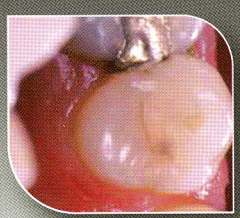
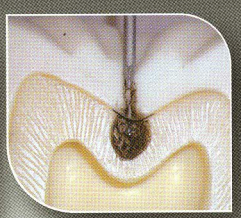
Microinvasive Dentistry

Clinical Strategies and Tools

John J Graeber

Preface

Tooth decay remains the most prevalent disease on earth. As Health Professionals, our goal is primarily to help heal our patients in need. This requires that we DO NO HARM.

In my opinion, **we do harm** when we do not avail ourselves of the most up-to-date devices and methods, which aid in the earliest possible diagnosis and intervene with the least invasive treatment, preventive or otherwise.

Microinvasive Dentistry is a series of manuscripts, which address prevention, management, early diagnosis, and treatment of caries – the most prevalent disease of mankind.

This book begins with a review of preventive techniques and current best practices with fluoride. The earliest signs of tooth decay can be treated with penetrating resins, sealants, and fluoride preparations when utilized early in the disease process.

Earlier diagnosis presents us with an opportunity to provide a better service, but only when we have the tools necessary for objective measurement and/or monitoring of the decay process. Several chapters of this book explain, in practical detail, devices, which far exceed the accuracy of the oldest dental instruments – the **explorer** and the dental bitewing X-ray.

The latest microbiological findings about caries are published here for the first time – shattering traditional concepts, not only in the discovery of novel causative species but also questioning current concepts of the anti-caries value of restorative materials. The potential of regeneration of dental materials is discussed by world-class researchers and clinicians.

Where caries has extended into the dental tissue, new methods of caries excavation and cavity preparation are explained and demonstrated in great detail by leading edge clinicians, based on years of real-life experience. The advantages of air-abrasives and all-tissue laser devices have been shown over the decades to be far safer on human teeth than the high-speed drills, which have been in common usage for the past 70 or so years. The time has arrived when we should be retiring the GV Black concepts designed for metallic restorations.

So, I invite you to read and study this book on **Microinvasive Dentistry** and challenge you to become part of the **New Age in Dentistry**.

John J Graeber
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Contributors

Stephen Abrams DDS
President & Founder
Quantum Dental Technologies
Briar Hill Avenue
Toronto, Ontario, Canada

Manaf Taher Agha DDS MD PhD (researcher)
Head of Laser Research Unit "Faculty of Dentistry"
Ajman University, UAE
Chairman of scientific and research committee/
ALD - USA
Lecturer and Private practitioner, Dubai, UAE

Mahmoud K AL-Omiri BDS PhD FDS RCS (England), FDS RCPS (Glasgow) Jordanian Board DCE (Ireland) FIADFE (USA)
Professor and Senior Consultant
Department of Prosthodontics, School of Dentistry
University of Jordan, Amman 11942, Jordan; and
Department of Prosthodontics, The City of London
School of Dentistry, London, UK

Hema P Arany BDS MDS CAGS
Restorative Dentistry and
Paediatric Dentistry, University at Buffalo
New York, United States

Praveen Arany BDS MDS MMSc PhD
Oral Biology & Biomedical Engineering
School of Dental Medicine, Engineering & Applied Sciences
University at Buffalo
New York, United States

Rella Christensen PhD
Former Founder and Director of CRA
Founder and Director of TRAC Research
(Technologies in Restorative and Caries Research)
Provo, Utah, United States

Arun Darbar BDS DGDP (UK)
Managing Director Smile Creations Innovations Ltd
Leighton Buzzard, Bedfordshire, UK

Jacob Graca BS
Oral Biology, University at Buffalo
New York, United States

Lawrence Kotlow DMD MAGD MALD FICD
Graduate of SUNY Buffalo Dental School 1972
Pediatric Dental fellowships 1972–1974 Cincinnati Children's Hospital
Board Certified Pediatric Dentistry 1980
Life member of the American Dental Association, (ADA)
Life Fellow of the American Board of Pediatric dentistry (FABPD)
Life member of the NYSDA and 3rd District Dental Society of NY
Member of American Academy of Physiologic Medicine and Dentistry (AAPMD)
Member of Academy of Laser Dentistry since 2000
Mastership Academy of Laser Dentistry (MALD)
ALD advanced proficiency in Erbium:YAG, Nd:YAG, Standard Proficiency in Diode 810 nm, and 9300 nm CO_2 lasers
Albany, New York, United States

