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Demystifying the Minimal Invasive Concept

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ABSTRACT

Dental caries is the most common chronic oral disease afflicting mankind. It is a dynamic progressive multifactorial disease with waxing and waning of demineralization and remineralization. With the advancement of science and technology there is marked shift in our understanding of caries process. The evidence - based studies have led to evolution of newer concepts which in turn has led to development of state of art equipment and emergence of path breaking management strategies. The need of the hour is judicious integration of systematic assessment of clinically relevant scientific evidence in dental care, an approach that is especially relevant for incipient and hidden caries. Thus, to achieve this goal it is imperative that the dentist integrates the newer diagnostic aids which will aid in early detection and minimally invasive management of the carious lesion. This presentation gives an insight to the present status and also to the current and emerging minimal invasive trends and concepts of dental caries in the new millennium.

KEYWORDS; Dental caries, evidence based, incipient caries, hidden caries, minimally invasive.

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INTRODUCTION

The past few decades have seen tremendous developments in the understanding of the concept of dental cariology, diagnostic systems and dental materials. These have changed the clinician's approach to the management of dental caries. Our past understanding of the carious process, and limitations of available restorative options was responsible for invasive nature of management protocol. [1]

The management of dental caries till recently followed a particular pattern. However, it was in 1886 North Western University of Chicago, the legendary G. V. Black prophesized "The day is surely coming, and perhaps within the lifetime of you young men before me, when we will be engaged in practicing preventive, rather than reparative, dentistry." Today, well after a century, we are at the threshold of realizing his prophecy. But it's ironical in doing so we are abandoning his popularized concept "Extension for prevention" and embracing "Extension for preservation" a concept of minimal invasive dentistry which rest on the cornerstone of prevention, early identification, and restoration. Simonsen made the first reference to this phrase in literature. Dan Ericson in 2003 addressed as "maximal preservation of healthy dental structures". [2,3]

Minimally invasive dentistry rests on the strong tenets of prevention, remineralization minimal interception and replacement of existing defective restoration with minimal collateral damage. It achieves the management objective using the minimally invasive surgical approach, with the removal of the miniscule amount of healthy tissues. With advanced techniques of diagnosis and the principles of microdentistry, dental caries now is detected much earlier. The application of its concepts has been termed 'Minimally Invasive Dentistry', 'Minimal Intervention Dentistry' or 'Preservative Dentistry'. [2,3]

The objective is to preserve the natural teeth by circumventing or postponing surgical intervention whenever possible. The essential aspect of this approach shows a stress on risk assessment, prevention, early diagnosis of carious lesions, and remineralization of non-cavitated carious lesions. When a lesion necessitates restoration, removal of decay with maximal conservation of healthy tooth structure should be the holy grail.

This relatively new concept encompasses the following principles:

- Diagnosis and caries risk assessment.
- New cavity classification proposed by Mount and Hume which encompasses minimum intervention approach
- Non invasive management of initial carious lesion by remineralization.
- Minimal intervention preparation techniques

- Mechanical
  - Atraumatic restorative treatment
  - Polycarbonate burs
  - Sonic oscillation.
- Chemomechanical
  - Carisolv and enzymes.
- Kinetic
  - Air abrasion
- Hydrokinetic
  - Lasers

CARIES DIAGNOSIS AND RISK ASSESSMENT

Dental caries is a complex multi factorial disease that reflects change in one or more significant factors in the total oral habitat. CAMBRA stands for "Caries Management by Risk Assessment". The Caries Risk Assessment (CRA) measures the caries balance of a patient at a point in time. Patient management is according to their specific individual oral milieu and not treated generally. Treatment involves strategies that put the patient into a healthy balance.

The risk factors can predominantly be divided into two categories: Primary and modifying factors. The primary factors are the biological factors that act directly: saliva, diet, oral hygiene practices, inclusion of fluoride in caries preventive protocol. The modifying factors are those which have an oblique influence on caries process like socioeconomic standing, lifestyle and behavioural, ethnicity, customs and tradition, outlook towards general and oral hygiene, compliance and past dental history. The interplay of primary and modifying factors determine whether the biofilm is going to be healthy or cariogenic. In the case of CAMBRA, it requires an comprehensive understanding of the cariogenic biofilm, the caries risk factors determinants, diagnostic acumen of the clinician, treatment plan, monitoring and longitudinal assessment of lesions, and methods and means to measure treatment outcomes. [4,5]

