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Fluoride and Titanium Based Orthodontic Arch wire
(Review article)

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Abstract

Fluoride is commonly employed in toothpaste and mouthwashes in concentrations of up to 1%, whereas for the purpose of addressing enamel discolorations, concentrations of approximately 2% are utilized. The potential of dental hygiene products containing fluoride ions to degrade the oxide deposit generated on titanium surfaces raises concerns regarding the suitability of titanium for dental applications. When conducting a search on PubMed using the keywords "fluoride" and "titanium orthodontic wires," a total of approximately 105 results were obtained. The bulk of these studies primarily focus on investigating the impact of fluoride on various mechanical characteristics of orthodontic wires (like friction, surface roughness, load deflection). for that this review focus on effect of fluoride on friction and surface roughness of titanium-based wire and it found that fluoride significantly affect.

Key words: Fluoride. Titanium wire, friction, surface roughness, corrosion

Introduction

The utilization of titanium-based wires in orthodontics is prevalent due to its distinctive characteristics of super elasticity and shape memory, which enable the consistent application of force during orthodontic tooth movement. In the field of comprehensive orthodontic treatment, it is common to utilize stainless steel and titanium-based arch wire alloys at various phases, following the principles of "Variable modulus orthodontics" as proposed by (Burstone in 1981). Maintaining proper oral hygiene is a crucial element in achieving favorable outcomes in orthodontic treatment. In order to mitigate insufficient cleanliness practices, a considerable number of orthodontic professionals recommend the implementation of a daily topical fluoride therapy (Alexander and Ripa, 2000).

According to Jasim et al. (2016), the use of fluoride and fluoridated solutions serves as a fundamental protective measure against the decalcification that occurs around orthodontic brackets. This decalcification can lead to irreversible damage and compromise the aesthetic outcomes acquired during orthodontic treatment, potentially requiring extra operational interventions.

The bactericidal effect of the fluoride ion is exerted by the production of hydrofluoric acid (HF). Although fluoride has been found to be effective in preventing caries, it is important to note that the generation of hydrofluoric acid (HF) can have negative effects on orthodontic wires and brackets (Kwon et al., 2005; Kao et al., 2006; Graber). According to Alexander and Ripa (2000), there is a suggestion that the presence of fluoride solutions may lead to the deterioration of orthodontic arch wires. According to a study conducted by Nahidh et al. (2017), it is important to exercise caution when using herbal mouthwashes due to their higher release of ions compared to chlorhexidine. An additional matter of concern has been the potential impact of these chemicals on the physical characteristics and clinical efficacy of orthodontic equipment, which has prompted scrutiny on the use of fluorides during orthodontic treatment (Toms, 1988; House et al., 2008). According to several studies (Toumelin-Chemla et al., 1996; Kim and Johnson, 1999; Watanabe and Watanabe, 2003; House et al., 2008; Alavi et al., 2015), it has been observed that fluoride prophylactic agents have the potential to promote corrosion and subsequent discolorations of orthodontic wires made from titanium-based materials.

According to a study conducted by Al-Joubori and Hashim (2018), it was found that the presence of fluoride ions has an impact on the mechanical properties of titanium-based wire, namely thermal Ni-Ti. The occurrence of bracket debonding, loss of anchoring, and restriction of tooth movement can be attributed to high frictional resistance and surface roughness. Therefore, it is imperative to minimize these properties in order to mitigate these issues (Alavi and Farahi, 2011). According to Abd Awn et al. (2007), the average load deflection of titanium-based (Ni-Ti) arch wire exhibits a decline following immersion in AMF.

Discussion

The effect of fluoride on frictional resistance

Friction, a phenomenon characterized by the resistance encountered when one surface glides over another, is a complex phenomenon influenced by multiple factors. According to the study conducted by Braga et al. (2011).

