
**“EVALUATION OF THE EFFECT OF THREE
MOUTHWASHES ON THE MECHANICAL
PROPERTIES AND SURFACE MORPHOLOGY
OF DIFFERENT NITI ORTHODONTIC
WIRES: AN IN VITRO STUDY”**

By
REG. NO. II0220006

Dissertation

Submitted to
KAHER, Belagavi, Karnataka
In partial fulfilment of the requirements for the degree of

**MASTERS OF DENTAL SURGERY
IN
ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS
(BRANCH – V)**

**DEPARTMENT OF
ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS
KLE VISHWANATH KATTI INSTITUTE OF DENTAL SCIENCES,
KAHER, BELAGAVI, KARNATAKA.**

2020 – 2023

KAHER, BELAGAVI

**Endorsement by the Head of the Department
and Principal/Head of the Institution**

This is to certify that the dissertation entitled “EVALUATION OF THE EFFECT OF THREE MOUTHWASHES ON THE MECHANICAL PROPERTIES AND SURFACE MORPHOLOGY OF DIFFERENT NITI ORTHODONTIC WIRES: AN IN VITRO STUDY” is a bonafide research work done by REG. NO. II0220006.


Head of Department

Dr TEJASHRI PRADHAN M. D.S.
Professor & Head,
Department of Orthodontics and
Dentofacial Orthopaedics,
KLE Vishwanath Katti
Institute of Dental Sciences,
KAHER, Belagavi.

Date : 22/12/2022
Place: Belagavi


Principal

Dr ALKA KALE M. D.S.
Principal,
KLE Vishwanath Katti
Institute of Dental Sciences,
KAHER, Belagavi.

Date : 22/12/22
Place: Belagavi

PLAGIARISM CHECK REPORT

Scientific Correspondence and Review Committee



KLE VK Institute of Dental Sciences

A Constituent Unit of KLE Academy of Higher Education and Research
(Deemed-to-be-University u/s 3 of the UGC Act, 1956)

Nehru Nagar, Belagavi - 590 010, Karnataka State

Accredited 'A' Grade by NAAC (2nd Cycle)

Placed in Category 'A' by MHRD (GoI)

☎: 0831-2470362

Web: <http://www.kledental-bgm.edu.in>

FAX: 0831-2470640

E-mail: principal@kledental-bgm.edu.in

Date : 20.12.2022

Serial No. : 118

PLAGIARISM CHECK REPORT

Name of the Applicant : **REG. NO. II0220006**

UG / PG / Ph.D / Staff : *POST GRADUATE*

Batch & Year : *2020 - 2023*

Department : *ORTHODONTIC AND DENTOFACIAL ORTHOPAEDICS*

The soft copy of Research Work / Manuscript by **REG. NO. II0220006** entitled

".. EVALUATION OF THE EFFECT OF THREE MOUTHWASHES ON THE MECHANICAL PROPERTIES AND SURFACE MORPHOLOGY OF DIFFERENT NITI ... ORTHODONTIC WIRES : AN IN VITRO STUDY .."

under the guidance of has been submitted for

Anti-Plagiarism check to the Scientific Correspondence & Review Committee of KLE VK Institute of Dental Sciences using "Turn-it-in" software.

The scan has been carried out and the scanned output reveals a Similarity Index of3.....%, which is within / not within the acceptable limits of 10% as per the UGC guidelines.

Member Secretary
Scientific Correspondence and Review Committee
KLEVK Institute of Dental Sciences
KAHER-Belagavi

Chairman
Scientific Correspondence and Review Committee
KLEVK Institute of Dental Sciences
KAHER - Belagavi

UNDERTAKING

I, **REG. NO. II0220006** Post-Graduate student in the subject of Orthodontics and Dentofacial Orthopaedics, have completed research work on the topic **“EVALUATION OF THE EFFECT OF THREE MOUTHWASHES ON THE MECHANICAL PROPERTIES AND SURFACE MORPHOLOGY OF DIFFERENT NITI ORTHODONTIC WIRES: AN IN VITRO STUDY”**, in the year 2022.

I have been given to understand that any research work I undertake for dissertation, oral presentation or publication during my study course shall be the property of the KLE Academy Of Higher Education and Research, (KAHER) KLE V. K. Institute of Dental Sciences, Belagavi. Hence, I hereby declare that the name of the Department, Institute and University shall be mentioned in my publications. The authorship shall be according to the guideline informed to me.

REG. NO. II0220006

UNDERTAKING

I, **REG. NO. II0220006** hereby declare that the information and data mentioned in my thesis entitled **“EVALUATION OF THE EFFECT OF THREE MOUTHWASHES ON THE MECHANICAL PROPERTIES AND SURFACE MORPHOLOGY OF DIFFERENT NITI ORTHODONTIC WIRES: AN IN VITRO STUDY”** belongs to me and is original.

I am aware of the definition of plagiarism as detailed below:

- An act or instance of using or closely imitating the language and thoughts of another author without authorization and the representation of that author’s work as one’s own, as by not crediting the original author.
- A piece of writing or other work reflecting such unauthorized use or imitation.
- The deliberate or reckless representation of another’s words, thoughts or ideas as one’s own without attribution in connection with the submission of academic work, whether graded or otherwise.

I hereby declare that the thesis prepared by me is an original one and does not involve plagiarism anywhere. In case at a later stage, it is found that I have indulged in plagiarism, then I am solely responsible for the same and the Institution is at liberty to take any disciplinary action against me including cancellation of dissertation or any other penalties imposed by the University.

Place:

Date:

REG. NO. II0220006

BIOSTATISTICS CLEARANCE CERTIFICATE



KLE V.K. Institute of Dental Sciences

(A Constituent unit of KLE Academy of Higher Education & Research
Deemed-to-be-University u/s 3 of the UGC Act, 1956)
Nehru Nagar, Belagavi-590 010 INDIA

Re-Accredited 'A' grade by NAAC (2nd Cycle) & Placed in Category 'A' by MHRD (GoT)

Phone : 0831-2470362
FAX: 0831-2470640

Web: <http://www.kledental-bgm.edu.in>
E-mail: principal@kledental-bgm.edu.in



Biostatistics Clearance Certificate

This is to certify that the Biostatistics aspect of the Dissertation / Research work of REG. NO. II0220006 Post Graduate Student, under the guidance of _____; Department of Orthodontics and Dentofacial Orthopaedics, entitled "EVALUATION OF THE EFFECT OF THREE MOUTHWASHES ON THE MECHANICAL PROPERTIES AND SURFACE MORPHOLOGY OF DIFFERENT NITI ORTHODONTIC WIRES: AN IN VITRO STUDY" has been done under my guidance and considered satisfactory.

Dr. Asawari Shidhore

Place: Belagavi

Name & Signature of Biostatistician

Date: 16-12-22

ABSTRACT

Introduction: Orthodontic treatment is vital for correcting the malpositioned teeth. One of the most important aspects of a successful orthodontic treatment is the maintenance of good oral hygiene and caries control. Orthodontists recommend that patients regularly use mouthwash during orthodontic treatment to prevent tooth decay. Orthodontic appliances are therefore continuously exposed to fluoride and other components present in a substantial quantity in these products.²

Fluoride or chlorhexidine mouthwash may be used to decrease plaque buildup and pathogenic germs.² The use of herbal mouthwashes by orthodontic patients has recently increased.¹

The purpose of this *in vitro* study is to evaluate the potential effects of three mouthwashes on the mechanical and surface properties of different NiTi orthodontic wires so that the clinician can accordingly make modifications in the treatment procedures and hence help in making it more efficient and effective and thereby find an appropriate mouthwash for use during orthodontic treatment.

This study was undertaken to assess the changes in the mechanical properties and surface morphology of different NiTi wires.

Materials and methods: The study was an In-vitro study conducted using three mouthwashes and three types of NiTi wires. The study was conducted at BSRC, KLE Academy of Higher Education and Research (KAHER), KLE VK institute of Dental Sciences, Belagavi. A sample size of of 48 specimens was derived.

Three types of round 0.016 NiTi orthodontic wires (Superelastic NiTi, Copper NiTi and NiTi coated with epoxy resin) were tested upon to see the changes that occur in their mechanical properties and surface morphology when treated with three different

mouthwashes (Chlorhexidine mouthwash, Sodium Fluoride mouthwash and Herbal mouthwash). Everyday, for 1 month, wires were treated with the respective mouthwashes for 60 seconds. At the end of the study, all the samples were tested upon for the changes in their mechanical properties and surface morphology.

To assess the changes in mechanical properties (loading and unloading force) , a three point bending test was conducted which was done on a Universal testing machine. To assess the changes in the surface morphology (surface roughness), we did a profilometry test for which a Surfcom testing machine was used.

Results: The loading force of Copper NiTi (mean value = 2.2875 ± 0.04787) and Coated NiTi (mean value= 4.0130 ± 0.00872) is least in Hiora mouthwash. The Unloading force of Copper NiTi (mean value= 1.37450 ± 0.001915) is least in Sodium fluoride mouthwash whereas that of Superelastic NiTi (mean value= 2.3485 ± 0.002517) and Coated NiTi (mean value= 2.34825 ± 0.003304) is least in Hiora mouthwash. The Modulus of elasticity of Copper NiTi (mean value= 11501.5 ± 1.914854) and Superelastic NiTi (mean value= 34530.25 ± 1.258306) is least in Sodium fluoride mouthwash whereas that of Coated NiTi (mean value= 16461.25 ± 1.5) is least in Hiora mouthwash. The Surface roughness of all three types of NiTi- Copper NiTi (mean value= 0.1085 ± 0.000957), Superelastic NiTi (mean value= 0.1045 ± 0.001414) and Coated NiTi (mean value= 0.1011 ± 0.000816) are least in Hiora mouthwash compared to the other two mouthwashes.

Conclusion: We concluded that Hiora Herbal mouthwash can be used in place of Hexidine mouthwash as it has almost similar effects on the mechanical properties and surface characteristics of the NiTi wires.

CONTENTS

SL NO.	PARTICULARS	PAGE NO.
1.	INTRODUCTION	1-2
2.	AIM AND OBJECTIVES	3
3.	REVIEW OF LITERATURE	4-12
4.	METHODOLOGY	13-23
5.	RESULTS	24-43
6.	DISCUSSION	44-46
7.	LIMITATIONS OF THE STUDY	47
8.	CONCLUSION	48-50
9.	SUMMARY	51-53
10.	BIBLIOGRAPHY	54-58
11.	ANNEXURES	59-61

LIST OF FIGURES

FIGURE NO.	PARTICULARS	PAGE NO.
1.	Labelled petri dishes with different NiTi wires treated with 3 different mouthwashes	19
2.	Incubator machine set at 37 degree Celsius to simulate oral environment	19
3.	Universal Testing machine	20
4.	Mounted wire on the lower jaw of the jig	21
5.	Surface roughness testing machine	22

LIST OF TABLES

TABLE NO.	PARTICULARS	PAGE NO.
1.	Descriptive statistics: Mean (SD) of the Loading values of various NiTi orthodontic wires in different mouthwashes	24
2.	Descriptive statistics: Mean (SD) of the Unloading values of various NiTi orthodontic wires in different mouthwashes	25
3.	Descriptive statistics: Mean (SD) of the Modulus of elasticity of various NiTi orthodontic wires in different mouthwashes	26
4.	Descriptive statistics: Mean (SD) of the Surface roughness of various NiTi orthodontic wires in different mouthwashes	27
5.	Intergroup comparison between the effect of different mouthwashes at Loading amongst different orthodontic wires	28
6.	Pairwise multiple comparison between the effect of different mouthwashes at Loading amongst various orthodontic wires	29
7.	Intergroup comparison between the effect of different mouthwashes at Unloading amongst various orthodontic wires	30
8.	Pairwise multiple comparison between the effect of different mouthwashes at Unloading amongst various orthodontic wires	31
9.	Intergroup comparison between the effect of different mouthwashes assessing the modulus of elasticity amongst various orthodontic wires	32

10.	Pairwise multiple comparison between the effect of different mouthwashes assessing the modulus of elasticity amongst various orthodontic wires	33
11.	Intergroup comparison between the effect of different mouthwashes assessing the surface roughness amongst various orthodontic wires	34
12.	Pairwise multiple comparison between the effect of different mouthwashes assessing the surface roughness amongst various orthodontic wires	35

LIST OF GRAPHS

GRAPH NO.	PARTICULARS	PAGE NO.
1.	Mean Loading values of various NiTi orthodontic wires in different mouthwashes	36
2.	Mean Unloading values of various NiTi orthodontic wires in different mouthwashes	38
3.	Mean Modulus of elasticity of various NiTi orthodontic wires in different mouthwashes	40
4.	Mean Surface roughness of various NiTi orthodontic wires in different mouthwashes	42

LIST OF ANNEXURES

ANNEXURE NO.	PARTICULARS	PAGE NO.
I	Ethical clearance	59
II	Test Reports	60

INTRODUCTION

Orthodontic treatment is vital for correcting the malpositioned teeth as well as creating an attractive smile which helps in improving and maintaining good oral and dental health and contributes to the development of self-esteem of the patient.¹

One of the most important aspects of a successful orthodontic treatment is the maintenance of good oral hygiene and caries control. Compromised oral hygiene can lead to enamel demineralization and decay. Orthodontists recommend that patients regularly use mouthwashes and gels, in addition to the daily use of fluoride toothpaste during orthodontic treatment to prevent tooth decay. Orthodontic appliances are therefore continuously exposed to fluoride and other components present in a substantial quantity in these products.²

Currently, more patients are seeking orthodontic treatment, and so there is an increasing demand for improvement in the aesthetic quality of orthodontic appliances.¹

One of the principle of orthodontic therapy is to utilize the stored elastic energy in the orthodontic wires to carry out desired tooth movement.⁷

Efficient orthodontic treatments rely on the perfect design and condition of the wires. Mechanical properties and surface characteristics of the orthodontic wires play a key role during the entire treatment⁷ as it is the driving force which influences the treatment outcome; it can lead to delay in the treatment and unsatisfied results.