V Kim Kutsch DMD
Past president of the Academy of Laser Dentistry and the World Congress of Minimally Invasive Dentistry
Board of directors for the World Clinical Laser Institute and the American Academy of Cosmetic Dentistry
CEO of Dental Alliance Holdings LLC, Manufacturer of the Carifree system, and Remin Media
Scientific Advisor of Dental Caries at the prestigious Kois Center
Albany, Oregon, United States

Nathaniel Lawson DMD PhD
Assistant Professor and Division Director of Biomaterials
University of Alabama Birmingham
Alabama, United States

Richard Chaet DDS MS
Private Practice in Pediatric Dentistry
Scottsdale, Arizona, United States

Joel H Berg DDS MS
Professor, Pediatric Dentistry
The University of Washington
Seattle, Washington, United States

Erica Levere DDS
Paediatric Dentistry and Oral Biology
University at Buffalo
New York, United States

Michael Lippe
Surgical/Dental microscope Industry leader since 1983 CJ-Optik, Leica and Zeiss Tampa
Florida, United States

Edward Lynch PhD (London) MA BDentSc TCD FDSRCSEd FIADFE FDSRCSLond FASDA
Honorary Professor in DeMontfort University, UK
Head of Dentistry, University of Warwick
Professor and Principal Director of Biomedical and Clinical Research
School of Dental Medicine
University of Nevada Las Vegas, United States

Alec Starostik BS MA
Oral Biology, University at Buffalo
New York, United States

John G Sulewski MA
Director of Education and Training
The Institute for Advanced Dental Technologies
Huntington Woods, Michigan, United States
Director or Education
Millennium Dental Technologies, Inc.
Cerritos, California, United States

Arthur R Volker DDS MSEd
Private Practice
New York, United States

Angie Wallace RDH
Laser Educator
Mastership with Academy of Laser Dentistry Tulsa
OK, United States

John C Comisi DDS
Associate Professor
Restorative Dentistry
Department of Oral Rehabilitation
James B Edwards College of Dental Medicine
Medical University of South Carolina
Charleston, United States

Andrej M Kielbassa Prof. Dr med. dent. Dr. h. c.
Professor and Head
Center for Operative Dentistry
Endodontology, and Periodontology
Danube Private University
Steiner Landstraße 124
A-3500 Krems
Austria

6 The canary system

Stephen Abrams

Introduction

The Canary System, developed by Quantum Dental Technologies (**Figure 1**) uses a low-power laser diode (<45 mW at the tooth surface) at 660 nm and modulated at 2 Hz[1] to examine the tooth. Its unique energy conversion technology [photothermal radiometry and luminescence (PTR-LUM)] allows it to image and examine the crystal structure of the tooth. The PTR-LUM is able to measure and monitor two different phenomena: (1) modulated thermal infrared radiation (PTR), and (2) alternating current LUM.[2] When pulses of laser light are shone on the tooth, the laser light is converted to heat (photothermal radiometry or PTR) and light (luminescence or LUM), which are emitted from the tooth surface in response to these modulated pulses.

Caries, cracks and erosion modify the thermal properties (PTR) and LUM of healthy teeth. As a lesion grows, there is a corresponding change in the PTR-LUM response signal. In effect, the heat confined or trapped in a region with crystalline disintegration (dental caries) increases the PTR and decreases the LUM response signal. As remineralization progresses and enamel prisms start to reform their structure, the thermal and luminescence properties begin to revert toward those of healthy tooth structure.[3-7] The Canary System detects very small changes in heat (<1–2°C), much less than that generated by a dental curing light. These pulses of laser light enable the clinician to examine lesions up to 5 mm below the surface.[8-11]

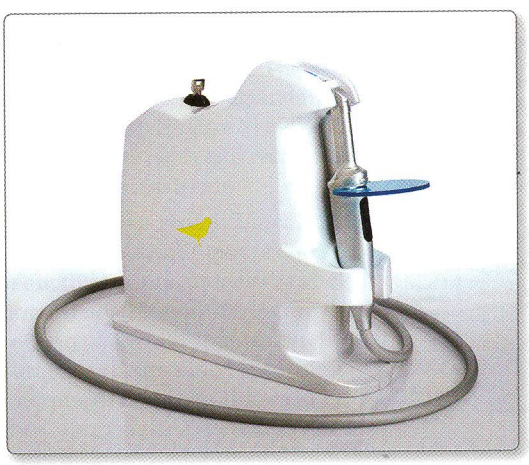

Figure 1 The Canary System.

