



Taper

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Digital Dentistry – Tomorrow's Dentistry

In recent years, the world has witnessed a rapid integration of digital technologies across various industries, revolutionizing the way we live, work, and even receive healthcare. Dentistry, too, has experienced a profound transformation with the advent of digital influence. From diagnosis and treatment planning to patient communication and education, digital tools have significantly enhanced the practice of dentistry, leading to improved patient outcomes and a more efficient healthcare system. Digital impressions obtained using intraoral scanners have replaced the traditional messy and uncomfortable impression materials, leading to improved patient comfort and accurate restorations. Digital workflow has not only increased efficiency but also improved the overall quality and longevity of dental restorations.

Digital tools have transformed the way dentists communicate with their patients and educate them about oral health. Intraoral cameras and chairside monitors allow dentists to capture images and videos of patients' oral conditions, providing visual evidence and enhancing patients' understanding of their dental issues. Dentists can use these tools to explain treatment options, demonstrate procedures, and address patients' concerns, fostering a more collaborative and informed decision-making process. Additionally, dental software applications and online platforms offer patients access to educational resources, preventive care tips, and appointment reminders, promoting proactive oral healthcare and empowering patients to take charge of their dental well-being.

Digital dental records and management systems have simplified administrative tasks, reducing paperwork and allowing for more efficient appointment scheduling, billing, and inventory management. Moreover, the integration of digital technologies with electronic health records (EHRs) facilitates seamless communication and data exchange among healthcare providers, improving coordination of care and enabling a more comprehensive approach to overall health.

While the digital influence in dentistry presents numerous advantages, it is essential to acknowledge the challenges that accompany this transformation. Embracing innovation and staying informed about emerging trends is essential for dental professionals striving for excellence in patient care. The remarkable advancements in digital dentistry, biomaterials, minimally invasive techniques, tele-dentistry, and integrative dentistry are shaping the future of dental practice. By integrating these innovations into our daily routines, we can elevate the standard of care, improve patient outcomes, and contribute to the overall advancement of the dental profession. Let us continue to embrace change, push the boundaries of our knowledge, and work together to create a brighter future for dentistry and the patients we serve.

Dear Friends & Colleagues,

I am happy to present the first edition of this volume of TAPER, the Journal of the Indian Dental Association, Thiruvalla Branch. A robust team headed by our dear president Dr Lanu Abraham and secretary Dr Thomas Jacob has really made my work lighter. Gratitude to all the authors for their contributions and timely responses. Thank you dear friends once again to have reposed confidence in me and given me this opportunity. *I remain.*

Dr Subbalekshmi

Editor, Taper



Presidential Address

Friends ,

At the onset let me express my heartfelt gratitude to all esteemed members of IDA Thiruvalla Branch for the overwhelming support that you are extending to our office in all its activities , like Sukrutham Project in World Cancer Day , Dentist Day honouring branch past presidents and secretaries , Tribal Project , public awareness posters , videos , other CDH , CDE,WDC , Sports and the latest in this series is the state wide call for dental protest .The preparation of the protest was complete and is historic in many ways . It was an eye opener for the Government officials and related departments . We proved our unity .

I'm deeply indebted to you all for the trust bestowed upon me to lead this organization through the year 2023 . Coming year's ahead many challenges can take place in our profession , be it starting of new colleges or new legislations . Our IDA should play the lead role in directing the policy makers to transform our profession in the best of interest for dentist as well as society .

I urge our IDA Thiruvalla Branch members to get involved in all branch activities and at the state level which reflects the professional nature of our association .

The work done by my predecessors are commendable and my efforts are aimed at carrying those forward. The journal Taper has accomplished its aim in publishing the academic and professional expertise of our IDA members. I congratulate our branch editor Dr.Subbalekhami for the commendable effort she has taken for this issue of 'TAPER'.I extend my sincere gratitude to the executive members for their valuable support.

I hope each member will join hands to stand by me in achieving the future goals of IDA Thiruvalla.

Thanking you all once again ,

With regards ,

Dr Lanu Abraham

President IDA Thiruvalla Branch .



Secretarial Address

Greetings from IDA Thiruvalla branch

“Alone we can do so little, together we can do so much” - Helen keller

It is with great enthusiasm and anticipation we look forward to this new edition of our branch journal ‘TAPER’.

An enormous amount of work has gone into the development of this journal and I believe you will see the effort reflected in the journal and in the impact it will have on our Dental practice.

As we look at the journal ‘TAPER’ it is important to keep in mind that it represents the collective thinking of a group of innovative individuals who share their knowledge in dentistry.

The journey of our journal ‘TAPER’ has been an interesting one since it’s Inception. As you all know that the print media is loosing its importance it was a great challenge for the editorial team to maintain its consistency for the past few years.

It was a privilege for me to serve as the Hon:Secretary of this branch for the past five years. I would like to appreciate the president, journal editor, editorial board and all who contributed for in bringing out another edition of ‘TAPER’.

Dental profession is facing obstacles of great Intensity, as the old and new generation of Dentist struggling to survive, It is very important for us to update ourselves through continuing dental education programs and journals to catch up with the latest trends and studies in dentistry.

Hope this journal will help us in enhancing our knowledge in dentistry.

Thanking you all

Jai IDA



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Thiruvalla Branch

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HOPE MEDI

Tailor Made Group Medical Insurance Policy for IDA Hope Members.

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Claim Management Guidelines- Reimbursement

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In emergency contact:
Hon. Secretary IDA HOPE
@ 9847240328

UNIQUE TO HOPE MEDI

- Parents of primary members are also covered
- No age limits for parents
- No check up tests prior to joining
- Pre existing illness of parents also covered* (after 1 year for new joining)
- Additional expenses bound to occur for treatment in higher centers also covered*

HOPE MEDI-HIGHLIGHTS

- All HOPE members are automatically eligible
- Tailor-made policy for US, 4th term running with minimum glitches and complaints
- No age limit for joining
- No medical checkups prior to joining
- All pre existing illness covered for members and after one year for family
- No additional premium for pre existing illnesses
- Newborn baby cover from day 1 without any additional premium*
- Cashless treatment facility available*
- Standard treatment charge reimbursed*
- Premium subject to revision each year in accordance to cash out flow
- Policy premium in shared and hence the lowest figure quoted
- Minimum exclusion applicable for payment denial
- Premium paid is eligible for income tax exemption under section 80D.

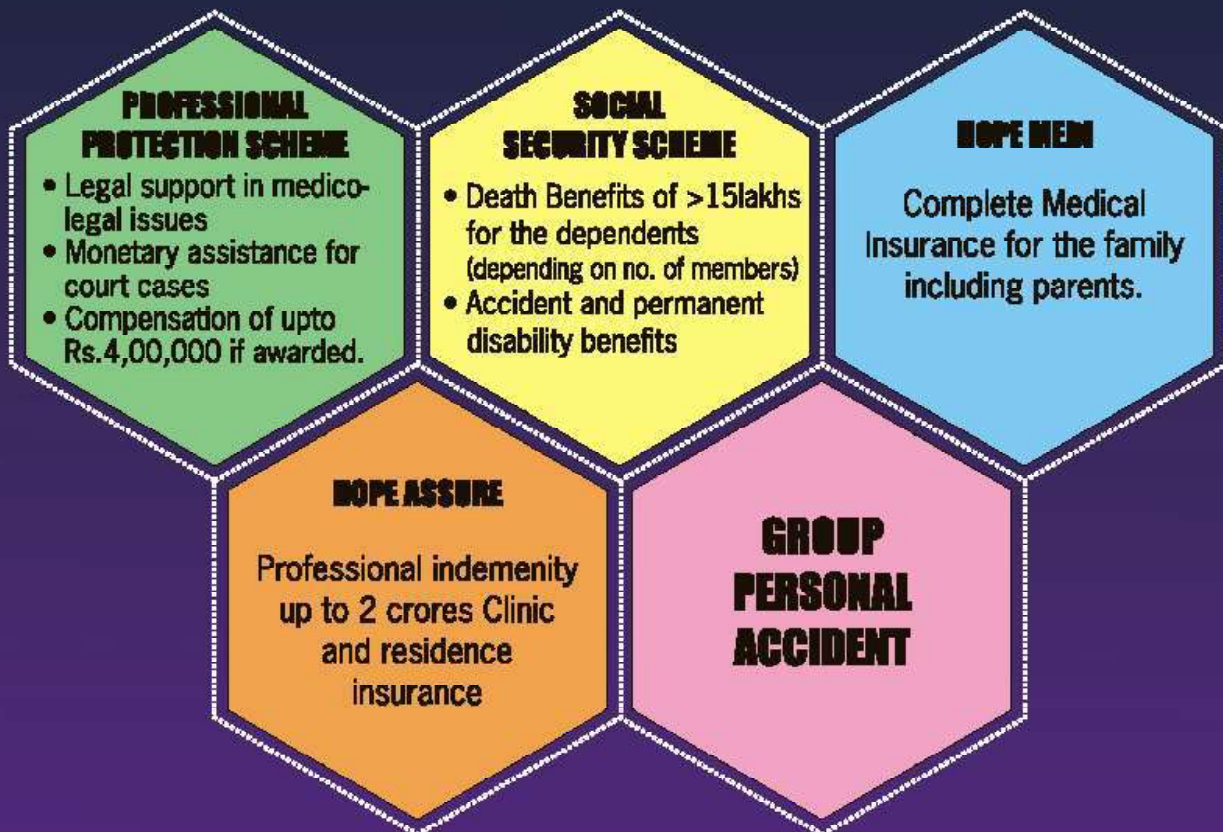
RENEWAL-30th SEPTEMBER

Getting Hospitalised??

Contact:
Jubilee Insurance
Broking Services
Rahul R : 7736810082
Jancy George : 9544157066



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Kerala State Branch**



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HOW TO BECOME A MEMBER ?

Apply to the Hon. Secretary, IDA HOPE through the branch representative with

1. Completely filled application in the prescribed form attested by the branch secretary /representative
 2. Admission fee (depending on age) taken as DD/ NEFT in favour of IDA HOPE Payable at Attingal or Account transfer (proof of transfer compulsory)
 3. Two recent passport size photographs
 4. Copy of Degree certificate
 5. Updated Dental Council Registration copy
 6. Age and Address proof
- Enrollment subject to confirmation of credit of the amount to HOPE account.
 - Joining fee and Renewal fee will not be collected from newly joining members in the same calendar year.

New memberships stops at the age of 50
(as on 1st April of current year)

Who can become a member of IDA HOPE ?

Members of IDA Kerala State up to the age of 50 who have a valid dental council registration are eligible to join IDA HOPE.

DEFAULTERS & DROPPED OUT MEMBERS

Members who do not renew by 31st of May will not be eligible for Social Security Coverage. They can renew up to 30th of September by paying a penalty of Rs.500. After 30th of September they will be considered as dropped out from the scheme. If they wish to rejoin, they can enter as a new member if below the age of 50.

