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QUANTITATIVE LIGHT-INDUCED FLUORESCENCE (QLF) IN ORTHODONTICS – A REVIEW

[1] Ravi S
Associate Professor Department of Orthodontics and dentofacial orthopedics JSS dental college Mysore
raviortho11@gmail.com
[2] Ferin Fathima
Post graduate student Department of Orthodontics and dentofacial orthopedics JSS dental college Mysore
ferinortho@gmail.com
[3] Pradeep S
Assistant Professor Department of Orthodontics and dentofacial orthopedics JSS dental college Mysore
dr.pradeeps@jssuni.edu.in
[4] I.Girish kumar
Assistant Professor Department of Orthodontics and dentofacial orthopedics JSS dental college Mysore
[5] Bosy Thankam Mathew
Post graduate student Department of Orthodontics and dentofacial orthopedics JSS dental college Mysore
bosymathew@gmail.com

Abstract
Oral hygiene maintenance is usually more strenuous in patients undergoing orthodontic therapy as food lodgement occurs in between bands and brackets . Within a month of treatment this can lead to loss of mineral content of enamel. Preventive measures along with reinforcement and clinical evaluation is necessary. Mineral loss can occur before a white spot becomes visible on the enamel surface. Loss of minerals usually diagnosed by the clinician with visual evaluation alone cannot identify the mineral loss. This article attempts to identify and evaluate QLF as a diagnostic apparatus to detect white spot lesions and as a oral hygiene reinforcement reinforcement tool. A QLF apparatus consists of a DSLR camera along with filters and lighting to produce images. The photograph obtained in then uploaded into the

software for analysis of initial lesions. After which fluorescence of the surface can be quantitatively analysed comparing to the normal index of the enamel. QLF could be a new ally to the orthodontist to detect and prevent lesions at the earliest .

Key words – White spot lesions , Quantitative light induced fluorescence , Orthodontics , Enamel , Demineralization

Literature Reviewed

This literature review comprised of 32 articles which were grouped on the basis of the type data provided and thoroughly reviewed . 6 articles features QLF used during orthodontic treatment as a oral hygiene reinforcement tool and detection of WSL's , 2 were an orginal articles by the manufacturer , 1 listed the potential applications and limitations of QLF in dentistry , 18 articles included the diagnostic potential of QLF to detect white spot lesions , 2 introduced QLF for detection and quantification of coronal caries and 1 article included QLF as an apparatus to quantify fluorosis .

INTRODUCTION

Prevention of demineralization and advancement of remineralization in the beginning phases of dental caries have become the improvement of contemporary dentistry, alongside resotarative procedures(1). White spot lesions is an acceleration of demineralization and are mostly found in patients getting orthodontic therapy. It presents on the cervical and center third of the labial aspect of the maxillary dentition, mandibular canines, along with lingual surface around the orthodontic attachments that can be seen following fixed orthodontic treatment(2). Prospective factors, for example, age and improper oral hygiene maintenence preceding as well as during treatment, were attributed in caries improvement during the treatment. Great oral hygiene maintenance and utilization of antimicrobial agents are seen as powerful countermeasures for WSL improvement.

In any case, persistent hygiene is barely accomplised and it stays to be probably the greatest problems faced by the orthodontists .(3) Because of the elective nature of large numbers of these orthodontic procedures,diagnosing and prevention of these lesions is of high importance. In-vitro evaluation are reasonable, existing scientific rules demonstrate that researches could be the accessible proof. To accomplish the above , a strategy to distinguish, evaluating, and longitudinal checking of mineral loss in within the oral cavity is required . Quantitative light-induced fluorescence (QLF) may provide such a method (van der Veen and de Josselin de Jong, 2000). (4)

Background – The problem .

Need for non invasive diagnostic apparatus – Clinically efficient tools are a necessity in diagnosing the mineral loss of enamel surface (5)(6) Dentistry is in a paradigm shift from treating already developed caries to early diagnosis and preventive measures . In the US, dental

caries are the category one childhood disease. Adolescents suffer from dental caries majorly eventhough it is an easily preventable disease when diagnosed early.

