Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2051-2061 | ISSN:2251-6727

Evaluation of Microbiological Colonisation on Various Types of Orthodontic Archwires - an in Vivo Study

[1]Dr. Yashchand G, [2]Dr. Falguni Mehta, [3]Dr. Renuka Patel, [4]Dr. Rahul Trivedi, [5]Dr. Venkatesh Saravana, [6]Dr. Ashmy Saju

[1.] Post Graduate Student,
[2.] Professor and Head of Department,
[3.] Professor,
[4.] Assistant Professor,
[5.] Post Graduate Student,
[6.] Post Graduate Student

Affiliation - Department of Orthodontics and Dentofacial Orthopedics, Government Dental College and Hospital, Ahmedabad, Gujarat.

(Received: 16 September 2024 Revised: 11 October 2024 Accepted: 11 December 2024)

KEYWORDS

microbial colonization, orthodontic archwires, retrieved,colony count

ABSTRACT:

Introduction: Orthodontic archwires create an environment that promotes the colonization of oral microorganisms, potentially leading to dental issues like caries and periodontal diseases. **Objectives:** This study aims to evaluate the microbial adherence on different types of orthodontic archwires by comparing the Colony Forming Units (CFUs) of *Staphylococcus aureus*, *Streptococcus mutans*, and *Candida albicans.*

Methods: The study involved 120 orthodontic patients, divided into four groups based on the type of archwire used, all with the same cross-sectional size of 0.017 × 0.025 inches. The groups were:

- **Group I:** Aesthetic Coated Stainless Steel
- **Group II:** Stainless Steel (SS)
- **Group III:** Heat Activated Nickel Titanium (HANT)
- **Group IV:** Nickel Titanium (NiTi)

After a period of one month in the oral cavity, the archwires were retrieved and subjected to quantitative microbiological analysis.

- **Results**: For *S. mutans*, significant differences were observed between aesthetic coated SS and HANT (P=0.002), and NiTi (P=0.001).
- For *S. aureus*, a significant difference was noted between NiTi and aesthetic coated SS (P=0.01).
- For *C. albicans*, significant differences were found between aesthetic coated SS and HANT (P=0.0001), and NiTi (P=0.01).

Conclusions:All types of archwires showed significant microbial colonization, with *Streptococcus mutans* demonstrating the highest affinity for NiTi wires, followed by HANT, SS, and aesthetic coated SS. *Staphylococcus aureus* and *Candida albicans* exhibited varied colonization patterns. Overall, aesthetic coated SS archwires showed the least microbial colonization.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2051-2061 | ISSN:2251-6727

1. Introduction

During fixed orthodontic treatment, archwires play a crucial role in facilitating tooth movement, improving occlusion, and enhancing aesthetics. However, the placement of bands, brackets, and archwires creates new retentive surfaces that promote the accumulation of microbial dental biofilms. These biofilms can lead to iatrogenic decalcification of enamel, resulting in the formation of white spot lesions, which are early indicators of dental caries. These biofilms consist of dynamic and structured microbial communities embedded in a self-sustaining extracellular matrix. *Streptococcus mutans* is the primary bacterium responsible for dental caries, producing glucosyltransferases and other proteins that help form dental plaque and the biofilm matrix, thereby contributing to caries development. Additionally, *Candida albicans* and *Streptococcus mutans* form a symbiotic relationship within biofilms, enhancing their virulence. Many pathogenic bacteria exploit biofilm formation to mediate localized infections. The increasing prevalence of these bacteria in biofilms is a major factor in enamel demineralization and the deterioration of periodontal health.

Orthodontic archwires have evolved from traditional stainless steel to nickel-titanium alloys and, more recently, to aesthetic-coated archwires, driven by a growing demand for more aesthetically pleasing appliances. Archwires, with varying properties such as surface roughness, surface free energy, and surface topography, provide an environment conducive to microbial adhesion.

2. Objectives

To study and compare the microbiological colonization of *Streptococcus mutans, Staphylococcus aureus*, and *Candida albicans* on four types of archwires with similar cross-sections: Aesthetic Coated Stainless Steel, Stainless Steel (SS), Heat-Activated Nickel-Titanium (HANT), and Nickel-Titanium (NiTi) in an in vivo setting.

3. Methods

The present study was carried out at the Department of Orthodontics and Dentofacial Orthopaedics, Government Dental College & Hospital, Ahmedabad. It was approved by the Institutional Ethical Committee (IEC). For this study 120 subjects undergoing fixed orthodontic therapy at the Department of Orthodontics are divided into 4 equal groups based on the type of archwire of same cross section.

