

TEETH WHITENING AGENTS : A brief review

¹Dr. Priya Kasana, ²Dr. Puja Bansal, ³Dr. Deepak Bhargava, ⁴Dr. Ritu Sharma

¹Intern, ²Professor, ³Professor, ⁴Assistant Professor
School of Dental Sciences
Sharda University

Abstract: Tooth whitening has become one of the most frequently requested dental procedures by the people nowadays. The people have come to demand whiter teeth, more perfect smiles and aesthetics. People apart from dental problems like dental caries, periodontal problems, etc are more concerned about their dental esthetics in today's time. Tooth whitening procedures provide a conservative and effective means to improve dental esthetics. Frequently used whitening agents are abrasives, anti-redeposition agents (prevention of deposition of chromophores), colorants, proteases, peroxides, and surfactants (removal of hydrophobic compounds from tooth surface).

Keywords: teeth, enamel, abrasives, peroxides, toothpaste

Introduction: The mineral phase of human teeth consists of calcium phosphate in the form of hydroxyapatite, $\text{Ca}_5(\text{PO}_4)_3(\text{OH})$ [1]. Enamel, the outer part of a tooth, is a highly mineralized tissue containing about 97% hydroxyapatite in the form of micrometer-long needles that form a complex hierarchical organized microstructure [2][3].

The inner part of a tooth is called dentin, which is a protein-rich bone-like biocomposite containing about 70% hydroxyapatite with proteins (mainly collagen) and water forming the rest [4][5].

There are several different methods for teeth whitening, each with their own mechanism of action. These different methods depend on the particular tooth discoloration that is being treated.

Causes of tooth discoloration can be: **intrinsic staining and extrinsic staining.**

Intrinsic staining, can be due to factors such as genetics, age (from enamel wear over time exposing yellower dentin), antibiotics, high levels of fluoride (fluorosis), and developmental disorders. After eruption of the tooth some dental restorations can cause tooth staining like amalgam etc.

Extrinsic staining, sometimes called external staining, is largely due to smoking, pigments in food and beverages like soft drinks, coffee, tea etc, antibiotics, and metals such as iron or copper. An increasing number of oral care products also (sometimes mainly) focus on teeth whitening. This is due to cosmetic reasons, because many people prefer white teeth and a bright smile as it may also affect their quality of life [6][7].

Tooth whitening can be performed both by professionals in the dental practice ("in-office") and at home (over-the-counter; "OTC") by patients themselves. Chemically, bleaching with hydrogen peroxide (H_2O_2 ; H-O-O-H) or calcium peroxide (CaO_2 ; $\text{Ca}^{2+} \text{O-O}^-$) and related compounds are prominent options [8][9][10][11][12].

TYPES OF TEETH WHITENING SYSTEM:

Whitening systems can be variously categorized. The following approach is in accordance with the American Academy of Cosmetic Dentistry. [13]

- **Whitening toothpastes:**

Whitening toothpastes typically contain higher amounts of abrasives and detergents than standard toothpastes, to remove tougher stains. Whitening toothpastes do not contain bleach (sodium hypochlorite) but some contain low concentrations of carbamide peroxide or hydrogen peroxide that help lighten tooth colour. Whitening toothpastes typically can lighten tooth colour by about one or two shades.

- **Dental prophylaxis:**

Professional hygiene procedures and polishing are performed to eliminate extrinsic staining by use of an abrasive paste and a rubber cup on a slow speed rotary instrument. Extrinsic stains can influence tooth color assessment and it has been shown that performing dental prophylaxis has a positive effect on patients' perception of the whiteness of their teeth [14]

- **OTC PRODUCTS**

There are several available over the counter (OTC) tooth whitening agents that patients can purchase and apply independently. The percentage of bleaching agent contained within a product dictates whether the product can be made available over the counter. The allowed concentration varies among different jurisdictions and is governed by the respective regulatory bodies. The formulations for OTC tooth whitening agents are as follows, dentifrices, mouth rinses, intraoral strips, varnishes, gels and toothbrushes among others.

Historically, it has been demonstrated that the most effective component of whitening dentifrices has been abrasives. These act by eliminating and preventing the formation of extrinsic stains. [15][16].

OTC Whitening strips and gels deliver a thin layer of peroxide gel on plastic strips shaped to fit onto the buccal surfaces of the teeth. There are a variety of white strip products on the market with varying instructions. A typical set of instructions are to apply the strips twice daily for 30 minutes for 14 days. Tooth lightening can be seen in several days and this method can lighten the teeth by 1 or 2 shades. There are some newer whitening strip products that require only one 30-minute application per day that have the same whitening end point as the two-a-day products.