As dental caries has a rapid progression rate only invasive treatment is left if left undiagnosed. Cavities were added greatly until previous eras using the G.V. Black definition which governsprobability for preventive measures. Such a traditional approach to dentine lesion therapy includes elimination of all dentinally infected and affected individuals (12).(12). As the demineralization occurs earlier diagnosis helps in more remineralization of the enamel surface than advanced lesions. Hence it is of utmost importance of detect any mineral loss at the earliest and take preventive measures. However clinicians have experienced difficulty in identifying occlusal caries through visual testing alone in recent years. Comparison to visual inspection alone, any use of the explorer would not enhance the validity of the diagnosis of fissure caries Combinations of visual inspections and testing have for years been the cornerstone of the detection of occlusal caries. Fissure surfaces can be altered by applying pressure using a probe (9)(10)(11) carious surface when detected is subjected to examination for the following parameters ,brown or white color, dull or shiny surface and smooth or rough surfaces .(4) The tools available for detecting caries are already very effective for detecting incipient lesions. The naked eye identification system is difficult to strike with the exception of approximate surfaces through optical techniques crafted to quantify only the whether the caries is present or not . Surface staining can present problems in the technique to distinguish the lesion from the sound tooth structure(13)

Newer diagnostic tools for caries detection should be an adjuct along with the visual examination .

With regard to the rapid progression of dental caries and the need of the oral health care proficient to limit caries progression , it has gotten more significant for clinicians to record data for cavitated lesions, with addition to the non-cavitated starting phases of dental caries (14)

Surface area, depth of the lesion and mineral content loss Quantification could lead to a proper diagnosis of the incipient lesions. Precise diagnosis and prevention is possible when the carious activity can me quantified over time .(4)

Laser Auto Fluorescence (LAF)

Bjelkhagen et al. and Sundstro¨m et al.(15) put forward usage of laser autofluorescence (LAF) to assess loss of mineral components of sound enamel .The studies revealed that LAF had better contrast with differentiating between early caries and sound enamel structure .they also stated that images could be unclear due to reflection while using white light . The auto-fluorescence procedure used a strong Argon laser emitting blue light with 488 nm continuous wave illuminating the teeth. A yellow cut off filter , filtering out all reflected and back scattered light, was placed in front of the eye in order to view the lesion. In 1992 a quantitative LAF system for determination of mineral loss was described. This method was further developed as an intra-oral laser fluorescence system to assess the baseline mineral content and longitudinal change in the mineral content of early enamel lesions in vivo.

Quantitative light-induced fluorescence (QLF)

QLF comprises of visual, visible light diagnosis and quanity analysis gadget for diagnosing premature mineral loss of dentition. It comprises of aprefessional DSLR camera , (16) a source of illumination, and n electronic-computer. Foundation of this approach could be that in above described conditions human dentition should exhibit fluorescence . QLF makes use of the natural reflective feature of teeth. Requirement of colouring agents or different enhancers is ruled out. The operator with the device observes a dark area, which in ordinary sunlight hours without unique apparatus one could show no demarcation (4). A white spot seen using LAF isn't hindered with any light falling on it that can blur the picture of the surface seen under artificial light source. The dimness of a incipient lesion seen with e apparatus be modified with adjustments in dispersions.

During the caries progression inorganic components are restored, ensuing in a reduced reflective characteristics as compared to unaffected tooth. Protein chromophores are eliminated through the caries process. The piercing intensity of light-source withinside the white spot is reduced than in unaffected tooth. Light particles getting into compromised tooth are scattered. Majority of light getting into the surface could bounce back and the risk of light entering the surface is negligible. Photons getting into the surface does now no longer approach dentine surface.The mild scattering in a caries lesion is a whole lot more potent than in sound tooth(17) Light getting into sound tooth is dispersed with an average of ten lesser in compromised tooth. Light perticles move similarly in unaffected tooth and alongside the course can be absorbed through a fluorophore main to exciting of reflective particle. Photons getting into unaffected tooth can also rech the inner aspect of the teeth in which the risk of absorbing can be a fold increased (fig1).

