



Effect of S-PRG particles on demineralization and remineralization of dentin: a clinical case report

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Abstract

It is known that the production of acid by oral bacteria dissolves mineral phases on the enamel surface, facilitating the formation of dental caries, with lactic acid being the main cause of caries, followed by acetic and propionic acids. Fluoride-containing materials play an important role in preventing demineralization and remineralization and these are widely used in dentistry. Although the benefits of fluoride in terms of reducing the incidence of dental caries are well established, fluoride cannot prevent caries in all patients; thus, the development of new anti-caries agents with remineralization properties is necessary. Thus, new products are emerging with this purpose and in this article, a material with Surface Pre Reacted Glass ionomer (S-PRG) particles will be addressed, these are produced by the acid-base reaction of fluoroboroaluminosilicate glass and polyacrylic acid and are known to have a potential to release 06 ions, such as Al, B, Na, Si, Sr and F, where these released ions played an important role in pH neutralization, leading to inhibition of enamel demineralization early point, where strontium (Sr) is becoming as a strong inducer of dentin matrix remineralization. Thus, this work aimed to demonstrate with a clinical case using S-PRG materials that can become an ally in the remineralization of the dental element. In conclusion, among the innovations that promote the concept of preventive and minimally invasive management, the bioactivity containing S-PRG can avoid invasive and definitive procedures such as tooth extraction.

Keywords: Demineralization. Remineralization. S-PRG. Oral hygiene.

Introduction

In recent years the incidence of tooth decay has decreased, however, tooth decay remains a major health problem worldwide affecting adults and children alike. Acids produced by oral bacteria lead to the loss of calcium and phosphate from dental enamel, which is termed demineralization leading to caries after prolonged exposure to an acidic environment [1]. Various dental products and applications were introduced in the last half-century to enhance the remineralization of enamel and dentin structures, such as fluoride which increases hydroxyapatite (HA) mineralization and reduces solubility. Iino et al. [2] explain that in the oral environment, demineralization and continuous remineralization of the tooth structure normally occur, when this balance is interrupted, demineralization can lead to a carious lesion.

Remineralization is the process by which calcium and phosphate ions are supplied to tooth enamel and apatite-like crystals form on the enamel surface, tooth decay is caused by an imbalance between demineralization and remineralization [1]. Complex factors are related to demineralization and remineralization in a reversible lesion of incipient caries in the oral cavity, where the salivary pellicle works to control remineralization and can act to inhibit the excessive deposition of minerals on the tooth surface. Remineralization is a self-healing process through mineral diffusion from saliva to the demineralized porous surface of the tooth and works to promote the process of incorporation of Ca and P into the crystalline structure of enamel to accelerate the process and

thereby provide a biocompatible approach to tooth decay. Caries management has recently focused on preventing demineralization, promoting self-healing mechanisms, and stopping the onset of the disease process [3].

Many diagnostic techniques have been developed to detect early carious lesions resulting from the demineralization process [2]. Materials with Surface Pre Reacted Glass ionomer (S-PRG) particles have been introduced for use in preventing carious lesions and may help to increase mineralization and reduce acid attacks by oral cariogenic bacteria [4]. Glass ionomer cement (GICs) have been widely used for the conservative treatment of enamel and dentin due to their beneficial properties such as chemical adhesion and fluoride release, in addition to conventional and resin-modified glass ionomer cement. buffer lactic acid solutions releasing their constituent ions, thus, a new material with an ionomeric base, but with an improved glass of fluorine boron aluminum and silicate was developed (SHOFU patent).

This technology is called GIOMER, that is, S-PRG particles follow a glass structure coated by an ionomeric layer and over it, a permeable layer, in the ionomeric layer 6 ions are present: aluminum (Al), boron (B), fluoride (F), silicon (Si), sodium (Na) and strontium (Sr) [3,5,6] when in contact with water, sodium (Na) enucleates all ions and releases them to the dental structure and the oral environment thus achieving greater tissue regeneration and neutralization of salivary pH in a few seconds [4,7].

Naoyuki et al. [8] explain that strontium (Sr) reinforces the tooth structure by acting on hydroxylapatite to convert it to strontium apatite resulting in the formation of an acid-resistant layer on the tooth surface, where the strontium supplied from the S- PRG for the tooth substrate can be incorporated into Calcium (Ca) sites in the hydroxyapatite of enamel and dentin, so the S-PRG resin filler containing material functions as a storage site for these ions through its

recharging effect. be useful for neutralizing acids in plaques and promoting remineralization in clinical settings. Thus, recently the use of nanohydroxyapatite, which is similar to the apatite crystal of dental enamel, has been proposed for the remineralization of early carious lesions [7,9].

