A New Method of Treatment for Dentin Hypersensitivity by Precipitation of Calcium Phosphate in situ

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The hydrodynamic theory is generally accepted as an explanation of hypersensitive dentin and suggests that occlusion of exposed dentinal tubules should result in a reduction of hypersensitivity. We tried to block tubules by in situ precipitation of insoluble calcium phosphate. Calcium phosphate crystals precipitated in situ on patent dentin surfaces and formed in the tubules immediately upon serial application of sodium phosphate and calcium chloride solutions, thus occluding the tubules. The size of crystals, their degree of coverage, and the thickness of the precipitate depended on the method of application and concentration of the solutions. The application of 5% disodium phosphate solution followed by rubbing with 10% calcium chloride solution resulted in immediate relief from dental hypersensitivity in 84% of patients treated.

Key words: Dentin hypersensitivity, Calcium phosphate, In situ precipitation

INTRODUCTION

Dentin hypersensitivity is one of the least successfully treated chronic dental problems. Many agents and methods of treatment have been described and used in the past. Indeed, claims have been made that all of the following chemical agents can be effective in the treatment of hypersensitive dentin\(^1\)\(^-\)\(^3\)\): sodium fluoride, stannous fluoride, sodium monofluorophosphate, potassium oxalate, potassium nitrate, potassium ferrocyanide, strontium chloride, zinc chloride, sodium citrate, silver nitrate, silver iodide, silver diaminate, formaldehyde, resins and adhesives, and glucocorticoids.

Although several theories have been suggested for hypersensitive dentin, it appears that the hydrodynamic theory is generally accepted and that the mechanical blocking of tubules by the precipitation of compounds or by surface coating is required of effective desensitizing agents\(^4\). Almost all the agents described above are effective in so far as they are capable of occluding the dentinal tubules. No single agent, however, appears to fulfill the requirements suggested by Grossman in 1934\(^5\): In particular, desensitizing agents should (1) not unduly irritate or endanger the pulp; (2) be painless on application, or shortly afterward; (3) be easily applied; (4) be rapid in action; (5) be permanently effective, and (6) not discolor tooth structure. It would appear that further research is therefore needed.

Currently available desensitizing agents and methods usually involve 1-step medication, despite the fact that such medication generally seems less effective than 2-step methods in reducing the dentinal fluid flow rate, and thus, dentin sensitivity. Greenhill and Pashley\(^6\) experimentally tested many tubule occluding agents, and assessed their ability to reduce fluid
flow through dentin. Indeed, their date demonstrated the effectiveness of potassium oxalate, fluoride, barium sulfate, and silver nitrate. They also tested combinations of 2 medicaments for producing precipitates as follows: Sodium sulfate with barium chloride, potassium carbonate with calcium chloride, sodium carbonate with calcium chloride, silver nitrate with formalin, and silver nitrate with phosphate buffer. However, these same authors did not seem to have much interest in these combination systems, appearing more interested in potassium oxalate, the most effective agent in their tests.

On the other hand, the present authors elected to focus on 2-step medications that produce precipitates. As a starting point, we first selected a combination of sodium phosphate and calcium chloride as it seemed to be the most physiological combination, and in this paper we report on the preliminary results obtained.

MATERIALS AND METHODS

Treatment solutions: Aqueous solutions of 2.5, 5, and 10% disodium phosphate (NaP), and 5, 10, and 20% calcium chloride (Ca) were adjusted to pH 7.4 with 5% monosodium phosphate and 5% hydrochloric acid solution, respectively.

In vitro experiment: The dentin surface of bovine anterior teeth was exposed by cutting with a diamond saw* and was used without further preparation in the experiment. The dentin surface was treated with 0.5 M EDTA solution (pH 7.4) for 1 min, washed with water, and NaP followed by Ca was applied using a cotton swab. The specimen obtained was washed with water, dried, sputter-coated with gold/palladium and examined on a scanning electron microscope**.

In vivo evaluation: Thirtyeight patients complaining of hypersensitivity ranging in age from 20 to 75 years were enrolled in the study. Each tooth was treated and evaluated according to the following protocol: (1) oral hygiene, (2) water rinse followed by drying, (3) application of 5% NaP with a cotton swab followed immediately by rubbing with 10% Ca using another cotton swab, (4) reaction for 15 s, (5) mouth rinse, and (6) testing of the patient’s immediate response to air blast.