ADMISSION – RENEWAL FEES

Admission fee

- Up to the age of 30 - Rs. 5000
- 31-40 yrs of age - Rs. 7500
- 41-50 Years of Age - Rs. 10000

Annual Renewal fee:

- Annual renewal amount - Rs. 1200
- Additional Rs. 500 / per death claim in a year
- Platinum Benefit scheme contribution – Rs. 800 (for members >30 years)

Eligibility to join HOPE

- Valid membership in any local branch in IDA Kerala State certified by Branch Secretary.
- Bachelor Degree in Dentistry from any recognised institution in the Indian union.
- Valid registration in any state Dental Council in India.
- Certificate to verify proof of age
- Documental proof of address.

Contact your local branch Hope Representative to
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Account Details: IDA HOPE
A/c No: 0316053000008249
Bank : South Indian Bank
Branch : Attingal
IFSC : SIBL0000114

IDA HOPE - FORMATION

HOPE is the unique scheme, driven as a FREE professional indemnity for its members

Started as PPS in 2002
Formed as HOPE in the year 2007
merging the two schemes

SSS Social Security Scheme

PPS Professional Protection Scheme

MEMBERSHIP STRENGTH



3750+ MEMBERS

PRESENTLY IDA HOPE PROVIDES

Social Security (Death / Total Permanent Disability)
> 15 Lakhs for the dependents

Professional protection compensations up to Rs. 4 Lakhs (with co-pay of 25% for 2 lakhs)

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- **Add on policy for Neon Signage & Plate Glass.**
- **New Public Liability cover**

RENEWAL - JULY 10

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LEGAL AID to the members for cases that may arise during the course of their professional practice.

The coverage for the new members starts **one month** after the acceptance of the complete documents including membership fee by the Hon. Secretary.

Takes up Dento - Legal cases of HOPE members from the first stage itself - Lawyer's Notice.

Engages and gets advice and support of Advocate Pays Advocate's / Legal fee and other expenses.

Fights out the case in Forum / Court Pays the compensation amount, if awarded

For Legal Assistance Contact **Dr. Sathesh K Joseph**, Vice Chairman-Legal Cell **Mob 9447141008**

SOCIAL SECURITY

- Supporting the family in the event of **Death / Total Permanent Disability** of a member.
- The contribution to the family (**Fraternity Contribution**) is collected from the members of the scheme @ **Rs. 500** per claim in a year.
- The coverage for the new members Starts **one year** after the acceptance of the complete documents including membership fee by the Hon. Secretary.

Dr. Anwar M Ali Vice Chairman- Social Security **Mob: 9446354333**

Local Drug Delivery Used an Adjunct for Non-Surgical Periodontal Therapy

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ABSTRACT: This article reviews local drug delivery systems containing antimicrobial agents. Further extensive comparative studies are required to optimize the use of novel drugs in the local drug delivery system to manage periodontal diseases. Periodontitis is a damaging inflammatory disease of the periodontium that is brought on by particular microorganisms and calls for more specialized care. Due to accessibility challenges in the deep periodontal pocket and the depth of microbial penetration into the periodontal connective tissues, standard mechanical therapy alone is insufficient for the treatment of moderate to severe periodontitis. Hence, local drug delivery into the periodontal pocket is advised to address the drawbacks of mechanical therapy. Chemotherapeutic drugs can be delivered locally to the location of a periodontal lesion, which has the benefit of delivering a larger concentration of the medication at the target site while limiting the drug's negative effects on the body's other systems. The local controlled-release drug delivery method should be viewed as an adjuvant. Periodontal disorders are treated with mechanical debridement. This article examines regional antimicrobial agent-containing drug delivery systems. To control periodontal diseases, more in-depth comparative research must be conducted in order to maximize the utilization of innovative medications in local drug delivery systems.

INTRODUCTION: A specific germ or collection of specific bacteria can cause periodontitis, an inflammatory illness of the teeth's supporting tissues that leads to periodontal pocket formation, gingival recession, or a combination of the two¹. Periodontitis is a multifactorial disease of the periodontium that is brought on by periodontal pathogenic microbes and modified by variables including tooth malformations during

development, systemic diseases that affect the tissues of the mouth, environmental factors, socioeconomic factors, and stress.

The interaction between the microorganisms, the oral environment, and the host's defence mechanisms against the bacterial assault, which is primarily composed of gram-negative anaerobic bacteria², determines the type of periodontal disease. This pathogenic microbiota develops as a result of subgingival plaque buildup. Eliminating oral biofilms is the current idea behind treating periodontal disorders. Reducing or potentially eliminating the pathogenicity of the periodontal pathogenic microorganisms in the subgingival periodontal area is a fundamental goal of periodontal therapy. There are two methods of periodontal therapy, according to theory:

The specific pathogens in the subgingival plaque using antimicrobial agents as an addition to mechanotherapy, to diminish or remove the entire plaque microflora utilizing mechanotherapy, such as scaling and root planning. Periodontitis is typically treated with oral prophylaxis, which includes patient education about periodontal diseases, methods for maintaining good oral hygiene, professional mechanical debridement such as scaling and root planning, and an air-abrasive polishing system. Mechanical debridement was used to create hard, clean, smooth, and suitable root surfaces by eliminating the supragingival and subgingival bacteria. However, in some circumstances, the intricate root structure and the precise location of the periodontal lesion may affect the best possible treatment outcome and prevent an appropriate reduction in the microbial load.

Because deep periodontal pockets are difficult to access, mechanical therapy's effectiveness is constrained³. Several antiseptics and

antimicrobials have been shown to be effective against putative microorganisms linked to periodontal diseases^{4,5}. In the management of periodontal infections, antibiotics have been utilised as a supplemental treatment to mechanical debridement. Antimicrobial medicines must penetrate past the depth of the periodontal pocket and raise the concentration of gingival crevicular fluid over the Minimum Inhibitory Concentration (MIC) of the suspected periodontal microorganisms in order for periodontal therapy to be successful. Antimicrobial drugs have been applied locally and systemically. Scaling and root planning are typically recommended in addition to systemic medication to stop the recolonization of harmful germs.

It is given for 7 to 14 days. However in order to maintain the effective dose level, a larger concentration must be given every few hours. It could result in negative consequences like bacterial resistance, hypersensitivity reactions, and GIT problems. If the antibacterial medicines are given locally into the periodontal pockets, these negative effects would be much lessened. Hence, local medicine delivery utilized in conjunction with scaling and root planning aids in reducing the growth of harmful germs.

The agent must reach the base of the periodontal pocket and the concentration must be kept there by using a device like a reservoir for long enough for the antibacterial action to take place. This is the primary criterion for the success of local drug delivery⁶. Dr. Max Goodson and colleagues⁷ first presented the idea of controlled release medication administration for the treatment of periodontitis in the year 1979. The specifics of local drug administration are covered in this review as they relate to the effective therapy of periodontal diseases.

Classification of Local Drug Delivery: Various classification systems of local drug delivery systems were evolved.

A Based on the Application Rams and Slots⁸ 1996:

- ◆ Personally applied (Patient self-care application)
- ◆ Nonsustained subgingival drug delivery
- ◆ Home oral irrigation

- ◆ Home oral irrigation jet tips
- ◆ Traditional jet tips
- ◆ Oral irrigation (water pick)
- ◆ Soft cone rubber tips (Pickpocket)
- ◆ Sustained subgingival drug delivery

Professionally Applied in Dental Office:

- ◆ Nonsustained subgingival drug delivery
- ◆ Professional pocket irrigation
- ◆ Sustained subgingival drug delivery

Controlled release devices

- ◆ Hollow fibers
- ◆ Dialysis tubing
- ◆ Strips
- ◆ Films

B Based on the Duration of Medicament Release Greenstein and Tonetti 2000⁸:

- ◆ Sustained release devices
- ◆ These devices provide drug delivery for less than 24 h
- ◆ Require multiple applications
- ◆ Follow first-order drug kinetics
- ◆ Controlled release devices
- ◆ Drug release is for more than 24 h
- ◆ Administered only once

C Depending on degradability⁹:

- ◆ Non-degradable devices (First generation)
- ◆ Degradable devices (Second generation)

D Langer and Peppas¹⁰ 1989: Classified controlled drug release polymeric systems based on their mechanism of action.

- ◆ Diffusion Controlled Systems
- ◆ Matrices
- ◆ Reservoirs
- ◆ Chemically Controlled Systems

-
- ◆ Erodible systems
 - ◆ Pendant chain systems
 - ◆ Solvent Activated Systems
 - ◆ Osmotic systems
 - ◆ Swelling controlled systems
 - ◆ Release Induced by External Forces
 - ◆ Fibers
 - ◆ Films
 - ◆ Strips
 - ◆ Gels
 - ◆ Vesicular liposomal systems
 - ◆ Microparticle systems

E Kornman ¹¹ (1993) has Classified the Controlled Release Local Drug Delivery System as:

- ◆ Reservoirs without a rate controlling system like hollow fibers, gels and dialysis tubing.
- ◆ Reservoirs with a rate controlling system like erodible polymeric matrices, microporous polymer membrane, monolithic matrices and coated drug particles.

F Depending on the Origin:

- ◆ Allopathic or chemical local drug delivery
- ◆ Herbal or ayurvedic local drug delivery

G According to WHO Guidelines, Herbal Medicines Can Be Categorized Into Four Categories ¹²: Based on their evolution, origin, and forms of current usage as under:-

Category 1: Local groups or regions employ these herbal remedies that are indigenous to the area, and the local population has long-standing knowledge of their composition, use, and dosage.

Category 2: This section includes of herbal remedies that have been used for a long time and are based on theories and ideas that have been properly acknowledged by the respective nations.

Category 3: This consists of Modified herbal medicines which have been modified in relation to their shape, dose, administration mode, and composition. These medicines have to meet the national regulatory requirements in terms of their safety and efficacy.

Category 4: Imported products with a herbal medicine base include all the imported herbal medicines (raw materials and products). The national authority of the importing country should have safety and efficacy data.

H Based on the Types of Local Drug Delivery System ¹³:

- ◆ Nanoparticle systems

Indications for Local Drug Delivery ¹⁴:

- ◆ Localized periodontal pockets with probing pocket depth >5mm, after completion of successful phase I therapy,
- ◆ Medically compromised patients where surgical therapy is contraindicated or not suggested,
- ◆ As an adjunct to mechanical debridement,
- ◆ In patients suffering from recurrent or refractory periodontitis,

Contraindications of Local Drug Delivery ¹⁴:

- ◆ Patients with known hypersensitivity to the antimicrobials used, ? Patients susceptible to bacterial endocarditis who are contraindicated for subgingival irrigation devices to avoid the risk of bacteremia,
- ◆ Contraindicated in asthmatics, infective conditions such as AIDS, tuberculosis and those with cardiac pacemakers.
- ◆ In pregnant and lactating mothers.

Advantages of Local Drug Delivery ¹⁵:

- ◆ Improved patient compliance.
- ◆ Improved pharmacokinetics.
- ◆ Improved drug access to the site of disease.
- ◆ Lowers the total drug dosage.
- ◆ No risk of emergence of resistant microorganism.
- ◆ Drug can reach the site of action in adequate concentration.

- ◆ Maintain the drug level for a sufficient period of time.

Disadvantage of Local Drug Delivery ¹⁵:

1. Time-consuming and laborious
2. Difficulty in placing therapeutic concentration of antimicrobial agent into deeper periodontal pockets and furcation lesions
3. Personal application of antimicrobial agents by patients as a part of their home self-care procedure is compromised.

