OSR
ORAL SCIENCES REPORTS

Review Article

Received: October 25, 2024
Revised: October 29, 2024
Accepted: November 12, 2024

Corresponding Author:
Darren Dhananthat Chawhuaveang,
Division of Pediatric Dentistry,
Faculty of Dentistry, Thammasat
University, Pathum Thani 12120,
Thailand
Email: dhanant@connect.hku.hk

Oral Sci Rep. 2024; 45(3): 39-44

Factors Influencing the Protective Effect of Salivary Pellicle Against Dental Erosion: A Concise Review

Darren Dhananthat Chawhuaveang[1,2], Awiruth Klaisiri[3], Nantawan Krajangta[3], Ollie Yiru Yu[1]

[1]Division of Restorative Dental Sciences, Faculty of Dentistry, The University of Hong Kong, Hong Kong SAR, China
[2]Division of Pediatric Dentistry, Faculty of Dentistry, Thammasat University, Thailand
[3]Division of Restorative Dentistry, Faculty of Dentistry, Thammasat University, Thailand

Abstract

Dental erosion is the irreversible loss of dental hard tissue caused by chemical processes without bacteria involvement. Dental erosion prevalence has increased due to extensive consumption of acidic foods and drinks or suffering from gastrointestinal diseases. Salivary pellicle acts as a physical barrier that impedes direct contact between the tooth surface and erosive acids. Furthermore, it is a selectively permeable membrane that controls the diffusion of erosive acids to the tooth surface. Therefore, salivary pellicle can protect the tooth surface from erosive demineralization. The protective effect of salivary pellicle depends on the intraoral location, tooth substrate, thickness, formation time, composition, the pH level of erosive acids, and exposure time. This concise review aimed to provide an overview on factors influencing the protective effect of salivary pellicle against dental erosion.

Keywords: dental erosion, erosive acids, protective effect, salivary pellicle

Introduction

Dental erosion is the dissolution of dental hard tissue by chemical processes due to intrinsic and extrinsic acids without bacterial involvement.[1-3] It causes tooth hypersensitivity, discomfort, imperfect aesthetic of tooth, alteration in tooth shape, and loss of function.[4,5] The prevalence of dental erosion has significantly increased.[6] It is a consequence of extensive consumption of acidic foods and drinks or suffering from gastrointestinal diseases.[4-6]

The salivary pellicle is an important protective factor against dental erosion.[7] It is a thin proteinaceous film that covers the tooth surface.[1] It forms immediately after the exposure of the tooth surface to oral fluids.[8] The salivary pellicle consists of adsorbed salivary proteins, lipids, and carbohydrates.[4,7] The salivary pellicle lubricates the teeth during mastication and speech due to adsorbed salivary proteins such as mucin.[7,9] It is crucial to serve as a lubricant between teeth and other oral structures.[6,7,10] It reduces their friction coefficient.[7,11] Consequently, the lubrication function of the salivary pellicle could reduce tooth wear.[7,11] Besides, the saliva pellicle maintains mineral homeostasis by interacting with various types of saliva.[9,11] It ensures that the calcium concentration on the tooth surface remains a supersaturated state, thus preventing the dissolution of the tooth surface.[7,9,11] Moreover, calcium-binding proteins within the salivary pellicle inhibit the excessive precipitation of calcium and phosphate.[4,7,9,11]

Another important function of the salivary pellicle is protecting the tooth surface from erosive demineralization by serving as a barrier and inhibiting direct contact between erosive acids and the tooth surface.[12,13] The salivary pellicle is a selectively permeable membrane that regulates the acid diffusion rate and modifies the transportation of calcium ion, phosphate ion, and proton.[1,2,14] Thus, it could delay the dissolution rate of the tooth surface from erosive demineralization.[15] Furthermore, the salivary pellicle maintains the level of calcium and phosphate ions between saliva and the tooth surface.[14] These ions can diffuse freely among the salivary pellicle, saliva, and the tooth surface.[16] Consequently, the salivary pellicle plays a crucial role in maintaining the equilibrium between erosive demineralization and remineralization on the tooth surface.[12]

It should be noted that salivary pellicle alone may not have sufficient protective effect.[7] The protective effect of the salivary pellicle depends on many factors such as its intraoral location, tooth substrate, thickness, formation time, composition, pH level of erosive acids, and exposure time of erosive acids.[7,15,17,18] Understanding the role of these factors is beneficial to increase the protective effect of salivary pellicle in preventing dental erosion.[7,19] Therefore, this concise review aimed to provide an overview on factors influencing the protective effect of salivary pellicle against dental erosion.

