

# Efficacy of a Remineralized Dental Desensitizer in Treating Dentin Hypersensitivity: A Comparative Study

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**Abstract:** *This study evaluates the efficacy of Yikuangling Dental Desensitizer, developed by Xiling Zhenjiang Medical Technology Co., Ltd., in treating dentin hypersensitivity and promoting enamel remineralization. The fluoride dissolution rates, calcium and phosphorus content, and surface hardness of human tooth samples were tested. Clinical effects were compared between Yikuangling and a control desensitizer gel. Results showed that Yikuangling had a faster fluoride dissolution rate 92% in 3 minutes and a higher dental tubule sealing rate 83% than the control, significantly improving dentin sensitivity and remineralization. These findings highlight Yikuanglings potential as an effective treatment for dentin hypersensitivity.*

**Keywords:** Karidium Dental desensitizer Dental hypersensitivity Remineralization

## 1. Introduction

Dental hypersensitivity (DH) is a common oral disease, and its related treatment has been a hot topic at home and abroad in recent years [1, 2]. Dentin hypersensitivity is not an independent disease, but is related to many dental diseases [3]. Dentin hypersensitivity mostly occurs in adult patients, and it is more common in the cheeks and neck of permanent teeth, with a high prevalence rate of 72.5% - 98% [4]. In human oral environment, under normal circumstances, the enamel surface is in a dynamic balance of demineralization - remineralization, which maintains the structure, shape and function of tooth hard tissue. However, in some cases, the dynamic balance of demineralization - remineralization on enamel surface is broken by case factors, and demineralization exceeds remineralization, resulting in the slow loss of minerals on enamel surface and dental diseases such as tooth decay and sensitivity [5]. In this case, it is necessary to reduce the demineralization of the tooth surface by external interference or promote remineralization to repair the demineralization and sensitivity of the tooth [6].

Re - mineralization refers to the process of re - depositing inorganic salt ions such as calcium and phosphorus in the external environment of teeth on the inside and surface of demineralized teeth under certain conditions, rebuilding tooth structure and restoring tooth hardness [7]. Fluoride is a classic remineralization drug [8 - 9]. Inorganic substances in enamel are demineralized and dissolved. When fluoride ions exist in the surrounding environment, free inorganic ions will be redeposited on the enamel surface in the form of fluorapatite or fluorinated hydroxyapatite with low solubility to promote enamel remineralization [10 - 12]. The effective components in the dental remineralized gel studied by Xiling (Zhenjiang) Medical Technology Co., Ltd. are sodium fluoride and potassium nitrate. The sodium fluoride component in the product participates in the dissolution and redeposition process of hydroxyapatite on the tooth surface through fluoride ions, forming calcium fluoride and fluorapatite, which are deposited and sealed, promoting tooth remineralization, and playing the role of caries prevention and

desensitization. Potassium nitrate is rich in potassium ions, which can penetrate through dentinal tubules and reduce the excitability of nerve fibers, thus blocking dentinal tubules. Therefore, in this study, the dissolution characteristics of fluorine were detected, and the results were analyzed to study the relationship between fluorine release amount and release time; The demineralization - remineralization experiment of Yi Kuang Ling's teeth was carried out, and the remineralization effect of Yikuang Ling Dental remineralized gel was studied with Vickers hardness and calcium and phosphorus as indicators. Finally, the clinical effect of Yikuang Ling Dental remineralized gel on dentine hypersensitivity's disease was investigated.

## 2. Materials and methods

### 2.1 Experimental materials

2.1.1 Instrument Acidimeter PHS - 3C (Shanghai Leimagnetic Instrument Factory); Composite fluorine electrode PF2 - 01 (Shanghai Leimagnetic Instrument Factory); Electronic balance YP6002 (Shanghai Shuangxu Electronics Co., Ltd.); Water bath constant temperature oscillator HT - 110X30 (Shanghai Hetian Scientific Instrument Co., Ltd.); Vickers hardness tester DHV - 1000 (Suzhou Nanguang Electronic Technology Co., Ltd.); Energy spectrometer (EDAX, USA)

2.1.2 Reagents Artificial saliva (ISO/TR10271 standard); Sodium fluoride; TISAB; Yikuang Ling Dental remineralized gel (Xiling (Zhenjiang) Medical Technology Co., Ltd.); Tooth desensitization gel (Jiangxi Weide Medical Health Management Co., Ltd.)

