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Original article

Enamel protection after stripping procedures: An in vivo study

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Keywords
Stripping
Interproximal reduction
Fluoride varnish
Saliva

Summary

Introduction > Interproximal enamel reduction (IPR) is a clinical procedure that has been in use since the advent of non-extraction orthodontic techniques. However, such a procedure affects the surface condition of the enamel and may predispose patients to cavities and hypersensitivity. The use of a remineralizing agent is recommended to prevent these side effects. The objective of our study was to evaluate the evolution of stripped proximal dental surfaces after exposure to the oral environment for 4 months with and without fluoride protection.

Materials and methods > Our sample consisted of 14 premolars (PM) from 6 patients of the Dentofacial Orthopaedics Department of the Consultation and Dental Treatment Centre of Rabat (CDTC) who required orthodontic treatment with PM extraction and had given their informed consent. The teeth were divided into 5 groups: group 1: intact enamel; group 2: intact enamel + fluoride varnish + 4-month oral exposure; group 3: IPR (manual and mechanized) + extraction; group 4: IPR (manual and mechanized) without varnish + 4-month oral exposure; group 5: IPR (manual and mechanized) + fluoride varnish + 4-month oral exposure. Proximal surfaces were subjected to qualitative analysis by scanning electron microscopy and quantitative analysis by Dispersive Energy Spectroscopy (DES) to quantify the percentage of mineral elements.

Results > Exposure of stripped dental surfaces to the oral environment for 4 months with or without fluoride protection showed the persistence of surface irregularities caused by stripping. We noted an improvement in the percentage of mineral elements for both groups with and without fluoride protection. However, the percentages of calcium (Ca) and phosphorus (P) were close to that of intact enamel in the fluoride varnish group.

Conclusion > Protecting stripped surfaces with fluoride varnish could help preserve the integrity of the enamel surface by restoring some of the mineral elements lost during stripping.

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Original article

Mots clés
Stripping
Réduction amélaire interproximale
Vernis fluoré
Salive

Résumé

La protection de l'émail après procédures de stripping : étude in vivo

Introduction > *La réduction de l'émail interproximale (RIP) est une procédure clinique en vigueur depuis l'avènement des techniques orthodontiques non extractionnistes. Toutefois, une telle procédure affecte l'état de surface de l'émail et risque de prédisposer les patients aux caries et aux hypersensibilités. L'application d'agent de reminéralisation est recommandée pour prévenir ces effets secondaires. L'objectif de notre étude était d'évaluer l'évolution des surfaces dentaires proximales strippées après exposition à l'environnement buccal pendant 4 mois avec et sans protection fluorée.*

Matériels et méthodes > *Notre échantillon est composé de 14 prémolaires (PM) appartenant à 6 patients du service d'orthopédie dentofaciale du centre de consultation et des traitements dentaires de Rabat (CCTD) nécessitant un traitement orthodontique par extraction de PM et ayant donné leur consentement éclairé. Les dents ont été réparties en 5 groupes : groupe 1 : émail intact ; groupe 2 : émail intact + vernis fluoré + séjour en bouche 4 mois ; groupe 3 : RIP (manuelle et mécanisée) + extraction ; groupe 4 : RIP ([manuelle et mécanisée] sans vernis + séjour en bouche de 4 mois) ; groupe 5 : RIP (manuelle et mécanisée) + vernis fluoré + séjour en bouche de 4 mois. Les surfaces proximales ont été soumises à une analyse qualitative par microscopie électronique à balayage et analyse quantitative par spectroscopie à énergie dispersive (EDS) pour quantifier le pourcentage des éléments minéraux.*

Résultats > *L'exposition des surfaces dentaires strippées à l'environnement buccal pendant 4 mois avec ou sans protection fluorée a montré la persistance des irrégularités de surface causées par le stripping. Nous avons noté une amélioration dans le pourcentage des éléments minéraux pour les deux groupes avec et sans protection fluorée. Cependant les pourcentages de Ca et P étaient proches de celle d'un émail intact dans le groupe avec vernis fluoré.*

Conclusion > *La protection des surfaces strippées avec un vernis fluoré pourrait contribuer à préserver l'intégrité de la surface amélaire en restaurant certains éléments minéraux perdus lors du stripping.*