EARLY DIAGNOSIS OF HIDDEN AND INCIPIENT CARIES

Detecting early dental caries and monitoring the dynamic processes of demineralization and remineralization are challenging. Conventional diagnostic methods, such as visual observation and the use of a sharp explorer tool, rely on subjective clinical criteria. Approximately 30%–40% mineral loss is a prerequisite before an early enamel carious lesion is visible radiographically. The precision of a method or test of diagnosis depends on its validity and reliability. [6]

DIAGNODent LASER DEVICE

The DIAGNODent laser device (KaVo) uses laser fluorescence to detect incipient caries. The exact mechanism of detection has not been fully articulated, but the device appears to measure the fluorescence of bacterial products confined in the carious lesions namely, porphyrins as opposed to crystalline disintegration. The device triggers a beam of laser which is absorbed by materials within the tooth and is eventually emanates as infrared fluorescence. Lussi criteria give an index by which the quantification of caries is graded, this helps in longitudinal monitoring of dental caries. Validity of laser fluorescence in diagnostic predicaments of non cavitated carious lesions was compared contrasted and correlated with the visual, tactual and radiographic method by Sharma et al and it was observed that laser fluorescence can serve as valid and reliable aid in caries detection of non cavitated lesions. [6,7]

DIGITAL IMAGING FIBER-OPTIC TRANSILLUMINATION DEVICE

The Digital Imaging Fiber-Optic Transillumination (DIFOTI) system (DIAGNOcam -KaVo) is based on the principle that demineralised areas of enamel or dentine scatter high intensity white light more than sound areas and incipient caries appear as darker areas in the concomitant images. This technology gives the latitude of digitally capturing and storing images of complete tooth. This helps in record keeping and longitudinal assessment of a carious lesion. [6,7]

QUANTITATIVE LIGHT-INDUCED FLUORESCENCE

It is postulated that human enamel auto fluoresces in certain conditions, Bjelkhagen observed that there is reduction of fluorescence in demineralised enamel, and Angmar-Månsson and Ten Bosch suggested that the increased porosity of carious lesions leads to a decrease in the refractive index. Initially argon laser was used but now images are captured by charge coupled device (CCD) cameras. Hence longitudinal monitoring of individual carious lesions could be achieved. It has a variegated clinical application ranging from detection of non cavitated lesions, detection of hidden caries, detecting decalcification adjacent to orthodontic brackets, detection of failing fissure sealants, evaluation of erosion and measurement of planimetric plaque. [5-8]

REVISED CARIES CLASSIFICATION

It is based on the foundation that a minimal access of lesion is needed to clean carious lesions which are infected and whose integrity is lost beyond point of remineralization**.** The new classification system is based on site of the lesion size of the cavity. It is based on a treatment centric approach rather than a diagnosis centric one. [9]

CARIES CLASSIFICATION SYSTEM BASED ON SITE AND SIZE (BY MOUNT AND HUME 1997)

THE THREE SITES OF CARIOUS LESIONS

- Site 1 –Pit and fissure caries of posterior teeth
- Site 2 – Proximal surface immediately just below contact areas with intact contact with adjacent teeth.
- Site 3 – on the cervical one-third of the crown or in cases following gingival recession, or on the exposed root.

THE FOUR SIZES OF CARIOUS LESIONS

It is possible to consider restorations in four sizes regardless of the site of origin of lesion. [11]

- Size 1 – there is minimal involvement of dentin which can be treated by remineralization alone.
- Size 2 – there is moderate involvement of dentin. Following cavity preparation the enamel will be sound and will be well supported by remaining dentin and will not shear away under normal masticatory occlusal load.
- Size 3 – the cavity is enlarged beyond moderate involvement. The remaining tooth structure is weakened to the extent that cusps or incisal edges are split or likely to fail if left without intervention and bearing the occlusal load. The cavity design should include cuspal coverage.
- Size 4 – there is extensive caries and a great bulk loss of tooth structure has already occurred.