Friction has a significant function within the field of orthodontics when it comes to the process of space closure. The resistance to sliding observed in the pre-adjusted edgewise system is a result of multiple factors, including classical friction, binding between the arch wire and brackets, and notching of the arch wire (Kusy and Whitley, 1997). The elimination or minimization of frictional forces is crucial during the planning of orthodontic tooth movement. Friction is a physical phenomenon that hinders or opposes the relative motion between two materials that are in touch. The direction of frictional force is parallel to the common interface of the two surfaces. (Bednar et al., 1991; Ho and West, 1991; Keith et al., 1993).

The investigation focused on evaluating the degree of frictional resistance exhibited by several orthodontic archwires (TMA, Ni-Ti, SSW) when subjected to immersion in an APF gel. The findings of the study revealed that TMA wire demonstrated the highest level of friction among the tested materials. The acidic 0.2% APF solution led to an increase in the frictional resistance of the wires and brackets. The potential consequences of heightened levels of friction include an extended duration of therapy and compromised control over anchoring. The evaluation of methods for the meticulous administration of fluoride in orthodontic patients is warranted (Kao et al., 2006). Another study has demonstrated that the use of a 0.05% sodium fluoride mouthwash leads to a significant increase in the frictional resistance between brackets and various types of orthodontic wires,

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including SS, NiTi, Cu-NiTi, and TMA. This finding is particularly noteworthy, particularly in situations where critical anchorage is required. According to Geramy et al. (2017), the Cu-NiTi wire demonstrated the highest level of frictional resistance in both the sodium fluoride mouthwash and artificial saliva environments. The TMA, NiTi, and SS wires followed, in descending order, in terms of their rate of frictional resistance.

According to a research study, the utilizations of Sultan topical fluoride gel (APF 1.23%, pH=3.5) in conjunction with steel brackets and NiTi and steel wires has been found to result in an elevation of frictional forces. Hence, it is suggested by Alavi and Farahi (2011) to utilize preventive agents with elevated pH levels and reduced fluoride concentration while employing sliding mechanics for dental realignment.

The mechanical qualities of three types of wires had a significant deterioration as a result of intraoral usage of fluoride, as observed in a clinical investigation. According to Rajendran et al. (2019), the utilizations of daily prescription fluoride mouthwashes resulted in further degradation. The study conducted by Krishnan and Kumar (2004) suggests that there is an observed increase in friction at the contact between the archwire and bracket when TMA™ wires are utilized. According to Vijayalakshmi et al. (2009), the analysis of frictional resistance values indicates that the titanium niobium archwire exhibited the highest level of frictional force among the various archwires examined. This was followed by the TMA archwire, while the stainless steel archwire shown the lowest level of frictional force. Additionally, the timolium archwire exhibited a frictional force level that was lower than that of stainless steel. The levels of frictional force exhibited a higher value for TMA in comparison to CAN, with the lowest value observed for SS wire. According to the study conducted by Juvvadi et al. (2010).

Effect of fluoride on surface roughness

Surface texture measurement is a parameter that influences the manner in which an object can engage with its environment. The word "microtexture" is also referred to as such by Lou et al. (1999) and Rudge et al. (2015).

The evaluation of archwire performance in orthodontics is heavily reliant on the examination of surface roughness, as it is closely linked to various features (Rongo, 2014).

According to Elayyan et al. (2010), it has been observed that it has an effect on the surface contact area, plaque retention, and biocompatibility. Therefore, while attempting to choose an optimal archwire, it is important to consider the impact of surface topography on archwire behavior. This factor is of clinical relevance as it affects the quality and safety of orthodontic treatments (D'Antò et al., 2012).

Surface roughness is an inherent attribute of a material, influenced by factors such as its durability, shelf life, and the specific manufacturing techniques employed, including operations like polishing and heat treatment. According to Kapila et al. (1990), it is a common observation that even surfaces that appear smooth possess imperfections. Consequently, actual contact between surfaces is limited to a small number of localized peaks or asperities.

