Disinfectants to Clean Thermoplastic Polymeric Appliances in Orthodontics

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Chemical disinfectants can use corrosion of the thermoplastic appliances and change in color, resulting in shorter service life. It is difficult to determine the optimum disinfection time interval of chemical disinfectants, and most often, the treatments are not aligned with the consumer use patterns, making it difficult in regard to cleaning patterns.

chemical disinfectant clear aligner clear retainer

1. Introduction

The demands for esthetic treatment outcomes have recently increased [1], and the use of esthetic appliances during treatments has also extended. These have led the manufacturers to develop systems that are appealing to the patients, with an underlying goal of reducing appliance visibility [2]. Clear aligners gradually move teeth into an ideal position through computerized technology while minimizing microbial risk [3][4], dental trauma, and root resorption [5]. The orthodontic aligner protocol consists of 20–24 h of use, removal during meals, and brushing before re-wearing [4]. Similar instructions apply to thermoplastic clear retainers, a type of removable appliance that has grown in popularity due to its esthetic and translucency [6][7][8]. Wearing for a long time helps reduce relapse, while relapses can be influenced by a variety of factors [9][10].

Some studies on thermoplastic orthodontic appliances (TOA) revealed an increase in *S. mutans* and *Lactobacillus* spp. [11]. Alshatti [12] mentioned that the incidence and severity of white spot lesions were not significantly different among clear aligners, self-ligating brackets, and conventional brackets. On the other hand, it is reported that patients showed severe gingival inflammation and tooth decay after 4 months of eating and drinking without cleaning the appliance [13]. Thus, cleaning/disinfection of TOAs is important to maintain oral health and hygiene. For the chemical cleaning of prostheses or appliances, a variety of cleaning tablets are available, most of which are peroxide-generating in nature. These tablets are used in several studies [14][15][16] and are one of the most used remedies. Axe et al. [17] discovered various other household products used in different parts of the world for removable appliance cleaning/disinfection, with many such regimens recommended by dentists, prosthodontists, orthodontists, and other dental health care professionals. Over-the-counter mouthwashes, liquid hand soaps, vinegar, dishwashing detergents, salt, bicarbonate of soda, and plain water are examples of such products. Among various disinfectants, chlorhexidine has gained popularity [18] and is easy to use and has a pleasant smell. Corega®, Kukis®, Retainer Brite®, Invisalign Cleaning-Crystal Solution, etc. are examples and are available in the market. However, chlorhexidine can cause staining and unfavorable taste.

Clear intraoral appliances are disinfected using a variety of cleaning procedures and chemicals, although the efficacy of these methods and chemicals remains debatable.

2. Transparent Orthodontic Appliance Material

The types of materials used in the nine selected articles differ, and this may affect the adherence quantity and accumulation of the intraoral microorganism. It may have an impact on the performance of both physical and chemical cleaning methods because certain materials may contain niches that benefit the hidden bacteria. Low et al. (2010) also discovered that fingerprint patterns of polyurethane, the main ingredient in Invisalign, benefit the initial biofilm formation, whether coccal or rod species [19]. Aside from that, the polycarbonate-based material was found to be stainless steel than the polyurenate-based material [20]. Furthermore, intraoral use may alter surface morphology and change chemical and mechanical properties [21] as a result of an increase in colonization rate.

3. Changes in Physical Properties

The physical properties of the materials used are critical for establishing a successful orthodontic treatment, both in terms of tooth movement and retention, because mechanical or chemical cleaning may cause scratching on a material surface. According to a study that used different types of chemical cleaners for 6 consecutive months, Retainer Brite® could most effectively affect surface roughness when synthesizing an Essix C+ retainer made of polypropylene/ethylene. Furthermore, the presence of 3% hydrogen peroxide can alter flexural modulus [22]. Studies on polyurethane found that Invisalign® cleaning crystal, Polident®, and Listerine® can cause the most changes in light transmittance. However, there is no article concerning changes in physical properties.

