response Surface Methodology [Internet]. Vol. 2, Materials Today: Proceedings. 2015. p. 3520–6. Available from: http://dx.doi.org/10.1016/j.matpr.2015.07.328

Oniszczuk-Świercz D, Świercz R, Nowicki R, Kopytowski A, Dąbrowski L. Investigation of the influence of process parameters of wire electrical discharge machining using coated brass on the surface roughness of Inconel 718 [Internet]. AIP Conference Proceedings. 2018. Available from: http://dx.doi.org/10.1063/1.5056283

Azrak B, Callaway A, Kurth P, Willershausen B. Influence of Bleaching Agents on Surface Roughness of Sound or Eroded Dental Enamel Specimens [Internet]. Vol. 22, Journal of Esthetic and Restorative Dentistry. 2010. p. 391–9. Available from: http://dx.doi.org/10.1111/j.1708-8240.2010.00372.x