Group I - 30 subjects (0.017" *0.025" Aesthetic Coated SS)

Group II - 30 subjects (0.017" *0.025" Stainless SS)

Group III - 30 subjects (0.017" *0.025" HANT)

Group IV - 30 subjects (0.017" *0.025" NiTi)

After one month of the wires being in the oral cavity, they are retrieved, cut and subject to microbial analysis by colony counting of three microorganisms namely *Staphylococcus aureus*, *Streptococcus mutans* and *Candida albicans.*

Inclusion Criteria was patients undergoing fixed orthodontic therapy and with good oral hygiene. Exclusion Criteria was patients with any systemic diseases and patients undergoing any antibiotic therapy

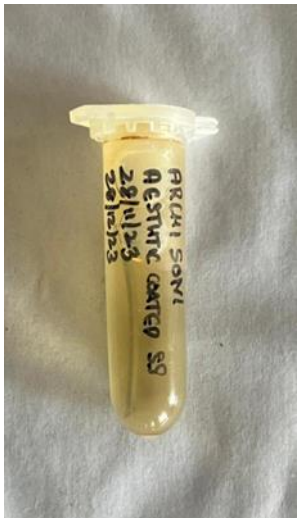

FIGURE 1: Wire in BHI Broth

Methodology:

Cross section of 0.017" *0.025" wires were inserted in patients undergoing Preadjusted Edgewise 0.022*0.028" MBT fixed mechanotherapy and ligated using stainless steel ligatures. After the archwires were inserted, the participants individually received basic

instructions on oral hygiene and care regarding the orthodontic appliance. Patients were recalled after 4 weeks and wires were carefully retrieved so as to not dislodge the adherent biofilm. Posterior segments of

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2051-2061 | ISSN:2251-6727

20mm were measured with divider and cut with a distal end cutter. Right posterior segment was subjected to biofilm measurement whereas the left posterior segment was subjected to quantitative microbial measurement.

Quantitative Microbiological Assessment:

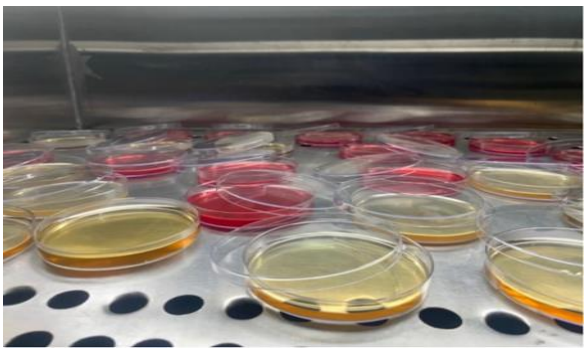

FIGURE 2: Pouring of culture media into Petri Dishes

1. The left segment is dipped in an Eppendorf tube containing 2ml of Brain Heart Infusion (BHI) broth which acts as a microbial environment and transport medium. Patient details, date of insertion, date or retrieval and type of archwire is written on the respective tubes with a marker pen and cello taped in order to prevent it from wearing off.

2. The tubes are incubated for 36 hours in an incubator at 37-degree Celsius.

3. After incubation, the broth is then vortexed for even distribution of growth and is then subject to microbiological analysis.

4. Selective Culture media - Mitis Salivarius agar, Mannitol salt agar and Potato dextrose agar are prepared for the isolation of *Streptococcus mutans, Staphylococcus aureus* and *Candida albicans.*

8. Pouring of agar into the petri dishes is done in the biosafety cabinet.

9. The prepared media are first diluted 3 times in BHI solution (6ml of BHI solution in 2 ml of sample), then cultured on the agar plates (mitis salivarius agar, mannitol salt agar, potato dextrose agar) and incubated at 37 degrees Celsius for 48 hours in an incubator.

10. After the incubation period, all plates are evaluated to count Colony Forming Unit. For counting colonies, a manual method is used, i.e., with the help of a magnifying glass, all colonies are counted and recorded.

11. Data thus obtained is subjected to statistical analyses.

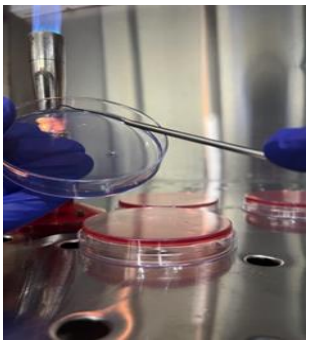

FIGURE 3: Streaking of sample on the culture media

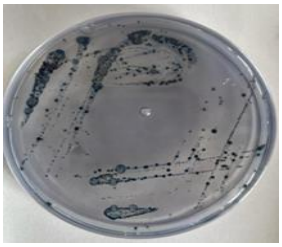

FIGURE 4: Staphylococcus Aureus on Mannitol Salt Agar

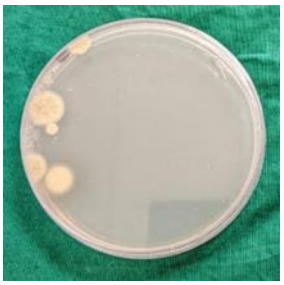

FIGURE 5: Streptococcus mutans on Mitis Salivarius Agar

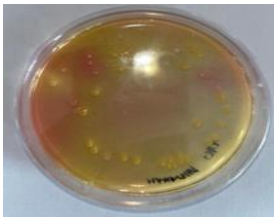

FIGURE 6: Candida Albicans on Potato Dextrose Agar

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2051-2061 | ISSN:2251-6727

Results

Table I, Graph I: Mean CFU for *Streptococcus mutans, Staphylococcus aureus, and Candida albicans,* along with biofilm absorbance and concentration for aesthetic coated SS, stainless steel, HANT, and NiTi archwires (0.017*0.025"):