Protective effect of salivary pellicle in the literature

The literature search of this concise review was conducted on three databases, EMBASE, PubMed, and Scopus, to recruit articles published between 1 January 2000 and 30 September 2024. The keywords used in the search were ("Salivary pellicle" OR "Acquired salivary pellicle" OR "Acquired enamel pellicle" OR "Acquired dentin pellicle") AND "Protection" OR "Protective effect*" OR "Anti-erosion" OR "Anti-erosive") AND ("Tooth erosion" OR "Dental erosion" OR "Eroded" OR "Erosive lesion" OR "Erosive tooth wear"). The inclusion criteria were (i) studies that assessed the protective effects of salivary pellicle and (ii) studies published between 1 January 2000 and 30 September 2024. The exclusion criteria were (i) studies on another type of tooth loss such as attrition, abrasion, and abfraction, (ii) studies of the protective effects of a salivary pellicle in animal study, (iii) studies on the anti-erosive effect of topical anti-erosive agents, (iv) studies on mucosal pellicle or whole saliva or dental plaque, (v) studies on restorative materials, and (vi) studies published in not English language. Figure 1 shows a flowchart of our systemic search of this concise review.

Factors influencing the protective effect of salivary pellicle against dental erosion

Intraoral location of salivary pellicle

The intraoral location of the salivary pellicle relates to the salivary gland.[20-22] Different salivary glands influence the composition, thickness, and protective effect of the salivary pellicle. Parotid salivary glands mainly secrete amylase and proline-rich proteins (PRPs).[20] It produces serous saliva, which contains more fluid composed of water and proteins.[23] The serous saliva has a high

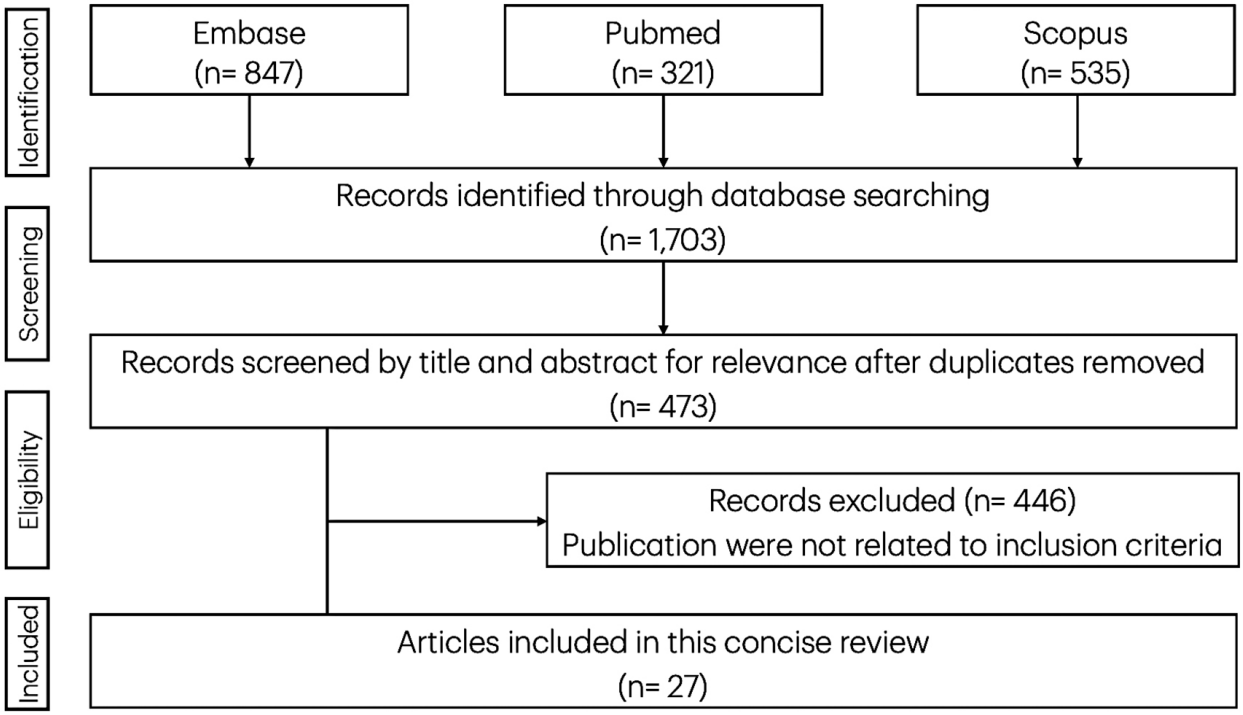

Figure 1: Flowchart summarizing the reference selection process.