In the study conducted by Rajendran et al. (2019), it was found that the application of fluoride intraorally resulted in a notable and statistically significant augmentation of surface roughness across all three types of TMA. Moreover, the use of fluoride prophylactic agents on a daily basis further intensified this increase in roughness. Notably, no significant disparities in roughness were observed among the various experimental intraoral conditions. According to Belasic et al. (2021), the

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initial samples had a higher average roughness, accompanied by a significantly greater degree of variability.

The TMA wires had the highest surface roughness (Ra) among the tested samples. Subsequently, NiTi, L-TMA, and SS were sequentially employed (Pulikkottil et al., 2016). According to Balakrishnan et al. (2021), the utilization of APF gel containing a high concentration of fluoride and low pH has been found to have a significant impact on titanium-based archwires, resulting in substantial deterioration in tensile capabilities and an increase in surface roughness. Figure 1 illustrates the impact of fluoride.

Other research by Ehrami, E. et al. (2022) showed that concentration of fluoride plays a crucial role in surface texture changing as showed in Figure 2.

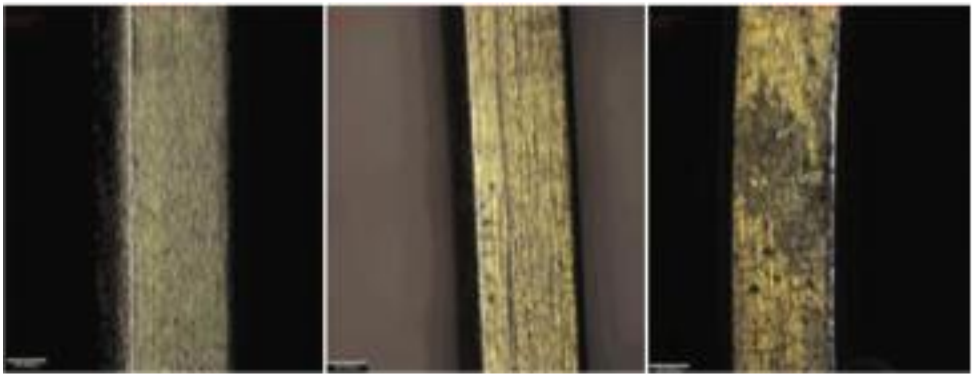

Figure 1 *show the change in surface texture of wire after fluoride used. (Left to Right) the left photo showed the wire in control state while the right one represents the wire after fluoride application (Rajendran et al., 2019)*

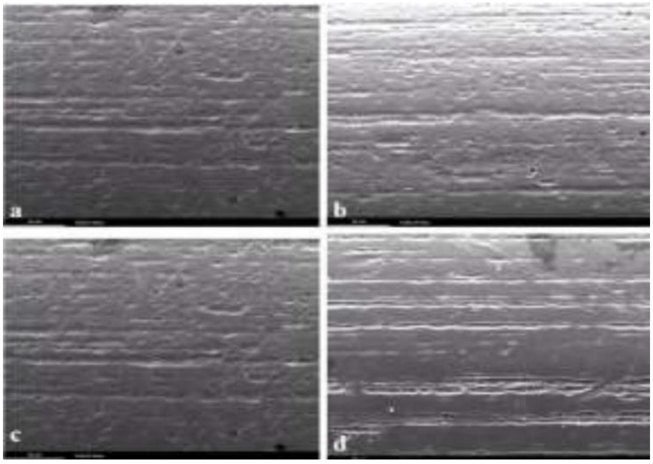

Figure 2 *Surface topography of 0.018-inch NiTi wires in different subgroups: (a) before immersion, (b) control group, (c) 0.2% NaF group, (d) 0.05% NaF group*

Importance of frictional resistance and surface roughness

The orthodontist's belief is that the roughness of the wire and bracket slot can affect the frictional coefficient and movement of teeth. According to Kappert et al. (1988), the quality and smoothness of dental materials' surfaces are crucial because they determine the contact area, which in turn affects corrosion behavior and biocompatibility. Additionally, the surface roughness of orthodontic archwires can impact the appearance of the appliance and the effectiveness of sliding mechanics. When a tooth is guided along an archwire, it may experience

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rotation and tipping, and the contact between the guiding wire and the bracket is relevant (Bourauel et al., 1998).