- *S. mutans*:Aesthetic Coated SS: 153.36 (±39.44), SS: 176.33 (±42.79), HANT: 190.86 (±33.62), NiTi: 196.2 (±38.53).

- *S. aureus:* Aesthetic Coated SS: 12.26 (±6.65), SS: 13.5 (±5.73), HANT: 14.7 (±6.94), NiTi: 17.73 (±6.70).

-*C. albicans*: Aesthetic Coated SS: 1.22 (±0.86), SS: 2.93 (±2.53), HANT: 4.62 (±3.51), NiTi: 3.5 (±2.86).

Tables II, III, IV: Show significant differences among archwires for S. mutans, S. aureus, and C. albicans ($P \leq 0.05$).

- For *S. mutans*: significant differences between aesthetic coated SS and HANT (P=0.002) and NiTi (P=0.001).

- For *S. aureus*: significant difference between NiTi and aesthetic coated SS (P=0.01).

- For *C. albicans*: significant differences between aesthetic coated SS and HANT (P=0.0001) and NiTi (P=0.01).

4. Discussion

In the oral cavity, the orthodontic appliance creates surfaces and retentive sites with properties such as surface roughness and surface free energy, different to those of the natural oral hard and soft tissue structures. Oral biofilms formed on these surfaces cause demineralization of enamel, leading to white spot lesions which are the precursors of dental caries, gingivitis leading to periodontitis and even bacteremia.40 Bjorn et al showed that white spot lesions are present even 5 years after fixed orthodontic treatment.[41] Today, on the basis of Variable modulus orthodontics that is, use of different materials with different moduli of elasiticity while maintaining the same or similar cross section of archwires, is employed in orthodontic treatment.[10] Based upon this, orthodontic archwires of different materials are used which have different surface characteristics such as surface roughness and surface free energy which influences and increases the amount of plaque formation leading to biofilm adhesion and microbial colonisation over them.[7, 12] The microorganisms in this biofilm are responsible for biocorrosion (microbiologically induced corrosion) of orthodontic appliances as they dissipate Fe, Ni, and Cr into the oral cavity, which can be a cause of metallic allergy.[42] Furthermore, biocorrosion from orthodontic archwires also leads to a vicious cycle in which there is increase in biofilm adhesion which inturn causes more corrosion, keeping this cycle intact.[43] The biofilm matrix consists of a multitude of opportunistic and pathogenic organisms, among them *Streptococcus mutans* plays a well- established role in initiating dental caries and enamel decalcification, commonly found in regions affected by white-spot lesions related to orthodontic appliances. This bacterium can generate exopolysaccharides (EPS) which is an essential part of biofilm. This EPS aids in the further increase of colonization of S. mutans and other cariogenic organisms on enamel and other surfaces, increasing the risk of dental decay.[44] *Staphlylococcus aureus* is a major causative agent of many diseases and is associated with infections of the dentoalveolar complex, oral mucosal lesions and is also found to be the commonest pathogen in acute gingivitis in orthodontic patients.[23] **Hibino et al** showed that the most common candidal species in orthodontic patients was *Candida albicans* and also found that orthodontic patients can become candidal carriers.[45] **Chandresh et al** also observed that *Candida albicans* and S*treptococcus mutans* increase in patients undergoing orthodontic treatment.[25] Hence, knowledge regarding the growth of cariogenic bacteria in subjects with orthodontic appliances and biofilm adherance to orthodontic archwires can offer a better insight in prevention of white spot lesions and periodontal complications. As archwires of different materials are used according to treatment needs, information regarding affinity to microbiological colonisation will provide the clinician with the better choice in the microbiologic perspective as well, especially in patients with higher risk of dental caries and periodontal diseases. Therefore, this study was conducted to evaluate the amount of biofilm adhesion and microbial count of *Streptococcus mutans, Staphylococcus aureus and Candida albicans* to various orthodontic archwires. For this study, 120 patients undergoing fixed orthodontic appliance therapy were selected and divided into 4 groups. 4 different orthodontic archwires Aesthetic coated Stainless Steel, Stainless Steel, Heat-Activated Nickel Titanium(HANT)

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2051-2061 | ISSN:2251-6727

and Nickel Titanium(NiTi) of 0.017*0.025 inch cross-section were placed in each group respectively. The wires are retrieved after 1 month, 2cm of the distal end was cut and subjected to microbiological analysis by evaluating the microbial count of *Streptococcus mutans, Staphylococcus aureus* and *Candida albicans.*

Overall, on all archwires, the microorganism showing maximum adhesion is *Streptococcus mutans* followed by *Staphylococcus aureus* and the least adhesion is by *Candida albicans.* These findings are concurrent with the study by **Pritish Polke et al.**,[32] in which *Streptococcus mutans* has the highest affinity for adhesion to orthodontic archwires and *Candida albicans* has the least affinity.