Research has demonstrated that Canary's energy conversion technology (PTR-LUM) can detect, diagnose, record and monitor:

- Lesions and defects 5 mm below the enamel surface[11-15]
- Occlusal pit and fissure caries[8,13-15]
- Smooth surface caries[3,16,17]
- Acid erosion lesions[7,18-21]
- Root caries[22,23]
- Interproximal caries lesions[24-29]
- Caries beneath fissure sealants[30-33]
- Caries around margins of restorations and crowns[34-40]
- Caries beneath the intact margins of composite resins[37]
- Caries beneath the intact margins of amalgam restorations[38,39]
- Caries beneath the intact margins of resin modified glass ionomer & compomer restorations[39,40]
- Demineralization and remineralization of early lesions[6,7,23,41-45]
- Caries beneath clear resin infiltrants[46,47]
- Caries around orthodontic brackets.[48,49]
- Lesions and teeth treated with SDF (silver diamine fluoride)
- High inter and intra-examiner repeatability[33,40]
- Detect and diagnose caries more accurately than radiographs[24-26]
- Detect and diagnose caries more accurately than fluorescence devices such as DIAGNODent or SPECTRA[13,17,30, 33, 37,39,40]

Clinical trials

The Canary System has been investigated in three clinical trials. The first Health Canada-approved investigational study was completed in December, 2009. The trial involved 50 patients using the first

prototype in a number of clinical situations and found no safety issues.[50,51] The second Health Canada clinical trial was a follow-on study designed primarily to help QDT define the Canary Scale and determine how to best integrate the system into a dental practice. The study involved 98 patients among four trial sites with 38 patients involved in multiple visits for monitoring the effects of remineralization therapy.[52-55] The third clinical study was performed in 2014 at the University of Texas to investigate interproximal caries detection. The investigators found Canary was able to detect 92% of the lesions while radiographs only found 62%.[26]

One could consider other caries detection systems but the critical question is what exactly are they detecting? Currently, on market there are three different approaches to caries detection – fluorescence (DIAGNODent, SPECTRA and SOPRO), transillumination (CARIVU, FOTI and DIFOTI) and PTR-LUM ('The Canary System').

Fluorescence

Fluorescence is simply the emission of light from an object that has absorbed light at a specific wavelength.

These devices measure glow from the tooth surface when an LED or laser light is shone on the tooth. The literature indicates that the glow or fluorescence is from stain, bacterial porphyrins, tartar or food debris on the tooth surface.[56]

Transillumination

Transillumination involves shining either visible light or near infra-red light through a tooth and measuring the scatter or disruption of the light. Sound enamel is composed of densely packed hydroxyapatite crystals which allow light to pass through them. When demineralization occurs, the light or photons are disrupted and the area will appear as a shadow. Shadows may indicate caries is present because demineralized areas of enamel or dentine scatter light more than sound areas. Therefore, caries appear as darker areas using FOTI,[51] DIFOTI and CARIVU. These detection methods still rely upon visual examination of grey shadows on images to determine the presence of caries and measurement of changes in lesion volume may be challenging. **Figures 2** and **3** provide a short summary of the clinical and technical characteristics of these systems.

Method

The Canary System has a voice which provides the Canary Number after each 4 second scan. This helps both the operator and the patient to understand what is being measured (**Figure 4**). The Canary System also has an intra-oral camera so images of the surface being examined can be shown to the patient. Using the detail scan mode the Canary Numbers are recorded on the image and a report can be generated for the patient showing the Canary Numbers and treatment