In previous studies conducted in 1990 (Kusy and Whitley, 1990b) and more recently in 2004 (Kusy et al, 2004), researchers examined the relationship between friction and the area of contact, as described by the second law of friction.

Their findings indicated that friction remains unaffected by the size of the contact area, as long as there is an area of contact. Additionally, these studies revealed no significant association between surface roughness and resistance to sliding.

The increased friction observed in certain materials such as NiTi and TMA can be attributed to the inherent reactivity of titanium, which leads to enhanced adherence during the sliding process. Compared to stainless steel and copper chromium wires, titanium-containing wires exhibit rougher surfaces and consequently exhibit higher levels of friction (Eliades and Brantley, 2016).

Conclusion

The frictional properties and qualitative surface topography of orthodontic wires made from titanium-based arch wire materials were found to be influenced by the exposure to agents with high concentrations of fluoride. Hence, the utilizations of topical gels containing elevated levels of fluoride in conjunction with titanium-based orthodontic wires may result in the deterioration of mechanical qualities attributable to fluoride, potentially leading to an extended duration of orthodontic therapy.

Reference

Warita H, Yamaguchi S, Matsumoto Y, Fujita Y, Domon S. A study on experimental tooth movement with Ni-Ti alloy orthodontic wires: comparison between light continuous and light dissipating force. Nippon Kyosei Shika Gakkai Zasshi 1996; 55:515-27.http://dx.doi.org/10.1093/ortho/29.2.129.

Alexander, S. A., & Ripa, L. W. (2000). Effects of self-applied topical fluoride preparations in orthodontic patients. *The Angle Orthodontist*, *70*(6), 424-430. https://doi.org/10.1043/0003-3219(2000)070%3C0424:eosatf%3E2.0.co;2

Kao CT, Ding SJ, Wang CK, He H, Chou MY, Huang TH. Comparison of frictional resistance after immersion of metal brackets and orthodontic wires in a fluoride-containing prophylactic agent. *Am J Orthod Dentofacial Orthop*. 2006. November;130(5): 568.e1–9.https://doi.org/10.1016/j.ajodo.2005.09.028

Kwon YH, Jang CM, Jang JH, Park JH, Kim TH, Kim HI. Effect of fluoride released from fluoride-containing dental restoratives on NiTi orthodontic wires. *Dent Mater J*. 2008. January;27(1):133–8 https://doi.org/10.4012/dmj.27.133

Kwon YH, Cho HS, Noh DJ, Kim HI, Kim KH. Evaluation of the effect of fluoride-containing acetic acid on NiTi wires. *J Biomed Mater Res B Appl Biomater*. 2005. January;72(1):102–8. https://doi.org/10.1002/jbm.b.30129

Kim H, Johnson JW. Corrosion of stainless steel, nickel-titanium, coated nickel-titanium, and titanium orthodontic wires. Angle Orthod 1999;69:39-44 https://doi.org/10.1043/0003-3219(1999)069%3C0039:cossnt%3E2.3.co;2
Watanabe I, Watanabe E. Surface changes induced by fluoride prophylactic agents on titanium-based orthodontic wires. Am J Orthod Dentofacial Orthop 2003;123:653-6. https://doi.org/10.1016/s0889-5406(03)00197-5

 ISSN (Paper)-1994-697X (Online)-2706-722X

Toumelin-Chemla F, Roulle F, Burdairon G. Corrosive properties of fluoride containing odontologic gels against titanium. J Dent 1996;24:109-15. https://doi.org/10.1016/0300-5712(95)00033-x
Toms AP. The corrosion of orthodontic wire.Eur J Orthod 1988;10:87-97 https://doi.org/10.1093/ejo/10.2.87

