

Treatment of Dental Fluorosis with Cold Light Whitening

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Abstract. Dental fluorosis is a localized dental disease caused by excessive fluoride intake in childhood. It is characterized by chalky, brown patches or dark brown patches on enamel. The changes in the color and shape of the patient's teeth seriously affect the beauty and even cause psychological burden. To remedy it, a variety of therapeutic methods have been developed, and at present, cold light whitening technology is considered to be one of the most effective and relatively safe treatments. In this review, the etiology and pathogenesis of dental fluorosis, the mechanism of cold light whitening technology in the therapies of dental fluorosis, its effect on tooth surface structure and its therapeutic effect are summarized, and the latest progress in this field is summarized to provide a theoretical basis for clinicians.

Keywords: Dental Fluorosis, Cold Light Whitening, Mechanism, Therapeutic Effect.

1. Background

Dental fluorosis is a regional disease that occurs during the development of enamel in children. This result is mainly related to the high fluoride content in drinking water. Mild cases present as chalky patches on the enamel surface, moderate yellow - brown or dark brown patches, and severe cases may have defects of various shapes[1]. It will seriously affect people's health and beauty and even produce a psychological burden.

Dental fluorosis has only been assessed three times in nationally representative oral health surveys in the United States, the most recent being an assessment of fluorosis in 2011-2012. Compared with the results of the survey twice before, the severity and prevalence of all social demographic categories increased sharply. This phenomenon is closely related to the increased fluoride content in water and the early use of fluoride toothpaste.[2] As a common endemic disease, the prevalence of dental fluorosis also varies geographically. The main reason for the regional differences is the different types of aquifers.[3] A mass of research survey data also indicated that the average prevalence of high fluoride drinking water is significantly higher than that of ordinary drinking water.

In this review, the etiology and pathogenesis of dental fluorosis, as well as the mechanism and effect of cold light whitening technology in the treatment of dental fluorosis are discussed, to supply a theoretical basis for clinicians. However, the etiology of dental fluorosis is still complex, and the therapeutic effect of cold light whitening technology is different for various individuals, which needs further study.

2. Etiology and formation mechanism of dental fluorosis

2.1. External factors

Fluorine is one of the essential trace elements in the human body. The main source of fluoride intake is drinking water, and the appropriate concentration of fluoride in drinking water is 0.5-1 mg/L. When drinking water chronically has a fluoride concentration higher than 1 mg/L, dental fluorosis may be caused, while when the fluoride concentration reaches 3-6 mg/L, skeletal fluorosis may be caused, endangering the people's overall health[4]. The prevalence of dental fluorosis is closely related to fluoride intake levels, and teeth are more prone to fluoride intake at certain ages.

Fluoride toothpastes play a chief role in replenishing fluoride properly, but it is particularly imperative to control the age and usage of fluoride toothpastes. This is mainly because preschool children swallow 30-50% of the toothpaste used when brushing their teeth, and the risk of dental

fluorosis increases with the increase in the amount of fluoride toothpaste used and the enhancement in the number of brushing teeth. Specific use should also be based on the individual needs of professional personnel to select the most appropriate method of use[5]. Excessive fluoride intake from the early growth of children has adverse effects on height and mental ability. A reasonable diet is also one of the vital measures to prevent dental fluorosis. It is suggested to intake calcium, magnesium, antioxidant and protective trace elements to effectively prevent and control dental fluorosis[6].

2.2. Internal factors

In recent years, with the advancement of science and technology, genetic variation has been found to be a significant factor in inducing dental fluorosis. Fluoride can lead to primary cultured rat S period block in nerve cells in the proliferation cycle and obviously the induced DNA damage. The enamel protein gene (ENAM gene) plays a central role in the formation of tooth enamel, and a change in the ENAM gene will impact the length of enamel crystals[7]. DNA damage is closely related to cell proliferation and apoptosis, but the relationship between the formation mechanism of dental fluorosis and DNA damage and cell cycle change needs to be further explored.

Excessive fluoride intake during tooth development is the root cause of dental fluorosis. Fluoride ions with high reactivity and low concentrations will accelerate the mineralization of enamel. Into glaze cell synthesis and secretion of enamel matrix proteins, and the protease and enamel matrix proteins hydrolyze and clear under the action of tooth enamel formation, and the bases of the enamel matrix proteins glaze the original proteins[8]. Fluorine can affect the expression of amelogenin mRNA in ameloblasts and the enamel matrix, and excessive fluorine will periodically inhibit the function of ameloblasts to secrete the enamel matrix and induce them to be unable to be fully degraded, resulting in incomplete mineralization, uneven mineralization and focal defects of enamel. The endoplasmic reticulum is a chief eukaryotic organelle, and protein synthesis and secretion are vital. In enamel cells, fluoride exposure affects the function of Ca^{2+} channel receptors located in the endoplasmic reticulum, resulting in increased Ca^{2+} content. When the Ca^{2+} content exceeds the regulation range of ameloblasts, cells will enter an endoplasmic reticulum stress state, resulting in disordered protein synthesis [9]. Fluoride also has a negative effect on mitochondrial respiration, causing mitochondrial membrane depolarization and damaging mitochondrial morphology. At present, the molecular mechanism of dental fluorosis has not been fully elucidated, and further research is needed.