Introduction

Reduction of interproximal enamel (IPR) is a clinical procedure that has been in use since the advent of non-extraction orthodontic techniques It consists of reducing the mesio-distal diameter of dental units by removing part of the interproximal dental enamel [1]. It is often used in orthodontics to correct disharmonies in dental shape or size as well as in the management of minor dental overcrowding [2,3]. Different stripping methods are available: abrasive strips, diamond discs and tungsten carbide or diamond burs [1]. However, scanning electron microscopy (SEM) observations have shown that regardless of the method used, all techniques affect the morphology of the enamel by leaving surface irregularities in the form of furrows and scratches [1,4–9] that could promote bacterial adhesion and plaque accumulation [4,6,10,11].

Indeed, enamel is a tissue with a complex structure, the chemical composition and surface condition of which change over time. It consists of a prismatic layer in its mass and two thin inner and outer aprismatic layers at its two ends. In its mature form, it contains more than 95% mineral element in the form of a stack of calcium phosphate or hydroxyapatite single crystals [12]. However, the reduction of enamel thickness involves the removal of the outer aprismatic layer, which is the protective layer of the enamel with the highest percentage of calcium and phosphate [10]. This can make the enamel sensitive to demineralization [10,13] and therefore predispose it to carious diseases and dental hypersensitivity. The application of a remineralizing agent then becomes crucial in improving the integrity of the enamel surface [14–16]. Several products have been cited in the literature for their anticariogenic and remineralizing effect, [4,5] including fluoride varnish. It is a concentrated form of fluoride with a resin or synthetic base, the chemical composition of which varies depending on the marketed products with a fluoride concentration ranging from 1000 to 56,300 ppm [17]. Thanks to its consistency, the varnish adheres to the dental surface allowing prolonged contact of the fluoride with the enamel. Indeed, fluoride ions will precipitate in the form of calcium fluoride microcrystals and act as an immediately available fluoride reservoir in the event of a drop in pH. Its incorporation into the mineral tissue allows the

transformation of hydroxyapatite crystals into fluorapatite or fluoridated hydroxyapatite, which have better stability and greater resistance to acid attack [18]. The study of the efficacy of fluoride varnish in preventing dental caries and intercepting initial lesions has been the subject of several studies [19,20]. However, very few studies have evaluated its effect and effectiveness in improving the integrity of stripped surfaces in the medium and long term. Therefore, we examined how these proximal surfaces react to oral exposure with and without fluoride protection. This evaluation involved a qualitative analysis by Scanning Electron Microscopy (SEM) and a quantitative analysis either by Dispersive Energy Spectroscopy (DES) to study the chemical composition of the enamel or by a hardness test to explore the mechanical properties of the enamel.

The purpose of this study was to evaluate, by qualitative (SEM) and quantitative (DES) analysis, the effect of fluoride varnish on stripped enamel surfaces after exposure to the oral environment for 4 months and compare it with the effect of saliva.

Materials and methods

Patient recruitment

For this preliminary study, 6 patients requiring orthodontic treatment with PM extraction were selected from the Dentofacial Orthopaedics Department of the Rabat CDTC. The selection criteria assumed good oral hygiene and intact PM. All patients and parents were informed of the study protocol and objective and they signed informed consent. All patients received clinical and radiographic evaluations by a single examiner. The patients who were not included in the study were affected by one or more problems like: systemic disease or taking medication that could affect salivary composition and flow; structural anomalies, white spots, cracks, cavities, restorative materials or exposure to chemical agents at the PM level; poor oral hygiene or wearing a multi-bracket appliance.

Protocol for reducing interproximal enamel

Patients were randomly assigned to 5 groups (*figure 1*):

- group 1: no stripping performed + extraction;
- group 2: no interproximal reduction + application of a fluoride varnish + exposure to the oral environment for 4 months + extraction;
- group 3: interproximal reduction + immediate extraction;
- group 4: interproximal reduction + exposure to the oral environment (saliva) for 4 months + extraction;
- group 5: interproximal reduction + application of a fluoride varnish on stripped surfaces + exposure to the oral environment for 4 months + extraction.