### 2.2 Experimental Content

#### 2.2.1 Determination of fluoride dissolution rate

##### (1) Drawing of standard curve

According to the requirements in YY0623 - 2007, the total ionic strength adjustment buffer and 100µg/mL fluoride

standard stock solution were prepared, and the fluorine standard solutions of 0.1mL, 0.5 mL, 1mL, 5 mL, 10 mL, 20mL and 50 mL were transferred to 100mL volumetric flasks, and 20mL of total ionic strength adjustment buffer (TISABII) was added to each volumetric flask. Purified water is added to dilute the fluorine concentration to 0.1µg/mL, 0.5µg/mL, 1µg/mL, 5µg/mL, 10µg/mL, 20µg/mL and 50µg/mL. Put the above solutions in 150mL polyethylene plastic cups, stir them on a magnetic stirrer, and measure their potential values from low concentration to high concentration with a potentiometer and a composite fluorine electrode in turn. Each potential value should be read after the value is stable. Draw the working curve of fluorine concentration - potential value on semi - logarithmic coordinate paper. The x - axis is the potential value (unit: mV); The y - axis is the fluorine concentration (unit: µg/mL). And the regression equation is obtained.

## (2) Sample detection

Yikuang Ling Dental remineralized gel from Xiling (Zhenjiang) Medical Technology Co., Ltd. and the dental desensitizer gel reference samples from Weide Medical were divided into nine groups, each group was prepared with 80ml pure water and 20ml total ionic strength adjustment buffer, and placed in a constant temperature water bath at 37°C. Accurately weigh 0.5 - 1.0g samples from each group into 100ml beakers, immediately pour the solution with good constant temperature into the plastic beakers after weighing, and put it in a water bath at 37°C for constant temperature. The potential values of nine groups of samples were measured at 1, 2, 3, 5, 10, 15, 20, 25, 30 and 35min respectively, and the corresponding concentrations were obtained according to the standard curve, and the soluble fluorine content in the samples was calculated. Each time, it was measured in parallel twice, and the average value was taken as the result.

### 2.2.2 Demineralization - remineralization Experiment

- 1) Collect 20 fresh premolars extracted from oral and maxillofacial surgery in Stomatological Hospital for orthodontics, clean the soft tissues such as tartar and periodontal ligament around the teeth, store them in 0.9% normal saline at 4°C for later use, and take them out and dry them naturally.
- 2) Experimental grouping: 20 teeth were randomly divided into 4 groups, with 5 teeth in each group. The second group: demineralization group; The third group: 0.3% sodium fluoride treatment group; The fourth group: Yi Kuang Ling dental desensitizer treatment group.
- 3) Treatment of human teeth: grind the tooth surface with 500 - mesh, 1, 000 - mesh and 1, 500 - mesh sandpaper under running water (about 0.1mm), rinse the ground teeth with purified water and dry them naturally.
- 4) Preparation of demineralized solution: Prepare 0.1mol/L lactic acid solution and 30g/L carboxymethyl cellulose solution respectively, mix them evenly, and adjust the pH to 4.2 with 0.2mol/L sodium hydroxide to obtain demineralized solution.
- 5) Establishing demineralization model: The teeth of the second group, the third group and the fourth group were soaked in demineralization solution and demineralized in a water bath constant temperature oscillator at 37°C for 96h. After demineralization, the tooth surface was observed to be white and dull.

- 6) The demineralized teeth were treated with 0.3% sodium fluoride solution and Yikuang Ling Dental remineralized gel for 10min, then naturally dried for 5min, then washed with purified water for 1min, and treated three times a day. The rest of the time, the teeth were stored in artificial saliva (30ml artificial saliva in each group) in a water bath constant temperature oscillator at 37°C and 40rpm, and the artificial saliva was changed every day for a total of two weeks.

### 2.2.3 Determination of Vickers Hardness

The surface microhardness was measured by Vickers hardness tester. Rinse the tooth surface with water, blow dry, and apply a load of 0.49N (equivalent to 50g load) to the enamel surface with a hardness tester indenter for 15s.

### 2.2.4 Energy spectrum analysis

A micron - sized platinum film was deposited on the enamel surface in vacuum, and three sites were randomly selected on the observation interface of each sample. The composition and content of calcium and phosphorus on the enamel surface were analyzed by X - ray energy spectrometer.