Caries detection systems
Clinical comparison

PRODUCT	Canary System	DIAGNOdent	Spectra	SoproLife	CariVu
MANUFACTURER	The Canary System by Quantum Dental Technologies	KaVo	AIR TECHNIQUES	ACTEON	DEXIS CariVu
Detects caries and cracks on all tooth surfaces	✓	✗	✗	✗	Interproximal Only
Detects caries under sealants – clear and opaque	✓	✗	✗	✗	✗
Detects sub-surface caries	✓	✗	✗	✗	✗
Detects and measures tooth structure beneath White/Brown spots	✓	✗	✗	✗	✗
Detects caries around margins of restorations (amalgam, composite, crowns and glass Ionomer)	✓	Not accurate measures porphyrins	Restorative materials glow preventing view of margin	Restorative materials glow preventing view of margin	Only large interproximal lesion at gingival margin
Detects caries around orthodontic brackets	✓	✗	✗	✗	✗
Quantifies changes in lesion size and volume	✓	Not accurate measures porphyrins	Not accurate measures porphyrins small scale	Image only no measurements	Subjective observation of black/white image
Monitors and creates reports on the effectiveness of remineralization agents	✓	✗	✗	✗	✗

*Comparison information is based on published studies

Figure 2 Caries detection system: Clinical features.

Caries detection systems
Technical comparison

PRODUCT	Canary System	DIAGNOdent	Spectra	SoproLife	CariVu
MANUFACTURER	The Canary System	KaVo	AIR TECHNIQUES	ACTEON	DEXIS CariVu
Measures changes in the crystal structure of tooth	✓	✗	✗	✗	✗
Method Of Detection	PTR-LUM Photothermal Radiometry and Luminescence	Measures porphyrins from bacteria, an indirect way to detect caries	Measures porphyrins from bacteria, an indirect way to detect caries	Measures porphyrins from bacteria, an indirect way to detect caries	Passes near infrared light through tooth (transillumination)
Use with ADA Code D0600 and CDA Code 04220 for caries detection – meets the code definition	✓	✗	✗	✗	Doesn't quantify lesion changes
Device output is quantifiable using a numerical scale	✓	Scale 0-100 does not measure changes in lesion volume	Scale 0 -5 creates large degree of variability	✗	✗
Software is provided	✓	✗	✓	✓	✓
Patient and dentist reports provided – engages patients	✓	✗	✗	✗	✗
Cloud storage with access to data, reports and analytics	✓	✗	✗	✗	✗

Figure 3 Caries detection systems: Technical features.

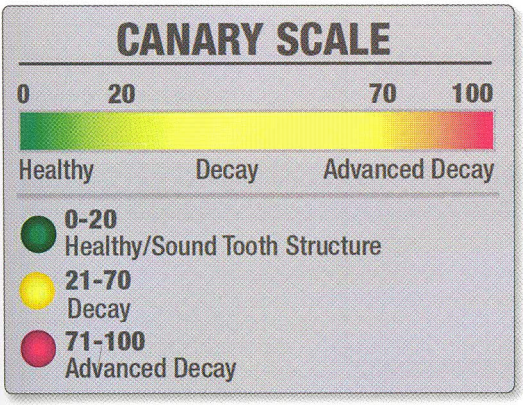

Figure 4 The Canary Scale.

recommendations. This creates the "medical model" for caries management. The patient can obtain a report (**Figure 5**) of the extent of the lesions on the teeth and recommendations on how best to treat them.

The earliest visual clinical sign of dental caries is the 'white spot lesion'. When this is first seen, the carious process has been going on potentially for months. **Figure 6** shows a cross-section of a white spot lesion. Even though the surface appears intact the lesion is at least 530 microns in depth. In this case, scanning with the Canary System detected this lesion. These early lesions can be treated, before cavitation and they are amenable to remineralization.[57,58]

The key is to find the lesion and use technology to monitor the changes in the lesion as it undergoes remineralization.

Integrating the Canary System into clinical practice

The Canary System can be integrated into three paths in a dental practice.

1. As part of the dental hygiene recall exam
2. Evaluating the progress of a remineralization/ prevention program
3. As part of the new patient exam

The chart below provides a summary of how The Canary System can be integrated into a dental practice (**Table 1**).

What should be scanned during a hygiene/ preventive visit?