The interproximal reduction of the enamel was performed by a single operator. The procedure involved both the mesial and distal surfaces of the premolars in the stripped groups. Before the procedure, some precautions were taken to prevent the risk of damaging adjacent teeth: in all subjects, elastic separators were placed mesially and distally to the premolars for 3 days; during stripping and polishing, metal strips were applied to the adjacent teeth to prevent any damage to the enamel. Stripping was carried out either manually with abrasive strips or with the mechanized "Intensiv® ortho strips" system.

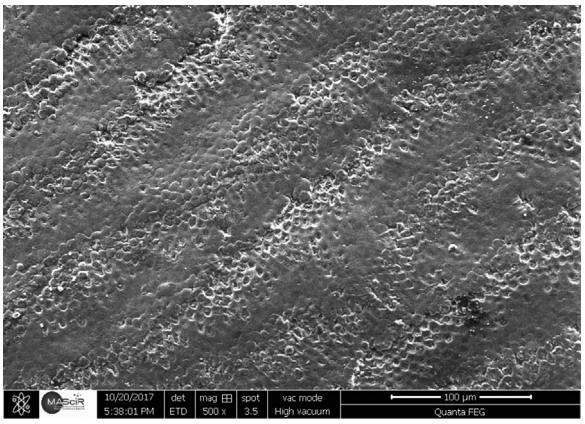

FIGURE 1

SEM photomicrographs (magnification × 500) of proximal surfaces of intact enamel (group 1)

Application of fluoride varnish

The application protocol of the remineralizing agent was performed by a single practitioner immediately after stripping. The application of the varnish was preceded by an isolation of the teeth using cotton rolls.

In accordance with the manufacturer's instructions, the fluoride varnish (Duraphat®) was applied to the stripped surfaces with a brush, then air-dried for 10 to 20 seconds, and the treated surface was protected against salivation for an additional 20 to 25 seconds. Patients were asked not to rinse, eat or drink for 3 hours after applying the varnish. Brushing was not resumed until after 24 hours, while the use of interdental floss or toothpicks was postponed to one week after the varnish application session.

Preparation of the extracted teeth

The samples were then thoroughly cleaned of debris and soft tissue using a diluted sodium hypochlorite solution and stored in a saline solution. Before the microscopic analysis phase, the teeth were immersed in ethanol for 24 hours and dried with a normal hair dryer.

Analysis of proximal dental surfaces (investigation)

The evaluation involved:

- a SEM analysis that enabled several photomicrographs for each sample with increasing magnifications (× 500, × 1000, × 2000, × 4000) to observe the enamel surface state in search of areas of demineralization or remineralization. This analysis took place in the technical platforms of the MAScIR Foundation (Moroccan Foundation for Advanced

Table I

Comparison of the chemical composition of enamel among the different groups.

Mineral elements	% of atoms				
	Intact enamel	Intact enamel + FV	IPR + extraction	IPR + oral exposure	IPR + FV + oral exposure
Calcium, (Ca)	13.06	19.03	4.09	7.88	12.59
Phosphate, (P)	6.96	10.46	2.55	4.56	7.42
Carbon, (C)	26.13	16.39	51.09	38.17	27.59
Oxygen, (O_2)	49.42	52.83	28.91	38.17	45.59
Nitrogen, (N)	3.34	–	7.14	5.24	2.44
Chlorine, (Cl)	0.05	0.24	2.96	2.05	0.35
Sodium, (Na)	0.46	0.54	3.33	2.33	3.61
Fluorine, (F)	0.54	0.47	–	0.15	–

FV: fluoride varnish; IPR: interproximal enamel reduction.

Science, Innovation and Research). The SEM used is the FEI, Quanta, 450 FEG, The Netherlands;

- a chemical analysis by DES to quantify both the changes in the percentages of the mineral elements mainly calcium and phosphate in order to highlight a possible mineral loss as well as the amount of carbon (C) as an organic component reflecting the adherence of bacteria to the enamel surface.

Results and discussion

Intact enamel

SEM observation of the surface of intact unvarnished enamel (group 1) revealed waves of perikymata forming regular troughs and crests (*figure 1*). This aspect is characteristic of young enamel [12]. The presence of many structural surface defects in the form of porosity was also noted. This aspect is consistent with what has been reported in the literature about the natural roughness of intact enamel [12–21]. Quantitative analysis of the intact enamel showed a percentage of 13% Ca and 6.96% P and a level of 26.13% carbon related to plaque retention on surface defects (*table I*).