Wires made of nickel-titanium alloys are commonly used in orthodontic treatment as they possess valuable mechanical properties of superelasticity and shape memory. Their unique properties are attributed to a phase transformation between the

austenitic form and martensitic structure of nickel-titanium, when wire is subjected to stress or temperature changes.⁷

In recent years, ample attention has been paid to identifying superelastic archwires which produce a very light force in the plateau range. Light continuous forces are preferred in orthodontic treatment because they permit efficient tooth movement and cause less damage to the teeth or periodontium. Wires made of NiTi are highly corrosion resistant because of having a protective oxide layer on their surface. Different components of fluoride containing agents, by destroying this protective layer, can cause corrosion, discoloration, and changing the mechanical characteristics of orthodontic wires.

Using different mouthwashes and prophylactic agents can hence change the oral environment.

In addition to fluoride mouthwashes, orthodontic patients may be utilising antiseptic mouthwashes such chlorhexidine to decrease plaque buildup and pathogenic germs.²

The use of herbal mouthwashes by orthodontic patients has recently increased.¹ They are safer than other mouthwashes due to the lack of chemical components.²

Due to the lack of studies on the effects of different mouthwashes on “NiTi” orthodontic wires, the purpose of this *in vitro* study is to evaluate the potential effects of three mouthwashes on the mechanical and surface properties of different NiTi orthodontic wires so that the clinician can accordingly make modifications in the treatment procedures and hence help in making it more efficient and effective and thereby find an appropriate mouthwash for use during orthodontic treatment.

AIM AND OBJECTIVES

AIM:

- To evaluate and compare the effects of three mouthwashes on the loading force, unloading force and surface roughness of different NiTi Orthodontic wires.

OBJECTIVES:

- To assess the changes in the mechanical properties of different NiTi wires.
- To assess the changes in the surface morphology of different NiTi wires.
- To study the effects of three different mouthwashes on NiTi Orthodontic wires.
- To formulate modifications in the treatment procedures.
- To find an appropriate mouthwash for use during orthodontic treatment.

REVIEW OF LITERATURE

Rajendran A, Sundareswaran S, Peediyekkal LV, Santhakumar P, Sathyanadhan S(2019)- They looked at three different TMA wire kinds with dimensions of 0.017" 0.025": Standard TMA (TMA), Ion-implanted, Low-Friction TMA (LF), and Colored, Honey Dew TMA (HD). The three groups were: Control (as received), No Fluoride (after intraoral usage without fluoride), and Fluoride (following intraoral use with fluoride rinses). Using a 3D optical profilometer, surface roughness was measured. Three-point bending tests were conducted to assess the Young's modulus, ultimate tensile strength, and load deflection characteristics (LDR) (E). These were their findings:

- For both varieties of TMA wires, intraoral circumstances drastically worsened mechanical characteristics and increased surface roughness. The degradation was significantly worse when fluoride mouthwash was used on a daily basis.

Dilipkumar D, Dhinahar S, Deenadayalan P, Tandon A, Suresh P(2017)- The study's goal was to assess how Noni mouthwash affected the compositional and surface quality of nickel titanium orthodontic wires. They used pre-formed 0.014 inch NiTi arch wire. Two 25mm-long samples, one serving as the control and the other as the test, were used in the investigation. Test sample was submerged in Noni mouthwash solution for 1.5 hours before being taken from the solution and washed with distilled water. Control sample was kept at room temperature without being altered. To qualitatively evaluate the topography of the wire surface, scanning

electron microscopy analysis was performed on both the control and test samples.

These were their findings:

- NiTi wire's composition and surface roughness were not significantly affected by noni mouthwash. Therefore, noni mouthwash may be recommended as a safe, all-natural preventative measure for orthodontic patients.

Aghili H, Yassaei S, Eslami F(2017)- conducted an invitro study on five specimens each of 0.016 inch nickel titanium (NiTi), coated NiTi, and stainless steel orthodontic wires. The specimens were immersed in 0.05% sodium fluoride (NaF), 0.2% chlorhexidine, *Zataria multiflora* extract, and distilled water (control) for 1.5 h at 37°C. After immersion, loading and unloading forces at 0.5 mm intervals and the elastic modulus (E) of the wires were measured using a three-point bending test. Surface changes were observed with a scanning electron microscope (SEM). They concluded that:

- All mouthwashes significantly reduced the stiffness of SS wires; fluoride treatment increased the stiffness of coated wires; fluoride and CHX mouthwashes increased the stiffness of coated wires; and ZM mouthwash significantly decreased the stiffness of SS wires.
- All mouthwashes altered the surface morphology and loading and unloading forces of various wires, which may have an effect on these wires' mechanical characteristics during orthodontic therapy.

Nalbantgil D, Ulkur F, Kardas G, Culha M (2016)- The study compared the corrosion resistance of four various arch wires and the impact of several mouthwashes on corrosion. Four wire samples measuring 2 cm (0.016 x 0.022 inch) each made up each group. Ion-implanted nickel titanium is in the first group, nickel titanium without ion implantation is in the second group, micro-layered aesthetic nickel titanium is in the third group, and stainless steel (SS) wires are in the fourth group. For 24 hours, they were submerged in 2 ml of artificial saliva solutions (AS) for the control group and one of the three mouthwashes for the study groups. These mouthwashes contained sodium fluoride, chlorhexidine, and essential oils (NaF). Electrochemical impedance spectroscopy observations were performed using an electrochemical analyzer. The findings indicated:

- The impedance responses of all materials significantly increased in the presence of both NaF and CHX mouthwash. Micro layered aesthetic nickel titanium wires are found to be biocompatible among other wires, and NaF and CHX mouthwashes can be recommended for their good corrosion resistance during fixed orthodontic therapy.
- Esthetic Nickel Titanium (ENT) obtained higher corrosion resistance than the other wires.

Ahrari F, Ramazanzadeh BA, Sabzevari B, Ahrari A (2012)- The goal of the study was to determine how a fluoride mouthwash affected the load-deflection properties of three different kinds of nickel-titanium-based orthodontic archwires. From the single-strand NiTi (Rematitan "Lite"), multi-strand NiTi (SPEED Supercable), and Copper NiTi (Damon Copper NiTi) wires, 20 maximum 0.016 inch spherical specimens were

chosen. The samples were stored for 24 hours (N = 10) in either 0.2% NaF or synthetic saliva solutions at 37°C. Using a three-point bending test, the wire load-deflection characteristics were assessed by a Zwick testing apparatus. The findings indicated that:

- Fluoride agents decreased related unloading forces, especially at smaller deflections, and may cause delayed tooth alignment.
- Immersion in NaF solution had an impact on the load-deflection characteristics of NiTi wires.

Ramazanzadeh BA, Ahrari F, Sabzevari B, Zebarjad SM, Ahrari A (2011)- This study's objectives were to assess the load-deflection characteristics of three different types of nickel-titanium wires and look into how recycling affected their superelastic qualities. Tests were conducted on 30 samples of each type of NiTi, including single-strand NiTi (Rematitan "Lite"), multi-strand NiTi (SPEED Supercable), and Copper NiTi (Damon Copper NiTi). Ten samples of each wire, in their as-received state, were put through a three point bending test (T0). For two months, the remaining wires were preserved in a mock oral environment. The load-deflection characteristics of half of these specimens were then tested (T1), while the remaining specimens were autoclave sterilised prior to testing (T2). The findings indicated that:

- Damon Copper NiTi demonstrated significantly more force than Supercable, whereas Rematitan "Lite" demonstrated significantly more force than those materials.
- Nickel-titanium wires' bending characteristics were significantly affected by recycling.

- Damon Copper NiTi may be appropriate for routine orthodontic treatment in adolescent and adult patients.
- Supercable is helpful when very little force is required during orthodontic therapy.

Walker MP, Ries D, Kula K, Ellis M, Fricke B(2007)- They tested beta titanium and stainless steel rectangular wires. For 1.5 hours at 37°C, wires were submerged in either an acidulated fluoride agent, a neutral fluoride agent, or distilled water (control). After immersion, a 3-point bend test was used to gauge the wires' loading and unloading elastic modulus and yield strength. The wire topography was also qualitatively assessed using scanning electron microscopy.

The findings imply that:

- Using topical fluoride agents with beta titanium and stainless steel wire could impair the wires' functional unloading mechanical characteristics and possibly result in longer orthodontic therapy.

Razavi, E.S.E., Nik, T.H., Hooshmand, T., Farzadaghi, H. and Arefi, A.H. (2021)- They evaluated how chlorhexidine and mouthrinses containing Persica affected the friction between orthodontic stainless steel wires and brackets and the surface characteristics of the appliances. 75 orthodontic patients (aged 13 to 30) were divided into a control group and two experimental groups. After two weeks, the patients were brought back, the ovoid stainless steel archwires were taken out, and new ones were put in their place. With the use of atomic force microscopy and scanning electron microscopy, the surface analysis of archwires and brackets was

assessed. Using a universal testing device, the frictional forces between the archwires and brackets were measured. The findings indicated that:

- The friction force between the archwires and brackets was significantly higher for the chlorhexidine than for the Persica, and the surface roughness of the archwires was significantly greater for the chlorhexidine than for the Persica after the intervention.
- When compared to chlorhexidine, the mouthrinse containing Persica may be a better option for orthodontic patients' dental hygiene from a biomechanical and biochemical perspective.

Liu JK, Lee TM, Liu IH (2011)- The purpose of the study was to look at how bending stress affected how much nickel commercial NiTi orthodontic wires released. Two different NiTi wire kinds that had not undergone any internal stress were submerged in synthetic saliva. Throughout the 14-day trial period, half of the NiTi wires were continuously under bending stress. The findings indicated that:

- Bending stress affects the nickel release of NiTi wires; Stressed NiTi wires showed a significant increase in nickel release compared to unstressed specimens.

Huang HH, Chiu YH, Lee TH, Wu SC, Yang HW, Su KH, Hsu CC (2003)- An atomic adsorption spectrophotometer was used in this work to measure the amount of Ni and Ti ions emitted from four different types of NiTi orthodontic wires while they were submerged in fake saliva for varying lengths of time (1-28 days). The findings indicated that:

- The amount of Ni-ions produced in all test solutions was below the threshold required to cause allergy
- The TiO₂ coating on NiTi wires demonstrated corrosion resistance because the amount of Ti ions emitted could not be detected.
- Corrosion may prefer to form in pre-existing surface flaws on NiTi wires.
- After an immersion test, the surface roughness of NiTi wire with the highest metal ion release had the greatest rise, although a rougher surface did not necessarily result in a larger metal ion release.

Bourauel C, Fries T, Drescher D, Plietsch R. (1998)- A titanium wire, stainless steel, and NiTi wires' surface roughness were all measured as part of the investigation.

The findings indicated that:

- The surface roughness for the -titanium wire determined by all three methods was roughly 0.21 μ m.
- Stainless steel, the smoothest wire, had an optical roughness of 0.10 μ m, compared with 0.09 μ m from AFM and 0.06 μ m from profilometry.
- Surface roughness has an impact on the efficiency of sliding mechanics, corrosion behaviour, and the aesthetics of orthodontic components; therefore, manufacturers of orthodontic wires should work to improve the surface quality

of their products. The surface roughness of the NiTi wires ranged from 0.10 to 1.30 m.

Alwafe, N.A., Hammad, S.M., AbdelMawla El-wassefy, N. and Hafez, A.M. (2019)- The purpose of the study was to assess the frictional resistance and surface roughness between brackets and two different types of rectangular archwires using an experimental herbal mouthwash and mouthwash containing sodium fluoride. With 0.019 to 0.025 inch stainless steel and NiTi alloy archwires, 60 premolar brackets divided into three groups were fastened. For 90 minutes, these samples were submerged in fake saliva (control group), herbal mouthwash, and mouthwash with sodium fluoride (study groups). The three groups' levels of resistance to friction were tested using a universal testing equipment. Wire surface roughness and bracket surface topography were both assessed using atomic force and scanning electron microscopes, respectively. The findings indicated that:

- The highest mean friction resistance and mean surface roughness were shown by samples submerged in sodium fluoride mouthwash, followed by herbal mouthwash and the lowest by artificial saliva.
- For orthodontic patients, herbal mouthwash may be administered as a non-destructive preventive measure.