Pharmacokinetic Parameters Criteria for Local Application ¹⁶:

Site of Action: Local drug delivery targets microbiota deep into the connective tissue of periodontal pocket altered and exposed cementum of radicular dentin. Thus local drug delivery is not used as monotherapy and is always done as an adjunct to SRP.

Adequate Concentration: The minimum inhibitory doses of antimicrobial drugs should be at least 50 times greater than for bacteria growing in planktonic conditions, according to numerous experimental studies. It is ensuring adequate medication concentration and improving its effectiveness subgingivally at the local location.

Substantivity: A drug reservoir is created at the local location when an antibiotic has the ability to bind or adsorb to the soft and/or hard tissue lining of the periodontal pocket. The half-life of a medication administered into a periodontal pocket was calculated to be approximately one minute based on an expected pocket volume of 0.5 cuml and a gingival crevicular fluid flow rate of 20 l/h. Thus, its substantivity is improved by including local drug delivery agents in a variety of vehicles or devices before inserting them into the periodontal pocket.

Ideal requisite of Locally Delivery System ⁷:

- ◆ It should be easy to deliver into the periodontal pocket.
- ◆ It should retain at the proximity of periodontal pocket after placement.
- ◆ It should be biodegradable.
- ◆ It should not develop bacterial resistance.

- ◆ It should be safe without any adverse effects.
- ◆ It should not affect the commensal microflora of periodontal pocket.

According to Liechty et al., the Drug Can Follow one of the Following Mechanism for Controlled Release ¹⁷.

- ◆ Desorption of surface-bound/ adsorbed drugs
- ◆ Diffusion through the carrier matrix
- ◆ Diffusion (in the case of nanocapsules) through the carrier wall
- ◆ Carrier matrix erosion ? Combined erosion/ diffusion process

The biological environment, the characteristics of the polymer, and the medication's properties are the major factors influencing a drug delivery system's effectiveness ¹⁸. The success or failure of a medicine is largely determined by the mode of distribution.

Different Local Drug Delivery Systems: To increase the local drug's bioavailability at the location, locally delivered drugs are prepared by inserting them into a vehicle in the form of fibres, gels, or strips, among other forms. The medicine should most likely have a resorbable vehicle such that the vehicle doesn't need to be removed after implantation¹⁹.

Fibres: Devices called fibres have a reservoir-based sustained release system and resemble threads. With an applicator, they are circumferentially inserted into the periodontal pockets. To provide a regulated release of the medication, cyanoacrylate is then used as a glue to fix the fibres.

Films: The medication is incorporated into the polymer in a matrix delivery system called film, and it is then released into the periodontal pocket either through drug diffusion, matrix erosion, or matrix dissolution. Because to its many positive qualities, this technique is more frequently utilised for the delivery of medications.

Preparation Methods for Films in Local Drug Delivery ²⁰:

- ◆ Solvent casting technique

- ◆ Semisolid casting method
- ◆ Hot-melt extrusion
- ◆ Solid dispersion extrusion
- ◆ Rolling method

Evaluation of Films In Local Drug Delivery ²¹:

- ◆ Uniform thickness
- ◆ Estimation of percentage moisture loss
- ◆ Uniformity of weight
- ◆ In-vitro drug release studies
- ◆ Uniform drug content
- ◆ Tensile strength

Injectable Systems: The quick and simple application is another benefit of injectable systems. Without inflicting discomfort on the patient, antimicrobial medicines can be injected directly into the periodontal pocket using a syringe.

Gels: The targeted administration of antimicrobial drugs has drawn attention to gels, which are semisolid mucoadhesive solutions. For instance, they are simpler to prepare for and administer.

Strips and compacts: Strips are thin and elongated matrix bands where the drug will be distributed throughout the system.

Microparticle Systems: Microspheres are spherical, solid formations that range in size from 1 to 1000 m. These materials consist of synthetics, modified natural compounds, and natural polymers.

Chemical Agent Used In Local Drug Delivery:
Tetracycline: -These medicines have a broad spectrum and work best against gram-positive bacteria. Tetracycline is a bacteriostatic antibiotic that prevents bacteria from making new proteins and stops tissue collagenase from working. Tetracycline concentrations in gingival crevicular fluid are 2 to 10 times higher than those in serum. For the local medication delivery method, tetracycline is available in both biodegradable and non-biodegradable forms.

Actisite: The first commercially available, controlled-release antibacterial local medication delivery device was called Actisite and it was

released in 1994. It is 0.55 mm in diameter and 23 cm long, containing 12.7 mg of tetracycline hydrochloride. The drawback of this approach is that the fibre is nonbiodegradable and must be collected after 10 days. Nevertheless, 250 mg of oral tetracycline achieves a concentration of 1 g/ml in the gingival crevicular fluid, while actisite achieves a concentration of 1590 g/ml in the periodontal pocket. With local medication delivery of Actisite²², the concentration level persisted at a mean of 1300 g/ml for 7 days.

Periodontal Plus AB: It biodegrades within 7 days, therefore a second session is not necessary. Tetracycline hydrochloride (2 mg of tetracycline) is present in a collagen fibril-based formulation that has 25 mg of tetracycline and can be used to treat all stages of periodontal diseases. When used in conjunction with scaling and root planing, tetracycline fibres were reported by Kataria et al.²⁴ to be more efficient at reducing gingival and periodontal inflammation (P 0.05). Maheshwari²⁵ et al. evaluated a Tetracycline-Serratiopeptidase-A combination gel of tetracycline and serratiopeptidase and found that the formulation had produced statistically meaningful results in addition to mechanical debridement. Tetracycline was created by Sachdeva and Agarwal²⁶ and used in conjunction with scaling and root planing.

Minocycline: It is a tetracycline derivative and a broad-spectrum antibiotic. It acts in a bacteriostatic manner. Compared to tetracycline, it has higher substantivity and lipid solubility. It comes in a number of forms, including film, microspheres, ointment, and gel.

Film: Ethylcellulose film with 30% minocycline is used as a sustained-release device drug delivery system.

Microsphere: As a local medication delivery device, the FDA has approved sustained-release minocycline microspheres. It is offered for sale under the brand name ARESTIN. ARESTIN has a resorption duration of 21 days and contains 2% minocycline enclosed in biodegradable microspheres with a 20–60 m diameter in a gel carrier.

Ointment: The amino alkylmethacrylate, triacetate, hydroxyethylcellulose, and glycerine matrix containing 2% minocycline hydrochloride. With a single topical application of 0.05 ml

ointment, the concentration of minocycline in the periodontal pocket is around 1300 g/ml of gingival crevicular fluid at 1 hour, and it decreases to 90 g/ml by 7 hours²⁷.

Doxycycline: It is bacteriostatic to use doxycycline. It has the ability to down-regulate matrix metalloproteinase (MMP's) and is effective against MMP's. Periodontal biomarkers called MMPs are what are causing the connective tissue in the gums to break down. Only ATRIDOX (42.5 mg Doxycycline) is a commercially available subgingival controlled-release local drug delivery system for doxycycline that uses a two-syringe mixing method. The ADA only accepts this 10% Doxycycline gel that has received FDA approval. In the two hours following the administration of ATRIDOX, the concentration of doxycycline in GCF reached a peak of 1,500–2,000 g/ml. Over the entire seven days, it was discovered that local Doxycycline levels remained much higher than the MIC for periodontal bacteria (6.0 g/ml). The bioabsorption of 95% of the ATRIDOX polymer occurs within 28 days²⁹.

Chlorhexidine: It is a mouthwash, gel, varnish, and chip that has antifungal and antibacterial properties. According to Rolla and Melsen³⁰, it works by attaching to anionic acid groups on salivary glycoproteins, which prevents pellicle formation and microbial colonisation of the plaque. Chlorhexidine has demonstrated higher substantivity as an effective agent. It is more responsive to salivary acidic proteins and hydroxyapatite. It works well as an antibacterial agent because it increases cellular membrane permeability and has the capacity to cause the coagulation of intracellular cytoplasm macromolecules.

Periochip: A biodegradable hydrolyzed gelatin matrix chip the size of a baby nail has been crosslinked with glutaraldehyde that contains glycerine and water. Periochip has a dimension of 4 x 5 x 0.35 mm with a chlorhexidine content of 2.5 mg. According to an in-vitro investigation, periochips release chlorhexidine in two phases: initially, they release around 40% of the drug within the first 24 hours, and then they release the remaining drug in a linear pattern over the course of seven to ten days³⁰. To prevent mechanical stress to the sulcular and junctional epithelium, one of the periochip's borders is

rounded and oriented apically as it is inserted into the periodontal pocket.

Periocol-CG: Periocol CG, another type of chlorhexidine chip, has dimensions of 4 x 5 x 0.25 to 0.32 mm and is made by mixing 2.5 mg of chlorhexidine into a collagen membrane. Periocol CG has a weight of 10 mg³¹.

Chlo-Site: It is a substance of the xanthan type with 1.5% chlorhexidine. A saccharide polymer called xanthan gel has a three-dimensional mesh structure and is biocompatible with chlorhexidine³².

Metronidazole: This substance is a nitroimidazole. Anaerobic organisms are bacteriocidal to it. It works by stopping the creation of bacterial DNA. For at least 8 hours following the introduction of Elyzol (25% Metronidazole), concentrations of the medication exceeding 100 g/ml in GCF were detectable in the periodontal pocket, and concentrations above 1 /ml were discovered after 36 hours. It is given to the pocket in a viscous consistency, where it becomes liquidised by body heat, hardens once more, and crystallises when it comes into touch with GCF or saliva³³.

Satranidazole (SZ): It is an additional antibiotic in the family of 5 nitroimidazoles. SZ is a new nitroimidazole that differs from previous 5 nitroimidazoles like metronidazole, ornidazole, and tinidazole in that two carbons of the imidazole ring are bonded through nitrogen to a modified imidazolidinone. When used in conjunction with scaling and root planing for the treatment of periodontitis, satranidazole gel considerably outperforms mechanical periodontal therapy alone in terms of clinical and microbiological outcomes³⁴.

Herbal Agents Used In Local Drug Delivery: Due to the relatively harmless nature of herbal extracts, the use of herbal products has recently expanded. Several herbal products and their components are employed as local drug delivery systems for the treatment of periodontitis. **Neem:** Neem leaf extract can assist in lowering the amounts of germs in dental plaque that lead to the beginning and development of periodontitis. It has been determined that the bioactive components in neem contribute to the presence of gallotannins in the early stages of plaque formation, which may help to reduce the bacterial load in dental plaque and

facilitate plaque removal from the tooth surface and oral cavity through the formation of aggregates. Furthermore, the efficient inhibition of glucosyl transferase activity as well as the decreased bacterial adherence to saliva-coated hydroxyl appetite imply some possibility.³⁵

Aloe vera: The Liliaceae family includes the ubiquitous medical cactus plant known as aloe vera. There are more than 300 different kinds of aloe plants in the globe, but only two of them—*Aloe barbadensis* Miller and *Aloe arborescence*—have been investigated for local medication delivery. In addition to its hypoglycemic benefits, aloe vera has anti-inflammatory, antibacterial, antioxidant, antiviral, and antifungal properties.