Burstone CJ. Variable Modulus Orthodontics. Am J Orthod 1981;80:1-16 https://doi.org/10.1016/0002-9416(81)90192-5

Kusy, R. P., & Whitley, J. Q. (1997, September). Friction between different wire-bracketconfigurations and materials. In *Seminars in orthodontics* (Vol. 3, No. 3, pp. 166-177). WB Saunders https://doi.org/10.1016/s1073-8746(97)80067-9

Ho, K. S., & West, V. C. (1991). Friction resistance between edgewise brackets and archwires. Australian orthodontic journal, 12(2), 95-99. https://doi.org/10.5005/jp-journals-10024-1015

Keith, O., Jones, S. P., & Davies, E. H. (1993). The influence of bracket material, ligation force and wear on frictional resistance of orthodontic brackets. British journal of orthodontics, 20(2), 109-115. https://doi.org/10.1179/bjo.20.2.109

Kao, C. T., Ding, S. J., Wang, C. K., He, H., Chou, M. Y., & Huang, T. H. (2006). Comparison of frictional resistance after immersion of metal brackets and orthodontic wires in a fluoride-containing prophylactic agent. *American Journal of Orthodontics and Dentofacial Orthopedics*, *130*(5), 568-e1. https://doi.org/10.1016/j.ajodo.2005.09.028
Geramy, A., Hooshmand, T., & Etezadi, T. (2017). Effect of sodium fluoride mouthwash on the frictional resistance of orthodontic wires. Journal of Dentistry (Tehran, Iran), 14(5), 254. http://www.ncbi.nlm.nih.gov/pmc/articles/pmc5748452/

Alavi, S., & Farahi, A. (2011). Effect of fluoride on friction between bracket and wire. *DentalResearchJournal*, *8*(Suppl1),S37.
http://www.ncbi.nlm.nih.gov/pmc/articles/pmc3556283/

Krishnan, V., & Kumar, K. J. (2004). Mechanical properties and surface characteristics of three archwire alloys. The Angle Orthodontist, 74(6), 825-831. https://doi.org/10.1043/0003-3219(2004)074%3C0825:mpasco%3E2.0.co;2

Vijayalakshmi, R. D., Nagachandran, K. S., Kummi, P., & Jayakumar, P. (2009). A comparative evaluation of metallurgical properties of stainless steel and TMA archwires with timolium and titanium niobium archwires-An in vitro study. *Indian Journal of Dental Research*, *20*(4), 448. https://doi.org/10.4103/0970-9290.59450

Juvvadi, S. R., Kailasam, V., Padmanabhan, S., & Chitharanjan, A. B. (2010). Physical, mechanical, and flexural properties of 3 orthodontic wires: an in-vitro study. *American journal of orthodontics and dentofacial orthopedics*, *138*(5), 623-630. https://doi.org/10.1016/j.ajodo.2009.01.032

Kapila, S., Angolkar, P. V., Duncanson Jr, M. G., & Nanda, R. S. (1990). Evaluation of friction between edgewise stainless steel brackets and orthodontic wires of four alloys. *American Journal of Orthodontics and Dentofacial Orthopedics*, *98*(2), 117-126. https://doi.org/10.1016/0889-5406(90)70005-w

Rajendran, A., Sundareswaran, S., Peediyekkal, L. V., Santhakumar, P., & Sathyanadhan, S. (2019). Effect of oral environment and prescribed fluoride mouthwashes on different types of TMA wires–An in-vivo study. *journal of orthodontic science*, *8*. https://doi.org/10.4103/jos.jos_72_18