4. Chemical Disinfectant

Brushing is widely accepted as a method of cleaning removable appliances, according to the Dental Professional Recommendation, even though brushing with or without toothpaste can still increase surface roughness [23]. There is currently no gold standard for cleaning dentures or removable orthodontic appliances, and mechanical cleaning alone cannot completely remove cariogenic and periodontal pathogens. In addition, wearing a full cuspal coverage intraoral appliance for nearly 24 h a day can reduce salivary flow and enhance the protective cover for bacteria. As such, an included chemical should help decrease pathogens, despite Albanna et al. [24] reporting that mechanical brushing has no effect when compared to its chemical counterpart. However, in an ACC group, CHX mouthwash was shown to acquire a more unique ability than other disinfectants, as CHX is a cationic compound that has been shown to bind to salivary proteins through electrostatic interactions, and if the retainer is immersed in CHX mouthwash for a certain time, CHX [18] can disinfect as well as prevent bacterial colonization. Nevertheless, there has been no research on the maximum bactericidal concentration (MBC) of ACC group products to determine if they are suitable for (denture) cleaning.

For vinegar or acetic acid, when bacteria are exposed to low-acidity acids, they are more susceptible than they would otherwise be, and this has long been recognized. They are considered to have several mechanisms for causing toxicity. Because of the balance between their ionized and non-ionized forms, weak acids may permeate bacterial membranes more easily than strong acids. The non-ionized form can freely diffuse across hydrophobic membranes [25]. Consequently, liberated anions (in this case, acetate) tend to collapse the proton gradients required for ATP synthesis because they interact with the electron transport chain-pumped out periplasmic protons and shuttle them across the membrane again without passing through F1Fo ATP synthetase. Acid-induced protein unfolding and membrane and DNA damage may occur because the cell's internal pH (usually around pH 7.6 [26][27] in neutralophilic bacteria) is greater than the external acid solution's pH (normally around pH 5.8). As a distinct source of toxicity, the anion generated by this mechanism is the result of a range of events, including osmotic stress on the cell. As a result, different weak acids at the same pH can have a wide range of toxic effects on cells, depending on the anion's nature, which is known but not fully understood [28][29][30].

Most OCC products contain a sulfate or carbonate group, which are alkalizing agents that aid in pH buffering. It can be hypothesized that variations in the effectiveness of appliance plaque removal by two chemical methods are due to their different mechanism of action. As an active gradient, sodium perborate is used in the cleaning tablet. Sodium perborate buffers H_2O_2 to a pH of about 10 in a saturated aqueous solution. Oxygen is liberated during the oxidation of H_2O_2. The effervescing action of the cleaner solutions is thought to be related to the evolved O_2, which is supposed to have a mechanical cleaning effect [31]. Different materials are used to make various products. The citric acid in a cleaning tablet, for example, reacts with sodium bicarbonate to form washing soda, which is ideal for removing biofilm from material surfaces.

5. Microbial Reduction Evaluation

There are several options for measuring bacteria reduction based on the data collected. One of the most fundamental methods in bacteria count or colony count, which can only measure actual bacteria when a concentration of harvested bacteria is diluted to the point where the separation of colonies is visible and thus countable. Another indirect technique measurement, namely the optical density at 595 mm, is simple and quick, whereas a required step of staining with violet, or other alternatives, may cause dye stains on the extracellular matrix or thermoplastic material due to surface roughness. As a result, this method cannot be used to measure microorganisms directly. Another study using SEM to examine the decreasing density of bacteria can only present qualitative data, not quantitative data [32]. Furthermore, neither of the options can distinguish between dead and live pathogens. A study found that using the LIVE/DEAD BacLight Bacterial Viability Kit (Life Technologies, Switzerland) in conjunction with flow cytometry and a confocal microscope can show both dead and live bacteria as well as quantitative data [33]. Using two or more evaluation methods can lead to more accurate results. The downside of crystal violet staining is that both living and dead bacteria, including extracellular polymeric substances (EPS) [34][35], are slimes composed mainly of polysaccharides, proteins, and DNA and biosynthesized by several strains of microorganisms. LIVE/DEAD staining, a kind of fluorescence stain, can reduce the weakness of crystal violet, which can confirm the live and dead bacteria.