RESULTS

Figure 1A shows a surface treated with 5% NaP followed by topical application of 5% Ca, revealing a heterogeneous appearance with some areas covered by large crystals while other areas have practically none. Figure 1B shows the surface treated with the same solutions as used in Fig. 1A, but with the 5% Ca applied by rubbing, and reveals an entirely different appearance characterized by a very homogeneous covering of fine crystals and penetration of the precipitate into tubules. Figures 2A through 2D are comparison of surfaces treated with different concentrations of NaP and Ca. Treatment with 2.5% NaP plus 10% Ca (Fig. 2A) did not occlude the tubule orifices, while the dentin surface was completely

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Fig. 1 The effect of the method of application of solutions on the appearance of dentin surface treated with 5% disodium phosphate followed by 5% calcium chloride solution.
(2000X)
A: Topical application of calcium chloride yielded heterogeneous appearance and large crystals.
B: Rubbing the second solution yielded a homogeneous covering and fine crystals.

Table 1 In vivo evaluation summary

<table>
<thead>
<tr>
<th></th>
<th>Significantly improved</th>
<th>Improved</th>
<th>No change</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>14</td>
<td>18</td>
<td>6</td>
<td>38</td>
</tr>
<tr>
<td>Percentage of patients</td>
<td>37</td>
<td>47</td>
<td>16</td>
<td>100</td>
</tr>
</tbody>
</table>

covered with very heavy precipitate when treated with high concentration of NaP and Ca(Fig. 2D).

Figures 3A and 3B show the dentin surface treated with 5% NaP and 10% Ca followed by 100 and 300 brushings, respectively. The specimen was brushed by hand without a dentifrice. Although the precipitates occluding the tubule orifices and on the surfaces were cleaned off by brushing, those within the tubules remained.

Table 1 shows a summary of the preliminary results of in vivo evaluations. The sequential application of 5% NaP and 10% Ca yielded immediate relief from hypersensitivity in 84% of patients treated.

DISCUSSION

Calcium phosphate crystals precipitated on the dentin surface and in the dentin tubules immediately upon sequential application of disodium phosphate and calcium chloride. The size of the crystals, their degree of coverage and the thickness of the precipitate depended on the method of application of the second solution and the concentration of the solutions. The
Fig. 2 The effect of the concentration of solutions on the surface appearance of dentin treated with disodium phosphate followed by rubbing with calcium chloride. (2000X)

A: 2.5% sodium phosphate with 10% calcium chloride.
B: 5% sodium phosphate with 10% calcium chloride.
C: 10% sodium phosphate with 10% calcium chloride.
D: 10% sodium phosphate with 20% calcium chloride.

Higher the concentration of the solutions, the denser and heavier the precipitates were and the thicker the layer of precipitate occluding tubular orifices became.

Higher concentrations of the solutions are not necessarily appropriate since heavy precipitate forming instantly on the surface tends to restrict diffusion of ions into the tubules and therefore leads to decreased penetration of crystals into the dentinal tubules. Moreover, heavy precipitate formed mainly on the surface is easily removed by brushing. A combination of 5% sodium phosphate and 10% calcium chloride seemed sufficient to block the dentinal tubules, since the treatment resulted in relief of pain in 84% of patients. We believe improvement in 84% of patients is rather impressive considering the fact that tooth pain arises due to various causes and mechanisms\textsuperscript{7,8}. Although the order of application of the solutions appeared to be virtually unrelated to the results, application of the lower concentra-
tion solution first is preferable in patients since low osmolarity minimizes irritation of pulp.

Although no following study was done, the treatment benefits seem to last at least 1 month since only 1 patient of the 38 treated visited a dental clinic with recurring hypersensitivity during the 1 month following the treatment. Moreover, the other patients have still not returned to dental clinics despite 2 to 12 months’ having passed since the treatment. Of course, we assume patients would visit a clinic if hypersensitivity recurred.

