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Clinical Significance of ICON and APF Topical Fluoride over Profoundness of Artificial Enamel Lesions: An In-Vitro Study

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Abstract

Introduction: Despite presence of many self or professional preventive treatments, dental caries has always been a public health challenge. One of them is ICON (Infiltration Concept), which has given promising results in many clinical & laboratory studies.

Aim: To evaluate the laboratory correlation between ICON resin infiltration (smooth surface) and APF topical fluoride in treating artificial enamel lesion on extracted human premolars and molars.

Materials and Methodology: In the laboratory quantitative research, microscopic assessment was done with 'Stereo-microscope' and 'Digital Imaging Software' 6.14.4 version on 22 extracted (treated with ICON & APF) human teeth after inducing artificial incipient caries.

Statistical analysis: t-test was applied to check effectiveness of APF-ICON in MATLAB software, to find mean, median, standard deviation, p-value and confidence level of mean to justify the results appropriately.

Results: A significant inference ($p<0.5$) was acquired at the end of the study i.e. at 6th week. Statistically, APF showed superiority to ICON with respect to lesion depth (mean 50.2mm).

Conclusion: ICON and APF are one of many ways to provide treatment of incipient caries or white spot lesions and maintain a natural anatomy of tooth structure with a clinical implication that they have potential as an agent.

Keywords: APF; ICON; Incipient Enamel Lesions.

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Introduction

In today's era, dental caries still poses a prevalent clinical condition worldwide among individuals. Despite presence of many self or professional preventive treatments be it fluoridated toothpastes, mouthwashes, topical applications or pit and fissure sealant, benefiting smooth or proximal surface caries, dental caries has always been a public health challenge.

Various minimally invasive approaches for the treatment of incipient lesions have been proposed in the past with some or other drawbacks. For example, a paste containing casein phospho-peptide amorphous calcium phosphate complexes (CCP-ACP) was used as the re-mineralization paste [1]. The major drawback of using this technique is the high amount of enamel that is eroded as a part of micro-abrasion [1].

And that is when in 2009, infiltration of porous lesion body with low-viscosity resin was approached. A new resin product was introduced with an assumption that it might be a promising non-invasive painless technique to restore the healthy form of a tooth structure.

Although, this concept at an early stage was not new. The first attempt to infiltrate porous de-mineralized enamel used a resorcinol - formaldehyde - based formulation in the 1970s but, due to its toxic nature, it was substituted for commercially available adhesives. However, due to its variable penetration coefficient, the poor ability of these materials to effectively penetrate natural carious lesions limits their use as agents for caries Infiltration [2].

As opposed to traditional techniques that superficially seal the enamel surface (without any resin penetration into the enamel lesion), this approach consists in infiltrating micro-spaces and micro-porosities of the subsurface lesion (up to a 450 µm depth) with a very low viscosity and high-penetration coefficient resin. Its penetration is driven by capillary forces and therefore time dependent. This infiltration technique has proven to hamper or even arrest caries progression in vitro [3]. Once it has infiltrated, the material is light cured. The refractive index of the resin is very close to that of enamel, which virtually eliminates the appearance of the "White-Spot Lesions".

Studies have been conducted investigating the ability of resin infiltrant to mask WSLs, and they have shown to do this effectively [4].

The infiltration technique has several advantages over other techniques. First, deeper lesions can be improved by the infiltration techniques which are not amenable to re-mineralization, and the aesthetic improvement can be seen instantly. Secondly, the infiltration is much less invasive compared to restoring the tooth [5]. No drilling and anesthesia is required, and the natural anatomy of the tooth form is preserved.

The ICON (Infiltration Concept) kit has (ICON Etch: 15% HCL, ICON – Dry: 99% ethanol, ICON – Infiltration: meth-acrylate – based resin matrix) unlike in pit and fissure which has 37% phosphoric acid etchant. From perseverance point of view, ICON provides less loss of tooth structure.

Based on the available laboratory and clinical studies, for example, Meyer-Lueckel H, et al. (2010) [6] assessed ICON radio-graphically into proximal lesions. The results showed that in the ICON treated lesions, 7% of the lesions showed progression, while in the placebo 37% lesions showed progression, it seems convincing that resin infiltration of enamel lesions should reduce (or even stop) the progress of white spot lesions. This technique is considered micro-invasive and might bridge the gap between non-invasive and minimally invasive treatment of initial dental caries, postponing if possible, the need for a restoration [7].

On the other hand, fluoride prevents caries mainly by its topical effect (keeping aside its systemic effect), they make teeth resistant to the acidic environment by lowering critical pH level of hydroxyl-apatite crystals.

Therefore, the aim of this study was to analyze the laboratory correlation between ICON resin infiltration (for smooth surface) and APF topical fluoride in treating artificial enamel lesion on permanent extracted sound human teeth. The purpose of the study so defined because none of the clinical or laboratory studies have compared ICON with APF topical fluoride on incipient caries lesions.