It effectively reduces gingival edoema, irritation, and bleeding. It can be used as a healer after tooth extractions and is effective³⁶.

Lemon Grass: It is a well-known healing plant. Due to its antibacterial, antiemetic, antirheumatic, analgesic, antispasmodic, and antipyretic qualities, this plant is frequently used in teas, cosmetics, and traditional medicine. Many biological activities, including antioxidant, anti-inflammatory, and anti-mutagenic properties, have been associated with its chemical components, such as phenol and flavonoids, both in vitro and in vivo. When combined with mechanical nonsurgical periodontal therapy and applied at a dosage of 2%, lemongrass essential oil seems to be a reliable.

Green Tea: Green tea is an effective local drug delivery method due to its richness of bioactive compounds such flavonoids, catechins, and their derivatives. Among its many health advantages are its anti-inflammatory, anti-cariogenic, anti-fungal, antiviral, and antibacterial qualities. Mageed JM et al³⁸ investigated the antibacterial effects of green tea extracts on *Porphyromonas gingivalis*. They discovered that green tea extract that had been exposed to alcohol might stop *Porphyromonas gingivalis*. local medicine delivery agent³⁷.

Tea Tree Oil: Tea tree oil comes from the paperbark tea tree (TTO). TTO has broad-spectrum antibacterial, antifungal, antiviral, antioxidant, and anti-inflammatory properties. Elgendy EA³⁹ proposed that TTO is effective as

a supplementary treatment to scaling and root planing based on clinical features.

Curcumin: Turmeric (*Curcuma longa*), a perennial plant belonging to the Zingiberaceae family, is a common seasoning in India. Turmeric contains large amounts of volatile oils (turmerone, atlantone, and zingiberene), carbohydrates, proteins, resins, and curcuminoids such demethoxycurcumin, bisdemethoxycurcumin, and curcumin (diferuloylmethane). Curcumin exhibits anti-inflammatory, antioxidant, anticancer, antiviral, and antibacterial effects. Curcumin regulates the inflammatory response by preventing the production of pro-inflammatory cytokines and reducing the activity of the enzymes cyclooxygenase 2, lipoxygenase, and inducible nitric oxide synthase⁴⁰.

Oak: The species of oak belonging to the Fagaceae family is found in western Iran. Because it offers a variety of hemostatic, antibacterial, anti-inflammatory, antinociceptive, and antioxidant actions, oak has been used for a long time to treat gastric ulcers, minor wounds, and local inflammation. Oak has been researched as a local drug delivery technique for periodontal diseases⁴¹.

Coriander: Coriander *Sativum*, a member of the Umbelliferae family, was used in traditional Persian medicine as a spasmolytic and carminative. It is an effective local medication delivery agent because of its anti-inflammatory, analgesic, anti-bacterial, and antioxidant characteristics. In the extract of *C. sativum*, tannins are also found. Yaghini J.⁴¹ conducted a randomised, double-blinded, controlled trial to ascertain the clinical effects of the subgingival use of herbal gel (extracts of oak and coriander) in periodontal pockets. It was determined that improvements in periodontal markers were statistically significant (P 0.05).

Babul: In addition to cyanogenic glycosides, babul includes numerous enzymes, such as oxidases, peroxidases, and pectinases, which have been shown to restrict microbial development. Its bark contains tannins (24–42%) that have narcotic and anti-inflammatory properties⁴². According to Rameshwari Singhal⁴³ et al., acacia gum may be clinically beneficial when used to treat suspected periodontal infections caused by *Actinobacillus action mycete mcomitans*, *Capnocytophaga* spp.,

Porphyromonas gingivalis, Prevotella intermedia, and their enzymes.

Bakul: Researchers have been interested in employing bakul for investigations due to the anti-inflammatory and anti-microbial properties of lupeol, one of the main pharmacologically active components in bakul⁴³.

Pomegranate: Rinsing with pomegranate lowers activity of alfa glucuronidase, an enzyme that breaks down sucrose while it increases activity of ceruloplasmin, an antioxidant. Pomegranate has active compounds containing polyphenolic flavonoids (e.g. Punicalagins and ellagic acid) that are believed to prevent gingivitis through a number of mechanisms, including reduction of oxidative stress in the oral cavity, antioxidant activity, anti-inflammatory effects, and Galleria mellonella was used as an in-vivo model in a study by Gomes LA⁴⁴ (2016) to assess the antibacterial activity of pomegranate glycolic extract (PGE) against the periodontal infection Porphyromonas gingivalis. The results were substantial.

CONCLUSION: According to the analysis of studies, local drug delivery devices can be a helpful addition to traditional surgical or non-surgical periodontal care but cannot take the place of these interventions. In the treatment of periodontitis, controlled release drug delivery systems with antibacterial, anti-inflammatory, and antioxidant capabilities are useful. Periodontal problems are best improved by local medication delivery. Several chemical and botanical materials are tested in regional controlled release medication delivery systems. It seeks to reduce drug loss and degradation, stop negative side effects, and boost drug bioavailability at the lesion site. Despite the large number of studies that have been done, there is not enough comparative data to show that any one of the local delivery systems is better than the others. Though there are many studies conducted, there is insufficient comparative data to support any one of the local delivery systems as superior to another, and so further comparative studies are required to optimize the use of such local drug delivery systems in periodontal therapy.

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Maximizing Success: The Role of Intracanal Medicaments in Endodontic Treatment

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Introduction

Kawashima defined intracanal medicaments as "temporary placement of medicaments with good biocompatibility into root canals for the purpose of inhibiting coronal invasion of bacteria from the oral cavity".¹ Intracanal medicament is generally recommended when treatment cannot be completed in one appointment; there are chances that surviving intracanal bacteria often proliferate between appointments.²

The role of intracanal medicaments becomes more relevant, and complex, in the treatment of cases with pulpal necrosis and apical periodontitis. There is overwhelming evidence in the literature that most of the root canals contain viable microorganisms even after the completion of the biomechanical preparation² and intracanal medicaments can be used to eliminate remaining microorganisms in the root canal, reduce inflammation of the pulp remnants, reduce pain, prevent inter appointment contamination, induce healing of calcified tissues, make the contents of the canal inert, neutralize tissue debris, act as a barrier against coronal leakage from temporary filling and aid in drying persistently wet canals.³

An effective intracanal dressing is a predictor of the outcome of endodontic treatment, especially in the presence of infected canals. The use of inter appointment medicament in a multi-visit approach results in maximum reduction in bacterial load prior to filling of the canals.⁴

Medicaments

In the past many a different medicament like phenol and its derivatives, eugenol, heavy metal salts have been used but they fell out of favour. The

commonly used medicaments include calcium hydroxide, chlorhexidine, antibiotics and most recently bioceramics. Research is being conducted on the use of naturally available materials as intracanal medicaments also. A few of these natural materials will also be mentioned here.

Calcium Hydroxide

Hermann introduced calcium hydroxide in dentistry as a pulp medicament in 1920 as Calxyl. It has been used for managing root fractures, perforations, resorptions, traumatic injuries, etc. Calcium hydroxide induces deposition and mineralisation of hard tissues as the high pH activates the alkaline phosphatase activity.⁵

Three types of vehicles are used to deliver calcium hydroxide to root canals.

- ◆ aqueous,
- ◆ viscous and
- ◆ oily vehicles

Aqueous vehicles:

The various aqueous vehicles used are sterile water, distilled water, bidistilled water, sterile saline, anaesthetic solutions with or without a vasoconstrictor, Ringer's solution, aqueous suspension of methylcellulose or carboxymethylcellulose anionic detergent solution.⁶

Proprietary brands

- Calvital (Neo Dental Chemical Products Co., Tokyo, Japan). This paste was originally proposed by Sekine et al. (1963) and is composed of a powder and a liquid. The powder has the following composition: calcium hydroxide

(78.5%), iodoform (20%), guanoflacin (0.1%) and sulphathiazol (1.4%), whilst the liquid is composed of T-cain (0.5%), propyleneglycol (50%) and distilled water (49.5%). This paste was evaluated for direct pulp capping, pulpotomy in deciduous teeth, pulpotomy in permanent teeth, intracanal dressing after vital pulpectomy and as a final filling coupled with gutta-percha points.⁶

- Reogan (Vivadent, Schaan, Liechtenstein). This paste is composed of calcium hydroxide, barium sulphate, casein and magnesium hydroxide. This paste has been indicated mainly for human apexification procedures and as a routine dressing in vital or non-vital teeth with or without periapical lesions radiographically.⁶
- Calcicur (VOCO, Auxhaven, Germany). According to the manufacturer, this paste is composed of radiopaque calcium hydroxide in an aqueous vehicle.⁶
- DT Temporary dressing (Dental Therapeutics AB, Nacka, Sweden). According to the manufacturer, this paste is composed of unoxxygenated calcium hydroxide and sterilized distilled water.⁶
- Calcipulpe (SpecialiteÂs Septodont, Saint-Maur, France). This paste is composed of calcium hydroxide and carboxymethylcellulose and was evaluated for its ionic liberation and pulp reactions after direct human pulp capping.⁶

Viscous vehicles:

The various viscous vehicles used are glycerine, polyethylene glycol, propylene glycol. The various oily vehicles are olive oil, fatty acids, camphorated parachlorophenol, metacresyl acetate, eugenol.⁶

Proprietary brands

- ◆ Calen (S.S. White ± Artigos DentaÂrios, Rio de Janeiro, RJ, Brazil). This paste is the proprietary brand of Leonardo & Leal's paste, the formulation of which is: calcium hydroxide (2.5 g), zinc oxide (0.5 g), hydrogenized colophony (0.05 g) and polyethyleneglycol 400 (1.75 mL). It has been used in apexification procedures, in the treatment of large periapical lesions originating from in-

fectured root canals, as an inter appointment dressing in cases of vital pulpectomy, in acute apical periodontitis and in endodontic retreatment after endodontic and surgical failures.⁶

- ◆ Calen + camphorated parachlorophenol (S.S. White ± Artigos DentaÂrios, Rio de Janeiro, RJ, Brasil). Leonardo et al. in 1991 added camphorated parachlorophenol (CMCP, 0.15 mL) to the original Calen formulation to be used in cases of non-vital and infected teeth with associated periapical lesions.⁶
- ◆ Calen + p-chlorophenol. This is the most recent formulation which doesn't have camphor in it.⁶

Oily vehicles:

The various oily vehicles used are silicon oil, olive oil, fatty acids, camphorated parachlorophenol, metacresylacetate, eugenol.⁶

Proprietary brands

- Endoapex (Lab. Inodon Ltda. Porto Alegre, RS, Brazil). This paste is composed of calcium hydroxide, liquid silicone and iodoform.⁶
- Vitapex (Neo Dental Chemical Products Co. Ltd, Tokyo, Japan). This paste is very popular in Japan and was introduced by Kawakami et al. in 1979. It is composed of calcium hydroxide (30.3%), iodoform (40.4%), silicone oil (22.4%) and other substances not described (6.9%).⁶
- Metapex (Meta Biomed, Cheongju, Korea). The compositions of Vitapex and Metapex are almost similar. The main difference is the composition ratio of calcium hydroxide and iodoform.