Chitra P, Prashantha GS, Rao A. (2020)- The objective was to compare patients who had and hadn't been exposed to fluorides in terms of the degree of corrosion of nickel titanium arch wires. 60 participants in fixed orthodontic treatment were placed into 3 groups for the study (unused, non-fluoridated mouthwash and fluoridated

mouthwash). Arch wires and brackets in three groups were exposed to SEM analysis after six months to look for variations. The findings indicated that:

- Fluoridated mouthwash and toothpastes may be used by orthodontic patients.
- Maximum deterioration, cracks, and dark spots were observed in fluoridated wires and brackets.
- Fluoridated wires and brackets throughout treatment showed increased metal ion leaching.

MATERIALS AND METHODS

STUDY DESIGN

An In-Vitro Study was conducted using three mouthwashes and three types of NiTi wires.

SOURCE OF DATA

- The study was conducted at BSRC, KLE Academy of Higher Education and Research (KAHER), KLE VK institute of Dental Sciences, Belagavi.
- The mechanical properties (loading, unloading force and elastic modulus) and the surface roughness of the wires was assessed at Praj Metallurgical Laboratory, Pune.

SAMPLE SIZE ESTIMATION

The sample size (n) is derived by using the “comparing two means” formula:

$$n = \frac{(\sigma_1^2 + \sigma_2^2/\kappa) (Z_{1-\alpha/2} + Z_{1-\beta})^2}{\Delta^2}$$

Where, σ_1 = standard deviation of Group 1,

σ_2 = standard deviation of Group 2

Δ = difference in group means (master article reference –Aghili H et al)

κ = ratio = n_2/n_1

$Z_{1-\alpha/2}$ = two-sided Z value (eg. Z=1.96 for 95% confidence interval).

$$Z_{1-\beta} = \text{power}$$

Substituting the values in the above formula,

$$n = \frac{\{(0.01)^2 + (0.3)^2\} (1.96 + 0.84)^2}{(4.41 - 3.95)^2}$$

A sample size of 3.71~ 4 specimens in each subgroup is derived, considering 4 groups and 3 subgroups, a total sample size of 48 specimens is derived.

PERMISSIONS OBTAINED

- Institutional ethical clearance.

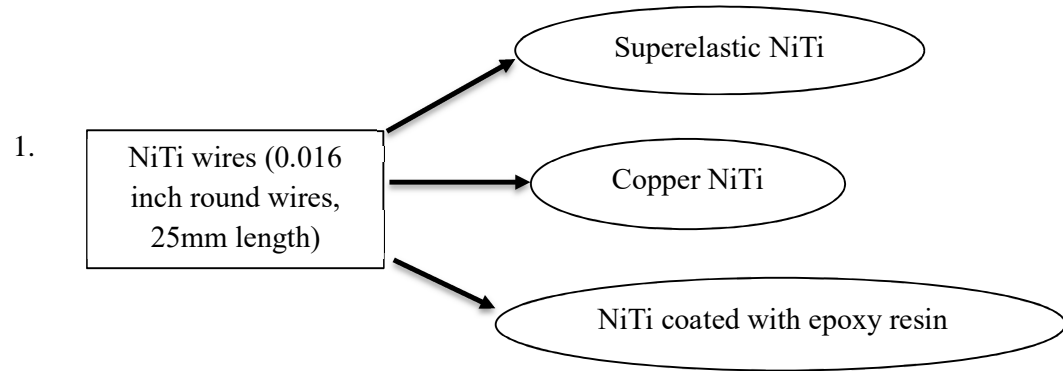
TOTAL BUDGET

- Material cost: Rs. 8500
- The cost incurred during the investigation: Rs. 12,000
- The cost incurred for statistical analysis: Rs. 3500
- Total cost: Rs. 24000

FUNDING DETAILS:

- No funding from any external source was required to conduct the study.
- I, Dr Tanvi Shukla took up the financial responsibility of my research and bore all the expenses incurred during the study.

INSTRUMENTS AND MATERIALS



2. Artificial saliva

3. Hexidine-EP (0.12% Chlorhexidine) mouthwash, Colgate Plax (0.05% Sodium Fluoride) mouthwash and Hiora (Herbal) mouthwash

4. Brackets

5. Incubator set at 37 degree celsius

6. Universal Testing machine

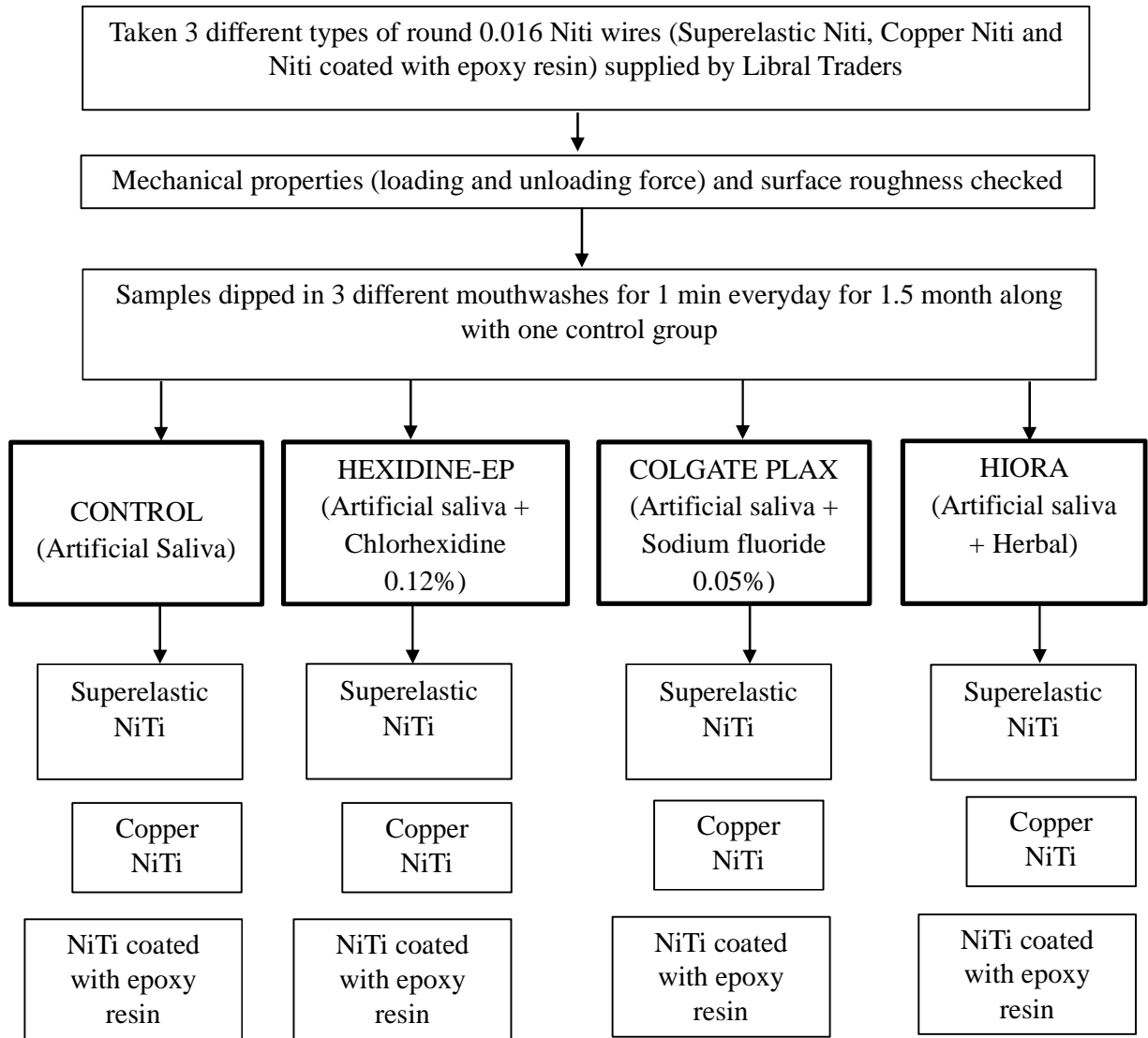
7. Surfcom testing machine

8. Petri dish

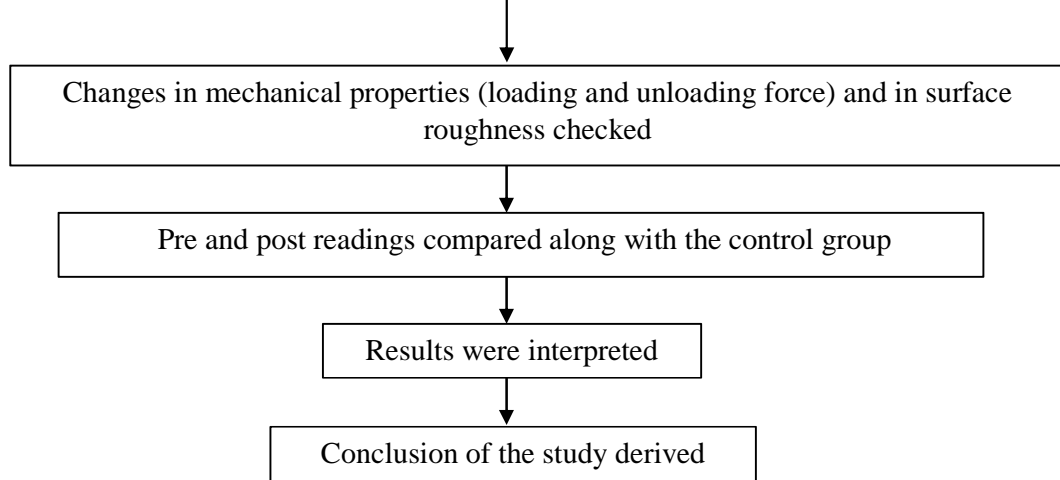
9. Wire cutter

10. Measurement scale

METHODOLOGY



*Wires were kept in artificial saliva at 37 degree Celsius.



Three different types of round 0.016 NiTi orthodontic wires were tested upon to see the changes (if any) that occur in their mechanical properties and surface morphology when treated with three different mouthwashes (Chlorhexidine mouthwash, Sodium Fluoride mouthwash and Herbal mouthwash). The NiTi wires (**Superelastic NiTi, Copper NiTi and NiTi coated with epoxy resin**) were supplied by Libral Traders. The mouthwashes used in the study were- **Hexidine-EP** (0.12% Chlorhexidine), **Colgate Plax** (0.04% Sodium Fluoride) and **Hiora** (Herbal).

The NiTi orthodontic wires were kept in artificial saliva and incubated at 37 degree Celsius at Basic Science and Research Centre, KLE VK Institute of Dental Sciences, Belagavi to simulate oral environment of human patients (Fig.2).

The artificial saliva was prepared for the study at Basic Science and Research Centre, KLE VK Institute of Dental Sciences, Belagavi.

Initially the mechanical properties (loading and unloading force) and the surface morphology (quantitatively- using Profilometry) of the wires were assessed after keeping the wires in saliva for one day without treating it with any of the mouthwashes. Thus, served as the control group of the study.

The study continued for 1 month which is roughly the time period upto which the NiTi wires are placed in the patient's oral cavity for the initial levelling and aligning phase of treatment. The groups formed were (Fig.1)-

Group 1a	Control group 1 (Superelastic NiTi kept in artificial saliva at 37 degree Celsius)
Group 1b	Control group 2 (Copper NiTi kept in artificial saliva at 37 degree Celsius)
Group 1c	Control group 3 (NiTi coated with epoxy resin kept in artificial saliva at 37 degree Celsius)
Group 2a	Superelastic NiTi treated with Chlorhexidine mouthwash
Group 2b	Copper NiTi treated with Chlorhexidine mouthwash
Group 2c	NiTi coated with Epoxy Resin treated with Chlorhexidine mouthwash
Group 3a	Superelastic NiTi treated with Sodium Fluoride mouthwash
Group 3b	Copper NiTi treated with Sodium Fluoride mouthwash
Group 3c	NiTi coated with Epoxy Resin treated with Sodium Fluoride mouthwash
Group 4a	Superelastic NiTi treated with Herbal mouthwash
Group 4b	Copper NiTi treated with Herbal mouthwash
Group 4c	NiTi coated with Epoxy Resin treated with Herbal mouthwash

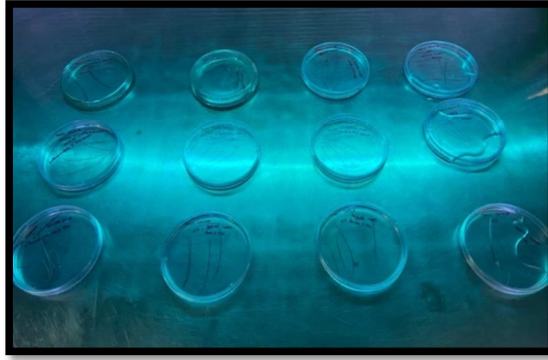


Fig.1.- Labelled petri dishes with different NiTi wires treated with 3 different mouthwashes

Everyday, for 1 month, Group 2a to Group 4c wires were treated with the respective mouthwashes for 60 seconds (Fig.1) and then were kept again in plain artificial saliva at 37 degree Celsius. This simulates the oral environment of the orthodontic patients because such patients are asked to use a mouthwash daily to maintain the oral hygiene during the course of the treatment.