buffering capacity.[23] Meanwhile, sublingual salivary glands mainly secrete mucins and lysozymes.[20] It produces mucous saliva, which contains high glycoprotein mucin.[23] The mucous saliva has a high flow rate and low buffering capacity.[23] Therefore, salivary pellicle derived from mucous saliva is easy to dissolve and has less protective effect.[20,23] In addition, the occlusal surface of posterior teeth and the incisal edge of anterior teeth are covered by salivary pellicle originating from mucous saliva.[23] Consequently, these surfaces have been reported as prone to dental erosion.[23] Moreover, the salivary pellicle at the area of mixed sublingual and submandibular salivary glands has a high level of mucins.[24] It can provide high protective effect against dental erosion.[24] It should be noted that the protective effect of intraoral location of salivary pellicle in previous studies was inconsistent and inconclusive, depending on the study design and methodology.[20,23,25]

Tooth substrate

Some studies reported that salivary enamel pellicle provided a superior protective effect than the salivary dentine pellicle.[12,22,26] Moreover, the salivary enamel pellicle exhibited a twofold protective effect compared to the salivary dentine pellicle.[26] It would be that during salivary dentine pellicle formation, adsorbed salivary proteins attach to either the dentine surface or dentinal tubule.[27] Dentinal tubular fluids may interfere with the formation of the salivary dentine pellicle.[27] Furthermore, numerous enzymes within the dentine structure, including matrix metalloproteinases and other proteolytic enzymes, can be released into the surrounding area following erosive acids attack.[12] These enzymes cause proteolytic activity of the adsorbed salivary proteins, potentially resulting in the dislodgment of the salivary pellicle.[12]

Thickness of salivary pellicle

The intraoral location of the salivary pellicle and type of salivary glands in the oral cavity influence its thickness.[12,27] The thickness of the salivary pellicle on the buccal site at the maturation stage is thicker than the palatal site.[6] Salivary pellicle near salivary duct openings is thinner.[27] The salivary pellicle on the lingual surface of the lower teeth is the thickest.[12] On the contrary, the salivary pellicle on the palatal surface of the upper teeth is the thinnest.[12] Furthermore, at the same intraoral location, the thicker salivary pellicle has a greater protective effect against dental erosion than the thinner salivary pellicle.[15]

Formation time of salivary pellicle

It takes 60-120 minutes for the salivary pellicle to reach the maturation stage of formation time.[6,12] Many *in situ* studies have investigated the protective effect of different formation times of salivary pellicle.[1,6,20,28] The results showed no significant differences in the protective effect of salivary pellicle with the formation time of 3 minutes, 30 minutes, 1 hour, and 2 hours.[1,6,20,28] Remarkably, even a salivary pellicle that formed in just 3 minutes was effective in protecting the tooth from dental erosion.[1] Nevertheless, another study showed that the salivary pellicle formed at a short-term was more soluble and rapidly dissolved during acidic demineralization.[14] Consequently, the salivary pellicle formed in 2 hours, effectively supported its maximum anti-erosive properties.[1,7] Notably, previous studies showed inconsistent results of the protective effect of various formation times of salivary pellicle.[6,12,14,25] Hence, further study is required to confirm its thickness and the protective effect of the salivary pellicle.