### 2.2.5 Clinical study on treatment of dentine hypersensitivity

A total of 54 cases of dentine hypersensitivity in dental clinic were selected, including the following symptoms:

- 1) Severe wear of occlusal surface. ②Tooth neck exposure caused by periodontal atrophy.
- 2) Shallow wedge - shaped defect in the neck of teeth. However, those who have the following conditions are not included in the experiment:
  - a) The teeth have pulpitis.
  - b) Desensitization treatment was done within 3 months.
  - c) Moderate and severe wedge - shaped defect. A total of 114 teeth, evenly distributed between men and women, aged 25 - 70 years (clinically, those with allergies of 2 - 3 degrees are called dentine hypersensitivity).114 teeth were randomly divided into group A (Yikuang Ling Dental remineralized gel) and group B (Weide Medical Tooth Desensitizer Gel), with 64 teeth in group A and 50 teeth in group B.

#### (1) Usage:

Yikuang Ling Dental remineralized gel: Before using this product, clean your mouth, remove the butterfly cap of the applicator, push out the gel the size of soybean, dip this product with cotton swab or plastic brush, directly apply it to dentine hypersensitivity, repeatedly apply it, rinse your mouth with clear water after 2 - 3min, once in the morning and once in the evening, for a total of 3 days.

Weide Medical Tooth Desensitization Gel: Squeeze a proper amount of this product onto the cleaned finger or toothbrush, spread it evenly on the tooth surface, and rinse your mouth with clear water for 3 minutes, three times a day, for a total of 3 days.

#### (2) Evaluation standard of curative effect:

According to Ishikawa Xiuji's evaluation standard [13], the degree of tooth allergy can be divided into 4 degrees.3 degrees: can induce significant pain and last for more than 10

seconds; 2 degrees: there is pain, but it is all tolerable pain; 1 degree: mild pain; 0 degrees: no pain. Remarkable effect: the sensitivity difference before and after treatment is  $\geq 2$ ; Effective: the difference before and after treatment is 1; Invalid: the difference is 0; Deterioration: The difference is negative. Effective rate calculation method (%) = (number of effective teeth+number of effective teeth) /total number of teeth  $\times 100\%$ .

**2.2.6 Statistical analysis**

SPSS statistical software was used to analyze the data, and the numerical values were represented by the mean. The Vickers hardness, the ratio of calcium to phosphorus and the effective rate of dentine hypersensitivity's disease among different groups were compared by one - way ANOVA. If the overall comparison was different, Bonferroni method was used for pairwise comparison, and the test level of statistical analysis was set at 0.05.

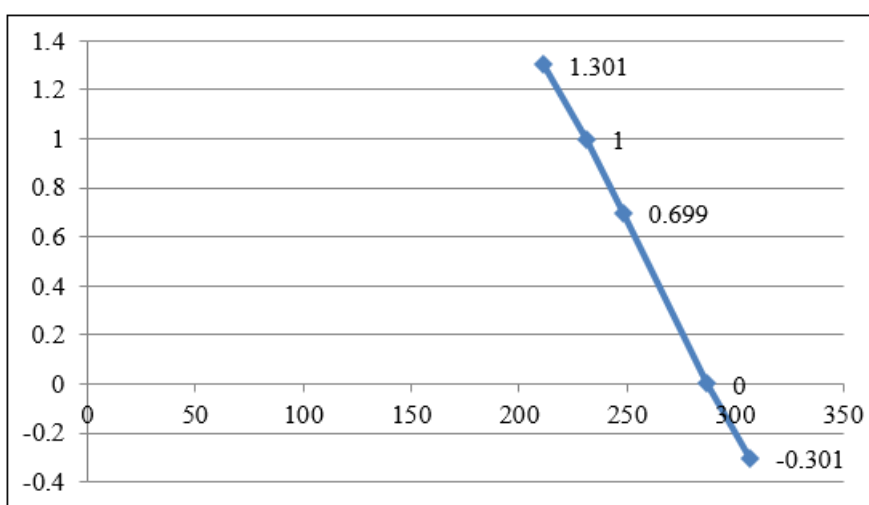
**3. Results**

**3.1 Fluorine dissolution**

**3.1.1 Standard curve**

**Table 2-1:** Fluoride ion series standard solutions and corresponding potential values

Fluorine content (µg/mL)	Logarithmic value of fluorine content (LogF -)	Potential value (mv)
0.5	- 0.301	307
1.0	0	287
5.0	0.699	248
10.0	1.00	231
20.0	1.301	211