At the end of the study, all the samples were tested upon for the changes in their mechanical properties and surface morphology.

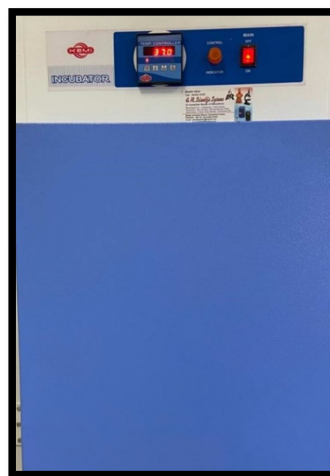


Fig.2.- Incubator machine set at 37 degree Celsius to simulate oral environment

<u>PROPERTIES TO BE MEASURED</u>	<u>UNIT OF MEASUREMENT</u>
1. Mechanical Properties	
Loading and Unloading force	Newton [N]
Elastic Modulus	Newton/(meter) ² [N/m ²]
2. Surface Roughness	Micrometer [μm]

To assess the changes in mechanical properties (loading and unloading force), a three point bending test was conducted which was done on a Universal testing machine (Fig.3).



Fig.3.- Universal Testing machine

For the three-point bending test, a jig with two parallel rods were mounted on the lower jaw of the machine (Fig.4).

Two brackets were bonded on the top of these rods with an inter bracket distance of 15.5 mm, according to Wilkinson's standards. This distance is selected to clinically simulate the distance between the middle of the central and canine brackets in a maxillary male dentition.



Fig.4.- Mounted wire on the lower jaw of the jig

The wires were placed in the brackets and fixed with elastomeric ligatures.

Once the test was done, we got a stress strain graph and from the initial linear portion of the graph we calculated the Elastic Modulus of the particular wire.

To assess the changes in the surface morphology (surface roughness), we did a profilometry test for which a Surfcom testing machine was used (Fig.5)



Fig.5.- Surface roughness testing machine

Finally, after performing the tests which assessed the changes in the mechanical properties and surface morphology of different NiTi wires when treated with 3 different mouthwashes, we compared the values obtained from the initial values that were obtained after keeping the wires in saliva for one day.

The changes in the value denoted the amount of change that occurs on the wires due to mouthwash usage.

STATISTICAL ANALYSIS

- Data obtained was entered in Microsoft Excel 2007/2013
- Descriptive and Frequency analysis was done by using Statistical Product and Service Solution (SPSS) (v.21.0) software.
- One-way ANOVA followed by Post hoc tests (Bonferroni, Tukey's HSD) was performed to determine the within group and inter-group comparisons.
- Paired t-test was performed to determine the significant differences between baseline and follow-up time period
- Chi-square test of proportion was performed, if required for significance within parameters.
- Non-parametric tests were performed wherever required.
- p value of <0.05 was considered statistically significant

RESULTS

- This study was done to evaluate and compare the effects of three mouthwashes on the loading, unloading force and surface roughness of different NiTi Orthodontic wires.
- A total of 48 specimens were divided into 12 groups based on the type of mouthwash and NiTi wire.

Table 1 – Descriptive statistics: Mean (SD) of the Loading values of various NiTi orthodontic wires in different mouthwashes

Mouthwash	Type of wire	N	Minimum	Maximum	Mean	Std. Deviation
Artificial Saliva	Copper NiTi	4	2.93	2.95	2.9400	.00816
	Superelastic NiTi	4	3.92	3.93	3.9250	.00577
	Coated NiTi	4	4.61	4.70	4.6530	.05427
Hexidine	Copper NiTi	4	2.54	2.57	2.5525	.01258
	Superelastic NiTi	4	3.53	3.60	3.5495	.03407
	Coated NiTi	4	4.70	4.80	4.7278	.04817
Sodium fluoride (NaF)	Copper NiTi	4	2.55	2.55	2.5483	.00126
	Superelastic NiTi	4	3.63	3.63	3.6288	.00096
	Coated NiTi	4	4.21	4.21	4.2133	.00096
Hiora	Copper NiTi	4	2.25	2.35	2.2875	.04787
	Superelastic NiTi	4	3.49	3.63	3.5540	.05631
	Coated NiTi	4	4.00	4.02	4.0130	.00872

- Table 1 shows descriptive mean and standard deviation of the Loading values of various NiTi orthodontic wires in different mouthwashes

Table 2 – Descriptive statistics: Mean (SD) of the Unloading values of various NiTi orthodontic wires in different mouthwashes

Mouthwash	Type of wire	N	Minimum	Maximum	Mean	Std. Deviation
Artificial Saliva	Copper NiTi	4	1.564	1.569	1.56725	.002217
	Superelastic NiTi	4	2.744	2.745	2.74450	.000577
	Coated NiTi	4	2.250	2.254	2.25275	.001893
Hexidine	Copper NiTi	4	1.862	1.865	1.86325	.001500
	Superelastic NiTi	4	2.638	2.646	2.64150	.003416
	Coated NiTi	4	2.646	2.648	2.64675	.000957
Sodium fluoride (NaF)	Copper NiTi	4	1.372	1.376	1.37450	.001915
	Superelastic NiTi	4	2.352	2.354	2.35325	.000957
	Coated NiTi	4	2.546	2.548	2.54700	.001155
Hiora	Copper NiTi	4	1.760	1.764	1.76150	.001915
	Superelastic NiTi	4	2.346	2.352	2.34850	.002517
	Coated NiTi	4	2.345	2.352	2.34825	.003304

- Table 2 shows descriptive mean and standard deviation of the Unloading values of various NiTi orthodontic wires in different mouthwashes.

Table 3 – Descriptive statistics: Mean (SD) of the Modulus of elasticity of various NiTi orthodontic wires in different mouthwashes

Mouthwash	Type of wire	N	Minimum	Maximum	Mean	Std. Deviation
Artificial Saliva	Copper NiTi	4	29605.000	29607.000	29606.250	.957427
	Superelastic NiTi	4	35600.000	35604.000	35601.500	1.914854
	Coated NiTi	4	21925.000	21926.000	21925.500	.577350
Hexidine	Copper NiTi	4	21283.000	21285.000	21284.000	.816497
	Superelastic NiTi	4	35600.000	35605.000	35602.750	2.217356
	Coated NiTi	4	17556.000	17559.000	17557.750	1.258306
Sodium fluoride (NaF)	Copper NiTi	4	11500.000	11504.000	11501.500	1.914854
	Superelastic NiTi	4	34529.000	34532.000	34530.250	1.258306
	Coated NiTi	4	21992.000	21998.000	21995.250	2.500000
Hiora	Copper NiTi	4	11879.000	11882.000	11880.500	1.290994
	Superelastic NiTi	4	35600.000	35602.000	35601.000	1.154701
	Coated NiTi	4	16460.000	16463.000	16461.250	1.500000

- Table 3 shows descriptive mean and standard deviation of the Modulus of elasticity of various NiTi orthodontic wires in different mouthwashes.

Table 4 – Descriptive statistics: Mean (SD) of the Surface roughness of various NiTi orthodontic wires in different mouthwashes

Mouthwash	Type of wire	N	Minimum	Maximum	Mean	Std. Deviation
Artificial Saliva	Copper NiTi	4	.110	.140	.12500	.012910
	Superelastic NiTi	4	.360	.370	.36500	.005774
	Coated NiTi	4	.340	.380	.35750	.017078
Hexidine	Copper NiTi	4	.300	.320	.15500	.010000
	Superelastic NiTi	4	.122	.126	.12425	.001708
	Coated NiTi	4	.112	.116	.11375	.001708
Sodium fluoride (NaF)	Copper NiTi	4	.272	.274	.27275	.000957
	Superelastic NiTi	4	.237	.239	.23825	.000957
	Coated NiTi	4	.220	.230	.22750	.005000
Hiora	Copper NiTi	4	.407	.409	.10850	.000957
	Superelastic NiTi	4	.326	.329	.10450	.001414
	Coated NiTi	4	.165	.167	.10110	.000816

- Table 4 shows descriptive mean and standard deviation of the Surface roughness of various NiTi orthodontic wires in different mouthwashes.

Table 5 – Intergroup comparison between the effect of different mouthwashes at Loading amongst different orthodontic wires

Comparison	Type of wire	Sum of Squares	df	Mean Square	F	p value
Artificial saliva Vs Hexidine vs NaF vs Hiora	Copper NiTi	.868	3	.289	459.374	.001*
	Superelastic NiTi	.378	3	.126	115.529	.011*
	Coated NiTi	1.424	3	.475	355.450	.026*

*p value <0.05 statistically significant

- Table 5 shows Intergroup comparison between the effect of different mouthwashes at Loading amongst different orthodontic wires. This comparison showed statistically significant differences (p value <0.05) between all the mouthwashes for all the different orthodontic wires.

Table 6 – Pairwise multiple comparison between the effect of different mouthwashes at Loading amongst various orthodontic wires

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p value
Copper NiTi	Artificial saliva	Hexidine	.387500*	.017742	.000*
		NaF	.391750*	.017742	.000*
		Hiora	.652500*	.017742	.000*
Superelastic NiTi	Artificial saliva	Hexidine	.375500*	.023361	.000*
		NaF	.296250*	.023361	.000*
		Hiora	.371000*	.023361	.000*
Coated NiTi	Artificial saliva	Hexidine	-.074750	.025842	.057
		NaF	.439750*	.025842	.000*
		Hiora	.640000*	.025842	.000*

*p value <0.05 statistically significant

- Table 6 shows Pairwise multiple comparison between the effect of different mouthwashes at Loading amongst various orthodontic. This comparison showed statistically significant differences (p value <0.05) for different mouthwashes between different wires; except for the Coated NiTi wire with Hexidine mouthwash which has a p value=0.057.

Table 7 – Intergroup comparison between the effect of different mouthwashes at Unloading amongst various orthodontic wires

Comparison	Type of wire	Sum of Squares	df	Mean Square	F	p value
Artificial saliva vs Hexidine	Copper NiTi	.562	3	.187	51632.207	.000*
	Superelastic NiTi	.489	3	.163	33902.074	.010*
NaF vs Hiora	Coated NiTi	.389	3	.130	31004.433	.013*

*p value <0.05 statistically significant

- Table 7 shows Intergroup comparison between the effect of different mouthwashes at Unloading amongst various orthodontic wires. This comparison showed statistically significant differences (p value <0.05) between all the mouthwashes for all the different orthodontic wires.

Table 8 – Pairwise multiple comparison between the effect of different mouthwashes at Unloading amongst various orthodontic wires

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p value
Copper NiTi	Artificial saliva	Hexidine	-.296000*	.001346	.001*
		NaF	.192750*	.001346	.000*
		Hiora	-.194250*	.001346	.020*
Superelastic NiTi	Artificial saliva	Hexidine	.103000*	.001551	.000*
		NaF	.391250*	.001551	.014*
		Hiora	.396000*	.001551	.032*
Coated NiTi	Artificial saliva	Hexidine	-.394000*	.001447	.000*
		NaF	-.294250*	.001447	.004*
		Hiora	-.095500*	.001447	.003*

*p value <0.05 statistically significant

- Table 8 shows Pairwise multiple comparison between the effect of different mouthwashes at Unloading amongst various orthodontic wires. This comparison showed statistically significant differences (p value <0.05) between all the mouthwashes for all the different orthodontic wires.

Table 9 – Intergroup comparison between the effect of different mouthwashes assessing the modulus of elasticity amongst various orthodontic wires

Comparison	Type of wire	Sum of Squares	df	Mean Square	F	p value
Artificial saliva vs Hexidine	Copper NiTi	895510790.188	3	298503596.729	172628586.060	0.011*
	Superelastic NiTi	3444343.250	3	1148114.417	399344.145	0.021*
NaF vs Hiora	Coated NiTi	100459007.688	3	33486335.896	12858752.984	0.03*

*p value <0.05 statistically significant

- Table 9 shows Intergroup comparison between the effect of different mouthwashes assessing the modulus of elasticity amongst various orthodontic wires. This comparison showed statistically significant differences (p value <0.05) between all the mouthwashes for all the different orthodontic wires.

Table 10 – Pairwise multiple comparison between the effect of different mouthwashes assessing the modulus of elasticity amongst various orthodontic wires

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p value
Copper NiTi	Artificial saliva	Hexidine	8322.250000*	.929830	.000*
		NaF	18104.750000*	.929830	.000*
		Hiora	17725.750000*	.929830	.000*
Superelastic NiTi	Artificial saliva	Hexidine	-1.250000	1.198958	.729
		NaF	1071.250000*	1.198958	.000*
		Hiora	.500000	1.198958	.974
Coated NiTi	Artificial saliva	Hexidine	4367.750000*	1.141089	.000*
		NaF	-69.750000*	1.141089	.000*
		Hiora	5464.250000*	1.141089	.000*

*p value <0.05 statistically significant

- Table 10 shows Pairwise multiple comparison between the effect of different mouthwashes assessing the modulus of elasticity amongst various orthodontic wires. This comparison showed statistically significant differences (p value <0.05) for different mouthwashes between different wires; except for the NiTi wire with Hexidine mouthwash which has a p value=0.729 and NiTi wire with Hiora mouthwash which has a p value=0.974.