Limitations of calcium hydroxide

There are concerns regarding the handling and placement of calcium hydroxide. Although various formulations are available, its placement in posterior tooth is difficult. Also the removal of calcium hydroxide is most frequently incomplete, resulting in a residue covering 20%-45% of the canal wall surfaces, even after copious irrigation

with saline, NaOCl or ethylenediaminetetraacetic acid. Residual calcium hydroxide in the canal is also a concern that it is not totally effective against endodontic pathogens, including *Enterococcus faecalis* and *Candida* species, leading to various incidence of reinfection or flare up. In vitro studies have shown that dentin can inactivate the antibacterial activity of calcium hydroxide.²

Antibiotics

Certain selected antibiotics have been reportedly used as a root canal antiseptic. These are active in the presence of tissue fluid, do not stain the tooth and are virtually non-irritant to tissue cells along with being antimicrobial. Triple antibiotic paste (TAP) contains both bactericidal (metronidazole, ciprofloxacin) and bacteriostatic (minocycline) agents to allow for successful resolution of periapical infection. The concern of triple antibiotic paste is that minocycline may cause tooth discoloration, hence double antibiotic paste (DAP) is used. DAP does not have minocycline. Another antibiotic paste PBSC consisting of penicillin, bacitracin, streptomycin and caprylate has been widely used. Another combination where nystatin has replaced sodium caprylate named as PBSN has also been used.⁵

Triple Antibiotic Paste (TAP): TAP is a combination of ciprofloxacin, metronidazole and minocycline in the ratio of 1:1:1. Metronidazole, as a nitroimidazole compound, is particularly toxic to anaerobes and is considered an antimicrobial agent against protozoa and anaerobic bacteria. Minocycline is bacteriostatic and shows activity against gram-positive and gram-negative bacteria. It also causes an increase in the amount of interleukin-10, which is an inflammatory cytokine. Moreover, ciprofloxacin - as a synthetic fluoroquinolone - possesses fast bactericidal action and exhibits high antimicrobial activity against gram-negative bacteria, whilst limited activity against gram-positive ones. Many anaerobic bacteria are resistant to ciprofloxacin. Hence, it is often used with metronidazole in treating mixed infections to compensate for its limited scope. Therefore, TAP can affect gram-negative, gram-positive, and anaerobic bacteria, and this combination can be effective against odontogenic microorganisms.⁸

Chlorhexidine

Chlorhexidine (CHX) has been used in endodontics and proposed as both an irrigant and an intracanal medicament. It is active against a wide range of microorganisms, such as Gram-positive and Gram-negative bacteria (including *Enterococcus faecalis*), yeasts and fungi.⁹ It can be used in concentrations of 1% or 2%.

One of the mechanisms that can explain its efficacy is based on the interaction between the positive charge of the molecule and the negatively charged phosphate groups on the bacterial cell wall, which allows the CHX molecule to penetrate into the bacteria with toxic effects. Therefore, its antimicrobial activity is not related to its pH (between 5.5 to 7).⁹

When used as an intracanal medicament, CHX is more effective than calcium hydroxide against *E. faecalis* infection in dentinal tubules. In fact, the antimicrobial activity of CHX is reduced when combined with other substances, including CH, CH plus zinc oxide, among others. However, CHX alone does not act as a physical barrier and does not present radiopacity.⁹

The use of CHX gel as intracanal medicament is recommended for a short period of time (3-5 days), particularly in those cases where the canals were fully instrumented but could not be root-filled due to the lack of time. It is also recommended in cases of exudation (unpublished data), as it retains its antimicrobial activity in the presence of blood and other organic matters. CHX gel is delivered into the canals with a syringe (e.g.: 24-gauge needle), being easily introduced and removed from the root canals.⁹

Substantivity: The effectiveness of CHX stems from its capacity to adsorb to negatively charged surfaces in the mouth (e.g. tooth, mucosa, pellicle, restorative materials), being slowly released from these retention sites and therefore maintaining prolonged antimicrobial activity for several hours. This process is known as substantivity, and only CHX and tetracycline have this property so far.¹⁰

Pulp Devitalizers

Devitalizing agents such as arsenic trioxide and paraformaldehyde are commonly used to devi-

talize inflamed pulps when effective anesthesia could not be obtained. Paraformaldehyde agents can play role as disinfectants as well. Formaldehyde can be placed in the pulp chamber or in the cervical third of the root canal space and it is effective in the apical portion when the canal is reasonably clean and dry. Rapid necrosis of pulp tissue has been reported by the use of formaldehyde and hence it is used for fixing of the pulp tissue⁵

Proprietary Brand

D-pulp(Ammdent)is an arsenic free paraformaldehyde based paste.Main constituents of pulp devitalizer include: formaldehyde, cresol, paraformaldehyde, and arsenic compounds. For pulp devitalising during root canal treatments.¹¹

Pulp-XTM(Prevest Denpro)contains formaldehyde liquid, parachlorophenol, polyethylene glycol, amorphous silica and vinyl siloxane.¹²

Bioceramics

Bio-ceramics are amongst the recently introduced materials in endodontics which have changed the face of endodontics. Ceramics are inorganic, non-metallic materials made by the heating of raw minerals at high temperatures. Bio-ceramics are biocompatible ceramic materials or metal oxides with enhanced sealing ability, antibacterial and antifungal activity applied for use in medicine and dentistry. They have the ability to either function as human tissues or to resorb and encourage the regeneration of natural tissues. ¹³

They include alumina and zirconia, bioactive glass, glass ceramics, calcium silicates, hydroxyapatite and resorbable calcium phosphates, and radiotherapy glasses. ¹³

Antibacterial properties of bioceramics are a result of precipitation in situ after setting, a phenomenon that leads to bacterial sequestration. Bioceramics form porous powders containing nanocrystals with diameters of 1-3 nm, which prevent bacterial adhesion. Sometimes, fluoride ions are constituents of apatite crystals, and the resulted nanomaterial has antibacterial properties. ¹³

Proprietary Brand

- ◆ Bio-C® Temp from Angelus® is a ready to use bioceramic intracanal medicament. It con-

sists of tricalcium silicate, dicalcium silicate, tricalcium aluminate, calcium oxide, salicylate ester, calcium tungstate polyethylene glycol and titanium oxide. The first four are the active components which release calcium and hydroxyl ions. ¹⁴

Natural Medicaments

Propolis (Propolis resin)

Pharmacologically active constituents in propolis are flavonoids, phenolics, and aromatics. It exhibits various biologic activities, including antimicrobial, anti-inflammatory, antioxidant, anesthetic and cytotoxic properties.¹⁵

The anti-inflammatory property of propolis is due to the presence of caffeic acid and phenethyl ester in propolis. In dental practice it is used as a pulp capping agent, intracanal irrigant, mouth rinse, cariostatic agent, treatment of periodontitis and denture stomatitis, etc.¹⁵

The antimicrobial activity of propolis with Ca(OH)₂ as intracanal medicament against *E. faecalis* found that propolis was effective in eliminating the microorganisms¹⁵

Nisin

Nisin is a naturally occurring antimicrobial peptide and was discovered in 1928, produced by strains of *Lactococcus lactis*. Nisin is an antibiotic peptide and is a class I bacteriocin. Nisin is safe to human and is used extensively as a food preservative over 40 years. The mode of action of nisin while not completely understood is due to interaction with the phospholipid membrane of the target bacterial cell. Nisin disrupts the cellular membrane inducing leakage of small intracellular contents from the cell.⁷

Curcuma Longa

Commonly known as turmeric. It exhibits good antioxidant, anti-microbial and anticancer activity with curcumin as an active ingredient. Curcuma longa can be used as an intracanal medicament as reported by Kumar et al 2013.⁵

Aloe Vera

Aloe vera belongs to the liliaceae family. Medici-

nal products are made from the mucilaginous tissue in the centre of the aloe vera leaf and is called aloe vera gel. Total leaf extracts contain anthraquinones, which have antibacterial properties. Aloe vera has also been evaluated for its antibacterial efficacy and tested as an intracanal medicament.⁵

Chitosan

Chitosan is a natural polysaccharide derived from deacetylation of chitin in crustacean shells. Chitosan has antimicrobial, antifungal properties and enhances wound healing. Chitosan can interact with microbial outer cellular components, cell membrane, and cytoplasmic constituents. Chitosan also has high biocompatibility and low toxicity; thus, it could serve as a good alternative medication in endodontic treatment.¹⁶

Conclusion

Intracanal medicaments in endodontics have been used for the reduction in the number of microorganisms, rendering canal content inert, prevention of post treatment pain and to improve anesthesia. They are effective in reducing the incidence of post treatment pain. Use of intracanal medicament differs from case to case and person to person depending on their clinical experience.

Calcium hydroxide is still the intracanal medication that meets the largest number of ideal properties for the eradication of endodontic infections, control of root resorption, and induction of mineralization. The literature has shown that the use of intracanal dressings with antibiotic associated with corticosteroid in the initial phase of the endodontic therapy followed by a calcium hydroxide dressing can be beneficial for the treatment of progressive root resorption and for periodontal healing. Different vehicles have been added to calcium hydroxide in an attempt to enhance its properties. Scientific reasoning indicates the use of aqueous vehicles (distilled water, saline) associated with calcium hydroxide because of their chemical characteristics of dissociation, diffusibility and filling capability which are decisive for the biological behavior, i.e., antimicrobial qualities and induction of tissue repair.

Often, different medicaments are combined in a cocktail in an attempt to elicit a variety of effects with single application. There is still a contro-

versy whether or not to use an intracanal medication. But the practice still continues.

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PERIODONTAL ENDOSCOPY- A NEW ERA IN PERIODONTAL THERAPY

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Abstract: The perioscope, which was only recently introduced, has greatly improved the removal of subgingival calculus during periodontal therapy. A fibre-optic periodontal endoscope was created to aid in the imaging of subgingival tissues and to improve periodontal disease diagnosis and treatment. The Perioscopy system was initially designed to visualize the subgingival region for diagnosis but has been subsequently adapted to aid the treatment of periodontitis. The perioscope is a small camera that is encased in a sleeve and inserted under the gingival sulcus or pocket for subgingivally visualisation and instrumentation. This technique gives the greatest conservative approach to non surgical and surgical periodontal care because it enables superb magnified visualisation of the root surface and ensures the total or near complete elimination of the bacterial infection. The ability to visibly debride roots using endoscopic technology can improve success rates in a more conservative and minimally invasive manner. Hence the aim of this brief review was to provide knowledge about periodontal endoscopy, and its implementation in day today practice.

Key words: Perioscope, Microdentistry, Charge Coupled Device Camera, Periodontal Endoscope.