**Figure 2-1:** Fluoride ion standard curve

With the potential value as the abscissa and the logarithm of fluorine concentration as the ordinate, fluorine standard solutions with concentrations of 0.5µg/mL, 1µg/mL, 5µg/mL, 10µg/mL and 20µg/mL are prepared respectively, and the corresponding potential values are determined. The specific data are shown in Table 2 - 1, and the standard curve is drawn as shown in Figure 2 - 1.

**3.1.2 Dissolution of fluorine**

**Table 2-2:** Fluorine Dissolution of Yikuang Ling Dental remineralized gel

Test item	Constant temperature time	Test result of parallel group 1 (%)	Test result of parallel group 2 (%)	Average value (%)
Dissolved content of fluorine	1min	0.11023	0.10974	0.11
	2min	0.12399	0.11897	0.1214
	3min	0.12897	0.1234	0.1262
	5min	0.13408	0.12836	0.1312
	10min	0.12897	0.12836	0.1287
	15min.	0.12897	0.12836	0.1287
	20min	0.12897	0.12836	0.1287
	25min	0.12897	0.1234	0.1262
	30min	0.12399	0.12836	0.1262
35min	0.12897	0.12836	0.1287	

**Table 2- 3:** Fluoride Dissolution of Tooth Desensitization Gel

Test item	Constant temperature time	Test result of parallel group 1 (%)	Test result of parallel group 2 (%)	Average value (%)
Dissolved content of fluorine	1min	0.07396	0.07621	0.0751
	2min	0.077	0.07594	0.0765
	3min	0.07857	0.07793	0.0783
	5min	0.0828	0.08127	0.082
	10min	0.08414	0.08865	0.0864
	15min.	0.0862	0.08394	0.0851
	20min	0.08655	0.08782	0.0872
	25min	0.0876	0.08546	0.0865
	30min	0.08812	0.08647	0.0873
35min	0.08993	0.09172	0.0908	

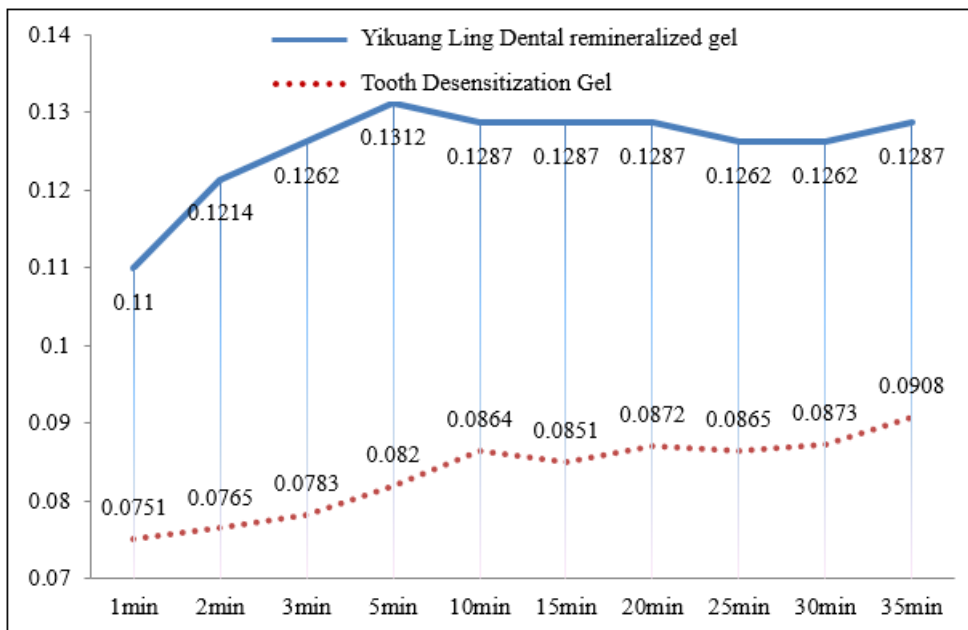


Figure 2- 2: Cumulative Dissolution of Fluorine from Yikuang Ling Dental remineralized gel and Reference