Composition of salivary pellicle

Adsorbed salivary proteins are a critical factor in the protective effect of the salivary pellicle.[22,29] Previous studies reported that the composition of salivary pellicle in dental erosion patients differed significantly from healthy volunteers.[11,15] The level of total proteins, statherin, and calcium-binding proteins in the salivary pellicle of dental erosion patients was reduced.[11,30] These proteins are acid-resistant proteins, maintain calcium and phosphate ions on the tooth surface, and have a strong adsorption capability to hydroxyapatite of tooth structure.[1,16] Hence, the salivary pellicle from dental erosion patients had a less protective effect than normal salivary pellicle from healthy volunteers.[11,15,30] However, the levels of mucins, albumin, and carbonic anhydrase were not significantly different in dental erosion patients and healthy volunteers.[4,11,15] In addition, lipids components such as phospholipids and fatty acids influence the composition and ultrastructure of salivary pellicle.[30,31] It also has an important role in the bioadhesion processes on the tooth surface.[31] Although phospholipids and fatty acids can modify the salivary pellicle, the study of lipids on the protective effect of the salivary pellicle is still limited.[31]

pH level of erosive acids

Erosive acids can demolish the outer layers of salivary pellicle during erosive challenge.[18] Consequently, the protective effect of salivary pellicle can significantly decrease with the increased acidity of acids.[18] The severity of salivary pellicle destruction depends on the pH level of erosive acids.[17,18] The pH of common commercial acidic beverages is approximately 2-3.[2] Carbonated drinks have a lower pH than fruit juices.[32] Carbonated drinks have tenfold more erosive potential than fruit juices.[17,32] Therefore, it can reduce salivary pellicle by half compare to fruit juices.[17] Notably, a low pH level of the acids with prolonged exposure time would synergistically diminish the protective effect of the salivary pellicle.[33]

The exposure time to erosive acids

Salivary pellicle counteracts erosive acids at the first second of exposure.[17] During the erosive challenge, the binding forces between the tooth surface and the salivary pellicle layer are decreased.[28,34] Adsorbed proteins of the salivary pellicle are detached, and the salivary pellicle is partially dislodged.[28,34] In addition, prolonged exposure time to erosive challenge can delay the re-organization and repair phases of the salivary pellicle.[28,34] Ultimately, prolonged exposure time results in a loss of structure and protective effect of the salivary pellicle.[18,34]

Modification of salivary pellicle against dental erosion

Modification of the salivary pellicle is an important concept to improve the protective effect of the salivary pellicle by altering the ultrastructure of the pellicle[35,36], modifying the composition of the pellicle[24], and promoting rehardening of the softened tooth surface by providing mineral contents from salivary pellicle.[37] To date, nutritional components such as casein in milk, polyphenolic compounds, lipophilic agents, fluoride, albumin, and xanthan gum have been investigated to modify salivary pellicle.

In preventive dentistry, modifying salivary pellicle could be developed to prevent and manage dental erosion.[19] Fluoride is the most common agent that has been investigated for modifying salivary pellicle against dental

erosion.[19] Sodium fluoride, stannous fluoride, amine fluoride, and silver diamine fluoride had a positively synergistic effect with salivary pellicle against dental erosion.[14,36,38,39] It could be explained that fluoride can be incorporated with the adsorbed salivary proteins during salivary pellicle formation.[36] After that, the composition of salivary pellicle may change properties to obtain more acid resistance.[40] The fluoride may facilitate the adsorption of adsorbed salivary proteins such as mucins and albumin on the tooth surface.[41,42] Furthermore, fluoride can increase the thickness of salivary pellicle on the surface.[36,40] Therefore, fluoride is a promising agent that enhances the protective effect of the salivary pellicle against dental erosion.

Conclusions

Salivary pellicle is a thin layer that covers all tooth surfaces. The salivary pellicle serves as a physical barrier to impede direct contact between erosive acids and the tooth surface. It is a semipermeable membrane that facilitates mineral ions diffusion. In addition, adsorbed salivary proteins, such as mucins, statherin, and PRPs in the salivary pellicle, contribute to its buffering capacity. The protective effect of salivary pellicle depends on two factors: 1) characteristics of the salivary pellicle, such as intraoral location, tooth substrate, thickness, formation time, and composition and 2) characteristics of erosive acids, such as pH level and exposure time. Therefore, these factors should be considered to enhance the protective effect of the salivary pellicle in preventing dental erosion. Future research should further investigate these factors to optimize the therapeutic applications of salivary pellicle in dental care.

