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Papain Gel as a Deproteinizing Agent for Tooth Enamel

Gel de papaína como agente desproteinizante del esmalte dental

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Abstract:

Papain gel has been shown to be an effective deproteinizing agent for tooth enamel in several studies. Papain, a proteolytic enzyme derived from papaya, it can break down proteins and remove organic substances adhering to the surface of the enamel. Its application prior to enamel etching has demonstrated significant benefits, such as removing organic residues and improving the adhesion of dental materials. In addition, papain has been shown to be safe and biocompatible in dentistry. Its mechanism of action is based on its ability to break protein bonds, allowing a deep and effective cleaning of the enamel without compromising its structure. Therefore, this review aims to highlight the importance of papain as an effective and safe alternative in dental treatment, emphasizing its ability to improve the adhesion of dental materials and its specific mechanism of action in the removal of organic residues from tooth enamel.

Keywords:

Papain, Deproteinization, Acid Etching, Tooth Enamel, Acid Etching Pattern

Resumen:

El gel de papaína ha demostrado ser un eficaz agente desproteinizante del esmalte dental en diversos estudios. La papaína, es una enzima proteolítica derivada de la papaya, posee la capacidad de descomponer proteínas y eliminar sustancias orgánicas adherida a la superficie del esmalte. Su aplicación previa al grabado del esmalte ha demostrado beneficios significativos, como la eliminación de residuos orgánicos y la mejora de la adhesión de materiales dentales. Además, la papaína ha demostrado ser segura y biocompatible en su uso dental. Su mecanismo de acción se basa en su capacidad para romper enlaces proteicos permitiendo una limpieza profunda y efectiva del esmalte sin comprometer su estructura. Por lo tanto, esta revisión pretende resaltar la importancia de la papaína como una alternativa efectiva y segura en el tratamiento dental, enfatizando su capacidad para mejorar la adhesión de materiales dentales y su mecanismo de acción especifico en la eliminación de residuos orgánicos del esmalte dental.

Palabras Clave:

Papaína, desproteinización, grabado ácido, esmalte dental, patrón de grabado ácido

INTRODUCTION

Over the past few years, numerous investigations have been conducted in the field of adhesive dentistry. These studies have led to significant advances in the chemistry of dental adhesives, allowing for better preservation of the dental substrate.[1]

Buonocore, in 1955, introduced the concept of acid etching, which has become a widely used technique in the placement of composite resins, fissure sealants, orthodontic attachments, and other dental procedures. Since then, this technique has been established as a standard in dentistry, allowing for better adhesion and durability of the materials used.[1] Its purpose is to clean the tooth surface, remove the mud cover, microscopically improve the roughness by erasing the prismatic and interprismatic crystals, and improve the free energy of the surface to produce acceptable penetration of the monomer, blocking the surface with adhesive and promoting retention.[2,3]

Enamel etching produces three different micromorphological patterns: Type I, Type II, and Type III.[4] In the case of Type I and Type II engraving, the engraving patterns are considered highly favorable for achieving optimal bond strength.[5]

To achieve this effect, it is essential that before proceeding with acid etching, the removal of any organic residue present on the surface of the enamel can be ensured.[6] This is crucial for obtaining an optimal acid etching pattern, as a more receptive surface is achieved and conducive to achieving proper

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adhesion.[2,3] This concept, known as deproteinization, was introduced by Justus as an innovative technique for the removal of proteins present on the enamel surface.[7]

Contemporary scientific literature reveals the existence of other deproteinizing agents that have been studied.[8] Among them is 5.25% Sodium Hypochlorite (NaOCl) (Figure 1), the enzyme bromelain obtained from the stem of the pineapple plant.[8,9]

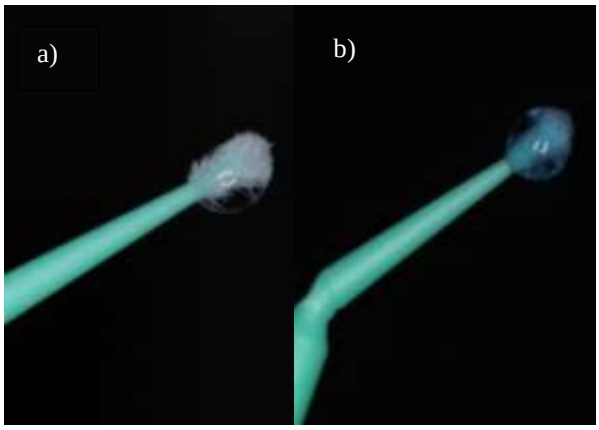

Figure 1. Brush with deproteinizing agents a) Sodium hypochlorite (NaOCl), b) Papain gel.