Table 2 - 2 and Table 2 - 3 show the fluoride dissolution amounts of Yikuang Ling Dental remineralized gel of Xiling (Zhenjiang) Medical Technology Co., Ltd. and the tooth desensitizer gel of Weide Medical, respectively. From the table, we can see that the fluoride dissolution amount of our products is much larger than that of the reference. As can be seen from Figure 2 - 2 cumulative dissolution curve of fluorine, the soluble amount of fluorine of Yikuang Ling Dental remineralized gel reached 0.1262 in 3 minutes, and increased with the increase of time in the first 10 minutes, and gradually stabilized after reaching 10 minutes, indicating that the fluorine of Yikuang Ling Dental remineralized gel basically no longer dissolved after 10 minutes; However, the fluoride dissolution amount of the tooth desensitizing gel of the control sample is also small at about 30min, which shows that the fluoride dissolution amount of the Yikuang Ling Dental remineralized gel is larger and the dissolution rate is faster, which is more conducive to the rapid and effective function of the product.

Table 2- 4: Dissolution Rate of Fluorine in Yikuang Ling Dental remineralized gel

Dissolution project	Constant temperature time	Fluorine dissolution content (%)	Total fluorine content (%)	Dissolution rate (%)
Dissolution rate of fluorine	1min	0.11	0.136	80.88
	2min	0.1214		89.26
	3min	0.1262		92.79
	5min	0.1312		96.47
	10min	0.1287		94.63
	15min.	0.1287		94.63
	20min	0.1287		94.63
	25min	0.1262		92.79
	30min	0.1262		92.79
	35min	0.1287		94.63

The dosage of sodium fluoride in the dental remineralized gel developed by Xiling (Zhenjiang) Medical Technology Co., Ltd. is 0.3%, and the fluorine content should be 0.136% according to the relative molecular weight of fluorine and sodium. Therefore, the dissolution rate is calculated

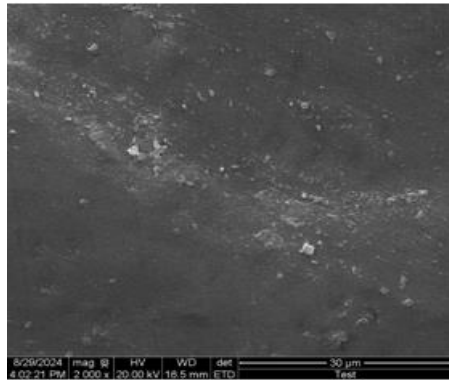
according to the fluorine dissolution content in each time period, as shown in Table 2 - 4. In 3 minutes, the fluoride dissolution rate of Yi Kuang Ling dental desensitizer reached about 92%, and the fluoride ion was released faster on the surface. The sealing rate of dental tubule of Yikuang Ling Dental remineralized gel was 83.0%, which can effectively relieve dentine hypersensitivity's symptoms.

3.2 Vickers hardness

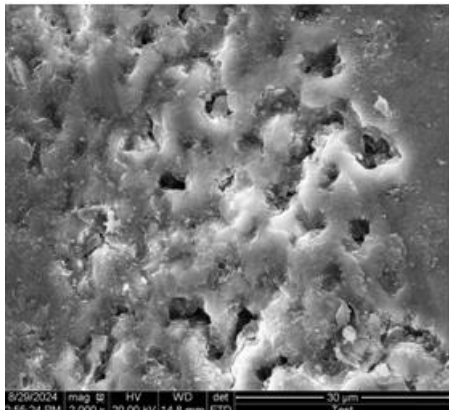
Table 2- 5: Vickers Hardness of each group

Group	Vickers Hardness
Untreated group	270.333±36.880
Demineralization group	240.704±7.706
Sodium fluoride group	294.798±36.957
Yikuang Ling Dental remineralized gel group	324.077±13.507