Aesthetic Coated SS showed the lowest adhesion of *Streptococcus mutans* followed by Stainless Steel and HANT, whereas the highest adhesion was found on NiTi archwires. These findings are concurrent with the findings of the study by **In-Hye Kim et al.**,[18] which showed that NiTi(7.70±3.38) archwires had significantly higher *Streptococcus mutans* colony count (expressed as log10 CFU) than the Stainless Steel archwires (4.70±1.34) and the Aesthetic Coated archwires had the lowest SM adhesion. ANOVA test was carried out to evaluate whether the difference was significant. A statistically highly significant difference was observed in the mean value of CFUs of *Streptococcus mutans* on all the archwires with a (P=0.002). Since the results showed Statistically significant difference between all the archwires, Post Hoc Tukey's test was carried out in conjunction with ANOVA to find out which of the readings are significantly different from one another. The Post hoc Tukey's test revealed that a statistically very significant difference was found between Aesthetic Coated SS and HANT archwires (P=0.002) and a statistically highly significant difference between Aesthetic Coated SS and NiTi (P=0.001). In the study by **In-Hye Kim et al.**,18 the Aesthetic wires showed a significantly lower SM adhesion than NiTi archwires.(P<0.05). Similar findings were observed in studies done by **Aliaa Abdul Rhman Al-Lami et al., [20] Reem A Rafeeq et al.[26]** and **Renea Radovic et al[37]** which showed NiTi archwires to have highest adhesion of *Streptococcus mutans* in comparison to the Aesthetic coated and SS archwires. Increased adhesion to NiTi archwires can be attributed to its high surface roughness which is explained by **Atia Yousif et al.[22]** and **Vincenzo D'Anto et al., [46]** making NiTi responsible for the increased count of *Streptococcus mutans* in comparison to SS which has a smoother surface. The reduced adhesion of *Streptoccocus mutans* to the Aesthetic coated SS can be attributed to the coatings present on it. Reduction in surface roughness of coated archwires reduces plaque accumulation onto them. This was observed in the study done by **Seyed Hamid Raji et al.[19]** who compared coated and uncoated archwires. Conflicting results by **Sevil Samadzadeh et al[35]** observed more *Streptococcus mutans* adhesion on stainless steel archwires(0.016*0.022") as compared to NiTi archwires(0.016*0.022") in an invitro study. The increased release of metal ions from stainless steel increased the surface energy of the archwires, may lead to greater colonisation. In the study by **Kleist Christian Costa Lima et al., [27]** the archwires, fully(rodium) coated NiTi, partially(teflon) coated NiTi, uncoated NiTi and SS with cross section of 0.016*0.022", were compared in vivo for *Streptococcus mutans* adhesion. It was found that coated NiTi had the highest adhesion of *Strepcoccus mutans* (11.80±0.82) (expressed in logarithmic scale) followed by uncoated NiTi (9.28±2.13), uncoated SS (8.15±1.37) and least was on partially coated-NiTi (7.01±0.79). The finding that uncoated NiTi has higher S*treptococcus mutans* adhesion in comparison to uncoated SS is similar to the present study. Whereas, the finding that the aesthetic fully coated archwire accumulating most microorganisms is contrary to the present study. This may be due to different materials investigated(rhodium, teflon, stainless steel, and nickel titanium), as the initial adhesion of bacteria to surfaces also depends on the composition of the solid substratum.

The colony count for Staphylococcus aureus is lowest for Aesthetic Coated SS, followed by Stainless Steel and HANT and is highest for Nickel Titanium. ANOVA test showed a statistically very significant difference of colony counts of staphylococcus aureus between all the four archwires.(P=0.014). Tukey's post hoc analysis showed a statistically highly significant difference only between NiTi and Aesthetic coated SS(P=0.01). In the study by **Pritish Polke et al., [32]** it was found that there was no statistically significant difference between Aesthetic coated SS and Stainless Steel. These findings are in accordance with the present study. Increased adhesion of *Staphylococcus aureus* to NiTi archwires can be due to corrosion induced nickel release from

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2051-2061 | ISSN:2251-6727

orthodontic appliances which could modify the behaviour of bacteria in the oral cavity due to which there is increased adaptation of Staphylococcus aureus to NiTi orthodontic archwires. This was observed by **Andrej Pavlic et al**[31] Similar results were seen in an in vitro experiment by **Manar Hussain Abbas et al.**,[23] in which there was a similar change in adhesion of S. Aureus on NiTi and SS archwires after incubation of 24-96 hours.