INTRODUCTION

Traditional periodontal therapy was based on the removal of plaque biofilms and calculus deposits from the tooth and root surfaces using manual and powered scalers and root planing devices. The success of this treatment is determined by a number of parameters, including subgingival access, root morphology, defect magnitude, and the periodontist's tactile skills.¹ Therefore, visualisation of the root surface under magnification was thought to increase the value of periodontal treatment.^{1,2}

Every patient deserves to have the best quality of care based on the latest evidence based treatment protocol that results in the most predictable outcome. The outcome includes the concept that every treatment plan is an opportunity to be less invasive and most effective treatment as possible. Fibre-optics have only recently been applied to dentistry.³ Particularly in the branch of periodontics, intrinsic restrictions such as visual and physical access to the disease-affected location of the periodontal pocket may be overcome through the use of fibre-optic technology.³

Microdentistry is a new idea that involves employing magnification under direct observation and instrumentation with a reduced armamentarium.^{3,4} Microdentistry treatment paradigm is to detect early, treat less, and thereby, maintain more of the original healthy oral tissues. The use of a perioscope, a miniature dental endoscope, for both detection and treatment of periodontal disorders is the most current advancement in periodontics micro-dentistry.⁴

The latest concept of micro dentistry as applied to periodontics is the use of a miniaturized dental endoscope called the Perioscope for both diagnosis and treatment of periodontal conditions. Perioscopy, previously called as periodontal endoscopy, is a procedure that pairs a miniature dental endoscope with advanced video, lighting and magnification technology for easy visualization sub-gingivally and hence enables us to diagnose and treat the subgingival region as conservatively as possible.^{4,5}

Perio-scope uses this fibre-optic technology to illuminate the periodontal pocket offering a clear and magnified view of the root surface and inaccessible areas such as trifurcations and bifurcations. The Perioscope can also be used to detect sub gingival calculus remnants, ulcerated sulcular epithelium, cemental perforations and the tortuous pathways of draining sinuses.⁶

ARMAMENTARIUM - THE PERIODONTAL ENDOSCOPE

Fibre-optic Strand A perioscope is made up of a sheath and a 0.5 mm fibre-optic strand. At the end of a two meters long fused fibre-optic bundle with 10,000 individual light-directing fibre pixels, a gradient index lens is installed. 7,8

Sterile Sheath

The sub gingival region of a periodontitis patient is a highly infectious region sterilization of the tip becomes mandatory if the distal tip of the fiber-optic strand (of the Perioscope) comes in direct contact with any of the sub gingival tissues. The fibre-optic strand is enclosed in a sterile disposable sheath that may be discarded after each use and acts as a barrier against subgingival infection. The fibre-optic wire can be clearly seen through the sapphire glass in the sheath.7,8

Peristaltic Pump

There is a risk of bleeding within the gingival pocket because the subgingival region of a pocket is inflammatory and bleeding will hinder vision from the perioscope. The perioscope contains a pulsatile peristaltic pump that keeps continuous water spray maintaining the working field free of blood and debris. A separate water tube connects the sheath to a peristaltic pump, which drives water from the strand to the strand's end, irrigating the working field.7,8

Charge Coupled Device Camera

The sheath's sapphire lens focuses on the tooth's surface and sends the image to a video sensor chip camera through a fibre optic thread [5]. This CCD is a video camera that uses a camera coupler to magnify and focus the image onto the CCD sensor. The camera's control unit digitises and converts the CCD's electric impulses into a standard S-video output, which is presented on an active matrix Liquid Crystal Display-Thin Film Transistor (LCD-TFT) monitor.7,8

Microsurgical Instruments

Curettes, explorers, and ultrasonic scalers are some of the latest endoscopic tools available. A gingival retractor (soft tissue shield) is now linked to the curette blade. The gingival tissue is kept away from the endoscope's tip using this retrac-

tor, to see the curette blade and tooth surface visibly. The distal tip features a gingival retractor fashioned into it. The ultrasonic adapter is made up of a collar, a strut, and a tube, all of which are stainless steel.7To keep the collar in place, it is screwed into the end of a standard ultrasonic scaler. The scaler tip as well as surrounding tooth surface are viewed through the endoscope window sheath. The distal tip of the tube is also fixed upfor irrigating fluid, while gingival tissue retraction ensures an unobstructed view of the active tip.7,8.

INDICATIONS FOR PERIO-SCOPY

- " Endoscopic visualisation and treatment will assist any periodontal problem with a probing pocket depth of greater than 4 mm.
- " Abnormal root deformities and anatomical changes can be detected, followed, and repaired without recurrence.6
- " The adjunctive use of perioscope provides some benefit to the treatment outcomes of non surgical periodontal therapy, especially, at deeper probing depths.6,7
- " Periodontal microsurgery allows in cases of teeth with a poor prognosis and limited access to abnormalities to be repaired with less invasive equipment and improved treatment outcomes.7,9

PERIO-SCOPY PROCEDURE

A perioscope allows the periodontist to observe the subgingival morphology in the least invasive method possible, for diagnosis and improved management strategies for root and soft tissue debridement.6 In traditional method the effectiveness of calculus removal decreases substantially with increasing pocket depth anatomy can inhibit calculus removal with an increased prevalence of residual deposits being associated with the cemento-enamel junction, line angles and furcations. For mild to advanced periodontitis, full mouth treatment takes an average of 90-120 minutes, however these time-frames are predicated on a dental expert, who is very efficient with a perioscope.5,10 On the LCD screen, the periodontist can see the magnified root surface at a magnification of 24X to 48X and around 3 mm of the root is checked at a time .6 The perioscope

is held with left hand by the clinician and debridement instrument is held in the right. Periodontal Endoscopy (PE) is a minimally invasive method that improves dental practitioners' ability to detect and remove calculus by allowing them to see the periodontal area more clearly.¹⁰

Role of Periodontal Endoscopy in Diagnosis

The periodontist with the use of perioscope can visually evaluate the gingival pocket in a magnified and lighted view, looking for biofilm, root deposits, granulation tissue, caries, and root fractures. Periodontist can rule out the confirm diagnosis and treatment plan with the help of periodontal endoscope.^{6,7}

ADVANTAGES

- " A Perioscope enables the periodontal surgeon to see the sub gingival morphology in the most minimally invasive way and thus helps in the diagnosis and management of root and soft tissue debridement.⁵
- " Accurate visualization under magnification of the root surface enables the periodontist to conduct not only the most efficient instrumentation as possible but also to ensure that no over-instrumentation of the root surface occurs.^{7,10}
- " It also helps in the enlarged visualisation of subgingival calculus adhering to the root surfaces.
- " The perioscope allows us to accurately see and demarcate any root surface anatomical aberrations or anomalies such as line angles and furcations, dilacerations that may affect the maintenance of periodontal health post treatment.^{6,8}

DISADVANTAGES OF PERIOSCOPY

- " The first and foremost disadvantage of Perioscope is the time factor despite being a game-changing tool in several aspect.
- " Although the majority of patients can undergo treatment without any anaesthesia, a few patients experience discomfort in the absence of anaesthesia and hence require the same quantum of anaesthesia like conventional

periodontal surgical procedures.⁷

- " Finally use of a Perioscope requires different clinical skills compared to conventional periodontal therapy and to achieve proficiency takes training and time to get used to the technology.^{6,7}

PERIOSCOPY IN

PERIODONTAL DISEASE

Armitage and Christie in a SEM study in 1973 reported that teeth involved in unresolved and aggressive forms of periodontitis exhibit cemental abnormalities particularly at the cemento-dentinal junction.¹¹ Yammaamoto in 1999 concur with their findings and added that such periodontal diseased root surfaces have extensive resorption lacunae that characterize the entire length of the root surface. These findings have implications for the refractory nature of periodontal disease and the clinical diagnosis and management of such patients may be made easier by the use of Perioscopy.¹²

Mellonig and Geisinger in 2007 did a study to determine whether use of the periodontal endoscope with scaling and root planing (SRP) resulted in a decrease in residual calculus compared to SRP alone and reported that the use of the periodontal endoscope resulted in a statistically significant overall improvement in calculus removed during SRP. ¹³

Avradopoulos et al in 2004 conducted a study to assess the clinical and inflammatory evaluation of Perioscopy on patients with chronic periodontitis.¹³ The purpose was to compare the changes in periodontal pocket depths and inflammatory markers (PGE₂) of sites treated by scaling and root planing alone with sites treated by scaling and root planing with Perioscopy. However the results showed no statistically significant differences in clinical and inflammatory parameters between control and experimental sites.¹⁴

Michaud and Mealey in 2007 did a study to determine whether endoscopy-aided scaling and root planing (SRP) resulted in a greater reduction of residual calculus compared to SRP alone in multi-rooted teeth and reported that in shallower inter-proximal sites with probing depths ≥ 6 mm there was significantly less residual calculus

seen in roots treated with endoscopy but overall the use of the endoscope as an adjunct to traditional SRP provided no significant improvement in calculus removal in multi-rooted molar teeth. Even with the benefits of this novel method for periodontal therapy, more clinical research is needed to confirm perioscopy's usefulness as a frontline periodontal therapeutic alternative.¹⁵

CONCLUSION

The first and foremost consideration for recommending a Perioscope is improved treatment outcomes with greater reductions in probing depths and better root surface attachment gains because a periodontal debridement done under the Perioscope leaves the root surface exceptionally clean and free of infected cementum and calculus which helps the surrounding tissues - the soft tissue wall of the pocket to heal faster and better. This is a definite advantage over blind instrumentation without magnification. Early management reduces treatment times and slows disease progression, avoiding the need for advanced periodontal surgery.

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Silver Diamine Fluoride: A versatile alternative treatment

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The application of silver compounds in the field of dentistry dates to China in 659 AD. Arresting of carious lesions by silver nitrate dates back to 1891. In 1917, Howe reported the use of an ammoniacal silver nitrate solution, (Howe's solution) and was used up until the 1950s. [1] Silver diamine fluoride [SDF] was studied first by Nishino, as a part of a PhD thesis at Osaka University in Japan in 1969, highlighting the potent antimicrobial properties of silver with the benefits of a high dose of fluoride. [2]

This formulation also resulted in a precipitate that occluded dentinal tubules and reduced hypersensitivity. Later on, "diammine silver fluoride" was approved by the Central Pharmaceutical Council of the Ministry of Health and Welfare of Japan as a cariostatic agent and was marketed as Saforide (Toyo Seiyaku Kasei Co. Ltd, Osaka, Japan). [3]

The Food and Drug Administration [FDA] granted a "Breakthrough Therapy Designation" for SDF in 2016 based on clinical trials that has demonstrated the ability of SDF to arrest dental caries and the American Academy of Pediatric Dentistry [AAPD] has published guidelines for the use of SDF in the targeted population in 2017. [4,5]

Thus, SDF gained attention of clinicians globally not just because of its effectiveness in preventing dental caries, but also in arresting the carious lesions. [1]

SDF in dentistry [4]

- ◆ Cavitated dental caries lesions that are difficult to access
- ◆ For controlling dental caries in individuals with several cavitated lesions, needing multiple visits to manage
- ◆ As a pulp capping agent
- ◆ Arresting caries to maintain the teeth near-erect
- ◆ Treatment of molar incisor

hypomineralization (MIH) to reduce dentinal hypersensitivity

- ◆ Treatment of recurrent caries (secondary caries) at the restoration margins
- ◆ Individuals with behavioural or medical management problems
- ◆ Individuals or communities lacking access to or with difficulty in accessing dental care

Side effects

Black discoloration of the carious lesion following application of SDF is the main side effect and has raised major concerns regarding parental satisfaction. Apart from the discoloration, it should be noted that SDF does not eradicate dental caries but, arrests its progression on the treated surfaces and might aid in remineralisation. Also, SDF should be handled with care as it can temporarily stain gingiva and skin. [5]



Before and After SDF Application

Contraindications [6]

- Silver allergy
- Significant desquamative gingivitis or mucositis
- Pregnancy
- Breastfeeding

- Restorations in the aesthetic zone
- Caries in the aesthetic zone
- Signs or symptoms of periapical pathology
- Radiographic signs or symptoms of periapical pathology.