Table 11 – Intergroup comparison between the effect of different mouthwashes assessing the surface roughness amongst various orthodontic wires

Comparison	Type of wire	Sum of Squares	df	Mean Square	F	p value
Artificial saliva vs Hexidine vs NaF vs Hiora	Copper NiTi	.167	3	.056	829.306	0.03*
	Superelastic NiTi	.138	3	.046	4696.519	.000*
	Coated NiTi	.132	3	.044	551.393	.010*

p value <0.05 statistically significant

- Table 11 shows Intergroup comparison between the effect of different mouthwashes assessing the surface roughness amongst various orthodontic wires. This comparison showed statistically significant differences (p value <0.05) for different mouthwashes between different wires.

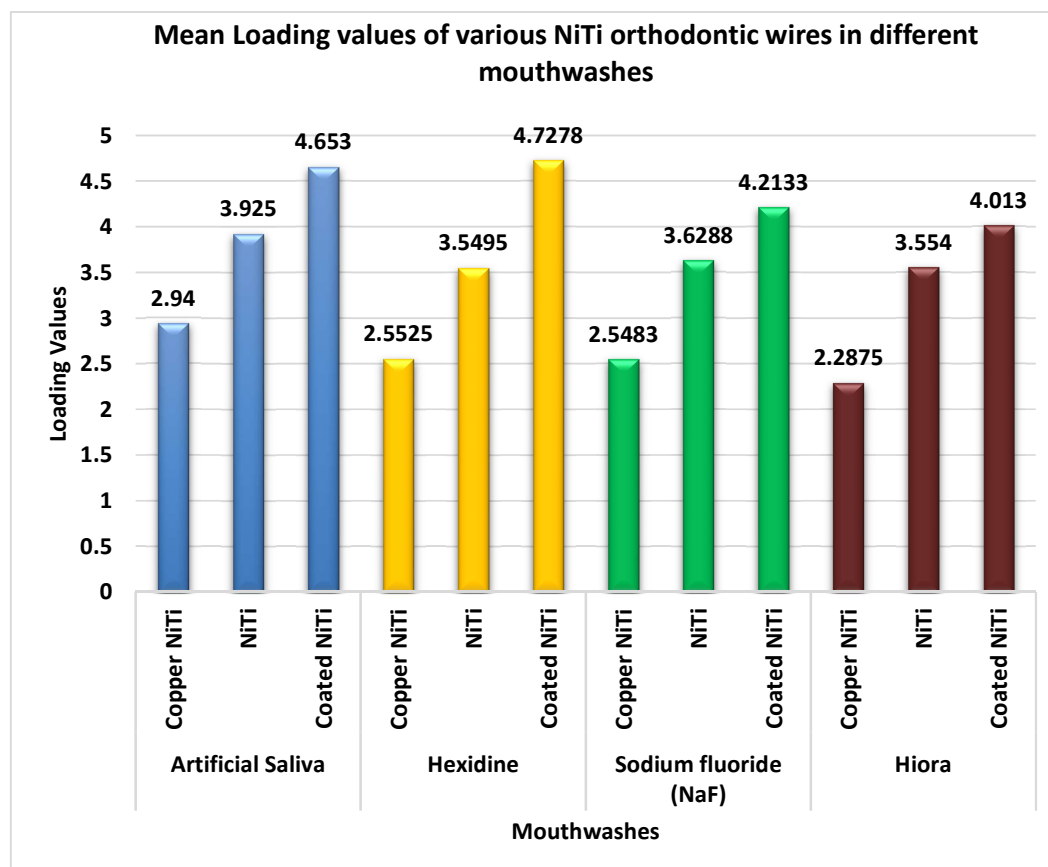
Table 12 – Pairwise multiple comparison between the effect of different mouthwashes assessing the surface roughness amongst various orthodontic wires

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p value
Copper NiTi	Artificial saliva	Hexidine	-.190000*	.005793	.000*
		NaF	-.147750*	.005793	.000*
		Hiora	-.283250*	.005793	.000*
Superelastic NiTi	Artificial saliva	Hexidine	.240750*	.002213	.020*
		NaF	.126750*	.002213	.045*
		Hiora	.037000*	.002213	.000*
Coated NiTi	Artificial saliva	Hexidine	.243750*	.006327	.000*
		NaF	.130000*	.006327	.001*
		Hiora	.191500*	.006327	.000*

*p value <0.05 statistically significant

- Table 12 shows Pairwise multiple comparison between the effect of different mouthwashes assessing the surface roughness amongst various orthodontic wires. This comparison showed statistically significant differences (p value <0.05) for different mouthwashes between different wires.

Graph number 1: Mean Loading values of various NiTi orthodontic wires in different mouthwashes



- The mean value for the loading force of Copper NiTi in artificial saliva is 2.94 ± 0.00816 ; Superelastic NiTi in artificial saliva is 3.925 ± 0.00577 ; Coated NiTi in artificial saliva is 4.653 ± 0.5427 .
- The mean value for the loading force of Copper NiTi in Hexidine mouthwash is 2.5525 ± 0.1258 ; Superelastic NiTi in Hexidine mouthwash is 3.5495 ± 0.3407 ; Coated NiTi in Hexidine mouthwash is 4.7278 ± 0.4817 .
- The mean value for the loading force of Copper NiTi in Sodium fluoride mouthwash is 2.5483 ± 0.00126 ; Superelastic NiTi in Sodium fluoride

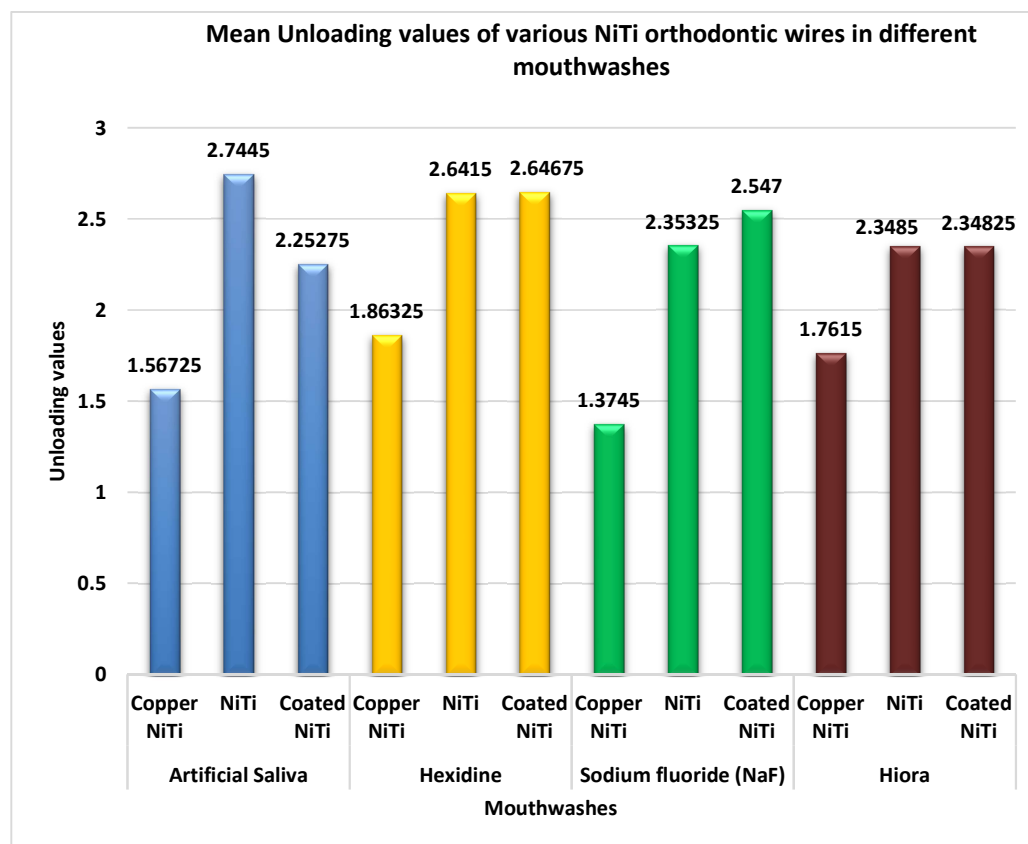
mouthwash is 3.6288 ± 0.00096 ; Coated NiTi in Sodium fluoride is 4.2133 ± 0.00096 .

- The mean value for the loading force of Copper NiTi in Hiora mouthwash is 2.2875 ± 0.04787 ; Superelastic NiTi in Hiora mouthwash is 3.5540 ± 0.05631 ; Coated NiTi in Hiora mouthwash is 4.0130 ± 0.00872 .

It can therefore be concluded that the loading force of

- Copper NiTi is least in Hiora mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Sodium fluoride mouthwash.
- Superelastic NiTi is almost equal in Hexidine and Hiora mouthwash and applies least force on the tooth compared to artificial saliva and Sodium fluoride mouthwash.
- Coated NiTi is least in Hiora mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Sodium fluoride mouthwash.

Graph number 2: Mean Unloading values of various NiTi orthodontic wires in different mouthwashes



- The mean value of Unloading force of Copper NiTi in artificial saliva is 1.56725 ± 0.002217 ; Superelastic NiTi in artificial saliva is 2.74450 ± 0.000577 ; Coated NiTi in artificial saliva is 2.25275 ± 0.001893 .
- The mean value of Unloading force of Copper NiTi in Hexidine mouthwash is 1.86325 ± 0.0015 ; Superelastic NiTi in Hexidine mouthwash is 2.64150 ± 0.003416 ; Coated NiTi in Hexidine mouthwash is 2.64675 ± 0.000957 .
- The mean value of Unloading force of Copper NiTi in Sodium fluoride mouthwash is 1.37450 ± 0.001915 ; Superelastic NiTi in Sodium fluoride

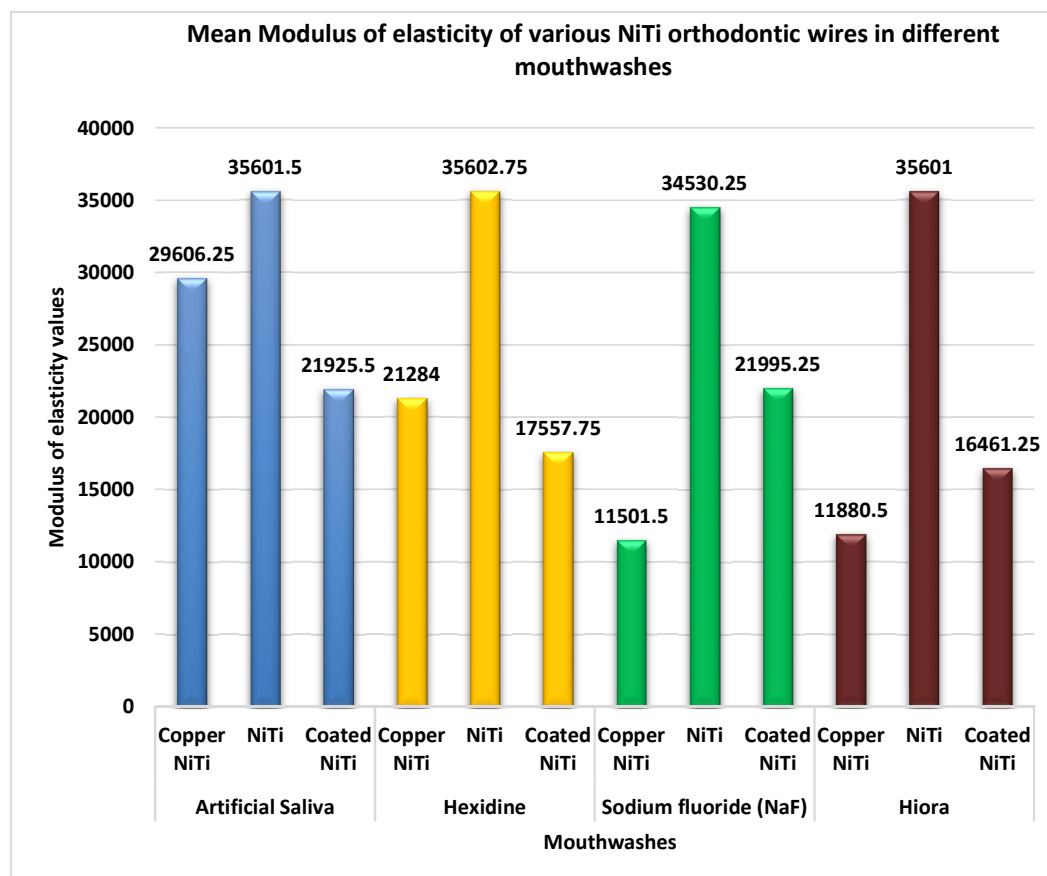
mouthwash is 2.35325 ± 0.000957 ; Coated NiTi in Sodium fluoride mouthwash is 2.547 ± 0.001155 .