The application of fluoride varnish on the surface of intact enamel with a 4-month oral exposure (group 2) slightly modified the surface topography of the enamel by reducing surface roughness (*figure 2*). This was materialized in chemical analysis by increasing the percentage of calcium (19.06%) and phosphate (10.46%) and a decrease in the amount of carbon (16.39%) which means that there was less retention of bacterial plaque related to the filling of surface depressions with mineral material. These results could confirm the remineralizing effect of the fluoride varnish reported in the literature [22–24].

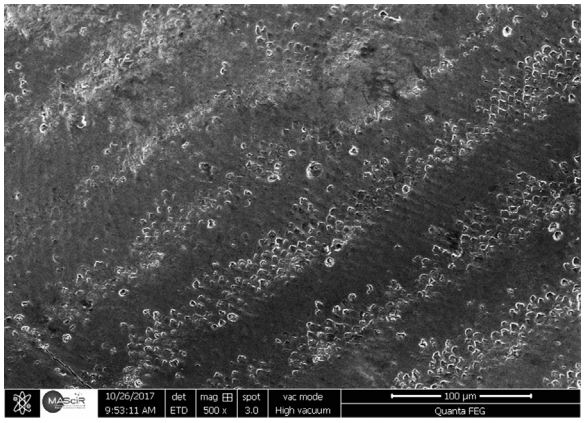

Figure 2

SEM photomicrographs (magnification × 500) of proximal surfaces of the intact enamel with application of fluoride varnish and 4-month exposure to saliva (group 2)

Stripped enamel: oral exposure

Stripping (group 3) using a manual or mechanized device has led to the disappearance of waves of perikymata, in connection with the elimination of the external layer of enamel as well as the increase in surface irregularities with the presence of fairly deep furrows and scratches (*figure 3*). The latter constitute preferential retention sites for bacterial plaque. This aspect has been described by several authors who have confirmed that interproximal reduction damages the integrity of the enamel surface by increasing surface defects [1,4–9]. Biochemical analysis of stripped enamel without exposure to the oral environment showed a decrease in the percentage of mineral elements (Ca = 4.09%, *P* = 2.55%) which is explained by the loss of mineral tissue when removing the protective outer

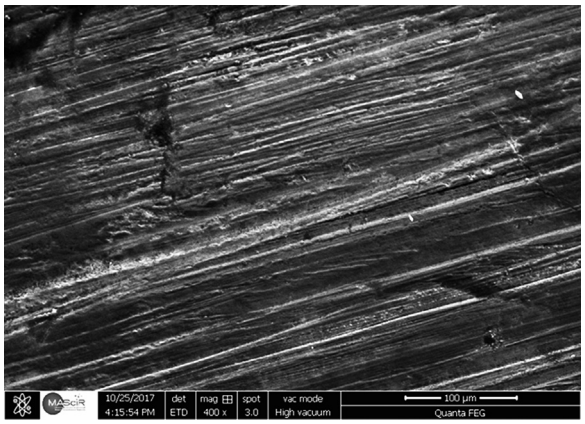

FIGURE 3

SEM photomicrographs (magnification × 500) of the proximal surfaces of the stripped enamel without application of fluoride varnish + immediate extraction (group 3)

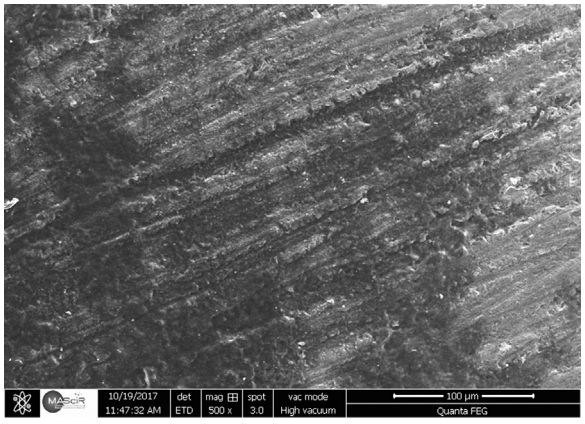

FIGURE 4

SEM photomicrographs (magnification × 500) of the proximal surfaces of the stripped enamel without application of fluoride varnish and 4-month exposure to saliva (group 4)