References

1. Hannig M, Hannig C. The pellicle and erosion. Monogr Oral Sci. 2014;25:206-14.
2. Hannig C, Becker K, Häusler N, Hoth-Hannig W, Attin T, Hannig M. Protective effect of the *in situ* pellicle on dentin erosion–an *ex vivo* pilot study. Arch Oral Biol. 2007;52(5): 444-49.
3. Schlueter N, Amaechi Bennett T, Bartlett D, Buzalaf MAR, Carvalho TS, Ganss C, *et al*. Terminology of erosive tooth wear: consensus report of a workshop organized by the ORCA and the cariology research group of the IADR. Caries Res. 2020;54(1):2-6.
4. Mutahar M, O'Toole S, Carpenter G, Bartlett D, Andiappan M, Moazzez R. Reduced statherin in acquired enamel pellicle on eroded teeth compared to healthy teeth in the same subjects: an *in-vivo* study. PloS One. 2017;12(8):e0183660-e60.
5. Lussi A, Bossen A, Höschele C, Beyeler B, Megert B, Meier C, *et al*. Effects of enamel abrasion, salivary pellicle, and measurement angle on the optical assessment of dental erosion. J Biomed Opt. 2012;17(2):97009-1-097009-13.
6. Hannig M, Fiebiger M, Güntzer M, Döbert A, Zimehl R, Nekrashevych Y. Protective effect of the *in situ* formed short-term salivary pellicle. Arch Oral Biol. 2004;49(11):903-10.
7. Chawhuaveang DD, Yu OY, Yin IX, Lam WYH, Mei ML, Chu CH. Acquired salivary pellicle and oral diseases: a literature review. J Dent Sci. 2021;16(1):523-9.
8. Hannig M, Joiner A. The structure, function and properties of the acquired pellicle. Monogr Oral Sci. 2006;19:29-64.
9. Siqueira WL, Custodio W, McDonald EE. New insights into the composition and functions of the acquired enamel pellicle. J Dent Res. 2012;91(12):1110-8.
10. Delecrode TR, Siqueira WL, Zaidan FC, Bellini MR, Moffa EB, Mussi MC, *et al*. Identification of acid-resistant proteins in acquired enamel pellicle. J Dent. 2015;43(12):1470-5.
11. Carpenter G, Cotroneo E, Moazzez R, Rojas-Serrano M, Donaldson N, Austin R, *et al*. Composition of enamel pellicle from dental erosion patients. Caries Res. 2014;48(5):361-7.
12. Vukosavljevic D, Custodio W, Buzalaf MAR, Hara AT, Siqueira WL. Acquired pellicle as a modulator for dental erosion. Arch Oral Biol. 2014;59(6):631-8.
13. Hara AT, Zero DT. The potential of saliva in protecting against dental erosion. Monogr Oral Sci. 2014;25:197-205.
14. Mutahar M, Carpenter G, Bartlett D, German M, Moazzez R. The presence of acquired enamel pellicle changes acid-induced erosion from dissolution to a softening process. Sci Rep. 2017;7(1):10920-8.
15. Moazzez RV, Austin RS, Rojas Serrano M, Carpenter G, Cotroneo E, Proctor G, *et al*. Comparison of the possible protective effect of the salivary pellicle of individuals with and without erosion. Caries Res. 2014;48(1):57-62.
16. Baumann T, Bereiter R, Lussi A, Carvalho TS. The effect of different salivary calcium concentrations on the erosion protection conferred by the salivary pellicle. Sci Rep. 2017;7(1):12999.
17. Jensdottir T, Holbrook P, Nauntofte B, Buchwald C, Bardow A. Immediate erosive potential of cola drinks and orange juices. J Dent Res. 2006;85(3):226-30.
18. Stroici C, Daraba OM, Cojocariu AM, Bîrgaoanu A, Sachelarie L, Nazarie S. Protective role of acquired pellicle on enamel erosion. Int J Med Dent. 2012;2(4):272-5.
19. Chawhuaveang DD, Yu OY, Yin IX, Lam WYH, Chu CH. Topical agents for nonrestorative management of dental erosion: a narrative review. Healthcare. 2022;10(8):1413.
20. Hannig M, Balz M. Protective properties of salivary pellicles from two different intraoral sites on enamel erosion. Caries