Recently, a study conducted by Pithon has shown that the use of a 10% papain gel (Figure 1) is an effective method to eliminate proteins present in certain simples.[8] This deproteinizing agent has been shown to be effective in removing protein impurities. Papain is extracted from the latex of *Carica papaya*, which belongs to the Caricaceae family.[9] It is a cysteine-type enzyme that possesses antibacterial and anti-inflammatory properties. In addition, this enzyme has been shown to act as a deproteinizing agent, removing the waste present without causing any harmful effects on normal tissues, making it a safe and effective option.[10]

ACID ETCHING PATTERNS

During the acid etching procedure applied to tooth enamel, significant variations in the topographies of the enamel surface can be identified. This phenomenon reflects the diversity in the response of enamel to acid treatment, manifesting itself in different patterns and surface textures that are crucial in the adhesion of restorative materials. The detailed observation of these topographical variations is mentioned below:

The Type I pattern is characterized by the dissolution of the prism nuclei without affecting the prism peripheries. It implies a greater dissolution in the center.[4]

The Type II etching pattern is different from the Type I, dissolution of the peripheral enamel occurs while keeping the prism cores intact. This results in a different surface texture, where the edges of the prism look more pronounced and prominent compared to the center of the prism.[11]

Type III etching exhibits fewer distinguishing features compared to the other two patterns. In some areas, similarities with other patterns can be found, and there are also areas whose topography bears no relation to the shape of the enamel prism (Table 1).[12]

In both Type I and Type II etching, the resulting patterns are considered highly beneficial in promoting optimal bonding. These etching patterns provide a rough, textured surface that improves bond retention and strength, which is critical to ensuring a successful outcome in adhesive procedure.[13]

Enamels etching patterns appear randomly at any point on the enamel and can appear together in any area of the adamantine fabric.[14]

The subsequent development of the acid etching technique was based on the idea of maximizing Type I and II patterns by optimizing the types, concentration, and duration of the etching acid.[15]

Silverstone showed that the patterns with the best retention were types I and II, due to the fact that they had a deeper and larger porous area. Type III does not have a deep and defined morphology, which means that it lacks micromechanical retention.[16]

Table 1. *Acid etching patterns identified in enamel after application of phosphoric acid.*[4,11-13]

Type I	It dissolves the head of the prism crystals, with an intact interprismatic substance or peripheral material.
Type II	It is achieved when acid dilutes the peripheral zone of the prisms, leaving the prism head relatively intact.
Type III	The surface has no definite characteristics and the surface changes, but generally the dissolution of the tissue is superficial, it does not alter the deeper layers of the enamel prisms.

DESPROTEINIZATION

Deproteinization is the process of eliminating the biofilm that is on the surface of the teeth, as well as the removal of collagen from previously conditioned surfaces, all this is achieved by applying substances such as alcohol, hypochlorite, papain, etc.[16] These products dissolve the proteins in the enamel, achieving a marginal seal, in order to avoid problems with the hybridization technique and thus be able to have an efficient resistance of the adhesive materials. It also favors the use of total etching adhesives and the adhesion between dentin and adhesive.[16,17]

The importance of this technique lies in the fact that it creates a barrier of organic material that prevents the dissolution of the prisms, which decreases the effectiveness of the adhesion of resinous materials.[18]

It was proposed using sodium hypochlorite (NaOCl) to improve binding in imperfect enamel in cases of hypocalcified amelogenesis.[19] Sodium hypochlorite is commonly used as a disinfectant, bleach, and as an irrigant in root canal treatment in dentistry.[20]

Piton et al, found that applying 10% papain gel prior to enamel etching helped remove organic substances and etching binding strength, giving another substance option for deproteinization.[8]

In studies carried out by Espinosa et al. on enamel deproteinization, it has been shown that by using an agent as a pretreatment for one minute before etching the dental organ, it is possible to increase surface retention by more than 45%, improving the quality of the etching and therefore the marginal retention and sealing of restorations (Figure 2).[21,22]

In 2015, Valencia et al. carried out a study in pediatric patients to examine the effect of deproteinization on primary and permanent enamel. The findings revealed that the etching of the enamel of a primary tooth is poorer than that of a permanent tooth, which in turn negatively affects the adhesion of various restorative materials.[18] However, it was highlighted that the implementation of a deproteinization procedure before acid etching shows significant potential to improve the quality of adhesion in dental restorations, applicable to both dental enamels. This observation underscores the importance of deproteinization as a valuable strategy to optimize results in dental restorations of both primary and permanent teeth.[22]