Lowest Candidal growth was seen on Aesthetic Coated SS followed by SS, NiTi and HANT. Similar findings were found in study by **Saloom HF et al**[16] who found that appliances with more aesthetic appearances such as coated archwires and brackets showed less candidal growth in comparison to appliances with more metallic components. ANOVA analysis found that the readings of all the archwires were statistically highly significant from one another(P=0.0002). Post Tukey analysis showed that there was a statistically highly significant difference between aesthetic coated SS and HANT(P=0.0001) and a statistically highly significant difference between aesthetic coated SS and NiTi group with a (P=0.01).No significant difference was found between HANT and NiTi archwires as well as Aesthetic coated SS and SS archwires. **Harikrishnan et al.**[17] observed no significant difference between teflon coated ligatures and stainless steel ligatures for the adhesion of *Candida albicans.* In the study conducted by **Pritish Polke et al.,** [32] significant difference was found between SS and Aesthetic Coated SS(P=0.01) which wasn't found in the present study. This may be attributed to the loss of coatings of Aesthetic coated SS during orthodontic treatment due to low pH, mechanical stress and brushing. This was observed by **Arata Ito et al.**[47]

5. Summary And Conlusion

Orthodontic archwires are an integral and active component of the fixed orthodontic appliance but are prone to and act as retention sites for plaque formation leading to biofilm adhesion and microbiological colonisation. This puts the patient at risk for increase in incidence of dental caries and periodontal diseases. The conclusions of the study are:

1. All the archwires show significant amount of microorganisms on them.

2. *Streptococcus mutans* had the highest affinity for retention on all the archwires followed by *Staphylococcus Aureus* and *Candida Albicans.*

3. *Streptococcus mutans* had highest affinity for NiTi wires, followed by HANT, SS and Aesthetic coated SS wires. HANT and NiTi archwires showed significant difference with Aesthetic coated SS.

4. For *Staphylococcus aureus*, NiTi archwires showed highest amount of adhesion followed by HANT, SS and Aesthetic Coated SS. However the difference is statistically not significant except between NiTi and Aesthetic coated SS wires.

5. For *Candida albicans*, HANT archwires showed highest amount of adhesion followed by NiTi, SS and Aesthetic coated SS. Both HANT and NiTi archwires shows significant difference with Aesthetic coated SS wires.

Hence, it is concluded that, in order to provide a more wholesome orthodontic treatment, keeping the patients' overall prognosis in mind, NiTi and HANT archwires, being the wires with more amount of microbial colonisation should be used for the most optimum and shortest period of time especially in patients with higher risk of dental caries and periodontal complications. Wire progression to wires with lesser biofilm adhesion and microbial colonisation such as to Aesthetic coated SS and SS at the earliest is recommended.

Limitations Of The Present Study: In the present study, microbiological evaluation was done by placing and retrieving archwires for the period of 1 month. Long-term studies would be more conclusive. On the Aesthetic coating SS archwires,coatings may peel during intervention or in areas where tooth brush can reach easily, can affect the outcome.

For this study, 0.017*0.025 rectangular cross section was taken. Different cross sections can change the outcome. The standardization of eating habits is not possible which may affect the outcome of the study.

Refrences

1. Hazel RJ, West VC. The importance of mechanical behaviour in orthodontic archwires. Australasian Orthodontic Journal. 1986 Oct 1;9(4):317-20.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2051-2061 | ISSN:2251-6727

2. Lazar L, Vlasa A, Beresescu L, Bud A, Lazar AP, Matei L, Bud E. White Spot Lesions (WSLs)—post-orthodontic occurrence, management and treatment alternatives: a narrative review. Journal of Clinical Medicine. 2023 Feb 28;12(5):1908.

3. Rather MA, Gupta K, Mandal M. Microbial biofilm: formation, architecture, antibiotic resistance, and control strategies. Brazilian Journal of Microbiology. 2021 Dec 1:1-8.

4. Bowen WH, Koo HJ. Biology of Streptococcus mutans-derived glucosyltransferases: role in extracellular matrix formation of cariogenic biofilms. Caries research. 2011 Feb 23;45(1):69-86.

5. Falsetta ML, Klein MI, Colonne PM, Scott-Anne K, Gregoire S, Pai CH, Gonzalez-Begne M, Watson G, Krysan DJ, Bowen WH, Koo H. Symbiotic relationship between Streptococcus mutans and Candida albicans synergizes virulence of plaque biofilms in vivo. Infection and immunity. 2014 May;82(5):1968-81.