Res. 2001;35(2):142-8.
21. Nekrashevych Y, Stösser L. Protective influence of experimentally formed salivary pellicle on enamel erosion. an *in vitro* study. Caries Res. 2003;37(3):225.
22. Wiegand A, Rosemann A, Hoch M, Barke S, Dakna M, Kanzow P. Erosion-protective capacity of the salivary pellicle of female and male subjects is not different. Caries Res. 2019;53(6):636-42.
23. Young WG, Khan F. Sites of dental erosion are saliva-dependent. J Oral Rehabil. 2002;29(1):35-43.
24. Ganss C, Lussi A, Schlueter N. Insights in etiological factors and pathomechanisms, and current strategies for prevention and therapy. Am J Dent. 2012;25(6):351-64.
25. Schestakow A, Echterhoff B, Hannig M. Erosion protective properties of the enamel pellicle *in-situ*. J Dent. 2024;147:105103.
26. Wiegand A, Bliggenstorfer S, Magalhães AC, Sener B, Attin T. Impact of the *in situ* formed salivary pellicle on enamel and dentine erosion induced by different acids. Acta Odontol Scand. 2008;66(4):225-30.
27. Wetton S, Hughes J, West N, Addy M. Exposure time of enamel and dentine to saliva for protection against erosion: a study *in vitro*. Caries Res. 2006;40(3):213-17.
28. Hara AT, Ando M, González-Cabezas C, Cury JA, Serra MC, Zero DT. Protective effect of the dental pellicle against erosive challenges *in situ*. J Dent Res. 2006;85(7):612-6.
29. Cheaib Z, Lussi A. Impact of acquired enamel pellicle modification on initial dental erosion. Caries Res. 2011; 45(2):107-12.
30. Delecrode TR, Siqueira WL, Zaidan FC, Bellini MR, Leite AL, Xiao Y, *et al*. Exposure to acids changes the proteomic of acquired dentine pellicle. J Dent. 2015;43(5):583-8.
31. Reich M, Hannig C, Hannig M, Kümmerer K, Kensche A. The lipid composition of the *in situ* pellicle. Arch Oral Biol. 2022;142:105493.
32. Hannig C, Berndt D, Hoth Hannig W, Hannig M. The effect of acidic beverages on the ultrastructure of the acquired pellicle—an *in situ* study. Arch Oral Biol. 2009;54(6): 518-26.
33. Nekrashevych Y, Hannig M, Stösser L. Assessment of enamel erosion and protective effect of salivary pellicle by surface roughness analysis and scanning electron microscopy. Oral Health Prev Dent. 2004;2(1):5-11.
34. Brevik SC, Lussi A, Rakhmatullina E. A new optical detection method to assess the erosion inhibition by *in vitro* salivary pellicle layer. J Dent. 2013;41(1):428-35.
35. Finke M, Parker DM, Jandt KD. Influence of soft drinks on the thickness and morphology of *in situ* acquired pellicle layer on enamel. J. Colloid Interface Sci. 2002;251(2): 263-70.
36. Chawhuaveang DD, Lam WYH, Chu CH, Yu OY. The preventive effect of silver diamine fluoride-modified salivary pellicle on dental erosion. Dent Mater. 2024. 29:S0109-5641(24)00306-3. doi: 10.1016/j.dental.2024.10.014.
37. Aykut Yetkiner A, Wiegand A, Attin T. The effect of saliva substitutes on enamel erosion *in vitro*. J Dent. 2014;42(6):720-25.
38. Kensche A, Kirsch J, Mintert S, Pötschke S, Basche S, König B, *et al*. Impact of customary fluoride rinsing solutions on the pellicle's protective properties and bioadhesion *in situ*. Sci Rep. 2017;7(1):16584-11.
39. Kensche A, Buschbeck E, König B, Koch M, Kirsch J, Hannig C, *et al*. Effect of fluoride mouthrinses and stannous ions on the erosion protective properties of the *in situ* pellicle. Sci Rep. 2019;9(1):5336-10.
40. Carvalho TS, Pham K, Rios D, Niemeyer S, Baumann T. Synergistic effect between plant extracts and fluoride to protect against enamel erosion: an *in vitro* study. PloS One. 2022;17(1):0277552. doi: 10.1371/journal.pone.0277552.
41. Algarni AA, Mussi MCM, Moffa EB, Lippert F, Zero DT, Siqueira WL, *et al*. The impact of stannous, fluoride ions and its combination on enamel pellicle proteome and dental erosion prevention. PloS One. 2015;10(6):0128196. doi: 10.1371/journal.pone.0128196.
42. Siqueira WL, Bakkal M, Xiao Y, Sutton JN, Mendes FM. Quantitative proteomic analysis of the effect of fluoride on the acquired enamel pellicle. PloS One. 2012;7(8):e42204. doi: 10.1371/journal.pone.0042204.