NON-INVASIVE management of initial carious lesion by remineralization

FLUORIDE PREPARATIONS

Preventive management strategies are directed towards making the enamel more resistant towards acid dissolution. Fluoride present in saliva and biofilm does not affect the biofilm formation and sugar metabolism, but reduces demineralization by concomitant precipitation of fluorohydroxyapaptite, a phase more stable than hydroxyapatite at any given pH. The first acidic dissolution occurs subsurface. The subsurface lesion has the potentiality to remineralize when calcium and phosphate ions re-enter and lead to a more acid resistant enamel crystal. The action of fluoride accelerates the rebuilding of enamel and can stop or even reverse the progression of dental decay. Fluoride, calcium and phosphate inclusions lead to increasing the acid resistance of enamel crystal. Fluoride offers protection by replacing the ions lost during demineralization with fluoride, thereby forming fluorapatite, which is a larger and stronger crystal than hydroxyapatite. Prolonged

fluoride exposure increases the amount of fluoride acquired, as found in one in vitro study comparing the use of varnish on teeth for one hour and for six hours. [10]

CASEIN PHOSPHOPEPTIDES (CPP)

In 1991 a milk protein, casein, derivative casein phosphopeptide amorphous calcium phosphate (CPP-ACP), was patented in America. it acts by meta stabilizing calcium phosphate, maintaining a state of supersaturation of these ions in the oral cavity and thereby suppressing enamel demineralization and enhancing mineralization. Evidence based literature has shown that fluoride and CPP-ACP are used as adjuncts in remineralization protocol with varying degree of success They are used alone or as CPP-ACP (casein phophopeptides with amorphous calcium phosphate) or CPP-ACFP (casein phophopeptides with amorphous calcium fluoride phosphate). CPP-ACP has shown to reduce demineralization and enhance remineralization of the enamel subsurface carious lesions. This may be attributable to CPP's ability to keep calcium and phosphate in a metastable state on surface of tooth. [11]

NOVAMIN TECHNOLOGY

Bioactive glass (Bioglass®) was invented by Dr. Larry Hench in1960s. This research was as a result of a chance encounter of Dr. Hench with a US army colonel who had witnessed the physical and mental trauma of the Vietnam war. Dr Larry Hench was working on making glass resistant to nuclear radiation. The Col implored him to work on something which could 'survive exposure to human body', two years later bioglass was invented.

NovaMin is a bioactive glass containing calcium sodium phosphosilicate, and comprises 45% SiO2, 24.5 Na 2O, 24.5% CaO and 6% 6% P_2O_5.Bioglass, is a compound formed of calcium, sodium, silica and phosphorus. Individually these elements have limited clinical application in oral health. However, in the presence of saliva and water, a calcium phosphate layer forms and crystallises to form hydroxyapatite, which is similar both chemically and structurally to the minerals in teeth. It acts as a biomimetic mineralizer and affects cell signals for induction of mineralization and lead to restoration of tissue architecture and function. Chemically and structurally, this apatite is nearly identical to bone and tooth mineral. [11]

SELF ASSEMBLING PEPTIDE

Self-assembling peptides are a patented P114 peptides that has ability to self-assemble and form a three-dimensional scaffold in specific demarcated conditions and causes de novo nucleation of hydroxy apatite, akin to regeneration by virtue of enamel matrix proteins during tooth formation.[11]

Thus, it can be interpreted as a form of regeneration not remineralization. A greatest leverage of using self-assembling peptides to build nanostructures in a bottom-up approach, is that desired specific elements and characteristics can be incorporated and the peptides can be modulated and individualized based on functionality. Thus, this application rests on the theory that final projected structures will be self-assembled or self-integrated from simple modest building blocks.

MINIMAL INTERVENTION PREPARATION TECHNIQUES

MECHANICAL

- **ATRAUMATIC RESTORATIVE TREATMENT: - (ART)**

ART is a clinical field-based procedure based on excavating soft decalcified tooth tissue using hand instruments and restoring the cavity with an adhesive restoration. ART was conceptualized in Tanzania in mid-1980's and few years later in Malawi introduced in a dentistry. It was then tested and tries in challenging field conditions in Thailand in 1991 by Dr. Jo Frencken. Officially the ART technique was introduced globally on 7th April 1994 to commemorate the World Health day. This procedure was developed because millions of people in underdeveloped countries and communities like refugees and socially and financially underprivileged groups are not able to obtain basic dental care. ART has been identified as a single sitting need based approach, where gross caries removal is done manually with hand instruments without anesthesia and resultant modified and prepared cavity restored with glass ionomer restoration. It allows restorative treatment plans in far flung areas locations with no power supply and where sophisticated bulky dental equipment is not feasible or practically not possible to cart and install. [12,13]