Materials and Methodology

It was a laboratory quantitative research in which at first an ethical clearance was taken from Research Review Board, MVGU, Jaipur. A pilot study was done to check the feasibility of de-mineralizing solution on creating artificial enamel lesions on 12 extracted sound human premolars and molars.

The total volume of solution per enamel surface was taken 2ml/mm^2 [7] and according to the pilot study, the total enamel surface area taken was 4mm X 3mm to have an appropriate examination of lesion framed by means of 'Stereomicroscope (Labomed Cx R3 model, USA)' and estimation through 'Digital Imaging Software, Carestream Health Inc. 2014 version 6.14.4, Canada'.

The study was conducted in the Department of Public Health Dentistry under the guidance of the Head of the Department. The time of study was of 2 months from June to July 2018 with support from Department of Oral Pathology & Department of Biotechnology, Jaipur Dental College.

An aggregate number of 22 sound human permanent premolars (11) and molars (11) extracted due to orthodontic reason were taken while considering convenience sampling method.

They were further equally divided into two groups of ICON and APF topical fluoride to have an individual as well as group comparison of each other.

Inclusion Criteria

- Sound extracted human premolars and molars.
- Teeth extracted only due to orthodontic reasons.
- Only permanent teeth of adults.

Exclusion Criteria

- No carious or traumatic teeth were considered.

Method of Preparing De-Mineralizing Solution

The de-mineralizing solution was composed of 8.2 mM acetate buffer solution containing 16.4 mM Ca $(NO_3)2.4H_2O$, 15.0 mM $NaH_2PO_4.2H_2O$, at a pH of 5.0 for 16 hrs. The specimens were immersed separately in an unstirred solution. The total volume of solution used was calculated using 2 mL/mm^2 of the enamel area [1].

Preparation of Samples

With the help of ruler metal scale and magnifying glass, an enamel surface area of 4mm X 3mm was marked on the buccal surface of each premolar and molar included in the study. And the rest of the surfaces of teeth were covered with nail varnish (red color) to avoid the response of undesirable tooth surface with de-mineralizing solution.

After immersing the specimens separately in the solution for 16 hours, their individual POP moulds were manually made to trim the tooth to 4-5 mm for the accurate visualization of the artificial enamel lesions under 'Stereomicroscope'.

After setting the degree of magnification at 0.7A, their individual photographs were taken from 'Sony R1plus' from the microscope lens distance to set the image size at 100kb-300kb to reduce errors in recording the estimation of lesion depth.

In the subsequent step, JPG images were imported to 'Digital Imaging Software 6.14.4' and profundity of penetration of artificial enamel lesions were recorded by drawing imaginary line from the maximum contour of enamel to the long-axis of teeth which consequently exclude the narrow cervical region of teeth.

Application of ICON and APF Topical Fluoride

In the study, two groups were made as described above, one of ICON and the other of APF topical fluoride with 22 sound extracted human premolars and molars respectively in each group.

ICON resin in filtrate was applied as per manufacturer's instructions and APF was applied with the help of an etchant brush over the exposed enamel surface.

After the application, the teeth were stored in normal saline for the period of 6 weeks and three recordings were taken one at the baseline after submersion in de-mineralizing solution for 16 hours then second reading after the application of materials at the 3rd week and the third reading at the 6th week to check the depth of penetration of the materials with the lesion depth.

Blinding Procedure

Both researcher and statistician were double blinded in the methodology of the study to reduce error of giving credit to the material which was already chosen by earlier studies.

Statistics

t-test was applied to check effectiveness of APF-ICON in MATLAB software, MathWorks Inc. version 9.2, Chicago, USA, to find mean, median, standard deviation, p-value and confidence level of mean to justify the results appropriately.

Results

After immersing teeth in the de-mineralizing solution for 16 hours, counterfeit caries lesions were observed by stereomicroscope and measured in micrometer with the help of dental imaging software. Off 22 teeth, artificial caries lesions were acknowledged on 21 teeth (95.45%).

After recording the baseline data, the methodology of the study entered the second phase.

Statistically Significant Result

ICON: Data at 3rd and 6th week: Two materials were applied on artificial lesions of the teeth and were kept in normal saline for the period of 6weeks. At the third week, penetration of ICON independent of lesion depth was admired clinically though it did not sow statistically significant result ($p \geq 0.05$) (Table 1).

APF: Data at 3rd and 6th week: As far as APF topical fluoride was concerned, at 3rd week, APF indicated more penetration when compared with ICON. Penetration of material was seen in 5 teeth.

The same penetration was seen in 8 teeth with slight increment at sixth week. It can be concluded that with the confidence level of APF penetration was absolutely valued (Table 2).