Thus, this work aimed to demonstrate with a clinical case using S-PRG materials that can become an ally in the remineralization of the dental element.

Clinical case report

Study Design

The present study was elaborated according to the rules of the CARE case report (<https://www.care-statement.org/>).

Ethical Aspects

The present study preserved the patient's anonymity, as well as preserving the rights and care of the patient and her information as recommended by the Declaration of Helsinki of 1964.

Patient Information and Clinical Findings, Timeline, Diagnostic Assessment, Therapeutic Intervention, and Follow-up

A 62-year-old adult female patient arrived at the office of Dr. Taylane referred by the surgery team of Unorp/Unipós because the patient did not want to lose another tooth. The surgery team had condemned the root of tooth 15, as it had softened dentin, which would make it difficult to cement and retain a fiber post. As the patient wanted another opinion, the team referred it to Prof. Dr. Taylane to give her opinion. In the periapical radiographic examination (Photo 1a) and intraoral image (1b) (**Figure 1**), dentin demineralization was observed in the root of element 15, after the removal of the prosthetic crown, it was found that the root was actually with softened tissue, and the tooth was sentenced to extraction.

Figure 1. Photo 1a, 1b: Initial radiograph and an intraoral image showing total demineralization of the tooth.



Source: Own clinical case.

However, the patient was reluctant to accept having to extract another tooth. Thus, it was proposed to make an adjustment of the core and root with PRG PRO CARE GEL (**Figure 2**), and to carry out the cementation of the patient's core and crown, with calcium hydroxide cement mixed with PRG Pro Care Gel in a provisional and the patient would return in 1 week (**Figure 3**) for a new evaluation and, if the situation was the same, the extraction should be performed.

Figure 2. Photo 2: I use PRG PRO CARE GEL for the remineralization process.



Source: Own clinical case.

Figure 3. Photo 3: Evaluation at 7 days after prophylaxis with Giomer technology.



In the evaluation after 1 week, a satisfactory response with remineralization of the dental element can be noted. The entire softened structure had remineralized and it was possible to prepare the root canal, then cement a fiberglass post and reconstruct the dental crown with F-00 resin injectable with SPRG (**Figure 4**).

Figure 4. Photo 4: Cemented fiberglass post and injectable F00 resin filling core.



Source: Own clinical case.

Discussion

Many techniques have recently been introduced for the detection of demineralization that occurs as a result of the caries process [10-13]. Despite the availability of numerous interventions with fluoride, dental caries remains a common chronic disease with a global prevalence of 35% [14], which can cause continuous demineralization and remineralization in the oral environment [11].

A new ion-release varnish with S-PRG particles to control caries progression was developed for professional application, S-PRG particles are prepared by an acid-base reaction between fluorine boron aluminum silicate glass and acid polyacrylic in the presence of water to preliminarily form a stable glass ionomer phase within the glass particles [10].

Kotaku et al. [10] explain that dentin has a complex structure and comprises three main components: hydroxyapatite, an organic matrix based on collagen and tubules that permeate its entire mass, collagen fibrils are intertwined and arranged perpendicularly to the tubules while crystals of apatite tend to be positioned parallel to the long axis of collagen fibrins. Since Iino et al. [2] defends the importance of detecting and diagnosing caries lesions in the initial stage, delimiting the affected depth, as dentists can prevent the progression of caries and avoid the need for invasive removal of healthy dental structures.

Caries treatment has recently focused on detecting early carious lesions and noninvasive management to preserve tooth structure, with the expectation of self-repairing healing through remineralization. On the other hand, secondary caries remains a challenge in restorative dentistry, requiring bioactive materials that restore tooth health and promote dental healing during caries progression [3].

For this, Iino et al. [2], and Shimizubata et al. [6] report that S-PRG particles contain coating material that comprises a base and active liquids and can release various ions, including fluoride (F⁻), aluminum (Al³⁺), boron (B⁻) and strontium (Sr²⁺), which have an anti-demineralizing effect and in addition to their ability to remineralize, resins containing S-PRG fillers inhibit plaque formation. As for Murayama et al. [4], silicon (Si) is important in the mineralization of the dental substrate as it promotes the formation of hydroxyapatite by triggering the nucleation of hydroxyapatite in the presence of silica gel.