Belasic, T. Z., Pejova, B., Curkovic, H. O., Kamenar, E., Cetenovic, B., & Spalj, S. (2021). Influence of intraoral application of antiseptics and fluorides during orthodontic treatment on corrosion and mechanical characteristics of nickel-titanium alloy in orthodontic appliances. *The Angle Orthodontist*, *91*(4), 528-537. https://doi.org/10.2319/052620-480.1

Pulikkottil, V. J., Chidambaram, S., Bejoy, P. U., Femin, P. K., Paul, P., & Rishad, M. (2016). Corrosion resistance of stainless steel, nickel-titanium, titanium molybdenum alloy, and ion-implanted titanium molybdenum alloy archwires in acidic fluoride-containing artificial saliva: An in vitro study. *Journal of pharmacy & bioallied sciences*, *8*(Suppl 1), S96. https://doi.org/10.4103/0975-7406.192032

Balakrishnan, R., Jeri, S. Y., Rekha, V. R., Singh, G. B., Deepak, P. R., & Nair, A. (2021). Evaluation of the effect of different types of fluoride on tensile properties and surface roughness of different titanium-based archwires: An In vivo study. Journal of Pharmacy & Bioallied Sciences, 13(Suppl 2), S1193. https://doi.org/10.4103%2Fjpbs.jpbs_341_21

Alavi, S., Barooti, S., & Borzabadi-Farahani, A. (2015). An in vitro assessment of the mechanical characteristics of nickel-titanium orthodontic wires in Fluoride solutions with different acidities. *Journal of orthodontic science*, *4*(2), 52.https://doi.org/10.4103%2F2278-0203.156030

Bednar, J. R., Gruendeman, G. W., & Sandrik, J. L. (1991). A comparative study of frictional forces between orthodontic brackets and arch wires. *American Journal of Orthodontics and Dentofacial Orthopedics*, *100*(6), 513-522.https://doi.org/10.1016/0889-5406(91)70091-A

Geramy, A., Hooshmand, T., & Etezadi, T. (2017). Effect of sodium fluoride mouthwash on the frictional resistance of orthodontic wires. *Journal of Dentistry (Tehran, Iran)*, *14*(5), 254. https://pubmed.ncbi.nlm.nih.gov/29296110
Graber, L. V. (2011). R; and Vig, K. *Orthodontics: Current Principles and Techniques. 5th ed: Elsevier*.

House, K., Sernetz, F., Dymock, D., Sandy, J. R., & Ireland, A. J. (2008). Corrosion of orthodontic appliances—should we care?. *American journal of orthodontics and dentofacial orthopedics*, *133*(4), 584-592. https://doi.org/10.1016/j.ajodo.2007.03.021

Juvvadi, S. R., Kailasam, V., Padmanabhan, S., & Chitharanjan, A. B. (2010). Physical, mechanical, and flexural properties of 3 orthodontic wires: an in-vitro study. *American journal of orthodontics and dentofacial orthopedics*, *138*(5), 623-630. https://doi.org/10.1016/j.ajodo.2009.01.032

Kao, C. T., Ding, S. J., Wang, C. K., He, H., Chou, M. Y., & Huang, T. H. (2006). Comparison of frictional resistance after immersion of metal brackets and orthodontic wires in a fluoride-containing prophylactic agent. *American Journal of Orthodontics and Dentofacial Orthopedics*, *130*(5), 568-e1. https://doi.org/10.1016/j.ajodo.2005.09.028

Ehrami, E., Omrani, A., & Feizbakhsh, M. (2022). Effects of Two Fluoride Mouthwashes on Surface Topography and Frictional Resistance of Orthodontic Wires. *Frontiers in Dentistry*, *19*. https://doi.org/10.18502%2Ffid.v19i21.9968

Kapila, S., Angolkar, P. V., Duncanson Jr, M. G., & Nanda, R. S. (1990). Evaluation of friction between edgewise stainless steel brackets and orthodontic wires of four alloys. *American Journal of Orthodontics and Dentofacial Orthopedics*, *98*(2), 117-126. https://doi.org/10.1016/0889-5406(90)70005-W