Comparison between APF-ICON: A significant inference ($p \leq 0.5$) was acquired at the end of the study i.e. at 6th week. Statistically, APF showed superiority to ICON with respect to lesion depth (Table 3).

Clinically Significant Result

ICON (infiltration concept) has shown more penetration with respect to lesion depth when compared with APF penetration to lesion depth (Figure 1 and Figure 2).

Discussion

In 2008, out of infinite methods, ICON (infiltration concept) is a material used to treat lesions on smooth surfaces as well as inter-proximal areas of the teeth.

The baseline measurements were taken after demineralization of the teeth. There was no control group in this study. Both the groups were equally treated with ICON and APF.

But by the end of 6th week, some significant results ($p \leq 0.05$) were noted down in which APF showed superiority in penetrating artificially created lesions compared with resins. From this observation, it can be concluded that frequent application of materials is required in a short period of time.

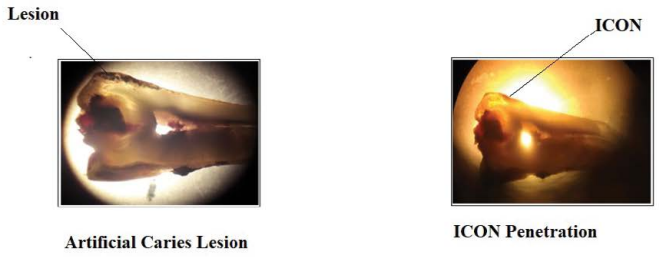

Figure 1: Penetration of ICON penetration with respect to artificial lesion depth.

Figure 2: Penetration of APF topical fluoride penetration with respect to artificial lesion depth.

Table 1: 't'-test applied to check effectiveness of ICON with/without respect to lesion depth.

ICON		Mean (mm)	Median	Standard Deviation	P-value	Confidence Level of Mean
Penetration	3 Weeks	4.2	0	13.9	0.38	61.80%
	6 Weeks	14.7	0	24.8	0.28	72.30%
Penetration-Lesion Depth	3 Weeks	-26.6	-8	42.5	0.73	26.50%
	6 Weeks	-16.1	-6	51.7	0.62	37.80%

Table-2: 't'-test applied to check effectiveness of APF with/without respect to lesion depth.

ICON		Mean (mm)	Median	Standard Deviation	P-value	Confidence Level of Mean
Penetration	3 Weeks	34.9	0	63.5	0.29	70.90%
	6 Weeks	50.7	27	62.9	0.21	79.00%
Penetration-Lesion Depth	3 Weeks	18.3	-0.2	62.3	0.38	61.50%
	6 Weeks	34.1	4	61.8	0.29	70.90%

Table-3: 't'-test applied to check effectiveness of ICON-APF.

ICON		Difference	t-Stat	P-value	Confidence Level of Mean
Penetration	3 Weeks	30.7	1.57	0.13	86.70%
	6 Weeks	36	1.77	0.09	90.70%
Penetration-Lesion Depth	3 Weeks	44.9	1.98	0.06	93.80%
	6 Weeks	50.2	2.1	0.05	94.80%

However, clinically, materials gave an inclination to perform well as the re-mineralization could easily be detected in microscopic images.

Why ICON?

Many studies have demonstrated the effectiveness of ICON with and without compared to fluorides.

Several previous studies have given good results like, by Paris S, et al. (2010) [8], which described the application techniques for the ICON material in detail. The authors concluded that the ICON infiltration material required two applications to penetrate to the depth of the lesion.

A similar type of study was done CRG Torres CR, et al. (2012) [7], which evaluated the effect of a caries infiltration technique and fluoride therapy on the micro-hardness of enamel carious lesions on 60 bovine teeth. The authors concluded micro-hardness of carious lesions increased with the infiltration of resin over a time.

Cost-effectiveness of ICON

ICON (smooth caries) is expensive than APF topical fluoride solution. This is based on the ICON kit which costs around Rs. 6500, for which the manufacturer states that 6 lesions can be treated with one kit. Considering the following, it is not evident whether it is possible in a clinical situation. In addition, it is a time-consuming procedure.

On the other hand, one bottle of APF topical fluoride solution costs around Rs. 500 and as per manufacturer, it gives a full-mouth coverage on 20-25 individuals.

Looking at the cost and the inconvenient process of the procedure, ICON material does not seem to fit in a public health setting.

Conclusion

ICON and APF are one of many ways to provide treatment of incipient caries or white spot lesions and maintain a natural anatomy of tooth structure with a clinical implication that they have potential as an agent.

Limitations

In the present study, 22 extracted sound human premolars (11) and molars (11) were taken. Since they were trimmed to a thickness of 3-4 micro-meter for the proper analysis under stereomicroscope, their anatomy could not be differentiated. Therefore, each tooth was considered as an individual entity. And the second taken limitation was use of scarce parameters.

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