References

1. Rokaya, D.; Kitisubkanchana, J.; Wonglamsam, A.; Santiwong, P.; Srithavaj, T.; Humagain, M. Nepalese esthetic dental (ned) proportion in nepalese population. Kathmandu Univ. Med. J. 2015, 13, 244–249.
2. Hirani, S.; Patel, U.; Patel, N. Invisible orthodontics—A review. IOSR J. Dent. Med. Sci. 2016, 15, 56–62.
3. Harradine, N.W. Self-ligating brackets: Where are we now? J. Orthod. 2003, 30, 262–273.
4. Lagravere, M.O.; Flores-Mir, C. The treatment effects of Invisalign orthodontic aligners: A systematic review. J. Am. Dent. Assoc. 2005, 136, 1724–1729.
5. Kalra, S.; Gupta, P.; Tripathi, T.; Rai, P. External apical root resorption in orthodontic patients: Molecular and genetic basis. J. Fam. Med. Prim. Care 2020, 9, 3872–3882.
6. Mai, W.; Meng, H.; Jiang, Y.; Huang, C.; Li, M.; Yuan, K.; Kang, N. Comparison of vacuum-formed and Hawley retainers: A systematic review. Am. J. Orthod. Dentofac. Orthop. 2014, 145, 720–727.
7. Singh, P.; Grammati, S.; Kirschen, R. Orthodontic retention patterns in the United Kingdom. J. Orthod. 2009, 36, 115–121.
8. Hichens, L.; Rowland, H.; Williams, A.; Hollinghurst, S.; Ewings, P.; Clark, S.; Ireland, A.; Sandy, J. Cost-effectiveness and patient satisfaction: Hawley and vacuum-formed retainers. Eur. J. Orthod. 2007, 29, 372–378.
9. Littlewood, S.J.; Millett, D.T.; Doubleday, B.; Bearn, D.R.; Worthington, H.V. Orthodontic retention: A systematic review. J. Orthod. 2006, 33, 205–212.
10. Melrose, C.; Millett, D.T. Toward a perspective on orthodontic retention? Am. J. Orthod. Dentofac. Orthop. 1998, 113, 507–514.
11. Türköz, Ç.; Bavbek, N.C.; Varlik, S.K.; Akça, G. Influence of thermoplastic retainers on Streptococcus mutans and Lactobacillus adhesion. Am. J. Orthod. Dentofac. Orthop. 2012, 141, 598–603.
12. Alshatti, H. Comparison of White Spot Lesions among Clear Aligners, Self-Ligating Brackets and Conventional Brackets—A Randomized Controlled Clinical Trial; University of Connecticut: Storrs, CT, USA, 2017.
13. Moshiri, M.; Eckhart, J.E.; Mcshane, P.; German, D.S. Consequences of poor oral hygiene during clear aligner therapy. J. Clin. Orthod. 2013, 8, 494–498.
14. Apratim, A.; Shah, S.S.; Sinha, M.; Agrawal, M.; Chhaparia, N.; Abubakkar, A. Denture hygiene habits among elderly patients wearing complete dentures. J. Contemp. Dent. 2013, 14, 1161.