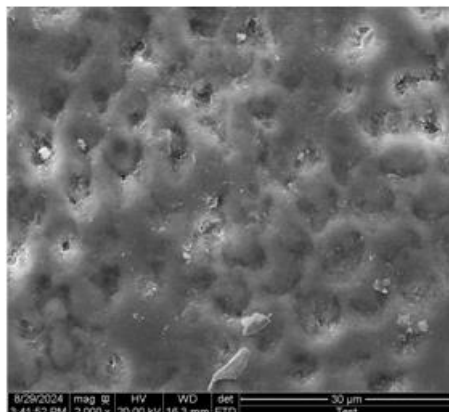
The values are all expressed by mean standard deviation. Statistical analysis of Vickers hardness shows that the hardness of enamel after demineralization is significantly reduced (P<0.05), and the hardness of both groups after remineralization is significantly improved (P<0.05). Pairwise comparison shows that the Vickers hardness of enamel surface from low to high is demineralized group, untreated group, sodium fluoride group and Yikuang Ling Dental remineralized gel, in which sodium fluoride group is lower than Yikuang Ling Dental remineralized gel group.



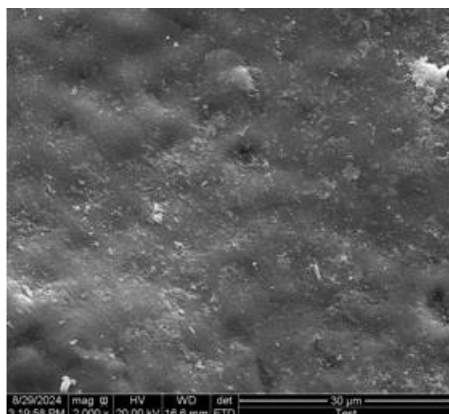
a. Untreated group



b: Demineralization group



c: Sodium fluoride group



d. Yikuang Ling Dental remineralized gel group

Figure 2- 3: Surface morphology of isolated teeth under 2500 times electron microscope

### 3.3 Calcium and phosphorus elements

Table 2- 6: Calcium - phosphorus ratio of each group

Group	Calcium - phosphorus ratio
Untreated group	2.801±0.083
Demineralization group	2.468±0.131
Sodium fluoride group	2.586±0.410
Yikuang Ling Dental remineralized gel group	3.647±0.405

The data are expressed by mean standard deviation. From the quantitative analysis of Ca/P ratio in Table 2 - 6, it can be seen that the Ca/P ratio decreased significantly after enamel demineralization ( $P < 0.05$ ), and the Ca/P ratio increased significantly after remineralization treatment in both groups ( $P < 0.05$ ), especially in the Yikuang Ling Dental remineralized gel group. Pairwise comparison shows that the ratio of calcium to phosphorus on enamel surface from low to high is demineralized group, untreated group, sodium fluoride group and Yikuang Ling Dental remineralized gel group.

### 3.4 Pictures of enamel surface before and after using dental remineralized gel

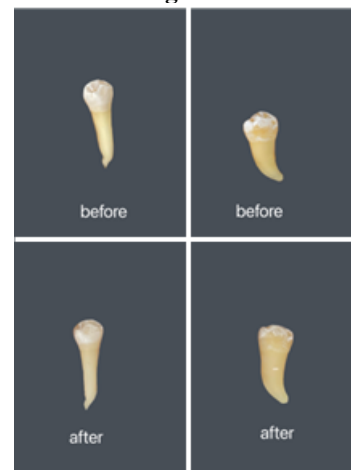


Figure 2- 4: Tooth surface before and after using Yikuang Ling Dental remineralized gel

As can be seen from Figure 2 - 4, when the tooth is demineralized and remineralized without using Yikuang Ling Dental remineralized gel, some white spots appear on the surface. After remineralization with Yikuang Ling Dental remineralized gel, the white spots on the tooth surface are obviously reduced, which indicates that Yikuang Ling Dental remineralized gel has a good remineralization effect on teeth.

### 3.5 Clinical efficacy of dentine hypersensitivity

Table 2- 7: Effective rate of dentine hypersensitivity

Group	Show effect	Effective	With good efficiency	Be invalid
Yikuang Ling group	26	30	87.50%	8
Weide medical group	21	20	82.00%	9

The results showed that the effective rate of Yikuang Ling Dental remineralized gel was 87.5%, and the effective rate of tooth desensitization was 82.00%. There was no significant difference ( $P > 0.05$ ).