Whitening gels are peroxide-based gels applied with a small brush directly to the surface of the teeth. Manufacturer's instructions are usually twice a day application for 14 days. Like the whitening strips, the teeth can usually be lightened by 1 or 2 shades.

- **Whitening mouth rinses:**

Whitening mouth rinses containing a low concentration of hydrogen peroxide (1.5%) and sodium hexametaphosphate have been applied with moderate success [17]. Furthermore, mouth rinses do not contain any abrasives, i.e., the stain removal properties are generally inferior to a toothpaste.

- **Bleaching:**

The common chemicals used for dental bleaching are hydrogen peroxide and carbamide peroxide in varying concentrations. Carbamide peroxide is a stable chemical that reacts with water to release its active components (hydrogen peroxide and urea) while hydrogen peroxide is an unstable chemical that decomposes into water and reactive oxygen free radicals [18]

Bleaching agents may contain hydrogen peroxide as an active agent, glycerine as a carrier, carbopol as a thickening agent and a number of flavoring agents .[19][20]. Bleaching works by destroying one or more of the double bonds within the conjugated chain often through an oxidative process. [21]

IN-OFFICE BLEACHING

In office bleaching is performed under the direct supervision of a dentist. This typically involves application of a high concentrations of hydrogen peroxide (35-40%) for 15–20-minute periods over a 45-60-minute clinical session. This procedure can be repeated for multiple sessions until the desired whitening effect is achieved. Care must be taken to avoid contact of the bleaching agent with the soft tissues as this may be caustic [22].

Some in-office bleaching systems are marketed to be used with an activating light source that allegedly enhances the whitening effect. The light source theoretically produces heat that in turn accelerates the catalytic decomposition of the bleaching agent to form free oxygen radicals. The different sources of light include LEDs, lasers, Plasma Arc lamps and halogen lamps. A systematic review and meta-analysis was conducted to establish whether there were differences in the bleaching efficacy and tooth sensitivity of bleaching protocols performed with or without light using low and high hydrogen peroxide concentrations. It was found that light did not significantly increase colour change in delta E or Shade Guide Units. There was also no difference in tooth sensitivity between the two test groups though they did report high heterogeneity in the data [23]. A systematic review and meta-analysis of the literature to evaluate the influence of light on bleaching efficacy and tooth sensitivity during in-office bleaching found that light increases the risk of tooth sensitivity during in-office bleaching [24]. This review also found that light did not improve the bleaching effect when high concentrations of hydrogen peroxide (25–35%) were employed.

AT-HOME TRAY BLEACHING:

Night guard vital bleaching is indirectly supervised by the dentist but is administered at home by the patient. It is a widely used technique. This procedure entails application of low concentration of bleaching agents (10-20% carbamide peroxide which is the equivalent of 3.5-6.5% hydrogen peroxide) loaded into a customized bleaching tray. These trays are often worn overnight or 3-4 hours daily for a 2–6-week period [25].

At-home tray bleaching can also be performed accompanying orthodontic treatment by utilizing either Invisalign aligners or Vivera retainers as custom bleaching trays [26].

NON-VITAL BLEACHING

This procedure is indicated for intrinsically discoloured teeth that have undergone endodontic treatment.

In 1951, hydrogen peroxide was used for non-vital tooth bleaching [27]. Currently both carbamide peroxide and sodium perborate (mixed with distilled water or hydrogen peroxide) can be used for non-vital bleaching. Teeth indicated for non-vital bleaching should be asymptomatic with a good quality root filling.

RISKS ASSOCIATED WITH TEETH WHITENING:

Tooth whitening include increased risk of tooth sensitivity and gingival irritation. The degree of side effects depends on the concentration of the peroxide-bleach component, duration of the treatment, and the non-bleach composition of the product used. Tooth sensitivity usually occurs at the time of treatment and can last for several days.

Gingival irritation begins within a day of the treatment and can also last several days. There are additional risks that have been reported from *in vitro* studies which include tooth erosion, tooth mineral degradation, increased susceptibility to demineralization, and pulpal damage. [28]

Tooth whitening agents cause a number of adverse effects on the hardness of human enamel, making it more susceptible to deformation and fracture [29][30]. The oxidation process that the organic and inorganic components of enamel undergo when exposed to whitening agents. This leads to changes in enamel morphology by the development of porosities and micro-cracks, ultimately causing a reduction in hardness [31][32].