- Status of pits and fissures on posterior teeth – helping to decide if sealants or restorations are required
- Status of the margins of restorations including composites, glass ionomers, amalgams, porcelain and metal crowns
- Stained marginal ridges to detect cracks
- White and brown spots on enamel or root surfaces
- Scan around orthodontic brackets to check for the development of white spots or caries beneath the bracket
- Interproximal areas to detect caries not seen on bitewing radiographs

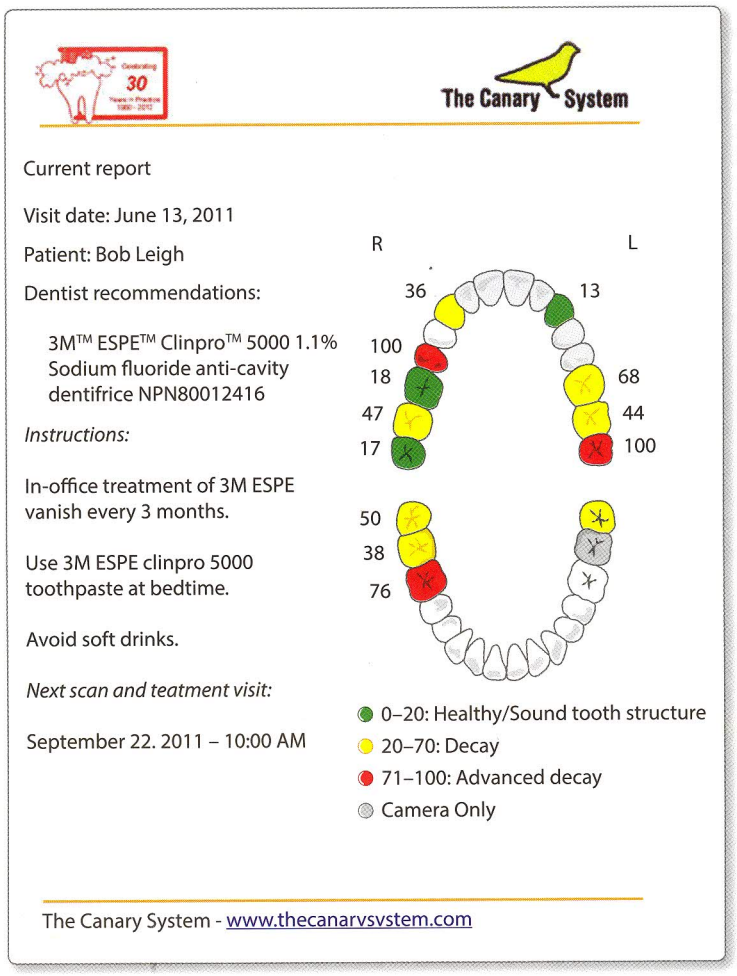

Figure 5 Canary patient report; it is available on the Canary Cloud or can be printed for the patient.

One should simply pick a quadrant (3–5 teeth) of most concern and assess all posterior teeth at the end of the appointment or scan teeth that are of concern.

Who can use the Canary System?

Any member of the dental team can use the Canary System, including dental assistants, dental hygienists and dental therapists. Once the scans are done, the dentist can then review the information and develop a treatment plan. Our canary recommended treatment guide provides guidance on how to treat various clinical situations.

Clinical cases

Remineralization of brown spot lesions: A female patient, in her mid-twenties, had brown spot lesions along the gingival crest of the second molars and the mandibular first molars. A remineralization program was started 4 years ago in an attempt to stabilize the lesions and prevent cavitation. At that time, the lesion surfaces were brown in color but had some surface roughness. Results from monitoring the mandibular left second molar over the last 42 months are displayed in **Figure 7**. The remineralization therapy consisted of a combination of 3M ESPE Vanish White Fluoride Varnish applied every 3–4 months in the office and the home use of 3M ESPE's Clinpro 5,000 toothpaste used nightly.

Initially, the patient started on the program and was able to decrease the Canary readout Number from "75" to "55" within the first 9 months of the program. There was no visible change but the patient was able to track their