- The mean value of Unloading force of Copper NiTi in Hiora mouthwash is 1.7615 ± 0.001915 ; Superelastic NiTi in Hiora mouthwash is 2.3485 ± 0.002517 ; Coated NiTi in Hiora mouthwash is 2.34825 ± 0.003304 .

It can therefore be concluded that the Unloading force of

- Copper NiTi is least in Sodium fluoride mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Hiora mouthwash.
- Superelastic NiTi is least in Hiora mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Sodium fluoride mouthwash.
- Coated NiTi is least in Hiora mouthwash and hence applies the least force on the tooth compared to Hexidine and Sodium fluoride mouthwash.

Graph number 3: Mean Modulus of elasticity of various NiTi orthodontic wires in different mouthwashes



- The mean value of Modulus of elasticity of Copper NiTi in artificial saliva is 29606.25 ± 0.957427 ; Superelastic NiTi in artificial saliva is 35601.5 ± 1.914854 ; Coated NiTi in artificial saliva is 21925.5 ± 0.577350 .
- The mean value of Modulus of elasticity of Copper NiTi in Hexidine mouthwash is 21284 ± 0.816497 ; Superelastic NiTi in Hexidine mouthwash is 35602.75 ± 2.217356 ; Coated NiTi in Hexidine mouthwash is 17557.75 ± 1.258306 .
- The mean value of Modulus of elasticity of Copper NiTi in Sodium fluoride mouthwash is 11501.5 ± 1.914854 ; Superelastic NiTi in Sodium fluoride

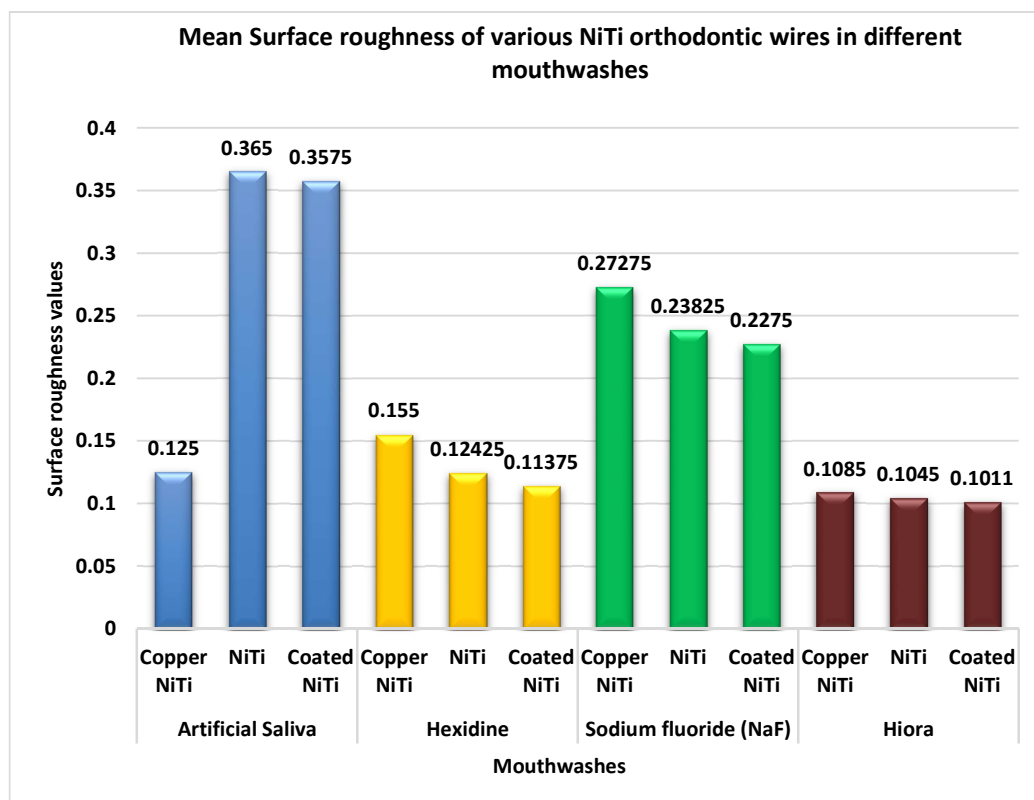
mouthwash is 34530.25 ± 1.258306 ; Coated NiTi in Sodium fluoride mouthwash is 21995.25 ± 2.5 .

- The mean value of Modulus of elasticity of Copper NiTi in Hiora mouthwash is 11880.5 ± 1.290994 ; Superelastic NiTi in Hiora mouthwash is 35601 ± 1.154701 ; Coated NiTi in Hiora mouthwash is 16461.25 ± 1.5 .

It can therefore be concluded that the Modulus of elasticity of

- Copper NiTi is least in Sodium fluoride mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Hiora mouthwash.
- Superelastic NiTi is least in Sodium fluoride mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Hiora mouthwash.
- Coated NiTi is least in Hiora mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Sodium fluoride mouthwash.

Graph number 4: Mean Surface roughness of various NiTi orthodontic wires in different mouthwashes



- The mean value of Surface roughness of Copper NiTi wire in artificial saliva is 0.125 ± 0.01291 ; Superelastic NiTi in artificial saliva is 0.365 ± 0.005774 ; Coated NiTi in artificial saliva is 0.3575 ± 0.17078 .
- The mean value of Surface roughness of Copper NiTi in Hexidine mouthwash is 0.155 ± 0.01 ; Superelastic NiTi in Hexidine mouthwash is 0.12425 ± 0.001708 ; Coated NiTi in Hexidine mouthwash is 0.11375 ± 0.001708 .
- The mean value of Surface roughness of Copper NiTi in Sodium fluoride mouthwash is 0.27275 ± 0.000957 ; Superelastic NiTi in Sodium fluoride mouthwash is 0.23825 ± 0.00957 ; Coated NiTi in Sodium fluoride mouthwash is 0.2275 ± 0.005 .

- The mean value of Surface roughness of Copper NiTi in Hiora mouthwash is 0.1085 ± 0.000957 ; Superelastic NiTi in Hiora mouthwash is 0.1045 ± 0.001414 ; Coated NiTi in Hiora mouthwash is 0.1011 ± 0.000816 .

It can therefore be concluded that the Surface roughness of

- Copper NiTi is least in Hiora mouthwash.
- Superelastic NiTi is least in Hiora mouthwash.
- Coated NiTi is least in Hiora mouthwash.

DISCUSSION

Compromised oral hygiene, which promotes caries and enamel demineralization, is one of the drawbacks of orthodontic treatment.⁹ Additionally, some patients may experience periodontal issues while undergoing orthodontic treatment, necessitating the use of various mouthwashes to prevent plaque buildup.

In the current study, we compared and evaluated the effects of three mouthwashes on the loading, unloading force, and surface roughness of various NiTi Orthodontic wires.

It was seen that the loading force of Copper NiTi and Coated NiTi is least in Hiora mouthwash, the unloading force of Superelastic NiTi and Coated NiTi is least in Hiora mouthwash. Also, the modulus of elasticity of Coated NiTi is least in Hiora mouthwash.

Interpretation of our test results also concluded that the Surface roughness of all three wires- Copper NiTi, Superelastic NiTi and Coated NiTi is least in Hiora mouthwash.

We can therefore conclude that Hiora herbal mouthwash produced the least amount of force on the teeth and did not cause the wire's surface to become more rough, preventing the development of plaque and calculus.

In the study conducted by Dilipkumar et al.¹, they examined the impact of Noni mouthwash on the surface quality and compositional alterations of NiTi wires in a manner similar to our study. It was discovered that Noni mouthwash had little to no effect on the NiTi wire's composition or surface roughness. Therefore, noni

mouthwash may be recommended as a safe, all-natural preventative measure for orthodontic patients.³

In their investigation, Aghili et al.² examined the impact of fluoride mouthwash on the elasticity modulus of coated wires and discovered that using fluoride agents significantly increases the E of coated wires. Additionally, they discovered that ZM (herbal) mouthwash decreased the stiffness of coated wires, but fluoride and chlorhexidine mouthwash increased it.²

The intraoral circumstances considerably increased surface roughness and degraded mechanical qualities of all types of TMA wires, according to Rajendran et al.³'s study of the effects of fluoride mouthwash on three different types of TMA wires. The degradation was significantly worse when fluoride mouthwash was used on a daily basis.³

Ahrari et al.⁶ investigated the effect of a fluoride mouthwash on the load-deflection properties of three distinct types of NiTi wires. A Zwick testing device evaluated the wire load-deflection characteristics using a three-point bending test. The researchers discovered that immersion in NaF solution affected the load-deflection properties of NiTi wires and that fluoride agents decreased the associated unloading forces, especially at smaller deflections, which could delay tooth alignment. Walker et al. examined rectangular wires made of stainless steel and ⁶ Beta titanium¹⁷. Wires were immersed in either acidulated fluoride solution, neutral fluoride solution, or distilled water. After immersion, a 3-point bend test was performed to determine the wires' yield strength and elastic loading and unloading modulus. The wire topography was also qualitatively assessed using scanning electron microscopy. According to the findings, employing topical fluoride agents with beta titanium and stainless steel wire

may reduce the wires' useful unloading mechanical qualities and possibly cause orthodontic treatment to last longer.¹⁷

There haven't been any other published investigations on the impact of Hiora herbal mouthwash on various NiTi wires as of yet. The use of this mouthwash does not improve the mechanical properties and surface features of nearly all NiTi wires, according to the first study that we are aware of that looked at the impact of this mouthwash on NiTi orthodontic wires.

We discovered that Hiora herbal mouthwash reduced the values of the loading force, unloading force, elastic modulus, and surface roughness in NiTi wires.

The procedure used in our study was 60 seconds every day for a month. This exposure time was comparable to the period of time before a NiTi wire is initially put in the patient's mouth cavity for aligning and levelling purposes. In medical settings, patients are instructed to use mouthwash once daily for one minute and are thereafter forbidden from doing so for at least 30 minutes.^{6,9} The layer of orthodontic wires may also be affected by mastication and the oral environment, but this effect could not be assessed in this in vitro study. Despite having a same composition, the surface roughness and mechanical qualities of different manufacturers' wires may vary.

Further research is advised to compare the wires supplied by various manufacturers to check for any variation in the properties of different products by comparing their mechanical properties and surface morphology.

LIMITATIONS OF THE STUDY

- This is an in vitro study; all the clinical conditions could not be simulated.
- Oral cavity of a patient consists of various digestive enzymes that are secreted during digestion of the bolus which could not be included in our study's control and study groups.
- Forces of mastication, also to an extent influence the mechanical properties and surface morphology of the Orthodontic wires which could not be taken into account in our present study.
- The study consisted of Orthodontic wires being immersed in stagnant saliva, whereas in the oral cavity, the Orthodontic wires are in saliva which is not stagnant.
- Every patient has a different consistency of saliva which could not be considered in our present study.
- Due to frequent ingestion of food, there are considerable changes in temperature and pH that occur in the oral cavity which could not be simulated in this study.
- The mechanical properties that changes in the wire due to ligation to the bracket, that could not be considered.

CONCLUSION

This study was conducted to evaluate and compare the effects of three mouthwashes on the loading force, unloading force and surface roughness of different NiTi Orthodontic wires.

The following conclusions can be drawn from the present study:

1) The loading force of

- Copper NiTi is least in Hiora mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Sodium fluoride mouthwash.
- Superelastic NiTi is almost equal in Hexidine and Hiora mouthwash and applies least force on the tooth compared to artificial saliva and Sodium fluoride mouthwash.
- Coated NiTi is least in Hiora mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Sodium fluoride mouthwash.

2) The Unloading force of

- Copper NiTi is least in Sodium fluoride mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Hiora mouthwash.
- Superelastic NiTi is least in Hiora mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Sodium fluoride mouthwash.

- Coated NiTi is least in Hiora mouthwash and hence applies the least force on the tooth compared to Hexidine and Sodium fluoride mouthwash.

3) The Modulus of elasticity of

- Copper NiTi is least in Sodium fluoride mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Hiora mouthwash.
- Superelastic NiTi is least in Sodium fluoride mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Hiora mouthwash.
- Coated NiTi is least in Hiora mouthwash and hence applies the least force on the tooth compared to artificial saliva, Hexidine and Sodium fluoride mouthwash.

4) The Surface roughness of

- Copper NiTi is least in Hiora mouthwash.
- Superelastic NiTi is least in Hiora mouthwash.
- Coated NiTi is least in Hiora mouthwash.

Owing to the various side effects of the 'Gold standard' Hexidine mouthwash like :

- Mouth irritation
- Alteration of taste
- Staining of teeth
- Dry mouth

There arises a need to look for an alternative mouthwash for the patients undergoing orthodontic treatment.

In cases where the patient is using Sodium fluoride mouthwash or Hexidine mouthwash, the NiTi wires should not be kept for a long time (1 month) in the mouth as it applies excessive force (loading and unloading) on the teeth.