6. An JS, Lim BS, Ahn SJ. Managing oral biofilms to avoid enamel demineralization during fixed orthodontic treatment. Korean Journal of Orthodontics. 2023 Nov 11;53(6):345.

7. 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. The Angle Orthodontist. 2016 Mar 1;86(2):285-91.

8. Mei L, Chieng J, Wong C, Benic G, Farella M. Factors affecting dental biofilm in patients wearing fixed orthodontic appliances. Progress in orthodontics. 2017 Dec;18:1-6.

9. Haryani J, Ranabhatt R. Contemporary Esthetic Orthodontic Archwires-A Review. Journal of Dental Materials & Techniques. 2016 Sep 1;5(3).

10. Burstone CJ. Variable-modulus orthodontics. American journal of orthodontics. 1981 Jul 1;80(1):1-6.

11. Lundström F, Krasse BO. Caries incidence in orthodontic patients with high levels of Streptococcus mutans. The European Journal of Orthodontics. 1987 Jan 1;9(1):117-

12. Quirynen M, Marechal M, Busscher HJ, Weerkamp AH, Darius PL, van Steenberghe D. The influence of surface free energy and surface roughness on early plaque formation: an in vivo study in man. Journal of clinical periodontology. 1990 Mar;17(3):138-44.

13. Eliades T, Eliades G, Athanasiou AE, Bradley TG. Surface characterization of retrieved NiTi orthodontic archwires. The European Journal of Orthodontics. 2000 Jun 1;22(3):317-26.

14. Yu JH, Wu LC, Hsu JT, Chang YY, Huang HH, Huang HL. Surface roughness and topography of four commonly used types of orthodontic archwire. J Med Biol Eng. 2011 Nov;31(5):367-70.

15. Erriu M, Genta G, Tuveri E, Orrù G, Barbato G, Levi R. Microtiter spectrophotometric biofilm production assay analyzed with metrological methods and uncertainty evaluation. Measurement. 2012 June 1;45(5):1083-8.

16. Saloom HF, Mohammed-Salih HS, Rasheed SF. The influence of different types of fixed orthodontic appliance on the growth and adherence of microorganisms (in vitro study). Journal of clinical and experimental dentistry. 2013 Feb;5(1):e36.

17. Harikrishnan P, Subha TS, Kavitha V, Gnanamani A. Microbial adhesion on orthodontic ligating materials: An in vitro assessment.

18. Kim IH, Park HS, Kim YK, Kim KH, Kwon TY. Comparative shortterm in vitro analysis of mutans streptococci adhesion on esthetic, nickeltitanium, and stainless-steel arch wires. Angle Orthodontist. 2014 Jul 1;84(4):680-6.

19. Raji SH, Shojaei H, Ghorani PS, Rafiei E. Bacterial colonization on coated and uncoated orthodontic wires: A prospective clinical trial. Dental research journal. 2014 Nov;11(6):680.

20. Al-Lami AA, Al-Sheakli II. Quantitative assessment of Mutans Streptococci adhesion to coated and uncoated orthodontic archwires (in vitro study). Journal of Baghdad College of Dentistry. 2014;26(4):156-62.

21. Kumar A, Konda P. X-ray diffraction of orthodontic archwires for evaluation and comparison of surface

deposits: An in vitro study. Journal of Orthodontic Research. 2014 May 1;2(2):74.

22. Yousif AA, Abd El-Karim UM. Microscopic study of surface roughness of four orthodontic arch wires. Tanta Dental Journal. 2016 Oct 1;13(4):199-207.

23. Abbas MH, Al-Yasseen AK, Alhamadi WW. Prevalence of Staphylococcus aureus among gingivitis in patient with orthodontic wires in Kufa City/Iraq. Pakistan Journal of Biotechnology. 2017 Mar 25;14(1):91-6.

24. Hassan SS. Evaluation of Microbial Contamination of as Received Orthodontic Arch Wire from Manufacture (An In Vitro Comparative Study) (Doctoral dissertation, University of Baghdad).

25. Shukla C, Maurya R, Singh V, Tijare M. Evaluation of role of fixed orthodontics in changing oral ecological flora of opportunistic microbes in children and adolescent. Journal of Indian Society of Pedodontics and Preventive Dentistry. 2017 Jan 1;35(1):34-40.

26. Rafeeq RA, Saleem AI, Taha SS, Al-Duboni GI. Differences in the Microbial Colonization Among Arch Wire Types, Gauges and Cross Sections. Health Sciences. 2018 Jan 1;7(2):110-6.

27. Lima KC, Paschoal MA, de Araújo Gurgel J, Freitas KM, Pinzan- Vercelino CR. Comparative analysis of microorganism adhesion on coated, partially coated, and uncoated orthodontic archwires: a prospective clinical study. American Journal of Orthodontics and Dentofacial Orthopedics. 2019 Nov 1;156(5):611-6.