Moreover, this treatment might well be utilized in diagnosing the cause of dental pain, since noneffectiveness of the treatment would tend to exclude the possibility of exposed dentinal tubules and point to other causes such as caries, inflammation of pulp, or alteration of pulpal sensory nerve activity.

Calcium phosphate formed in the tubules is expected to promote the natural occlusion of peritubular dentin, the physiological response of teeth to dentinal sensitivity.

Moreover, in situ precipitation of calcium phosphate may be useful not only in treating dentin hypersensitivity, but also for the post-periodontal surgical treatment of patients. Indeed, it might well be used as a liner or base for protecting pulp before application of dental adhesives and resins.

The treatment described here appears almost completely to fulfill Grossman’s requirements, though the efficacy and long-term effectiveness of the treatment needs further evaluation. In the future, the practice of precipitation of insoluble substances in situ might also be modified by addition of various substances including potassium phosphate, sodium fluoride, thickeners, or polymerizable monomer salts.

CONCLUSION

The sequential application of disodium phosphate and calcium chloride on patent dentin immediately yielded calcium phosphate crystals in situ, thus occluding dentin tubules and
yielding immediate relief from hypersensitivity in 84% of patients.

REFERENCES

術前後で比較することによって評価した。その結果、これらの3種類の刺激に対する反応は、70％以上の症例でいずれも術後には明らかに減少し、35％HEMA水溶液による象牙質知覚麻痺性作用が、前報のウサギを使った生理学的な検討に加えて、臨床的にも確認された。しかしながら、今回の被検者とした48歯のうち10症例では冷水に対応する反応が軽減しないなど、すべての症例に完全に奏功させることは出来ず、今後、効果の確実性と持続性を検討する必要があると考えられる。現在、このような鎮静効果の発現については、象牙牙細胞株を用いた微小管観察像で可逆的な変化を受ける可能性を検討しており、次報で報告す所存である。

リン酸カルシウムのその場での沈澱を利用した象牙質知覚過敏の新しい処置方法
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象牙質知覚過敏は動水力学説によって最もよく説明されており、したがって露出した象牙質管を塞ぐことにより知覚過敏を低下させることができ期待できる。そこで我々はリン酸カルシウムのような不溶性の物質をその場で沈澱させることにより管を封鎖することを試みた。リン酸カルシウムに続き順次塩化カルシウム水溶液を象牙質に塗布すると、閉口した象牙質表面、細管内にただちにリン酸カルシウムの結晶が沈澱し、細管を封鎖した。結晶の大きさ、打撃物の硬度、厚さは、塗布方法や塗布する溶液の濃度によって変化した。5％リン酸ニトリウム水溶液を塗布した後、30％塩化カルシウム水溶液を知覚過敏歯にすりこむように塗布することにより、処置した患者の84％において痛みはただちに消失した。

牛エナメル並びガラスセラミックス実習用模型歯の静止負荷切削挙動に及ぼす
市販歯科用ダイヤモンドポイントのダイヤモンド砥粒サイズの影響
平 雅之*, 若狭邦男*, 山本昌雄*, 松井 昌**
*広島大学歯学部歯科工学講座
**歯学研究所以

市販歯科用ダイヤモンドポイントのダイヤモンド砥粒サイズ（普通粗粒、微粒、超微粒）が歯科高速切削に及ぼす影響を明らかにする目的で、牛エナメルとglass-ceramic実習用模型歯を被削材とした静止負荷切削実験をair-bearing式並びにball-bearing式ターピンを用いて行った。実験データとしては、負荷荷重の増加に伴う切削回転数の減少傾向と切削量の増加傾向を観察した。得られた知見は以下の通りである。
(1) 微粒ポイントの切削効率と切削回転数は普通粗粒ポイントのものと類似していた。従って、日常の歯科臨床において微粒ポイントを頻繁にすることが推奨される。修復物研磨用の超微粒ポイントの切削効率は他の2ポイントに比べると著しく小さかった。
(2) glass-ceramic模型歯を用いる切削実習では、エナメル切削と同様の切削量を得るためには若干大きな負荷荷重を必要とすることが示唆された。
(3) air-bearing式ターピンはball-bearing式ターピンに比べると切削回転数が低下しやすかったが切削量は大きかった。