The surface roughness value of Hexidine mouthwash and Sodium fluoride mouthwash is more than that of Hiora mouthwash which indicates that there is an increased tendency for plaque and calculus formation and hence retention in the mouth when Hexidine or Sodium fluoride mouthwash is used.

It can therefore be concluded that Hiora Herbal mouthwash can be used in place of Hexidine mouthwash as it has almost similar effects on the mechanical properties and surface characteristics of the NiTi wires.

SUMMARY

The goal of the study was to assess and contrast how three mouthwashes affected the surface roughness, loading force, and unloading force of various NiTi orthodontic wires.

In the trial, three mouthwashes were employed.

Mouthwashes used were- **Hexidine-EP** (0.12% Chlorhexidine), **Colgate Plax** (0.04% Sodium Fluoride) and **Hiora** (Herbal).

Superelastic NiTi, Copper NiTi and NiTi coated with epoxy resin are the three types of NiTi wires that were utilized in the investigation.

To mimic the oral environment of human patients, the NiTi wires were maintained in fake saliva and incubated at 37 degrees Celsius.

First, the wires that served as the study's control group had their mechanical characteristics (loading and unloading force) and surface morphology (quantitatively using profilometry) evaluated.

Based on the type of mouthwash and NiTi wire utilized, 12 groups were created. Wires were exposed to the corresponding mouthwashes for 60 seconds each day for a month.

All of the samples were examined at the conclusion of the study to determine whether their surface morphology and mechanical properties had changed.

A three point bending test was performed on a Universal testing machine to evaluate the changes in mechanical properties (loading and unloading force).

A Surfcom testing device was utilized for a profilometry test in order to evaluate the changes in surface morphology (surface roughness).

The values obtained were contrasted with the values of the control group. The variations in value represented the degree of change brought about by mouthwash use on the wires.

The results of the test showed that:

- The loading force was lowest in the Hiora mouthwash group in the presence of Superelastic NiTi and Coated NiTi; and
- The unloading force was lowest in the Hiora mouthwash group in the presence of Hexidine and Sodium fluoride mouthwash. Mouthwash containing sodium fluoride exhibited the least amount of unloading force in the Copper NiTi group.
- When coated NiTi was present, the Hiora mouthwash group's modulus of elasticity was the lowest. Mouthwash with sodium fluoride exhibited the lowest elastic modulus in comparison to the groups of Copper NiTi and Superelastic NiTi.
- In comparison to the Hexidine and Sodium Fluoride mouthwash group, the surface roughness was lowest when Hiora mouthwash was present.

In accordance with our test results, Hiora Herbal Mouthwash is safe for daily use of patients undergoing orthodontic treatment.

Hexidine mouthwash is seen to have a few side effects. Extrinsic tooth staining being the most common side effect. Such tooth staining seems to be the result of a local precipitation reaction between tooth-bound chlorhexidine and chromogens found within foodstuffs and beverages. The cationic nature of the chlorhexidine molecule reduces activity of the agent in the presence of anionic agents, specifically

those found within certain types of toothpaste; thus care is required when using normal toothbrushing alongside chlorhexidine.^{29, 30,32}

Discoloration of the tongue has been observed after chlorhexidine use, and it is assumed to be due to interference with the bacterial flora followed by overgrowth of stain-producing species.³²

Studies have also shown that chlorhexidine may irritate and damage the oral mucosa in some instances.³²

Its application to mucous membranes can cause severe anaphylactic reactions.³³

The use of chlorhexidine at a 0.05% concentration on wounds and intact skin was thought to be safe but Hypersensitivity to chlorhexidine is rare and its potential to cause anaphylactic shock is probably underestimated.³³

Numerous adverse effects of the "Gold standard" Hexidine Mouthwash makes it important to find an alternative mouthwash which doesnot have such side effects and can be used daily by the patients.

Our study concludes that Hiora Herbal Mouthwash can be used in place of Hexidine Mouthwash since it has practically equal effects on the mechanical properties and surface features of the NiTi wires.

BIBLIOGRAPHY

1. Dilipkumar D, Dhinahar S, Deenadayalan P, Tandon A, Suresh P. Repercussion of noni mouthwash on surface characterization of Nickel-Titanium archwire. *Indian Journal of Dental Research*. 2017 Nov 1;28(6):671.
2. Aghili H, Yassaei S, Eslami F. Evaluation of the effect of three mouthwashes on the mechanical properties and surface morphology of several orthodontic wires: An in vitro study. *Dental research journal*. 2017 Jul;14(4):252.
3. Rajendran A, Sundareswaran S, Peediyekkal LV, Santhakumar P, Sathyanadhan S. Effect of oral environment and prescribed fluoride mouthwashes on different types of TMA wires—An in-vivo study. *journal of orthodontic science*. 2019;8.
4. Gupta D, Gupta AK, Gupta AK, Shukla G. Evaluation of the effects of fluoride prophylactic agents on mechanical properties of nickel titanium wires using scanning electron microscope. *The journal of contemporary dental practice*. 2018 Mar 1;19(3):283-6.
5. Nalbantgil D, Ulkur F, Kardas G, Culha M. Evaluation of corrosion resistance and surface characteristics of orthodontic wires immersed in different mouthwashes. *Bio-medical materials and engineering*. 2016 Jan 1;27(5):539-49.
6. Ahrari F, Ramazanzadeh BA, Sabzevari B, Ahrari A. The effect of fluoride exposure on the load-deflection properties of superelastic nickel-titanium-based orthodontic archwires. *Australian orthodontic journal*. 2012 May;28(1):72-9.

7. Ramazanzadeh BA, Ahrari F, Sabzevari B, Zebarjad SM, Ahrari A. Effects of a Simulated Oral Environment and Sterilization on Load-deflection Properties of Superelastic Nickel Titanium–based Orthodontic Wires. *IJO*. 2011;22(1).
8. Bailey LT, Dover AJ, Proffit WR. Long-term soft tissue changes after orthodontic and surgical corrections of skeletal class III malocclusions. *The Angle Orthodontist*. 2007 May;77(3):389-96.
9. Hammad SM, Al-Wakeel EE, Gad ES. Mechanical properties and surface characterization of translucent composite wire following topical fluoride treatment. *The Angle orthodontist*. 2012 Jan;82(1):8-13.
10. Krishnan V, Kumar KJ. Weld characteristics of orthodontic archwire materials. *The Angle Orthodontist*. 2004 Aug;74(4):533-8.
11. Wilkinson PD, Dysart PS, Hood JA, Herbison GP. Load-deflection characteristics of superelastic nickel-titanium orthodontic wires. *American journal of orthodontics and dentofacial orthopedics*. 2002 May 1;121(5):483-95.
12. Walker MP, White RJ, Kula KS. Effect of fluoride prophylactic agents on the mechanical properties of nickel-titanium-based orthodontic wires. *American journal of orthodontics and dentofacial orthopedics*. 2005 Jun 1;127(6):662-9.
13. Kapila S, Sachdeva R. Mechanical properties and clinical applications of orthodontic wires. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1989 Aug 1;96(2):100-9.
14. Segner D, Ibe D. Properties of superelastic wires and their relevance to orthodontic treatment. *The European Journal of Orthodontics*. 1995 Oct 1;17(5):395-402.

15. Powers JM, Messersmith ML, Brantley WA, Eliades T. Orthodontic materials: scientific and clinical aspects.
16. Burstone CJ. Variable-modulus orthodontics. American journal of orthodontics. 1981 Jul 1;80(1):1-6.
17. Walker MP, Ries D, Kula K, Ellis M, Fricke B. Mechanical properties and surface characterization of beta titanium and stainless steel orthodontic wire following topical fluoride treatment. The Angle Orthodontist. 2007 Mar;77(2):342-8.
18. Airoidi G, Riva G, Vanelli M. Superelasticity and shape memory effect in NiTi orthodontic wires. Journal de Physique IV. 1995 Dec 1;5(C8):C8-1205.
19. Hussein LM, Ghaib NH. The Effect of Fluoridated and Non Fluoridated Mouth Washes on Color Stability of Different Aesthetic Arch Wires At Different Time Intervals (An in Vitro Study). Journal of University of Babylon for Pure and Applied Sciences. 2018 Jan 10;26(3):174-83.
20. Razavi, E.S.E., Nik, T.H., Hooshmand, T., Farazdaghi, H. and Arefi, A.H., 2021. Surface characterization and frictional force between stainless steel brackets and archwires in orthodontic patients using chlorhexidine-and Persica-containing mouthrinses: A randomized controlled trial. *Dental research journal*, 18.
21. Dhivya Dilipkumar MD. Evaluation of the Effect of Pudhina Mouthwash on Surface Characterisation of Nickel Titanium Archwires Used in Orthodontics– An Invitro Study. Annals of the Romanian Society for Cell Biology. 2021 May 25;25(6):4696-702.
22. Brar AS, Singla A, Mahajan V, Jaj HS, Seth V, Negi P. Reliability of organic mouthwashes over inorganic mouthwashes in the assessment of corrosion

- resistance of NiTi arch wires. *Journal of Indian Orthodontic Society*. 2015 Jul;49(3):129-33.
23. Alwafe, N.A., Hammad, S.M., AbdelMawla El-wassefy, N. and Hafez, A.M., 2019. Evaluation of the effect of an experimental herbal versus fluoridated mouthwash on frictional resistance and surface roughness between orthodontic brackets and two types of archwire: In vitro study. *Journal of Dental Materials and Techniques*, 8(4), pp.205-214.
24. Bourauel C, Fries T, Drescher D, Plietsch R. Surface roughness of orthodontic wires via atomic force microscope, laser specular reflectance, and profilometry. *The European Journal of Orthodontics*. 1998 Feb 1;20(1):79-92.
25. Eggertsen PA, Mattiasson K. An efficient inverse approach for material hardening parameter identification from a three-point bending test. *Engineering with Computers*. 2010 Apr;26(2):159-70.
26. Chitra P, Prashantha GS, Rao A. Effect of fluoride agents on surface characteristics of NiTi wires. An ex vivo investigation. *Journal of Oral Biology and Craniofacial Research*. 2020 Oct 1;10(4):435-40.
27. Liu JK, Lee TM, Liu IH. Effect of loading force on the dissolution behavior and surface properties of nickel-titanium orthodontic archwires in artificial saliva. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2011 Aug 1;140(2):166-76.
28. Huang HH, Chiu YH, Lee TH, Wu SC, Yang HW, Su KH, Hsu CC. Ion release from NiTi orthodontic wires in artificial saliva with various acidities. *Biomaterials*. 2003 Sep 1;24(20):3585-92.
29. Jones CG. Chlorhexidine: is it still the gold standard?. *Periodontology* 2000. 1997 Oct 1;15:55-62.

30. Flötra L. Different modes of chlorhexidine application and related local side effects. *Journal of Periodontal Research*. 1973 Dec;8:41-4.
31. Goldschmidt P, Cogen R, Taubman S. Cytopathologic effects of chlorhexidine on human cells. *Journal of periodontology*. 1977 Apr 1;48(4):212-5.
32. FLÖTRA L, Gjermo PE, RÖLLA G, WAERHAUG J. Side effects of chlorhexidine mouth washes. *European Journal of Oral Sciences*. 1971 Apr;79(2):119-25.
33. Krautheim AB, Jermann TH, Bircher AJ. Chlorhexidine anaphylaxis: case report and review of the literature. *Contact dermatitis*. 2004 Mar;50(3):113-6.

ANNEXURE – I

ETHICAL CLEARANCE



Research and Ethics Committee
KLE V K INSTITUTE OF DENTAL SCIENCES
KLE University



Accredited 'A' Grade by NAAC Placed in Category 'A' by MHRD (GoI)

Nehru Nagar, Belagavi - 590 010, Karnataka State

☎: 0831-2470362
FAX: 0831-2470640

Web: <http://www.kledental-bgm.edu.in>
E-mail: principal@kledental-bgm.edu.in

Sl. No. : 1478

CERTIFICATE

This is to Certify that the synopsis titled

evaluation of the effect of three month washes on the mechanical properties & surface morphology of different orthodontic wires - An in-vitro study Submitted by

Dr. REG. NO. II0220006 P. G. Student /

Staff, Guided by _____ from Department of Orthodontics & dentofacial orthofacialis has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study

Date : 5/5/21

Member Secretary
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi


Research and Ethical Committee
KLEVK Institute of Dental Sciences
BELAGAVI.

Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi


Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belgaum

ANNEXURE- II

TEST REPORTS



DENTAL MATERIAL TEST FACILITY
MDS Thesis in various fields
i.e. Orthodontic, Prosthodontics, Endodontics, Periodontics, Oral Surgery, etc.




PRAU
Metallurgical Laboratory
B-38, Indra Shankar Nagar,
Paud Road, Near Kothrud PHT Depot,
Kothrud, Pune - 411 038
Tel. : +91 - 20 - 2528 1584,
Cell : 96650 11314, 9158658674
E-mail : prajendra@gmail.com
Website: www.praulab.com

TEST REPORT


Name : _____ Date: 21/09/2021
Name of Institute : KLE VK Institute of Dental Sciences, Belgavi.
Subject of research : Evaluation of the effect of three mouthwashes on the mechanical properties and surface morphology of different NiTi orthodontic wires : An in-vitro study.