15. Baran, I.; Nalçacı, R. Self-reported denture hygiene habits and oral tissue conditions of complete denture wearers. Arch. Gerontol. Geriatr. 2009, 49, 237–241.
16. Barreiro, D.M.; Scheid, P.A.; May, L.G.; Unfer, B.; Braun, K.O. Evaluation of procedures employed for the maintenance of removable dentures in elderly individuals. Oral Health Prev. Dent. 2009, 7, 243–249.
17. Axe, A.S.; Varghese, R.; Bosma, M.; Kitson, N.; Bradshaw, D.J. Dental health professional recommendation and consumer habits in denture cleansing. J. Prosthet. Dent. 2016, 115, 183–188.
18. Freitas, L.B.; Vassilakos, N.; Arnebrant, T. Interactions of chlorhexidine with salivary films adsorbed at solid/liquid and air/liquid interfaces. J. Periodontal Res. 1993, 28, 92–97.
19. Low, B.; Lee, W.; Seneviratne, C.J.; Samaranayake, L.P.; Hägg, U. Ultrastructure and morphology of biofilms on thermoplastic orthodontic appliances in ‘fast’ and ‘slow’ plaque formers. Eur. J. Orthod. 2011, 33, 577–583.
20. Liu, C.-L.; Sun, W.-T.; Liao, W.; Lu, W.-X.; Li, Q.-W.; Jeong, Y.; Liu, J.; Zhao, Z.-H. Colour stabilities of three types of orthodontic clear aligners exposed to staining agents. Int. J. Oral Sci. 2016, 8, 246–253.
21. Bakdach, W.M.M.; Haiba, M.; Hadad, R. Changes in surface morphology, chemical and mechanical properties of clear aligners during intraoral usage: A systematic review and meta-analysis. Int. Orthod. 2022, 20, 100610.
22. Wible, E.; Agarwal, M.; Altun, S.; Ramir, T.; Viana, G.; Evans, C.; Lukic, H.; Megremis, S.; Atsawasuwan, P. Long-term effects of various cleaning methods on polypropylene/ethylene copolymer retainer material. Angle Orthod. 2019, 89, 432–437.
23. Kiesow, A.; Sarembe, S.; Pizzey, R.L.; Axe, A.S.; Bradshaw, D.J. Material compatibility and antimicrobial activity of consumer products commonly used to clean dentures. J. Prosthet. Dent. 2016, 115, 189–198.e188.
24. Albanna, R.H.; Farawanah, H.M.; Aldrees, A.M. Microbial evaluation of the effectiveness of different methods for cleansing clear orthodontic retainers: A randomized clinical trial. Angle Orthod. 2017, 87, 460–465.
25. Walter, A.; Gutknecht, J. Monocarboxylic acid permeation through lipid bilayer membranes. J. Membr. Biol. 1984, 77, 255–264.
26. Slonczewski, J.L.; Rosen, B.P.; Alger, J.R.; Macnab, R.M. pH homeostasis in Escherichia coli: Measurement by 31p nuclear magnetic resonance of methylphosphonate and phosphate. Proc. Natl. Acad. Sci. USA 1981, 78, 6271–6275.

27. Slonczewski, J.L.; Fujisawa, M.; Dopson, M.; Krulwich, T.A. Cytoplasmic pH measurement and homeostasis in bacteria and archaea. Adv. Microb. Physiol. 2009, 55, 1–79, 317.
28. Roe, A.J.; McLaggan, D.; Davidson, I.; O'Byrne, C.; Booth, I.R. Perturbation of anion balance during inhibition of growth of Escherichia coli by weak acids. J. Bacteriol. 1998, 180, 767–772.
29. Hirshfield, I.N.; Terzulli, S.; O'Byrne, C. Weak organic acids: A panoply of effects on bacteria. Sci. Prog. 2003, 86, 245–270.
30. Salmond, C.V.; Kroll, R.G.; Booth, I.R. The effect of food preservatives on pH homeostasis in Escherichia coli. Microbiology 1984, 130, 2845–2850.
31. Mueller, H.J.; Greener, E.H. Characterization of some denture cleansers. J. Prosthet. Dent. 1980, 43, 491–496.
32. Levrini, L.; Novara, F.; Margherini, S.; Tenconi, C.; Raspanti, M. Scanning electron microscopy analysis of the growth of dental plaque on the surfaces of removable orthodontic aligners after the use of different cleaning methods. Clin. Cosmet. Investig. Dent. 2015, 7, 125.
33. Manoil, D.; Filieri, A.; Gameiro, C.; Lange, N.; Schrenzel, J.; Wataha, J.C.; Bouillaguet, S. Flow cytometric assessment of Streptococcus mutans viability after exposure to blue light-activated curcumin. Photodiagnosis Photodyn. Ther. 2014, 11, 372–379.
34. Pantanella, F.; Valenti, P.; Natalizi, T.; Passeri, D.; Berlutti, F. Analytical techniques to study microbial biofilm on abiotic surfaces: Pros and cons of the main techniques currently in use. Ann. Ig. 2013, 25, 31–42.
35. Li, X.; Yan, Z.; Xu, J. Quantitative variation of biofilms among strains in natural populations of Candida albicans. Microbiology 2003, 149, 353–362.