3. The principle of cold light whitening

Tooth beauty is one of the imperative contents of dental aesthetics, and cold light whitening technology is one of the vital techniques of modern tooth beauty and whitening. The principle of this technology is to illuminate the whitening agent with high-intensity light of a certain wavelength so that it can momentarily penetrate into the enamel and dentin tubules, decompose the pigment on the tooth surface and deep layer, and produce a redox reaction to achieve the whitening effect. The traditional standard operation method is to compare and record the color of the teeth before whitening, which can be archived by photo. A small amount of water is added to the polishing sand to remove the protein film attached to the tooth surface. Wet cotton slivers into the inside of the lip, daub lip oil. The mouth opener was put into the patient's mouth, and the whitening agent was adjusted to cover the tooth surface with a thickness of approximately 2-3 mm. The cold light lamp holder was adjusted to 90° vertical to the tooth surface and illuminated for 8 min. The whitening agent was removed from the surface of the tooth and the whitening agent was applied again and illuminated with cold light. Then the process of applying the whitening agent and cold light was repeated three times. Due to individual differences in dental conditions, the technology still needs to be improved to further meet the individual requirements of patients.

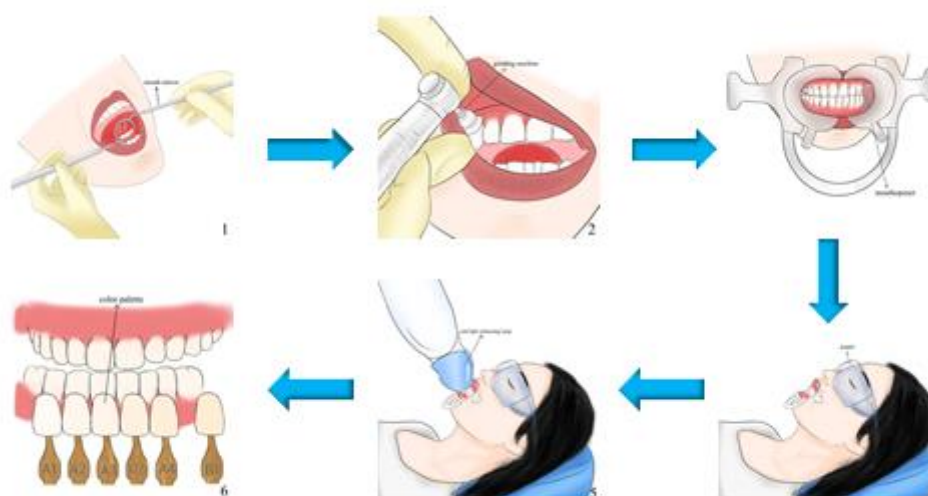


Figure 1. Flow chart of cold light whitening technology

1. Oral examination and photograph for color comparison
2. The polishing sand gives simple treatment to the tooth surface
3. The mouthopener is placed in the mouth
4. Patient puts on goggles
5. Shine a cold light whitening lamp on the evenly applied tooth
6. Use a color palette to compare the color of the teeth before whitening

4. Effect of cold light whitening technology on tooth structure

The main component of the cold light whitening agent for hydrogen peroxide, hydrogen peroxide can degrade into water and oxygen and has a strong oxidation of superoxide free radicals in a brief period, functioning in the degradation of pigment molecules[10]. The loss of tooth surface minerals can change the microscopic structure of tooth enamel. However, the results of studies on the changes in tooth microstructure caused by tooth bleaching vary. A previous study confirmed that cold light whitening can whiten the enamel of human molars in vitro after more than 10 min, which is significantly improved compared with the untreated group[11]. More important is the pH of the bleach to determine whether it causes a change in enamel hardness. A lower the pH value of bleach is more acidic, and is more likely to cause the enamel mineralization[12]. In addition, hydrogen peroxide can also cause organic matter degeneration in enamel, thus influencing the metabolism of enamel and reducing the hardness of enamel. In recent years, with the development of biological materials, some studies have explored the application of zinc-containing hydroxyapatite material as a whitening agent mediated by cold light whitening technology in tooth bleaching. An experiment has proven that zinc-containing hydroxyapatite is obviously beneficial to enamel mineralization through in vitro PH cycle experiments[13]. Cold light whitening technology fundamentally solves the traditional shortcomings, and achieves the purpose of whitening, and is a safe, fast and effective tooth whitening technology.