POLYMER BURS IN MID

SS White Burs (Lakeland, N.J.) have introduced a medical grade polymer bur (SmartPrep), a patented product of Daniel Boston, DMD.,Temple University School of Dentistry Philadelphia, for selective removalof carious dentin with a knoop hardness less than that of healthy dentin. The Knoop hardness (KH) Test is a micro -indentation modality suitable for assessing the hardness of brittle materials like dentin and enamel. It is postulated that if the KH Value of an instrument is higher than carious dentin, it can remove carious dentin but when it encounter healthy dentin whose knoop hardness value is However, if the KH Value of the instrument is lower than healthy dentin it will spare healthy dentin and thus as result conserve tooth structure . The SmartPrep instrument is patented and designed for minimal invasive cavity preparation after access has been created using another instrument. [14,15]

Sonic and ultrasonic Oscillating Systems

To overcome indiscriminate cutting of healthy tooth structure newer designs of oscillating instruments sonic and ultrasonic tips have been introduced. The sonic instruments have one surface which is diamond-coated and other. The Sonicsys micro unit, was designed by Dr. Hugo, Dr. Unterbrink and Dr. Mösele as a joint venture of Ivoclar-Vivadent and KaVo (KaVoDental Ltd, Amersham, Bucks, UK). It utilizes the Sonicflex 2000L and 2000N air-scaler handpieces that oscillate in the sonic region (< 6.5 kHz). The tips have an elliptical motion with a transverse distance of between 0.08 - 0.15 mm and a longitudinal movement of between 0.055 - 0.135 mm. The diamond coated side is of 40 µm grit diamond and are cooled with water irrigant at a flow rate of between 20-30 mL / min [16]. When compared to hand instruments, the sonic instruments allow for significantly better finishing of the proximal bevels. [16] Improved manufacturing process with chemical vapor deposition method and diamond coating and improved specific tip designs has led to emergence of ultrasonic cavity preparation as a minimal invasive cavity preparation modality. The cutty efficiency of both sonic and ultrasonic instruments are not comparable to high speeds of air turbine but they are being researched and evaluated as an alternative precise ultraconservative modality for cavity preparation and refinement of finishing lines. [18]

Chemomechanical Caries Removal

Chemomechanical caries removal is based on softening and removal of carious dentin by chemicals. Due to caries there is collagen degradation, two zones can usually be recognized within a lesion. There is a partially demineralised inner layer which has the potentiality to be remineralized as the collagen fibrils are still intact, and there is an outer layer which has no chance of being remineralized as the collagen fibrils are partially degraded. A chemomechanical caries removal reagent should be able to cause further degradation of the partially degraded collagen, by cleavage of the polypeptide chains in the triple helix and/or hydrolysing the cross linkages. The reagent advocated is made by mixing amino acids with sodium hypochlorite

In 1976, Goldman and Kronman N-monocloroglycine (NMG, GK-101). Further modification led to the Caridex system, containing N-monochloro D, L-2-aminobutyrate (NMAB, GK-101E), was introduced. A gel-based system, Carisolv, was later introduced. This gel has two constituents, a red gel containing 0.1M amino acids (glutamic acid, leucine and lysine), NaCl, NaOH, erythrosine (added in order to make the gel visible during use); and a second containing sodium hypochlorite (NaCl – 0.5% w/v). The gel has a pH of around 11 at which it is hypothesized that positively and negatively charged groups on the amino acids become chlorinated leading to disruption of the the collagen cross linkage in the matrix of carious . Recently proteolytic reagents, such as sodium

hypochlorite and papain can be used synergistically to further degrade the partially demineralized collagen dentin matrix. [19]

OZONE

Invitro studies have proved the toxicity of ozone to most strains of bacteria and thus it can be postulated that pumping ozone in carious lesions can reduced microbial load. This possibly could defer the progress of carious lesion and may lead to remineralization if fluoride is made available. This in turn would delay or prevent the need for traditional dental conservation by 'drilling and filling[20]. A number of units are commercially available that may be used for dental applications e.g. HealOzone. A burst of ozone gas at a preset concentration is delivered, after which the unit vacuums or removes any residual ozone back through a catalyst that converts this ozone back to oxygen within another ten seconds. To complete the treatment, the Heal Ozone pumps a reductant fluid/mineral wash on to the treated site, to kick-start the remineralization process, which takes 5 seconds. [20]