28. Hasipek S, Senisik NE, Cetin ES. An Examination of Bacterial Colonisation on Nickel-Titanium Arch-wires with Different Surface Properties. Journal of Clinical & Diagnostic Research. 2019 Jun 1;13(6).

29. Tawfik M, Maaly T, EL-Nagar RM. Evaluation of surface roughness and microbial biofilm adhesion of different orthodontic arch-wires. Egyptian Dental Journal. 2020 Apr 1;66(2-April (Orthodontics, Pediatric & Preventive Dentistry)):727-36.

30. Oliveira DC, Thomson JJ, Alhabeil JA, Toma JM, Plecha SC, Pacheco RR, Cuevas-Suárez CE, Piva E, Lund RG. In vitro Streptococcus mutans adhesion and biofilm formation on different esthetic orthodontic archwires. The Angle Orthodontist. 2021 Nov 1;91(6):786-93.

31. Pavlic A, Begic G, Tota M, Abram M, Spalj S, Gobin I. Bacterial Exposure to Nickel: Influence on Adhesion and Biofilm Formation on Orthodontic Archwires and Sensitivity to Antimicrobial Agents. Materials. 2021 Aug 16;14(16):4603.

32. Polke P, Jain U, Marothiya S, Agrawal P, Dixit S, Dubey C. Comparative Evaluation of Biofilm Adhesion to Different Types of Archwire and Microbiological Colonization during Orthodontic Treatment. Journal of Indian Orthodontic Society. 2021 Apr;55(2):150-7.

33. Kula B, Yılmaz B, Karaaslan E. Changes in color stability and surface roughness of teflon-coated arch wires after clinical use. Turkish Journal of Orthodontics. 2022 Dec;35(4):260.

34. Mohan R, Jain RK. An in vitro comparative evaluation of surface roughness characteristics of different orthodontic archwires: An atomic force microscopy study. Journal of Dental Research, Dental Clinics, Dental Prospects. 2022;16(2):91.

35. Sevil Samadzadeha , Ahmad SheibaniNiab , Maryam Rezaeic , Alireza Jafari-Naeimid.The effects of NiTi and stainless steel archwires on the adherance levels of streptococcus mutans.European chemical bulletin,Volume -12, issue-3 (2023)

36. Thanetchaloempong W, Koontongkaew S, Utispan K. Fixed orthodontic treatment increases cariogenicity and virulence gene expression in dental biofilm. Journal of Clinical Medicine. 2022 Oct 3;11(19):5860.

37. Radovic R, Begic G, Blagojevic SL, Karleusa L, Spalj S, Gobin I. Temporal dynamics of adhesion of oral bacteria to orthodontic appliances. Dental materials journal. 2023 Jul 25;42(4):469-77.

38. Sukriti Raj , Karamdeep Singh Ahluwalia ,. Lokendra Singh Dagur,Hari Narayan Chaudhary,Shiva Gupta, Nayan Jyoti Borah Comparative analysis of microorganism adhesion on coated and uncoated orthodontic archwires: A prospective clinical study Eur. Chem. Bull. 2023, 12(Special Issue 8),3539-3547

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2051-2061 | ISSN:2251-6727

39. Kamimura R, Kanematsu H, Ogawa A, Kogo T, Miura H, Kawai R, Hirai N, Kato T, Yoshitake M, Barry DM. Quantitative analyses of biofilm by using crystal violet staining and optical reflection. Materials. 2022 Sep 28;15(19):6727.

40. Ren Y, Jongsma MA, Mei L, van der Mei HC, Busscher HJ. Orthodontic treatment with fixed appliances and biofilm formation—a potential public health threat?. Clinical oral investigations. 2014 Sep;18:1711-8.

41. Øgaard B. White spot lesions during orthodontic treatment: mechanisms and fluoride preventive aspects. InSeminars in orthodontics 2008 Sep 1 (Vol. 14, No. 3, pp. 183-193). WB Saunders.

42. Kameda T, Oda H, Ohkuma K, Sano N, Batbayar N, Terashima Y, Sato S, Terada K. Microbiologically influenced corrosion of orthodontic metallic appliances. Dental Materials Journal. 2014 Mar 26;33(2):187-95.

43. Pal MK, Lavanya M. Microbial influenced corrosion: understanding bioadhesion and biofilm formation. Journal of Bio-and Tribo-Corrosion. 2022 Sep;8(3):76.

44. Koo H, Xiao J, Klein MI, Jeon JG. Exopolysaccharides produced by Streptococcus mutans glucosyltransferases modulate the establishment of microcolonies within multispecies biofilms.

45. Hibino K, Wong RW, Haegg U, Samaranayake LP. The effects of orthodontic appliances on Candida in the human mouth. International ournal of paediatric dentistry. 2009 Sep;19(5):301-8.