Enamel Surface Loss because many whitening agents have an acidic pH, creating an erosive environment, and contributing to the loss of enamel inorganic matter [33]

WHITENING STABILITY AND STAIN ABSORPTION:

Patients are advised to minimise or eliminate dietary components that may cause enamel staining before, during, and after any whitening treatment, and for that reason, investigations on the susceptibility of whitened enamel to staining have been abundantly reported. Whitened enamel has a higher tendency for stain absorption, when compared to un-whitened enamel [34]. teeth staining is strongly correlated to other factors like smoking, chlorhexidine, alcohol consumption.

Conclusion:

Aesthetic dentistry has evolved in relation to the high public demand in the golden era of 21st century. Aesthetic dentistry involves Teeth whitening, smile designing and other dental procedures. Teeth whitening depends on many factors, like the concentration or pH of the whitening agent, application, duration, chemical additives, and re-mineralising agents used. Teeth whitening can be achieved by several means like toothpaste, prophylaxis, bleaching and many more. Teeth whitening has potential risks such as sensitivity, irritation to gingiva, softening of enamel or loss of enamel hardness and enamel surface loss leading to discomfort to the

patients. Teeth whitening is a procedure which needs to be maintained after its done as teeth can get stained by dietary components, adverse habits like smoking and drinking alcohol, because whitened enamel has a higher tendency to take up stains.

References:

1. Dorozhkin S.V., Epple M. Biological and medical significance of calcium phosphates. *Angew. Chem. Int. Ed.* 2002;41:3130–3146.
2. Brown P.W., Constantz B. *Hydroxyapatite and Related Materials*. CRC Press; Boca Raton, FL, USA: 1994.
3. LeGeros R.Z. Apatites in biological systems. *Prog. Cryst. Growth Charact.* 1981;4:1–45. doi: 10.1016/0146-3535(81)90046-0.
4. Forien J.-B., Zizak I., Fleck C., Petersen A., Fratzi P., Zolotoyabko E., Zaslansky P. Water-mediated collagen and mineral nanoparticle interactions guide functional deformation of human tooth dentin. *Chem. Mater.* 2016;28:3416–3427. doi: 10.1021/acs.chemmater.6b00811.
5. Forien J.B., Fleck C., Cloetens P., Duda G., Fratzi P., Zolotoyabko E., Zaslansky P. Compressive residual strains in mineral nanoparticles as a possible origin of enhanced crack resistance in human tooth dentin. *Nano Lett.* 2015;15:3729–3734. doi: 10.1021/acs.nanolett.5b00143.
6. Meireles S.S., Goettems M.L., Dantas R.V., Bona A.D., Santos I.S., Demarco F.F. Changes in oral health related quality of life after dental bleaching in a double-blind randomized clinical trial. *J. Dent.* 2014;42:114–121. doi: 10.1016/j.jdent.2013.11.022.
7. Pavicic D.K., Kolceg M., Lajnert V., Pavlic A., Brumini M., Spalj S. Changes in quality of life induced by tooth whitening are moderated by perfectionism: A randomized, double-blind, placebo-controlled trial. *Int. J. Prosthodont.* 2018;31:394–396. doi: 10.11607/ijp.5499.
8. Joiner A. Whitening toothpastes: A review of the literature. *J. Dent.* 2010;38(Suppl. 2):e17–e24. doi: 10.1016/j.jdent.2010.05.017.
9. Viscio D., Gaffar A., Fakhry-Smith S., Xu T. Present and future technologies of tooth whitening. *Compend. Contin. Educ. Dent. Suppl.* 2000;21:S36–S43.
10. Carey C.M. Tooth whitening: What we now know. *J. Evid. Based Dent. Pract.* 2014;14:70–76. doi: 10.1016/j.jebdp.2014.02.006.
11. Joiner A., Hopkinson I., Deng Y., Westland S. A review of tooth colour and whiteness. *J. Dent.* 2008;36:S2–S7. doi: 10.1016/j.jdent.2008.02.001.
12. Demarco F.F., Meireles S.S., Masotti A.S. Over-the-counter whitening agents: a concise review. *Braz. Oral Res.* 2009;23(Suppl. 1):64–70
13. American Academy of Cosmetic Dentistry [assessed 01.06.14]; *Teeth Whitening*.
14. R Pereira, D Corado, J Silveira, R Alves, A Mata, D. Marques Dental prophylaxis influence in tooth color assessment—Clinical study *J Esthet Restor Dent*, 32 (6) (2020), pp. 586-592
15. CN Soares, FL Amaral, MF Mesquita, FM Franca, RT Basting, CP. Turssi
Toothpastes containing abrasive and chemical whitening agents: efficacy in reducing extrinsic dental staining
Gen Dent, 63 (6) (2015), pp. e24-e28
16. BG Casado, SL Moraes, GF Souza, CM Guerra, JR Souto-Maior, CA Lemos, *et al*Efficacy of dental bleaching with whitening dentifrices: a systematic review *Int J Dentist* (2018) 2018 Oct 30
17. Demarco F.F., Meireles S.S., Masotti A.S. Over-the-counter whitening agents: a concise review. *Braz. Oral Res.* 2009;23(Suppl. 1):64–70.
18. SL Ziemba, H Felix, J MacDonald, M. Ward Clinical evaluation of a novel dental whitening lamp and light-catalyzed peroxide gel *J Clin Dent*, 16 (4) (2005), pp. 123-127
19. ADA, Statement on the Safety and Effectiveness of Tooth Whitening Products, June (2002), p. 2008.
20. E Thickett, MT. Cobourne New developments in tooth whitening. The current status of external bleaching in orthodontics
J Orthod, 36 (3) (2009), pp. 194-201
21. M Howe-Grant editor
(4th ed.), *Encyclopedia of chemical technology*, 4, John Wiley and Sons, New York (1992), pp. 290-291
22. M Abdollahi, A. Hosseini
Hydrogen peroxide
Encyclopedia of Toxicology (2014), pp. 967-970
23. BM Maran, A Burey, T de Paris Matos, AD Loguercio, A. Reis In-office dental bleaching with light vs. without light: a systematic review and meta-analysis *J Dent*, 70 (2018), pp. 1-3
24. He LB, Shao MY, Tan K, Xu X, Li JY. The effects of light on bleaching and tooth sensitivity during in-office vital bleaching: a systematic review and meta-analysis. *J Dent.* 2012;40:644–653.
25. M. Sulieman An overview of bleaching techniques: 2. Night Guard Vital Bleaching and non-vital bleaching *Dent Update*, 32 (1) (2005), pp. 39-46
26. L Levrini, L Paracchini, R Bakaj, A Diaconu, S Cortese Dental bleaching during orthodontic treatment with aligners
Int J Esthetic Dent, 15 (1) (2020), pp. 44-54 P. H Successful bleaching without secondary discoloration
J Can Dent Assoc, 17 (4) (1951), pp. 200-201
27. Goldberg M, Grootveld M, Lynch E. *Undesirable and adverse effects of tooth-whitening products: a review.* 2010;14:1–10.
28. R.F. Lia Mondelli, T.R.C. Garrido Gabriel, F.A. Piola Rizzante, A.C. Magalhães, J.F. Soares Bombonatti, S.K. Ishikiriyama, Do Different Bleaching Protocols Affect the Enamel Microhardness?, *European Journal of Dentistry* 9(1) (2015) 25-30.

29. N. Akal, H. Over, A. Olmez, H. Bodur, Effects of Carbamide Peroxide Containing Bleaching Agents on the Morphology and Subsurface Hardness of Enamel, *Journal of Clinical Pediatric Dentistry* 25(4) (2001) 293-296.
30. K. Eva, M. Marijan, R. Mira, S. Ivan, P. Katica, T. Zrinka, Surface Changes of Enamel and Dentin after Two Different Bleaching Procedures, *Acta Clinica Croatica* 52(4.) (2013) 413-429.
31. L. Markovic, R.A. Jordan, N. Lakota, P. Gaengler, Micromorphology of Enamel Surface after Vital Tooth Bleaching, *Journal of Endodontics* 33(5) (2007) 607-10.
32. F.F. Demarco, S.S. Meireles, H.R. Sarmiento, R.V.F. Dantas, T. Botero, S.B.C. Tarquinio, Erosion and Abrasion on Dental Structures Undergoing at-Home Bleaching, *Clinical, Cosmetic and Investigational Dentistry* 3 (2011) 45-52.
33. M. Karadas, E. Tahan, S. Demirbuga, N. Seven, Influence of Tea and Cola on Tooth Color after Two in-Office Bleaching Applications, *Journal of Restorative Dentistry* 2(2) (2014) 83- 87