Several more particles of fluorescence within tooth structure are released than with the lesion. Its believed that all light particle with fluroscence are re-scattered onto the tooth surface to reduce the process. In fact, all fluorescent photon transfer directions from the fluorophore are equally possible (18) Tranæus S et al examined portions of the teeth by , histology, transverse-microradiography andmicroscopy with polarized light. Study determined that the light fluorescence for the oral-lingual sample demonstrated 79 percent sensitivity and 75 percent accuracy within clinical conditions (19)

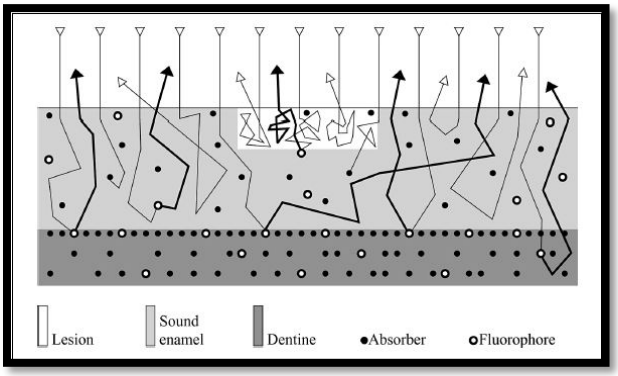

Fig1

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QLF- D

QLF was further developed into QLF-D which was digitized (4). This modification increased intensity of red-fluorescence. The system consists of an illumination tube with 8 LED's of violet blue. 4LEDs were white suspended on a ring tube around a 60-mm macro lens and a modified filter set. The red fluorescence is excited by U-V rays, and is encapsulated within a conspicuous photograph used for analysis afterwards. By usage of either os the LED's , DSLR apparatus can make QLF-D frames along with the standard frames for comparison .

In the photos, de-mineralized areas behave like unilluminated surfaces with loss of fluorescence which can be correlated with loss of inorganic substances (15). Analysis has shown that red fluorescence is caused by some compounds in bmicrobial anabolism, specifically porphyrin. Generally the red-fluorescence shows that there can be accelerated debris, calculus or gingival disease, independent of accumulated bits of food. Areas in which porphyrins were accumulated due to (anaerobic) microbial activity show light red/orange (Red Fluorescence)(20) (21). It is possible to physically track, record and measure these results.

Clinician has a total and incorporated diagnostic imaging at present with Q-Ray™ and which is accessible and designed scpecially for usageduring day to day clinical work.

APPLICATIONS

- QLF is a visual tool for determining incipient caries of enamel. QLF is appropriate for prospective observation of de- and remineralization in both therapeutic and experimental conditions (23). Thus QLF has tremendous potential in trials being a supportive tool for monitoring the effects of dental clinic preventive care on patients.

- Orthodontic patients are particularly prone to cavities. It is hard to clean the area from around brackets and thus it can be vulnerable to caries progression. Lesions are easily produced and can progress faster. It's possible to remineralize the lesions produced around the brackets. This leaves orthodontic patients particularly appropriate for QLF clinical trials. (24)

- QLF analysis for the quantitative analysis of lesions in primary dentition found that lesions of the very same depth on primary dentition were much easier to locate than on adult dentition. (25)

- QLF is ideally suited for clinical diagnosis on enamel surface with direct visualization of premature enamel lesions.

Quantification of Lesions with QLF

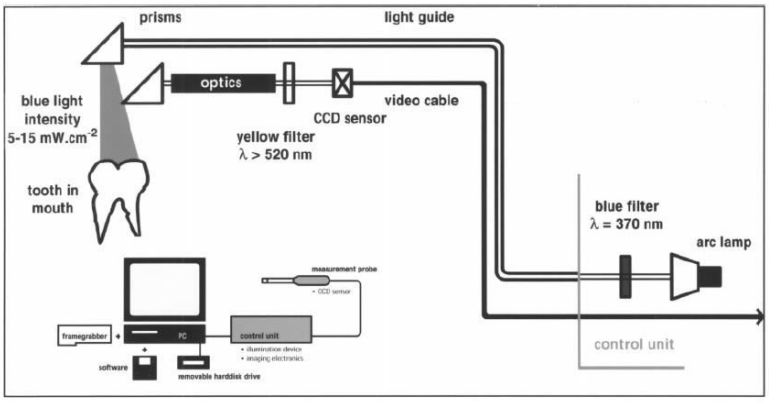
A base picture is taken when a dental specialist has discovered a white spot of the tooth surface caries. On a PC, the surface is marked to ensure visualization of limited surface, for example, caries are examined. A client shield with requirements constrained on the surfaces covering the surface was utilized to quantify the white spot. The illumination within the layer is rebuilt using 2-D linear interpolation of unaffected surface values on the patch edges. The drop in fluorescing can be calculated, measuring the percentages differences within the original and restored fluorescing area. Normally a surface with 5 percent or more can be called affected and should ne monitored. Fluorescence radiance loss is used to follow lesion severity in time with QLF for in vitro lesions, homogeneously formed and of fixed size. In vivo lesions are inhomogeneous and the lesion area varies in time. Thus, not only the fluorescence radiance but also the lesion area must be monitored to follow lesion progression or regression. QLF measures fluorescence radiance loss (%) and lesion size (mm2) as well as DQ (%·mm2) to describe lesion severity. DQ is defined as the fluorescence radiance loss integrated over the lesion area (%·mm2). DQ is comparable to the total amount of mineral lost from the lesion as measured with longitudinal microradiography. For clinical studies DQ is the lesion parameter to be monitored in time (26)