aprismatic layer from the enamel and by the increase in the amount of carbon (C = 51.09%) in relation to bacterial colonization of striations and surface furrows caused by stripping. These results confirm the data reported by some studies on the predisposition of stripped surfaces to demineralization compared to intact surfaces [10,13]. SEM observation of stripped surfaces after exposure to the oral environment (group 4) showed the persistence of surface irregularities caused by stripping even after 4-month oral exposure. However, in our study we noted a less rough and smoother appearance compared to stripped surfaces without exposure to saliva (*figure 4*). During the biochemical analysis, there was an increase in the

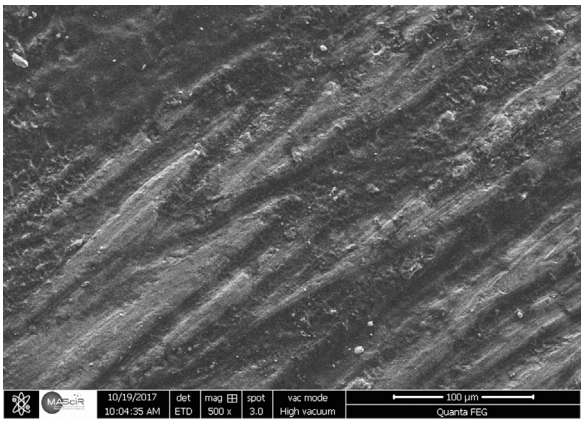

FIGURE 5

SEM photomicrographs (magnification × 500) of the proximal surfaces of stripped enamel with application of fluoride varnish and 4-month exposure to saliva (group 5)

percentages of Ca (7.88%) and P (4.56%) compared to stripped enamel not exposed to saliva as well as a decrease in the carbon content (38.17%). This result can be explained by the remineralizing role of saliva in relation to its physico-chemical properties [25,26], which contributed to the improvement of the surface state through the precipitation of Ca and P ions. This remineralizing effect of saliva has also been reported by Paganelli [27] and Bayram [21].

Stripped enamel: fluoride varnish and oral exposure

In the group of stripped surfaces with fluoride varnish application and oral exposure (group 5), there was a rougher surface appearance compared to stripped surfaces without varnish (*figure 5*), a result that was also reported by Bayram M et al. in 2017 [21]. During the biochemical analysis, we observed an increase in the percentages of mineral elements, with values of Ca (12.59%) and P (7.42%) exceeding the percentages found in groups 3 (stripped enamel + extraction) and 4 (stripped enamel + saliva exposure). In addition, there was also less carbon on varnished stripped surfaces, which implies that there was less retention of bacterial plaque. In summary, the exposure of stripped surfaces to the oral environment, with or without fluoride protection for a period of 4 months, showed the persistence of surface irregularities caused by stripping, however, the appearance became less rough after oral exposure. As for the chemical composition, an improvement in Ca and P levels, after 4-month oral exposure, was noted for both groups with and without fluoride protection in relation to the remineralizing effect of saliva and varnish. However, the percentages of Ca and P were close to that of intact enamel in the fluoride varnish group (*table I*).

Despite these convincing results, some limitations of the study are noteworthy, namely the sample size that was considered insufficient for statistical analysis since the number of dental

surfaces in each group was small. In addition, certain factors influencing the remineralization process could affect these results, such as oral hygiene, salivary properties, susceptibility to cavities and diet, which vary from one patient to another. To minimize the effects of these variations on the study results, further research is needed with a larger sample size and a longer follow-up time.

Conclusion

Despite the limitations of our study, we can conclude that interproximal reduction is a procedure that alters the surface condition of the tooth, and its mineral composition. Protecting stripped surfaces with fluoride varnish could help preserve the integrity of the enamel surface by reducing surface roughness and helping to recover some mineral elements lost during stripping. Until further in vivo studies are published, it is recommended to apply fluoride varnish after stripping in order to find or approach the properties of intact enamel.

Disclosure of interest: the authors declare that they have no competing interest.

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