Whether the application of cold light whitening technology will induce caries is also a concern of people. Bacteria in the biofilm state have strong acid production and tolerance, and certain concentrations of acid can lead to the occurrence of dental caries[14]. *Streptococcus mutans* is considered one of the most vital causes of caries bacteria[15]. Cold light whitening technology has certain bacteriostatic and bactericidal effects, and the single bacterial biofilm formation and the mouth of the bacterial biofilm difference is vary considerably hybrid biofilms and the formation of bacteria in the mouth of the biofilm are more similar[16]. Cold light whitening technology can inhibit the

formation of mixed bacterial biofilms on enamel surfaces in a certain period of time thus alleviating the occurrence of dental caries, but the specific time of effect needs to be further studied.

5. Curative effect of dental fluorosis

A large number of clinical practices have confirmed that tooth bleaching with a cold light whitening agent has favorable clinical efficacy and safety but is not suitable for the treatment of moderate and severe dental fluorosis. For the treatment of moderate and severe dental fluorosis, it is necessary to combine cold light whitening technology with fluoride removal agents to achieve benign results. Hydrochloric acid, the main ingredient of fluoride removal agents, can not only remove the coloring part of the enamel together with the surface but also contribute to the disposition of hydrochloric acid in the enamel dissolution permeability. Nevertheless, the accumulation of hydrochloric acid on the surface and gaps in enamel will also cause certain damage, so it is best to use dental protectants immediately after therapy to promote remineralization and repair[17]. If the patient is treated with cold light whitening combined with a fluoride removal agent, there are still trace stains on the enamel surface, which can be removed by micro-grinding and division. This method takes advantage of the fine particle emery drill to remove damage to tissue and polishing grinding to achieve the whitening effect[18]. At present, the combination of a low concentration of hydrogen peroxide and light source has been widely applied to implement efficient bleaching. Light activation using LEDs or lasers increased the whitening effect of hydrogen peroxide by 6% compared to the group without light activation. In addition, these two kinds of bleaching methods will not result in changes in dental enamel microhardness.

However, any bleaching treatment can only improve the appearance of yellow or brown-yellow patches on the tooth surface of patients with dental fluorosis, but not the chalky patches on the enamel surface of patients. Studies have found that using the permeability after tooth enamel resin processing, surface hardness and the hardness of the enamel normal were not significantly different[19]. This combined method also solved the problem of enamel structure collapse caused by cold light whitening technology alone. This may be because the acid etching treatment of penetration resin in the early stage can remove the damaged enamel layer, facilitate subsequent penetration and play a role of filling role to make the enamel surface microstructure relatively smooth[20]. Several studies have investigated the aesthetic satisfaction of lesions after one year of resin infiltration, the satisfaction of tooth sensitivity after treatment and the satisfaction of treatment duration, and the results demonstrate that combined technique is effective and stable in the regression of lesions[21].

Table 1. Methods and advantages and disadvantages of treating dental fluorosis

Treatment	Advantage	Disadvantage	References
Traditional bleaching	The earliest treatment	Easy to recolor, uneven color and damage enamel.	
Repair method	Suitable for the treatment of moderate and severe dental fluorosis.	Dislodge too much tissue, inappropriate color.	
Micro abrasive	Little damage to teeth.	The effect is worse than repair method.	
Cold light whitening	Less time and high security.	Not suitable for moderate and severe dental fluorosis	
Cold light whitening combined with fluoride removal agent	Ideal for moderate and severe dental fluorosis.	Adverse effects on enamel.	[17]
Cold light whitening combined with permeable resin	Ideal for patients with chalky plaque on enamel surface. The color of tooth surface can be maintained for a long time.	Not applicable to defects or moderate to severe.	[20] [21]

6. Conclusion

The effect of cold light whitening technology alone or in combination in the treatment of dental fluorosis has been verified by a large number of basic and clinical studies, with favorable biosafety and effectiveness. Nevertheless, the specific molecular mechanism of the effect of cold light whitening technology on fluorosis teeth has not been fully elucidated, and the current clinical studies are mostly small sample sizes or observational studies, lacking large sample sizes, randomness and prospective control studies. Further scientific clinical trials are still needed. In addition, combined with the results of current clinical studies, we believe that we can also try to introduce the concept of "personalized treatment" into the principle of cold light whitening treatment and classify treatment according to different types of dental fluorosis so that patients can benefit the most.

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