ISSN (Paper)-1994-697X (Online)-2706-722X

Keith, O., Jones, S. P., & Davies, E. H. (1993). The influence of bracket material, ligation force and wear on frictional resistance of orthodontic brackets. *British journal of orthodontics*, *20*(2), 109-115. https://doi.org/10.1179/bjo.20.2.109

Kim, H., & Johnson, J. W. (1999). Corrosion of stainless steel, nickel-titanium, coated nickel-titanium, and titanium orthodontic wires. *The Angle Orthodontist*, *69*(1), 39-44. https://doi.org/10.1043/0003-3219(1999)069%3C0039:COSSNT%3E2.3.CO;2

Krishnan, V., & Kumar, K. J. (2004). Mechanical properties and surface characteristics of three archwire alloys. *The Angle Orthodontist*, *74*(6), 825-831. https://doi.org/10.1043/0003-3219(2004)074%3C0825:MPASCO%3E2.0.CO;2

Pulikkottil, V. J., Chidambaram, S., Bejoy, P. U., Femin, P. K., Paul, P., & Rishad, M. (2016). Corrosion resistance of stainless steel, nickel-titanium, titanium molybdenum alloy, and ion-implanted titanium molybdenum alloy archwires in acidic fluoride-containing artificial saliva: An in vitro study. *Journal of pharmacy & bioallied sciences*, *8*(Suppl 1), S96. https://pubmed.ncbi.nlm.nih.gov/27829756

Rajendran, A., Sundareswaran, S., Peediyekkal, L. V., Santhakumar, P., & Sathyanadhan, S. (2019). Effect of oral environment and prescribed fluoride mouthwashes on different types of TMA wires–An in-vivo study. *journal of orthodontic science*, *8*. https://doi.org/10.4103%2Fjos.JOS_72_18

Toumelin-Chemla, F., Rouelle, F., & Burdairon, G. (1996). Corrosive properties of fluoride-containing odontologic gels against titanium. *Journal of dentistry*, *24*(1-2), 109-115. https://doi.org/10.1016/0300-5712(95)00033-X

Vijayalakshmi, R. D., Nagachandran, K. S., Kummi, P., & Jayakumar, P. (2009). A comparative evaluation of metallurgical properties of stainless steel and TMA archwires with timolium and titanium niobium archwires-An in vitro study. *Indian Journal of Dental Research*, *20*(4), 448. https://doi.org/10.4103/0970-9290.59450

Nahidh, M., Garma, N. M., & Jasim, E. S. (2017). Assessment of ions released from three types of orthodontic brackets immersed in different mouthwashes: An in vitro study. *The Journal of Contemporary Dental Practice*, *19*(1), 73-80. https://doi.org/10.5005/jp-journals-10024-2214

Al-Joubori, S. K., & Hashim, R. S. (2018). An In-vitro Study of the Load Deflection Characteristics of the Thermal Wires Immersed in Different Fluoride Prophylactic Agents. *HealthSciences*, *7*(4),1-5.https://www.researchgate.net/profile/Rawaa-Hashim/publication/337210628

Abd Awn, D. H., Al-Khatieeb, M. M., & Ghaib, N. H. (2007). The relation of load deflection of nickel titanium orthodontic wires and the application of different fluoride containing tooth paste (an in vitro study). *Journal of baghdad college of dentistry*, *19*(1). https://www.iasj.net/iasj/article/1362

Jasim, E. S., Garma, N. M., & Thyab, S. A. (2016). Comparative Assessment of In Vitro Effect of Three Fluoride Releasing Agents on Enamel Demineralization around Orthodontic Brackets. Journal of baghdad college of dentistry, 325(3500), 1-8. https://www.iasj.net/iasj/download/935903be3eff62f6

ISSN (Paper)-1994-697X (Online)-2706-722X