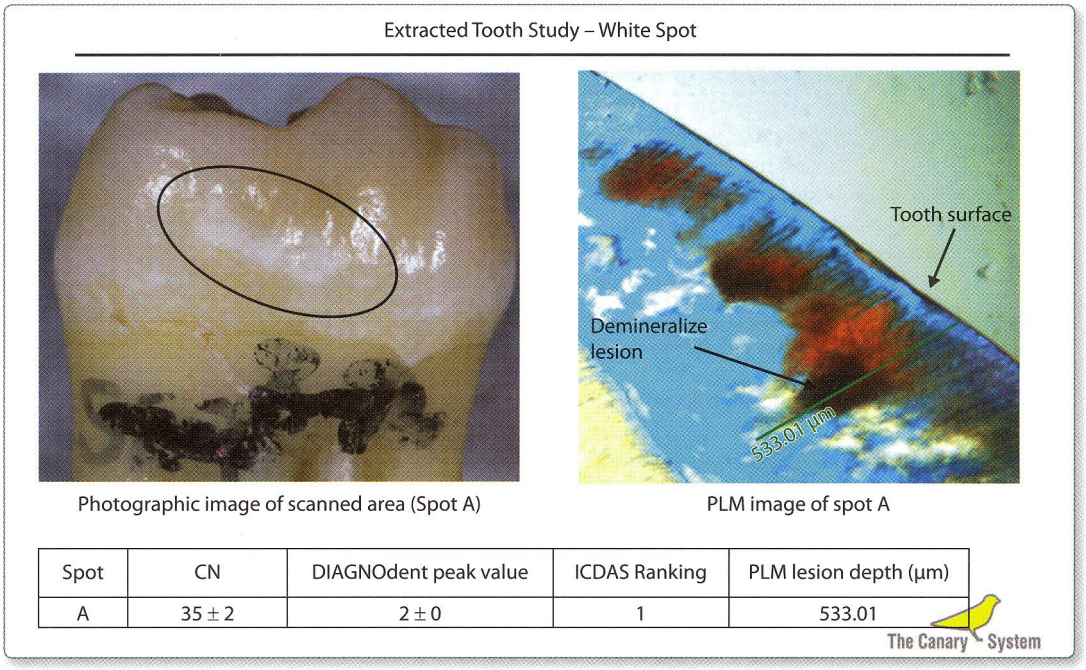

Figure 6 Extracted tooth study: Anatomy of a white spot lesion.

Table 1 Integration of the Canary System into clinical practice workflow

Examination type	Recall, re-care examination	Remineralization program	Full mouth examination
Details	Each scan takes 5 seconds. Scan 3–5 teeth and talk to the patient in under 4 minutes Scan at the end of the hygiene appointment while waiting for the dentist	Monitoring remineralization program using the Canary Book 15 minutes appointment to scan areas and apply remineralization product	A few offices book 45 minutes to 1 hour to scan the entire dentition. Some only focus on the posterior teeth and discolored areas on anterior teeth
Suggested billing code	Included in recall examination or use ADA code in the US (D0600) or Canadian Code (04220)	Remineralization/fluoride varnish or CAMBRA codes	US – ADA D0600* Canada – Specific Exam Code* or Caries Diagnostic code 04220
Staff	Hygiene team	Hygiene team or dental assistant	Hygiene team or dental assistant
Patient message	A new system for accurately evaluating the health of the tooth	Monitoring how our home and office tooth decay reversal program is working	There are a number of areas of concern that we can't assess with dental X-rays

*Refer to the specific billing codes used in the US and Canada.

progress by accessing their reports on the Canary Cloud.

From month 12 to month 36 the lesion did not decrease in size and this was due to poor compliance with the remineralization program. No surface cavitation developed nor was there any pain on temperature change or exposure to sweet carbohydrates.

From month 36 onward, the patient decided to try to improve her Canary Numbers and did follow the simple home care regime. The Canary Numbers dropped to "25" and remained stable going forward. The tooth surface became smoother and no cavitation developed. Visually, there are no signs of remineralization or color change since initially this is mostly a sub-surface