A) Three Point Bend Test & Modulus of Elasticity
Machine Specification : Universal Testing Machine (Computerized, Software based)
Company : Star Testing System, India, Model No. STS 248,
Accuracy of the machine : ±1%, Cross head speed : 1 mm/minute.
Distance between supports : 15.50mm

Sr. No.	Sample ID	Loading 2.5mm Deflection (N)	Unloading 2.5mm Deflection (N)	Modulus of Elasticity (MPa)
1	Copper NiTi	2.45	1.701	17819
2	NiTi	3.32	2.646	28490
3	Coated NiTi	3.629	1.760	14630
4	Coated NiTi + NAF	4.214	2.549	21996
5	Coated NiTi + Chlorhexidine	4.704	2.647	17559
6	Coated NiTi + Hiora	4.018	2.352	16460
7	NiTi + NAF	3.628	2.352	34530
8	NiTi + Chlorhexidine	3.529	2.646	35600
9	Copper NiTi + Hiora	2.254	1.761	11880
10	Niti + Hiora	3.626	2.352	35600
11	Copper NiTi + Chlorhexidine	2.548	1.861	21283
12	Copper NiTi + NAF	2.549	1.372	11501
13	Copper NiTi in Saliva	2.95	1.568	29606
14	NiTi in Saliva	3.92	2.745	35600
15	Coated in Saliva	4.606	2.254	21925




DENTAL MATERIAL TEST FACILITY
MDS Thesis in various fields
i.e. Orthodontic, Prosthodontics, Endodontics, Periodontics, Oral Surgery, etc.




PRAU
Metallurgical Laboratory
B-38, Indra Shankar Nagar,
Paud Road, Near Kothrud PHT Depot,
Kothrud, Pune - 411 038
Tel. : +91 - 20 - 2528 1584,
Cell : 96650 11314, 9158658674
E-mail : prajendra@gmail.com
Website: www.praulab.com

A) Three Point Bend Test & Modulus of Elasticity
Machine Specification : Universal Testing Machine (Computerized, Software based)
Company : Star Testing System, India, Model No. STS 248,
Accuracy of the machine : ±1%, Cross head speed : 1 mm/minute.
Distance between supports : 15.50mm

Sr. No.	Sample ID	Loading 2.5mm Deflection (N)	Unloading 2.5mm Deflection (N)	Modulus of Elasticity (MPa)
1	Copper NiTi	2.45	1.702	17820
2	NiTi	3.32	2.646	28490
3	Coated NiTi	3.629	1.760	14630
4	Coated NiTi + NAF	4.214	2.549	21996
5	Coated NiTi + Chlorhexidine	4.704	2.647	17559
6	Coated NiTi + Hiora	4.018	2.352	16460
7	NiTi + NAF	3.628	2.352	34530
8	NiTi + Chlorhexidine	3.529	2.646	35600
9	Copper NiTi + Hiora	2.254	1.764	11880
10	Niti + Hiora	3.626	2.352	35600
11	Copper NiTi + Chlorhexidine	2.548	1.861	21283
12	Copper NiTi + NAF	2.549	1.372	11501
13	Copper NiTi in Saliva	2.95	1.568	29606
14	NiTi in Saliva	3.92	2.745	35600
15	Coated in Saliva	4.605	2.253	21925




DENTAL MATERIAL TEST FACILITY
MDS Thesis in various fields
i.e. Orthodontic, Prosthodontics, Endodontics, Periodontics, Oral Surgery, etc.




PRAU
Metallurgical Laboratory
B-38, Indra Shankar Nagar,
Paud Road, Near Kothrud PHT Depot,
Kothrud, Pune - 411 038
Tel. : +91 - 20 - 2528 1584,
Cell : 96650 11314, 9158658674
E-mail : prajendra@gmail.com
Website: www.praulab.com

A) Three Point Bend Test & Modulus of Elasticity
Machine Specification : Universal Testing Machine (Computerized, Software based)
Company : Star Testing System, India, Model No. STS 248,
Accuracy of the machine : ±1%, Cross head speed : 1 mm/minute.
Distance between supports : 15.50mm

Sr. No.	Sample ID	Loading 2.5mm Deflection (N)	Unloading 2.5mm Deflection (N)	Modulus of Elasticity (MPa)
1	Copper NiTi	2.44	1.701	17820
2	NiTi	3.31	2.646	28490
3	Coated NiTi	3.629	1.760	14630
4	Coated NiTi + NAF	4.214	2.549	21996
5	Coated NiTi + Chlorhexidine	4.704	2.648	17559
6	Coated NiTi + Hiora	4.018	2.352	16460
7	NiTi + NAF	3.629	2.352	34530
8	NiTi + Chlorhexidine	3.529	2.646	35600
9	Copper NiTi + Hiora	2.254	1.764	11880
10	Niti + Hiora	3.626	2.352	35600
11	Copper NiTi + Chlorhexidine	2.548	1.861	21283
12	Copper NiTi + NAF	2.549	1.371	11501
13	Copper NiTi in Saliva	2.95	1.568	29605
14	NiTi in Saliva	3.92	2.745	35600
15	Coated in Saliva	4.604	2.253	21925




DENTAL MATERIAL TEST FACILITY
MDS Thesis in various fields
i.e. Orthodontic, Prosthodontics, Endodontics, Periodontics, Oral Surgery, etc.



PRAU
Metallurgical Laboratory
B-38, Indra Shankar Nagar,
Paud Road, Near Kothrud PHT Depot,
Kothrud, Pune - 411 038
Tel. : +91 - 20 - 2528 1584,
Cell : 96650 11314, 9158658674
E-mail : prajendra@gmail.com
Website: www.praulab.com

A) Three Point Bend Test & Modulus of Elasticity
Machine Specification : Universal Testing Machine (Computerized, Software based)
Company : Star Testing System, India, Model No. STS 248,
Accuracy of the machine : ±1%, Cross head speed : 1 mm/minute.
Distance between supports : 15.50mm

Sr. No.	Sample ID	Loading 2.5mm Deflection (N)	Unloading 2.5mm Deflection (N)	Modulus of Elasticity (MPa)
1	Copper NiTi	2.45	1.701	17820
2	NiTi	3.32	2.646	28490
3	Coated NiTi	3.629	1.761	14630
4	Coated NiTi + NAF	4.214	2.549	21996
5	Coated NiTi + Chlorhexidine	4.704	2.647	17559
6	Coated NiTi + Hiora	4.019	2.352	16461
7	NiTi + NAF	3.628	2.352	34530
8	NiTi + Chlorhexidine	3.529	2.646	35600
9	Copper NiTi + Hiora	2.254	1.764	11880
10	Niti + Hiora	3.626	2.352	35600
11	Copper NiTi + Chlorhexidine	2.549	1.861	21283
12	Copper NiTi + NAF	2.549	1.372	11501
13	Copper NiTi in Saliva	2.95	1.568	29606
14	NiTi in Saliva	3.92	2.745	35600
15	Coated in Saliva	4.605	2.253	21925



PRAU
Metallurgical Laboratory
B-38, Indra Shankar Nagar,
Paud Road, Near Kothrud PNH Depo,
Kothrud, Pune - 411 038
Tel: +91 - 20 - 2528 1584,
Cell: 96650 11314, 9158659674
E-mail: prajdentla@gmail.com
Website: www.prajlab.com


DENTAL MATERIAL TEST FACILITY
MDS Thesis in various fields
i.e. Orthodontic, Prosthodontics, Endodontics, Periodontics, Oral Surgery, etc.

Date: 21/09/2021

2.0 Surface roughness

Machine specifications: Surface Roughness Tester, Mitutoyo, Japan. Model: SJ 210
Stylus Speed: 0.5mm/s, Cut off Length : 1.25 mm

Sr. No.	Sample ID	Surface Roughness, Ra (in μm)
1	Copper NiTi	0.095
2	NiTi	0.118
3	Coated NiTi	0.312
4	Coated NiTi + NAF	0.232
5	Coated NiTi + Chlorhexidine	0.113
6	Coated NiTi + Hiora	0.166
7	NiTi + NAF	0.239
8	NiTi + Chlorhexidine	0.125
9	Copper NiTi + Hiora	0.408
10	Niti + Hiora	0.329
11	Copper NiTi + Chlorhexidine	0.321
12	Copper NiTi + NAF	0.272
13	Copper NiTi in Saliva	0.120
14	NiTi in Saliva	0.360
15	Coated in Saliva	0.381




PRAU
Metallurgical Laboratory
B-38, Indra Shankar Nagar,
Paud Road, Near Kothrud PNH Depo,
Kothrud, Pune - 411 038
Tel: +91 - 20 - 2528 1584,
Cell: 96650 11314, 9158659674
E-mail: prajdentla@gmail.com
Website: www.prajlab.com

DENTAL MATERIAL TEST FACILITY
MDS Thesis in various fields
i.e. Orthodontic, Prosthodontics, Endodontics, Periodontics, Oral Surgery, etc.

2.0 Surface roughness

Machine specifications: Surface Roughness Tester, Mitutoyo, Japan. Model: SJ 210
Stylus Speed: 0.5mm/s, Cut off Length : 1.25 mm

Sr. No.	Sample ID	Surface Roughness, Ra (in μm)
1	Copper NiTi	0.094
2	NiTi	0.118
3	Coated NiTi	0.312
4	Coated NiTi + NAF	0.231
5	Coated NiTi + Chlorhexidine	0.113
6	Coated NiTi + Hiora	0.166
7	NiTi + NAF	0.239
8	NiTi + Chlorhexidine	0.125
9	Copper NiTi + Hiora	0.408
10	Niti + Hiora	0.329
11	Copper NiTi + Chlorhexidine	0.322
12	Copper NiTi + NAF	0.272
13	Copper NiTi in Saliva	0.120
14	NiTi in Saliva	0.360
15	Coated in Saliva	0.381




PRAU
Metallurgical Laboratory
B-38, Indra Shankar Nagar,
Paud Road, Near Kothrud PNH Depo,
Kothrud, Pune - 411 038
Tel: +91 - 20 - 2528 1584,
Cell: 96650 11314, 9158659674
E-mail: prajdentla@gmail.com
Website: www.prajlab.com

DENTAL MATERIAL TEST FACILITY
MDS Thesis in various fields
i.e. Orthodontic, Prosthodontics, Endodontics, Periodontics, Oral Surgery, etc.

2.0 Surface roughness

Machine specifications: Surface Roughness Tester, Mitutoyo, Japan. Model: SJ 210
Stylus Speed: 0.5mm/s, Cut off Length : 1.25 mm

Sr. No.	Sample ID	Surface Roughness, Ra (in μm)
1	Copper NiTi	0.095
2	NiTi	0.118
3	Coated NiTi	0.312
4	Coated NiTi + NAF	0.232
5	Coated NiTi + Chlorhexidine	0.114
6	Coated NiTi + Hiora	0.166
7	NiTi + NAF	0.239
8	NiTi + Chlorhexidine	0.125
9	Copper NiTi + Hiora	0.409
10	Niti + Hiora	0.329
11	Copper NiTi + Chlorhexidine	0.321
12	Copper NiTi + NAF	0.272
13	Copper NiTi in Saliva	0.121
14	NiTi in Saliva	0.360
15	Coated in Saliva	0.381



PRAU
Metallurgical Laboratory
B-38, Indra Shankar Nagar,
Paud Road, Near Kothrud PNH Depo,
Kothrud, Pune - 411 038
Tel: +91 - 20 - 2528 1584,
Cell: 96650 11314, 9158659674
E-mail: prajdentla@gmail.com
Website: www.prajlab.com

DENTAL MATERIAL TEST FACILITY
MDS Thesis in various fields
i.e. Orthodontic, Prosthodontics, Endodontics, Periodontics, Oral Surgery, etc.

2.0 Surface roughness

Machine specifications: Surface Roughness Tester, Mitutoyo, Japan. Model: SJ 210
Stylus Speed: 0.5mm/s, Cut off Length : 1.25 mm

Sr. No.	Sample ID	Surface Roughness, Ra (in μm)
1	Copper NiTi	0.095
2	NiTi	0.119
3	Coated NiTi	0.312
4	Coated NiTi + NAF	0.232
5	Coated NiTi + Chlorhexidine	0.114
6	Coated NiTi + Hiora	0.167
7	NiTi + NAF	0.239
8	NiTi + Chlorhexidine	0.125
9	Copper NiTi + Hiora	0.409
10	Niti + Hiora	0.330
11	Copper NiTi + Chlorhexidine	0.321
12	Copper NiTi + NAF	0.272
13	Copper NiTi in Saliva	0.121
14	NiTi in Saliva	0.360
15	Coated in Saliva	0.382

Test conducted at Praj Metallurgical Lab, Pune (Maharashtra).

TEST CONDUCTED BY

SACHIN TEST ENGINEER
ASHOK BHAGAT PROPRIETOR