46. D'Antò V, Rongo R, Ametrano G, Spagnuolo G, Manzo P, Martina R, Paduano S, Valletta R. Evaluation of surface roughness of orthodontic wires by means of atomic force microscopy. The Angle Orthodontist. 2012 Sep 1;82(5):922-8.

47. Ito A, Kitaura H, Noguchi T, Ohori F, Mizoguchi I. Analysis of coating loss from coated stainless steel orthodontic wire. Applied Sciences. 2022 Sep 22;12(19):9497.

48. Wilson C, Lukowicz R, Merchant S, Valquier-Flynn H, Caballero J, Sandoval J, Okuom M, Huber C, Brooks TD, Wilson E, Clement B. Quantitative and qualitative assessment methods for biofilm growth: a mini-review. Research & reviews. Journal of engineering and technology. 2017 Dec;6(4).

49. Morris, R. 2015. Spectrophotometry. *Curr. Protoc. Essential Lab. Tech.* 11:2.1.1-2.1.30

Table I, Graph I: Mean of Colony Forming Units(CFU) of *Streptococcus mutans, Staphylococcus aureus, Candida albicans* and Biofilm Absorbance and Biofilm Concentration of Aesthetic Coated SS, Stainless Steel, Heat Activated Nickel Titanium and Nickel Titanium archwire of 0.017*0.025" cross section.

	Aesthetic Coated SS		Stainless Steel		HANT		NiTi	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Streptococcus Mutans	153.36	39.44	176.33	42.79	190.86	33.62	196.2	38.53
Staphlyococcus Aureus	12.46	6.65	13.5	5.73	14.7	6.94	17.73	6.70
Candida Albicans	1.22	0.86	2.93	2.53	4.62	3.51	3.5	2.86

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2051-2061 | ISSN:2251-6727

TABLE II shows Comparison of 'Streptococcus Mutans' on different 0.017*0.025" archwires - Aesthetic coated SS, Stainless Steel, HANT, and NiTi

	Mean	SD
Aesthetic Coated SS	153.36	39.44
Stainless Steel	176.33	42.79
HANT	190.86	33.62
Niti	196.2	38.53
ONE WAY ANOVA TEST P VALUE	0.002*	

Groups	Difference	95% Confidence Interval		P value
Aesthetic Coated SS vs Stainless steel	22.97	-3.0987 to	49.0387	0.10
Aesthetic Coated SS vs HANT	37.5	11.4313 to	63.5687	0.002*
Aesthetic Coated SS vs Niti	42.84	16.7713 to	68.9087	0.001*
Stainless Steel vs HANT	14.53	-11.5387 to	40.5987	0.46
Stainless Steel vs Niti	19.87	-6.1987 to	45.9387	0.19
HANT vs Niti	5.34	-20.7287 to	31.4087	0.95

TABLE III Comparison of 'Staphylococcus Aureus'on different 0.017*0.025" archwires - Aesthetic coated SS, Stainless Steel, HANT, and NiTi

	Mean	SD
Aesthetic Coated SS	12.46	6.65
Stainless Steel	13.5	5.73
HANT	14.7	6.94
Niti	17.73	6.70
ONE WAY ANOVA TEST	0.014*	

Groups	Difference	95% Confidence Interval		P value
Aesthetic Coated SS vs Stainless steel	1.04	-3.3489 to	5.4289	0.92
Aesthetic Coated SS vs HANT	2.24	-2.1489 to	6.6289	0.54
Aesthetic Coated SS vs Niti	5.27	0.8811 to	9.6589	0.01*
Stainless Steel vs HANT	1.20	-3.1889 to	5.5889	0.89
Stainless Steel vs Niti	4.23	-0.1589 to	8.6189	0.06
HANT vs Niti	3.03	-1.3589 to	7.4189	0.27

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(6), 2051-2061 | ISSN:2251-6727

TABLE IV Comparison of 'Candida Albicans' on different 0.017*0.025" archwires - Aesthetic coated SS, Stainless Steel, HANT, and NiTi

	Mean	SD
Aesthetic Coated SS	1.22	0.86
Stainless Steel	2.93	2.53
HANT	4.62	3.51
Niti	3.5	2.86
ONE WAY ANOVA TEST	0.0002*	

Groups	Difference	95% Confidence Interval		P value
Aesthetic Coated SS vs Stainless steel	1.71	-0.2203 to	3.6403	0.10
Aesthetic Coated SS vs HANT	3.4	1.4697 to	5.3303	0.0001*
Aesthetic Coated SS vs Niti	2.28	0.3497 to	4.2103	0.01*
Stainless Steel vs HANT	1.69	-0.2403 to	3.6203	0.10
Stainless Steel vs Niti	0.57	-1.3603 to	2.5003	0.86
HANT vs Niti	1.12	-3.0503 to	0.8103	0.43