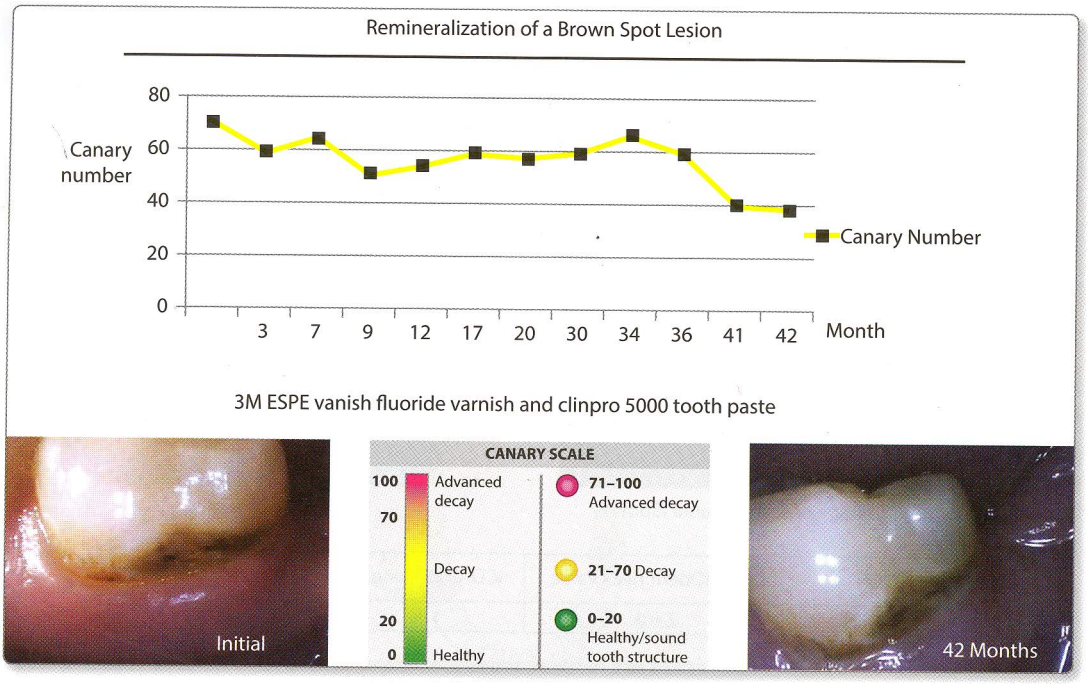

Figure 7 Monitoring the remineralization of a brown spot on mandibular second molar. (*Courtesy:* Quantum dental and Dr Stephen Abrams)

phenomena. The ICDAS II ranking has remained at "4" throughout this process since it could not detect any sub-surface remineralization. Using the Canary System, we were able to monitor remineralization of the lesion. The patient was able to follow the remineralization process by accessing her reports on the Canary Cloud and listening to the voice on the Canary System as each scan was taken. This allowed the patient to take ownership of the management of her oral health.

Clinical example of early caries detection using visual exam and radiographs

In this clinical situation, a 40-year-old female patient with minimal caries risk and only two pre-existing restorations was complaining of pain in the maxillary left first molar. The pain was low grade, not stimulated by chewing or cold. A routine bitewing radiograph (**Figure 8**) and visual examination revealed no sign of pathology, and both marginal ridges appeared intact with no signs of any radiolucency. Scanning the mesial contact area with the Canary System, however, indicated that a lesion was present beneath the occlusal aspect of the marginal ridge but toward

Figure 8 Bitewing radiograph showing no interproximal lesions on the left side.

the buccal surface (**Figure 9**). Preparation of the tooth for a conventional composite restoration (**Figure 10**) confirmed caries on the mesial contact area as indicated by the Canary System. This clinical example illustrates situations where radiographs and visual examination may not be able to detect lesions due to their placement beneath a hard intact shell of radiopaque enamel – but treatment was required.

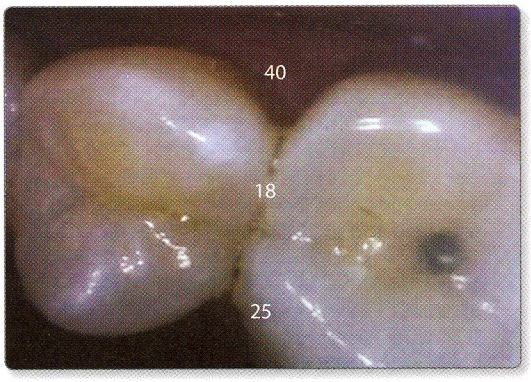

Figure 9 Canary scan of the mesial marginal ridge of the maxillary molar. The Canary has detected an interproximal lesion.

Figure 10 Opening the marginal ridge confirmed the presence of a lesion into the dentin not visible on radiographs.

Advantages

- Ability to detect lesions far earlier than with visual or radiographic methods
- Ability to measure objectively changes in lesion demineralization
- Cloud and audible options aid the patient's motivation in remineralization efforts
- Virtual Training and online videos are available for training new staff

Disadvantages

- Cost for equipment which is competitive with other technologies
- Time required for training/familiarization by the entire clinical team
- Time required for extensive testing of all suspected areas of demineralization

Conclusion

Caries a common oral disease treated in clinical practice. Treatment of the disease does not involve placement of restorations but the detection and monitoring of changes if one is placing restorations or remineralizing lesions. The Canary System detects monitors and measures the changes in the crystal structure of the tooth which means it can be used as diagnostic device for the detection and monitoring of caries in clinical practice.

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