Iijima et al. [2] report that, through an in vitro study, it was shown that the similar remineralization efficacy of toothpaste containing S-PRG was superior to that of toothpaste containing sodium fluoride (NaF), compared to the etched surface, the properties of mechanical properties of specimens immersed in toothpaste solution containing S-PRG filler and which after 3 months were significantly increased by similar in vitro remineralization effects.

Still for Nakamura et al. [5], and Iijima et al. [7] experimental pastes are recognized as the best source of fluoride, being the most effective treatment to protect primary and permanent teeth from caries. The fluoride concentration in all saliva is related to the effectiveness of caries prevention and the experimental pastes are usually diluted in the brushing process since the elements silicon (Si) and aluminum (Al) formed the structure of the glass, and strontium (Sr) and fluoride (F) were added as modifiers, boron was also included because it is highly soluble and exhibits antibacterial and antiinflammatory properties [1,12,13]. Yet Hiraishi et al [14]. agree that studies have reported that several bioactive effects are associated with the ions that are released from S-PRG, including antibacterial effects, prevention of demineralization, and increased remineralization, and that the borate ion (BO₃³⁻) is well known for its antibacterial effect.

Thus, varnish containing S-PRG fillers was developed to produce a material that exhibits structural strength and ion-releasing ability, it was reported that a newly developed all-in-one adhesive system containing S-PRG fillers was capable of forming a caries-inhibiting layer that provided acid resistance around restorative materials [10]. SPRG technology forms a stable glass ionomer phase only on the surface of multifunctional glass particles, thus maintaining their basic properties and size. Silicate and fluoride are known to be strong inducers of dentin matrix remineralization, strontium and fluoride also improve the acid resistance of teeth by acting on hydroxyapatite to convert it into strontium apatite and fluoroapatite, respectively [10].

Shimazu et al. [13] report that even when a low concentration of fluorine was used for recharge, an amount of fluorine was released from the sealant with the S-PRG filler in a previous study reported the discovery of a release of considerable levels of the chemical agents contained in the technology. S-PRG Among the ions released from the SPR filler, strontium (Sr) was thought to play an important role in the mineralization of the dental substrate. The influence of strontium (Sr) on tooth remineralization has also been investigated previously and appears to have an ability to enhance tooth remineralization in conjunction with fluoride (F). Furthermore, silicon (Si) is believed to promote the formation of hydroxyapatite, as hydroxyapatite nucleation is triggered in the presence of it [2]. Shimazu et al. [13] suggest that sealants containing S-PRG filler will be more effective than other resin-based sealants tested in preventing dental caries when combined with daily brushing with fluoride toothpaste, as well as periodic care in the dental office. which includes a professionally applied high concentration fluoride topical treatment.

This fact suggests that the demineralization-inhibiting effect of the S-PRG charge containing experimental pastes was not only due to fluoride (F) ions, but also related to other ions released from the S-PRG charges. A recent study of a coating material containing S-PRG also suggested that the release of various ions from these fillers increased the enamel's resistance to demineralization. The ions released from the S-PRG filler have been shown to have antibacterial and pH neutralizing effects in acidic solutions [5]. Murayama et al. [4], completes that in aqueous environments sodium ions (Na⁺) are quickly exchanged for hydrogen cations (H⁺ or H₃O⁺) from the solution and the soluble silica in the form of Si (OH₄) is lost in the solution after breaking the bonds Si-O-Si and the formation of Si-OH (silanols) at the interface of the glass solution. And Naoyuki et al. [8] add that aluminum (Al) and silicon (Si) is the main chemical constituents of GICs where the presence of aluminum (Al) has been shown to strongly influence the release of fluoride (F) in some GICs.

Conclusion

The dentin remineralization achieved with S-PRG particles in just one week can be seen with the naked eye, this clinical case shows a new possibility of conservative treatment for our patient.

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Funding

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Ethics aspects

The present study preserved the patient's anonymity, as well as preserving the rights and care of the patient and her information as recommended by the Declaration of Helsinki of 1964.

Informed consent

The patient signed the consent form.

Data sharing statement

No additional data are available.

Conflict of interest

The authors declare no conflict of interest.

Similarity check

It was applied by Ithenticate@.