Analysis and quantification using qlf (27)

Name	Symbol	Unit	Description
Delta F	ΔF	%	% loss of fluorescing when compared to unaffected teeth
Delta Q	ΔQ	%px2	% loss of fluorescing when compared to unaffected teeth relating to surface area.
Lesion Area	AΔF	px2	Surface ΔF whether its lesser or in accordance with threshold ΔF (default-5%).
Delta R	ΔR	%	% of increasing of the ratio of the red and the green parameters with comparing to that ratio of unaffected surface. Porphyrin composition and microbial activity has an effect on this value.
RF Area	AΔR	px2	Area with ΔR equal or higher than a specific threshold value of ΔR.
Simple Plaque Score™	SPS™	-	surface area with progressed (5) or incipient debris (0).

Two-Tone Plaque Score™	TTPS™	%	% of surface area with progressed or incipient debris .

Diagrammatic representation of QLF device (fig 2)



Advantages (28)

- Early caries detection
- Monitoring patients with high caries risk
- Identifying developmental disorders vs carious lesions
- Evaluation of fissue sealants and restorations
- Evaluation of plaque removal

Limitations(28)

- Degree of dehydration of teeth might influence fluorescence
- Lesions not limited to one surface cannot be recorded

QLF IN ORTHODONTICS

The microbial plaque easily builds up on the teeth under orthodontic care. That's because debris accumulates inside the braces quickly and while the brackets are in position, it is much more hard to clean. The deposition of plaque may result in the formation of decalcification (white spots) on the teeth. This is the beginning of deterioration which will contribute to the need for permanent traces and fillings. Sufficient oral hygiene is required ahead of the start of orthodontic care. In a report by Cara C. Miller et al(29) on QLF-D as an oral health measurement method to test debris aggregation and decalcification in orthodontic practice. It was apparent that Quantitative Light-induced Fluorescence-Digital could be used to identify and track decalcification and plaque during orthodontics.

It is critical that clinicians seek a better quality of oral hygiene during orthodontic treatment to reduce plaque formation and demineralisation from developing. Even so, this can be hard to perform because the microbial plaque is not easily detected. Patients would therefore not be able to see whether the regions need better cleaning of their teeth. Al-Khateeb et al. (30) in his research studied pregressive dental caries that were found after bracket and band removal in teenage patients treated. For a 12-month follow-up, the analysis showed that there was remineralization.

QLF is a non-invasive technique that utilizes fluorescent light to detect the demineralization necessary for pathogenic microorganisms in plaque. The in vitro identification using quantitative light-induced fluorescence or incipient surface lesions surrounding orthodontic attachments was performed by I. A. Pretty et al (31) and it was found to be similar in both demineralization and remineralization. Analyzing Photographs showed that QLF diagnosed early white spots. Benson et al reported that mineral loss around orthodontic attachments can be thoroughly analysed by pictures which can be diagnosed using QLF.(32)

Conclusion

An ounce of prevention is worth a pound of cure , similarly Diagnosis and prevention of caries at the earliest activity is of tremendous importance than the caries severity.caries risk is intensified during orthodontic treatment in young population. Diagnosing and taking preventive measures for early mineral loss around orthodontic attachments have become of great importance since orthodontics is a mostly undergone electively . Methods that enable diagnosis earlier and quantifying of caries lesions should be helpful to monitor and treat over time. QLF acts as a diagnosis apparatus during orthodontic therapy for quantitative examination of lesions of dental lesions, debris , microbial build up and white spot lesions. As an oral hygiene reinforcing aid, QLF may also be used to explain and instruct the patient on the relevance of oral hygiene maintenance and its possible concomitant. Applications are many and prospective for QLF, more studies and validation is needed to pertain these propositions in the current dental clinic situations , for diagnosis of white spot lesions .

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