Selection of Teeth for the Application of SDF [7,8]

- ◆ Absence of clinical signs related to inflamed pulp or history of spontaneous pain
- ◆ Carious lesions that are not infringing on to the pulp. When possible, prescribe radiographs to assess the proximity of pulp to caries lesions
- ◆ Carious lesions on any surface that are accessible with a brush during SDF application
- ◆ Before placement of restoration and as a cariostatic means

Steps in application

Before use

1. Always handle with care, wear gloves and change them frequently during use to avoid accidental staining of hands or clinic surfaces.
2. Ensure dentist, nurse and patient have personal protective equipment on
3. Obtain informed consent from the patient and, where necessary from their parent/carer.
4. Take photographs to record and assess the status of carious lesion

Clinical application

1. Remove gross debris from cavitation to ensure SDF reaches the carious tooth tissue or area of the tooth it is being applied to.
2. Apply petroleum jelly to the lips to reduce the chance of temporary staining.



3. Isolate the area with cotton roll and apply gingival barrier if the lesion is close to the gingiva. Alternatively, rubber dam can be used. However, take care not to coat parts of the carious lesion or tooth tissue it is being applied to.



4. Dry the carious lesion or tooth tissue with a gentle flow of compressed air or a cotton wool roll
5. Apply the SDF with a micro-brush directly onto the lesion or area of tooth being treated.



6. Allow the SDF to absorb into the tooth via capillary action for at least 1 minute. Try to keep isolated for up to 3 minutes.
7. Blot excess solution to reduce the chance of it contacting the patient's tongue.
8. 5% NaF varnish may be applied to the area if a carious lesion or MIH affected tooth is being treated as this may help to promote remineralisation.



- Consider placing a dab of toothpaste on the patient's tongue if they notice a metallic taste

Follow-up

- Follow-up at 2-4 weeks after the first application. Arrested carious lesions are hard to the touch when a ball ended probe is run across the surface. If the carious lesion is still active, a reapplication of SDF could be indicated.
- Cavitated lesions can be restored after treatment with SDF. If they are not restored, bi-annual SDF reapplications show a better arrest rate versus one-time application

Different manufacturers of SDF

- Product: Cariestop 30%, Item: 30% SDF solution Manufacturer: Biodinamica Country: Brazil
- Product: e-SDF Item: 38% SDF solution Manufacturer: Kids-e-Dental Country: India
- Product: Riva Star (38%) Items: (1) 38% SDF solution and (2) Potassium iodine solution Manufacturer: SDI Limited Country: Australia
- Product: Saforide (38%) Item: 38% SDF solution Manufacturer: Toyo Seiyaku Kasei Country: Japan



Postoperative instructions and follow-up[4,6]

Several studies on SDF recommended 30 minutes to 1-hour restriction on consumption of food and drinks after SDF application. Follow-up is advised at 2-4 weeks after the initial SDF treatment to check the arrest of the treated lesions (hard and dark)

The caries lesions can be restored after SDF treatment with resin modified glass ionomer or composites and is termed as SMART. When lesions are not restored after SDF application, biannual reapplication is advised to increase the caries arrest rate.

Conclusion

Silver diamine fluoride can be an effective, inexpensive, and sustainable option for high-risk children and adolescents across all the age groups in arresting dentin caries. Evidence suggests that twice a year application of SDF is useful in arresting or preventing dental caries compared to placebo or other alternative modalities. However the black discoloration after application of SDF is a major drawback. Studies are being conducted worldwide to address to reverse the discoloration caused by it.

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HUMAN DENTAL PULP STEM CELLS AND ITS REGENERATIVE APPLICATIONS IN MODERN MEDICINE

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Abstract:- Dental pulp stem cells (DPSCs) are a promising source of cells for numerous and varied regenerative medicine applications. Their natural function in the production of odontoblasts to create reparative dentin support applications in dentistry in the regeneration of tooth structures. DPSC's are highly proliferative, clonogenic, and are capable of differentiating into adipocytes, neural cells, odontoblasts, and various other cells. Thus it is a powerful weapon for the future of regenerative medicine. In this regard, the present review has described the recent

findings on the potential of dental stem cells to be used in tissue regeneration.

INTRODUCTION

Present in various tissues of our body, are cells that are immature and undifferentiated that self replicate for a prolonged period of time and are able to differentiate into specific types of cells and tissues referred to as " stem cells."(3)

Songtao Shi and Stan Gronthos were the first ones to discover the human dental pulp stem cells in the dental pulp tissues of extracted impacted third molars in the year 2000.

After this discovery, further types of human dental pulp derived stem cells have been successfully brought to light by Shi, namely,

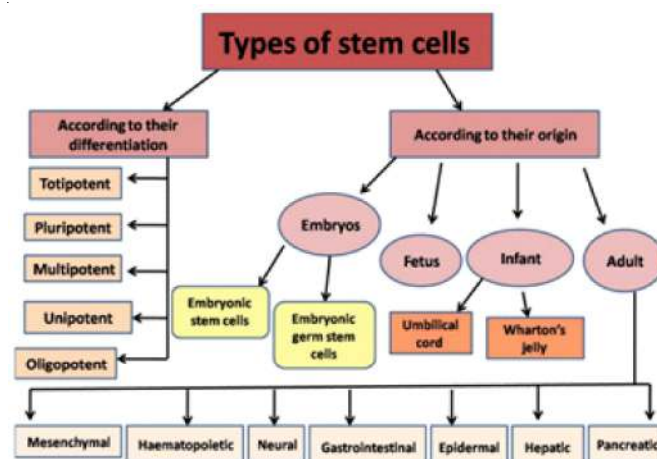
- ◆ Stem cells from human exfoliated deciduous teeth (SHED)
- ◆ Stem cells from apical papilla (SCAP)
- ◆ Human supernumerary tooth-derived stem

cells (SNTSCs) (1)

In dentistry as well as the medical field, these impressive discoveries, had various investigators focused on the properties and functions of the human dental pulp-derived stem cells.



Classification of stem cells



According to differentiation potential

Totipotent- Differentiation into embryonic and extraembryonic cell types, Capacity to form complete, viable organism

Pluripotent - Differentiation into nearly all cells of trilaminar germ layers: ectoderm, endoderm and mesoderm

Multipotent - Differentiation into a number of particularly closely related cell types.

Oligopotent- Differentiation into only a few cell types

Unipotent- Self renewal and proliferation, but produce one cell type only (5)

According to origin

Embryonic stem cells (ESC) - They are pluripotent cells derived from the inner cell mass of a blastocyst with distinctive self renewal potency. They are potentially teratogenic thus having various ethical restrictions. The FDA-approved human trials using ESC for treatment of paralysis from a spinal cord injury and diseases of the eye have been reported.(3,5)

Tissue derived stem cells -**◆ Fetal stem cells-**

- ◆ Fetal: Fetal blood and Bone marrow.
- ◆ Extra fetal: Placenta, Amniotic fluid, Wharton's Jelly and Umbilical cord .

Have better intrinsic homing, engraftment, multipotency and lower immunogenicity and with less ethical issues compared to ESCs, but with supply limitations for sustainable clinical applications. (5)

◆ Adult stem cells -**Induced pluripotent stem cells (IPS)**

Can be derived from all tissues generated by overexpressing embryonic genes

(Oct4/3, Sox2, Klf4, and cMyc) .Have similar properties of ESCs at cellular level . Clinical use remains challenged with cost , standard of production, and questionable safety due to potentials of teratoma formation.

Induced tissue-specific stem cells (iTS)

Generated by transient overexpression of the re-programming factors. Thought to be superior in differentiation and lack concerns of teratoma formation .

Mesenchymal stem cells (MSCs)

Derived from vascularized tissues such as, Bone Marrow, Adipose tissue, Skin, Periodontal tissue - They are multi-potent and self-renewing cells.(3,5)

DENTAL STEM CELLS

Teeth represent a very challenging material for regenerative medicine. They are difficult to recreate because of their function ,aspects such as articulation, mastication, or aesthetics and due to their complicated structure. Currently, there is a chance for stem cells to become more widely used than synthetic materials. Teeth have a large advantage of being the most natural and non-invasive source of stem cells.

Craniofacial stem cells, including dental stem cells (DSC), originate from neural crest cells and mesenchymal cells during development (3).Two major cell types are involved in dental hard tissue formation: Epithelium - derived ameloblasts that form enamel and the mesenchymal - originated odontoblasts that is responsible for the production of dentin.

Epithelium stem cells

Although significant progress has been made with mesenchymal stem cells, there is no information available on the use of Epithelium stem cells in humans, because their ameloblasts and ameloblast precursors are eliminated soon after eruption.

Mesenchymal stem cells

Mesenchymal stem cells (MSC) possess a high self-renewal capacity and the potential to differentiate into mesodermal lineages. It can be used autologously without concern of immunorejection, as it can be isolated from patients who need the treatment. MSC have been used allogeneically to heal large defects.(3)

The following dental mesenchymal progenitors have been used for tooth engineering purposes:

1) SHED (Stem cells from human exfoliated deciduous teeth)

They are among the most studied stem cell types and the most valuable source of stem cells in tissue engineering studies and cell-based regenerative medicine therapies.