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References

1. Iijima M, Kawaguchi K, Kawamura N, Ito S, Saito T, Mizoguchi I. The effects of single application of pastes containing ion-releasing particles on enamel demineralization. *Dental Materials Journal* 2017; 36(4): 461–468. doi:10.4012/dmj.2016-307 JOI JST.JSTAGE/dmj/2016-307.
2. Iino M, Murayama R, Shimamura Y, Kurokawa H, Furuichi T, Mizuki TM. Optical coherence tomography examination of the effect of S-PRG filler extraction solution on the demineralization of bovine enamel. *Dental Materials Journal* 2014; 33 (1): 48–53. doi:10.4012/dmj.2013-202 JOI JST.JSTAGE/dmj/2013-202.
3. Naoyuki K, Toshima H, Nagano TF, Hashimoto M, Nezu T, Yokoyama A, et al. Inhibition of enamel demineralization by an ion-releasing tooth-coating material. *American journal of dentistry*. 32. 27-30 (2019).
4. Murayama R, Nagura Y, Yamauchi K, Moritake N, Iino M, Ishii R, et al. Effect of a coating material containing surface reaction-type pre-reacted glass-ionomer filler on prevention of primary enamel demineralization detected by optical coherence tomograph. *Journal of Oral Science* July 2018. doi.org/10.2334/josnusd.17-0256.
5. Nakamura K, Hamba H, Nakashima S, Sadr A, Nikaido T, Oikawa M, et al. Effects of experimental pastes containing surface pre-reacted glass ionomer fillers on inhibition of enamel demineralization. *Dental Materials Journal* 2017; 36(4): 482–490. doi:10.4012/dmj.2016-303 JOI JST.JSTAGE/dmj/2016-303.
6. Shimizubata M, Inokoshi M, Wada T, Takahashi R, Uo M, Minakuchi S. Basic properties of novel S-PRG filler-containing cement. *Dental Materials Journal* 2020. doi:10.4012/dmj.2019-317.
7. Iijima M, Ito S, Nakagaki S, Kohda N, Muguruma T, Saito T, et al. Effects of immersion in solution of an experimental toothpaste containing S-PRG filler on like- remineralizing ability of etched enamel. *Dental Materials Journal* 2014; 33(3): 430–436. doi: 10.4012 / dmj.2013-224 JOI JST.JSTAGE / dmj / 2013-224.
8. Naoyuki K, Toshima H, Nagano TF, Hashimoto M, Nezu T, Yokoyama A, et al. Inhibition of enamel demineralization by an ion-releasing tooth-coating material. *American journal of dentistry*. 32. 27-30 (2019).
9. Iijima M, Ishikawa R, Kawaguchi K, Ito S, Saito T, Mizoguchi I. Effects of pastes containing ion-releasing particles on dentin remineralization. *Dental Materials Journal* 2018. doi:10.4012/dmj.2018-015 JOI JST.JSTAGE/dmj/2018-015.
10. Kotaku M, Murayama R, Shimamura Y, Takahashi F, Suzuki T, Kurokawa H et al. Evaluation of the effects of fluoride-releasing varnish on dentin demineralization using optical coherence tomography. *Dental Materials Journal* 2014; 33(5): 648–655. https://doi.org/10.4012/dmj.2014-072.
11. Murayama R, Furuichi T, Yokokawa M, Takahashi F, Kawamoto R, Takamizawa T, et al. Ultrasonic investigation of the effect of S-PRG filler-containing coating material on bovine tooth demineralization. *Dental materials journal*. (2012). https://doi.org/10.4012/dmj.2012-153.
12. Zan KW, Nakamura K, Hamba H, Sadr A, Nikaido T, Tagami J. Micro-computed tomography assessment of root dentin around fluoride-releasing restorations after demineralization/remineralization. *Eur J Oral Sci* 2018; (00): 1–10.
13. Shimazu K, Ogata K, Karibe H. Evaluation of the ion-releasing and recharging abilities of a resin-based fissure sealant containing S-PRG filler. *Dental Materials Journal* 2011; 30 (6): 923–927. doi:10.4012/dmj.2011-124 JOI JST.JSTAGE/dmj/2011-124.

14. Hiraishi N, Sayed M, Hill R, Tagami J, Hayashi F. Interações de boro liberado de ionômero de vidro pré-reagido na superfície com esmalte/dentina e seu efeito no pH. Rep. Sci. 2021;11(1):15734. doi:10.1038/s41598-021-95279-x