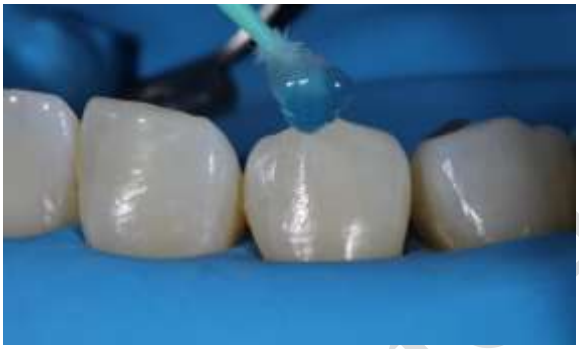

Figure 2. Application Papain gel in Tooth Enamel

ADVANTAGES OF DESPROTEINIZATION

Deproteinization, when used as a preliminary step before acid etching on the enamel, constitutes a significant advantage by increasing the retentive surface by more than 45%.[23] This process benefits both temporary and permanent enamel by improving the quality of the etch, facilitating greater retention and better marginal sealing in restorations. Additionally, a notable advantage of deproteinization is its ability to increase the resistance to detachment between resin and enamel by 30%, thus evidencing its added value in strengthening dental adhesion.[22]

PROTOCOL

Before carrying out this process, it is essential to understand its importance and the steps to follow to guarantee its effectiveness. Below is the recommended protocol to carry out dental deproteinization adequately and obtain optimal results in the adhesion of dental restorations.[7,15,28]

The procedure begins with the isolation of the operating field, followed by rubbing the surface with a deproteinizing agent for 60 seconds. Subsequently, rinsing is carried out for 60 seconds to ensure thorough removal of any residue. Then, the surface is etched with phosphoric acid (H3PO4) gel for 15 seconds, followed by another 60-second rinse to neutralize the acid and clean the surface. Complete drying is ensured before applying the adhesive. Photopolymerization is then performed according to the manufacturer's instructions. Finally, the restorative material is placed to complete the procedure.[7,15,28]

PAPAIN

Papain is a natural papain-based deproteinizing agent synthesized from papaya leaves and fruits. Papain is a proteolytic enzyme that is the product of the exudate of the green fruit of the Papaya (*Carica papaya*)[23], like human pepsin and acts as an anti-inflammatory debridement agent that does not harm healthy tissue and accelerates the healing process.[24]

Papain is an enzyme with bactericidal, bacteriostatic, anti-inflammatory, and proteolytic properties that allow it to break down short-chain peptides, proteins, and amide bonds. The active ingredient acts on the pre-degraded collagen of the lesion, favouring its softening, without acting on the adjacent healthy tissue and without causing pain. For this reason, it is used in the food industry and in the manufacture of medicinal products to facilitate the digestion of proteins.[25]

It has the ability to remove the collagen network from demineralized dentin by catalyzing the hydrolysis of this protein, which is broken down into amino acids, this makes the chemical composition of dentin more similar to that of enamel, by minimizing the organic component, which in turn promotes a change in the hydrophilic properties of dentin.[25] When this deproteinizing agent is used to remove collagen from previously etched dentin, there is an increase in the permeability of the dentin due to the enlargement of the dentin tubules in the superficial dentin, which improves the wetting and diffusion of the adhesive monomers through the dentin. In addition, the surface energy of the dentin increases as the removal of collagen that has a low surface energy increase, this also leads to a greater diffusion of monomers through the dentin tissue.[26]

As a result of this improvement in monomeric infiltration, less nano filtration is observed. It should be noted that this is an agent under study and that clinical results are not available, and laboratory results are scarce.[27]

In a study conducted by Bussadori et al., it was shown that the Papacarie® product contains a papain gel that causes the degradation of collagen molecules, being a highly effective chemical agent for caries removal and an effective deproteinizing agent.[28]

A wide variety of studies have been conducted evaluating the effectiveness of papain gel in comparison to other deproteinizing agents used in dentistry. These studies are essential to determine the effectiveness of these agents in preparing tooth enamel before restorative procedures.[29]

In an in vitro study conducted in 2022, the effectiveness of three deproteinizing agents: 5% sodium hypochlorite, papain gel, and bromelain gel, on the adhesion of pit and fissure sealants was investigated. It was found that the addition of this step significantly increased the shear resistance of the sealant, with the bromelain gel group being the most effective, followed by papain gel and ending with 5% sodium hypochlorite. The findings indicate that papain gel stands out as a highly effective option for improving adhesion compared to sodium hypochlorite, which is one of the most widely used deproteinizing agents.[30]

CONCLUSIONS

Dental deproteinization with papain represents an effective and safe option in dental care, standing out for its ability to remove proteins and debris from the tooth surface. Its compatibility with other dental materials makes it a versatile tool that can be easily integrated into various treatment plans. In addition, being a non-invasive procedure, it is well tolerated by patients and presents a low risk of side effects. Taken together, these aspects make papain deproteinization an attractive option for maintaining good oral health and improving the quality of adhesion of dental treatments.

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