#### 4. Discussion

The main components of Yikuang Ling Dental remineralized gel in Xiling (Zhenjiang) Medical Technology Co., Ltd. are sodium fluoride, potassium nitrate, glycerin, triethanolamine, carbomer, etc. Among them, fluoride ions can reduce the diameter of dentinal tubules, thus reducing hydraulic conduction, improving the acid resistance of tooth tissues, inhibiting the acid dissolution of dentin, preventing more dentinal tubules from opening due to dentin exposure, and thus promoting tooth remineralization. The main caries prevention mechanism of fluoride is that under acidic conditions, hydroxyapatite in enamel begins to dissolve, and fluoride ions will be deposited on the crystal plane, which can alleviate and organize the dissolution of hydroxyapatite [14]. The People's Republic of China (PRC) Health Industry Standard WST 87 - 2016 stipulates that the total fluoride intake of people aged 8 - 16 (including 16 years old) is  $\leq 2.4$ mg per person per day; For people over 16 years old (excluding 16 years old), the daily total fluoride intake per person is  $\leq 3.5$ mg. In clinical application, the dosage per person should not exceed 1ml (1.1g). According to the fluoride content (0.136%) in the dental remineralized gel produced by Xiling (Zhenjiang) Medical Technology Co., Ltd., 1ml of dental remineralized gel is equivalent to 1.496mg of fluorine content, which is less than the safety regulations of total daily fluorine intake per person stipulated in WST 87 - 2016. Therefore, the dental remineralized gel produced by Xiling (Zhenjiang) Medical Technology Co., Ltd. has very low risk of dental fluorosis and skeletal fluorosis under normal use, and will not cause harm to human body.

Potassium nitrate is rich in potassium ions, which can penetrate through dentinal tubules and reduce the excitability of nerve fibers, thus blocking dentinal tubules. Narhi [15] has done experiments on cats. The results show that when exposed to potassium chloride, the dental pulp nerve will temporarily burst into electrical activity, but it will be insensitive to further stimulation in the future. This phenomenon shows that potassium ions can indeed make nerves lose polarity, thus reducing pain. The desensitization mechanism is to increase the concentration of potassium ions around pulp sensory nerve receptors, resulting in depolarization. Secondly, it reduces nerve excitability and produces insoluble substances to block dentin tubules, thus alleviating the symptoms of dentin hypersensitivity [16]. Other components in Yikuang Ling Dental remineralized gel, such as glycerol and carbomer, play the role of thickening, and triethanolamine is mainly used as a neutralizer to achieve the effect of moisturizing.

The results of this study show that the dissolution rate of fluorine in Yikuang Ling Dental remineralized gel of Xiling (Zhenjiang) Medical Technology Co., Ltd. is fast, reaching about 92% in 3 minutes, and compared with the tooth desensitizer gel of Weide Medical, the dissolution amount of fluorine is larger, which can act on teeth faster and effectively relieve dentine hypersensitivity's symptoms. Generally speaking, the higher the calcium - phosphorus ratio, the stronger the acid resistance, that is, the higher the calcium - phosphorus ratio, the lower the solubility of sediments, indicating that the more stable the remineralized products are, the higher the remineralization degree. The results of Vickers

hardness and energy dispersive spectrometer show that the tooth remineralized by Yikuang Ling Dental remineralized gel has better hardness and calcium - phosphorus ratio than the demineralized tooth. The white spots on the tooth surface are also found to disappear in the comparison pictures of the teeth before and after, which shows that Yikuang Ling Dental remineralized gel has a certain remineralization effect on the teeth and is better than sodium fluoride. In the clinical study of dentine hypersensitivity's disease, the effective rate for treating dentine hypersensitivity's disease can reach about 87%, which is better than the tooth desensitization gel of Vader Medical. At present, there are many dental desensitizer products on the market, such as the desensitizer of American White Tooth Company, whose content of sodium fluoride is 0.2 - 0.3%, and the dental remineralized gel of Yi Kuang Ling of Xiling (Zhenjiang) Medical Technology Co., Ltd., whose content is 0.3%. Under the same condition, Yikuang Ling Dental remineralized gel not only has the effect of relieving dentine hypersensitivity's disease, but also has the effect of remineralization. Yikuangling Dental Remineralized Gel demonstrates significant potential in treating dentin hypersensitivity, with higher fluoride dissolution rates and improved enamel hardness compared to the control. Its ability to effectively seal dental tubules and promote remineralization makes it a promising option for clinical use. Further studies could focus on longterm efficacy and patient outcomes in varied clinical settings.

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