KINEMATIC

Air Abrasion

Air abrasion was first used by Robert Black (1940, SS White - Airdent). Air abrasion propels a stream of aluminium oxide particles generated from compressed air with or without water. The abrasive particles strike the tooth at high speeds thus abrading the tooth structure. Abrasives normally employed for cutting tooth structure is aluminium oxide 27 microns for mild removal of tooth structure and 50 microns if greater tooth structure is to be removed. [20] The commercially available machines have a pressure setting of 40 –140 psi (pounds per square inch). The lowest effective pressure should be used to achieve the desired tooth preparation. For pit and fissure sealant prior sealant placement a brief burst of exposure of 40 psi is sufficient to clean fissures. While more extensive decay removal may require a nozzle pressures of 80 psi or more. In a study done by Sharma et al it was observed that the cavities prepared by air abrasion were shallower and narrower as compared to conventional method tested on the contralateral tooth type. Thus, conserving tooth structure, increasing strength and longevity of restoration. The line angles and point angles were more rounded, thus reducing stress concentration in the cavity. Air abrasion offered the advantage of reducing chairside time and pain perception was lesser and it was the preferred modality over conventional preparation. [20,21]

HYDROKINETIC

Lasers

Wavelengths of high powered lasers like Erbium chromium: YSGG (2780 nm) and Erbium:YAG (2940 nm have the highest absorption in water and have a high absorption for hydroxyapatite.The laser energy couples into the hydroxyl radical in the apatite crystal and into the water that is bound to the crystalline structures of the tooth. The the water within the mineral substrate will vaporize and lead to a massive volumetric expansion, causing the surrounding material to literally explode away. Caries removal and tooth preparation are easily accomplished. Additionally, sound tooth structure can be better preserved when the carious material is being ablated the increased water content in dental caries allows the laser to preferentially interact with that diseased tissue. The healthy enamel surface can be modified for increased adhesion of restorative material by exposing it to the laser energy. [21,22]

CURRENT STATUS OF CARIES VACCINE

Caries vaccine trials in humans have not yet been carried out. Although animal experiments indicate that immunization against caries is a possibility, several questions must be answered before the principle can be applied in human. The most important question concern safety route of vaccination and the optimal immunogen all of which are inter connected problems. Although dental caries is a disease that is unpleasant and sometimes painful, it is in no way life threatening. A vaccine to prevent caries will therefore be acceptable for human use only if it can be shown to be absolutely safe and without undesirable side-effects with the parenteral vaccination procedure. [22]

FUTURISTIC APPROACH

LASER CARIES INHIBITION

Since its baptism in 1960, by Maiman, lasers have been revamped with the aim to improve acid imperviousness in dental hard tissues. The conjectured mechanisms of actions have ranged from reduced perviousness of enamel to chemicals caused by liquescence of hydroxyapatite crystals to transpose enamel crystal lattice orientation. The lasers which have been scrutinized in the past for caries prevention are Er:YAG, ErCr,:YSGG. CO2 and Nd: YAG. [22,23] These lasers had limitations of being expensive, being mammoth and cumbersome, moreover the results obtained were debatable. Further, most of the studies evaluating the high-power lasers are invitro studies. [24,25]

Presently research is unravelling to establish a diverse laser which is portative, efficacious, remunerative and has a wide range of scientific applications. Low powered laser has a large number

of scientific relevance mainly directed toward soft tissues. But today they are being explored as an alternative to high powered lasers in hard tissue applications. [26,27]

Currently, diode laser is being evaluated as a surrogate to high wattage lasers. The hypothesized mechanism of action is the altered mineral has greater uptake of topically applied fluoride and thus greater acid refractoriness and leads to remineralisation of non cavitated lesions. [28-30]

Sharma et al conducted an in vitro study to appraise the efficaciousness of different surface remedies by laser fluorescence and it was observed the aluminium gallium arsenide laser irradiation of 2 watts followed by CPP-ACPF application was observed as the most adequate surface remedial modality as opposed remineralizing pastes used alone. [29,30]

CONCLUSION

Minimal intervention means that there should be greater emphasis upon education and direction of the patient towards self-care with the intention of preventing or healing the disease in the first place and eliminating, or minimizing, the need for surgical intervention. In fact it is possible to heal and remineralize a lesion providing it has not progressed to the stage of surface cavitation. It is not suggested that this approach is any easier than traditional surgery but it is far more conservative of tooth structure and offers the possibility of far greater longevity for the dentition in general. It also means that it is unacceptable to sacrifice natural tooth structure through the preparation of relatively large architecturally designed cavities on the assumption that this will, in any way, prevent further disease.

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