These cells are immature, unspecialized cells in the teeth that are able to grow into specialized cell types by a process called 'differentiation'. In 2003, Miura et al., isolated cells from the deciduous dental pulp, which were highly proliferative and clonogenic.(3) They contain MSC markers such as STRO-1 and CD 146 and neuronal and glial markers such as Nestin and β III Tubulin. They have the capacity to produce bone and dentin in-vivo.(4)

SHED was used to proliferate odontoblasts with the expected markers (DSPP, DMP-1, and MEPE) within the full-length root canals on the injected scaffolds in-vitro and generate functional dental pulp in the subcutaneous space of mice (in-vivo). In this trial, cells could well occupy the root canal space and the tissue regeneration occurred with a promising growth rate (10²µm/day) providing adequate timing for the clinical uses (Martinez Saez et al., 2016; Rosa et al., 2016).(8)

2) Adult dental pulp stem cells (DPSCs)

Adult DPSCs are isolated from adult dental pulp and contain precursors capable of forming odontoblasts under appropriate signals.(3) They are multipotent and express STRO-1, CD 44 and CD 146 MSC markers. DPSC were first isolated from human teeth in 2000 and are capable of differentiating into osteogenic, odontogenic, myogenic, adipogenic and neurogenic components both in-vitro and in-vivo and can produce pulp-dentin complex in-vivo.(4)

3) Periodontal ligament stem cells (PDLSC)

Seo et al isolated and extracted PDLSC from separated periodontal ligaments of third molars in humans and contain progenitors for self-renewal of oral structures like cementum and bone(6). PDLSC transplants in immunocompromised mice formed cementum/periodontal ligament (PDL)-like structures that supported periodontal tissue repair. They can differentiate into adipogenic, chondrogenic and osteogenic components in-vitro

and cementum and periodontal ligament in-vivo. Another entity referred to as alveolar periodontal ligament stem cells have increased affinity for the production of adipocytes and osteocytes.(3)

4) Dental follicle stem cells (DFSC)

They are derived from the follicle surrounding human third molars and are pluripotent. They are made up of ectomesenchyme and contain markers such as Notch1, STRO-1 and Nestin. They have the potential to differentiate into osteoblasts, adipocytes and neuroblasts in-vitro and periodontal ligament in-vivo.(4)

5) Stem Cells from Apical Part of Papilla (SCAP)

These cells are having high proliferation, migration and regeneration capabilities and originates from the apical part of a developing tooth containing fibroblast-like and odontoblast-like cells with MSC markers that has the capability to differentiate into pulp-dentin complex in vivo.(3,4)

6) Bone marrow-derived mesenchymal stem cells

They originate from the mesoderm and can be obtained from several other sources such as the periosteum and synovial membrane but it is yet to be explored for clinical application. They are capable of forming in-vivo cementum, PDL, and alveolar bone, after implantation into defective periodontal tissues which promises an alternative source of MSC for the treatment of periodontal diseases.(3)

DENTAL PULP STEM CELLS

Characteristics

Self renewal capacity :- They represent the fundamental and specific characteristics of an adult stem cell with high proliferative and self renewal capacity(1,6)

High proliferate activity :- They express an immense proliferate capability than human bone marrow derived mesenchymal cells. It is found to be 3 - 4 times more proliferative than Human bone marrow derived mesenchymal cells. In addition to this, they have high telomeric activity.(1,6)

Ability to form colonies :- Human DPSC's are capable of forming colonies that contains spindle shaped cells called colony forming unit-fibroblasts, (CFU-F) . Interestingly, CFU-F analysis shows that Mesenchymal Stem Cell are abundant in human dental pulp than bone marrow.(1)

Capability to express cell surface markers :- Human Dental Pulp derived stem cells are negative to haematopoietic cell surface markers including CD34, CD45, CD14. On the other hand they are positive to STRO1, CD146

CD29 ,CD90 ,CD105 ,CD73 .These are well known specific markers for MSC.(1,6)

Multipotency:- Recent advances in stem cell technology enables human DPSC's into endodermal lineage cells such as hepatocytes, vascular endothelial cells, pancreatic islet insulin producing beta cells, and ectodermal lineage cells such as neural cells. These dental pulp stem cells are known to differentiate into mesenchymal lineage cells, like chondrocytes, adipocytes, myocytes, odontoblasts and osteoblasts.(1,6)

In vivo tissue regeneration capacity:- When human dental pulp-derived stem cells are subcutaneously transplanted with hydroxyapatite/tri calcium phosphate powders as carriers they express a specific and unique regeneration capability. DPSCs and SCAP regenerate only dentin in the implant tissues. They are also able to induce dental-pulp-like tissues containing blood capillary vessels and dense collagen fibers surrounded by the newly formed dentin, suggesting the effectiveness of DPSCs and SCAP which can reconstruct de novo dentin/pulp complex in vivo.(1,6)

Immunomodulation:- Human dental pulp-derived stem cells display immunomodulatory properties by affecting directly and indirectly the immune cells such as T cells. Regulate T

cell proliferation via releasing of transforming growth factor- β 1, hepatocyte growth factor and indoleamine 2, 3-dioxygenase.(1,6)

Applications Of Dental Pulp Derived Stem Cells

I) TISSUE ENGINEERING

A) Regeneration of dentin/pulp complex

DPSCs were mixed with a carrier and filled in a root canal of extracted tooth after root canal treatment, and the DPSC-filled tooth was transplanted into dorsal surface of immune compromised mice wherein regenerated dentin deposited along the existing dentin and blood vessels were found beneath the de novo dentin. Autologous transplantation of DPSCs from healthy dental pulp is clinically tried to regenerate dentin/pulp complex in the recent period.(1,6)

B) Root regeneration

SCAP is considered as a feasible cell source for dental root regeneration involving root growth in tooth development as they display remarkable cell-migration ability. (1)

It was observed that the root-form carrier was reconstructed with newly formed dentin/pulp-complex, and was surrounded by regenerated periodontal ligament on de novo cementum when a root formed carrier containing SCAPs covered with PDLSC-immersed absorbable gelatin sponge was implanted into a socket of mandibular bone of a swine. Additionally it was noted that the regenerated tooth root-like structure works functionally as a masticatory organ after the root-like structure is installed in a porcelain crown.(1)

C) Bone regeneration

A study was conducted to determine the efficiency of SHED for bone regeneration in the skull of mice and bone defect model of swine which displayed the unique bi-potency of SHED to regenerate dentin and bone. (1)

II) CELL TRANSPLANTATION

In addition to its application in dentistry, studies also confirmed the regenerative potential of dental pulp stem cells in diseases like Neurological disorders, Angiogenesis and vasculogenesis, Endocrinology, Craniofacial bone defects, and Immune related conditions.

A) Neurological disorders

Dental pulp derived stem cells shows a remarkable neuro-regeneration potential, both in the central and peripheral nervous system as they originate from neural crest cells.

Previous studies conducted reveals that DPSC's are capable of recovering impaired motor func-

tion in rat traumatic

brain injury (TBI) models by inducing M2 microglia polarization, which suggests it as a new remedy in TBI and other microglia-

mediated CNS diseases. Another

devastating condition, spinal cord injury in rats was overcome by the local implantation or injection of DPSC's - loaded hydrogel which suggests the therapeutic potential of DPSC.

Moreover, the intranasal administration of DPSC's also shows an increased treatment efficacy thus improving motor function of rats with Parkinson's disease.

It was discovered that the DPSC's are capable of inducing neurotrophin, that could benefit the treatment of neurodegenerative diseases like Alzheimer's and Parkinson's disease.(7,)

B) Angiogenesis and vasculogenesis

Several studies have discovered the potential of DPSCs and sub-fractions of DPSCs for the treatment of ischaemia and myocardial ischemia.

Due to secretion of paracrine factors, such as VEGF, it was observed that Human DPSC's were capable to repair the infarcted myocardium, by eliciting an increase in the number of vessels and reduction of infarct size.(2)

On a study conducted on chicken chorioallantoic membrane model, human DPSC's produce an immense amount of angiogenic molecules, thus stimulating endothelial cell migration for formation of blood vessels. This study stresses the suitability of DPSCs for treatment of all pathologies associated with inadequate angiogenesis such as myocardial infarction.

and stroke. (6)

C) Endocrinology

Stem-cell derived hepatocytes can be used for the cell therapy treatments for liver disease.

According to a study conducted by Chen et al in the year 2013, hepatic differentiation of cryopreserved human DPSC's from diseased tooth shows differentiated cells possessing a polygonal shape, and normal karyotype and expressing hepatic metabolic function genes and liver

specific genes. These differentiated cells are capable of glycogen storage and urea production.

The use of cryopreserved human DPSC's tissue provides a promising alternative for the treatment of liver diseases.

Diabetes is a chronic health condition caused by the autoimmune destruction of the pancreatic beta cells or decreased insulin sensitivity that leads to hyperglycemia.

Instead of conventional insulin based treatments, islet transplantation or differentiated stem cell therapy is an upcoming approach for replenishing the lost insulin producing cells. The generation of islet-like cell clusters (ICCs) from DPSCs and SHEDs demonstrates the physiological relevance of this technology.

Hyperglycaemia was controlled by ICCs from

SHEDs in experimental diabetic mice which demonstrates that dental pulp can provide an

autologous stem cell therapy (Kanafi et al., 2013).(2,6)

D) Craniofacial bone defects

The treatment of calvarial defects caused by congenital abnormalities or trauma is considered to be a grave challenge since a long period of time. Calvarial bone regeneration in rats was induced by Diomedea and colleagues, who constructed a platform with DPSC's and three-dimensional engineered scaffolds.(7)

E) Autoimmune Diseases

The tissue damages induced by hypersensitive immune response in autoimmune diseases like systemic lupus erythematosus (SLE) and inflammatory bowel disease were treated by the systemic transplantation of SHED and DPSC's in autoimmune model mice.(3)

III) CELL BANK FOR HUMAN DENTAL PULP-DERIVED STEM CELLS

Stem cell-bank is structured gradually by the ability of cryopreserved dental pulp tissues to maintain the stem cells. Induced pluripotent stem (iPS) cells can also be constructed from dental pulp derived stem cells.

Licensed tooth stem cell banks

1. In Japan, the first tooth bank was established in Hiroshima University and the company was named as 'Three Brackets' (Suri Buraketto).
2. BioEden (Austin, Texas), Stem Save, and Store?a?Tooth (USA)
3. The Norwegian tooth bank
4. In India, Stemade Biotech Pvt. Ltd. (Delhi, Chennai, Chandigarh, Pune, and Hyderabad).(3)

CONCLUSION

Human dental pulp is a fascinating source of adult stem cells which is useful in the treatment of various diseases as mentioned in the article. It is a powerful trump card in regenerative medicine and can be easily and safely obtained with non-invasive methods.

However, the researches are only confined to animal models and more human research trials are required. Regenerative medicine will be the future of modern medicine and therefore, further studies are needed to test the therapeutic application of human dental pulp stem cell with long term follow up.

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CARIES DIAGNOSIS : OLD AND NEW- A REVIEW

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Abstract: Diagnosis is the art or act of identifying a disease from its signs and symptoms. Numerous caries detection and diagnostic methods have been developed over the years which have always been ambiguous in nature. An ideal method for caries detection should offer high specificity, sensitivity, and reproducibility. Traditional methods have shown high specificity, but low sensitivity and reproducibility in approximal caries detection. Many advancements in radiography and the development of fluorescence, transillumination and electrical conductance devices potentially aid the detection of early carious lesion which could open the window of opportunity for less invasive treatment and potentially result in reduced expense of treatment for the patient. Proper use of appropriate technology and their correct interpretation can help to detect dental pathologies at very early stages, which can improve the quality of life of the patients.

Key words: Caries detection, Caries diagnosis, Conventional method, Non-Conventional method.

Introduction:

Early caries detection could lead to stabilization of the disease or even possible re-mineralization of the lesion. With the advent of minimal invasive treatment and conservative approaches in restoring the carious lesion, in order to retain the tooth in the oral cavity for functional and aesthetic purpose, early caries detection and diagnosis is of utmost importance (1,2)

Diagnosis is the process of determining the nature of a disease or disorder and distinguishing it from other possible conditions. This term is derived from the Greek word 'gnosis', meaning knowledge. There is often confusion in the literature in the terminology used for caries detection and caries diagnosis. (3)

Three terms have been agreed in terms of direct relevance to preventive caries care in the last dec-

ade: (3)

- " Lesion detection: implies an objective method of determining whether or not disease is present.
- " Lesion assessment: aims to characterize or monitor a lesion, once it has been detected.
- " Caries diagnosis: should imply a human, professional summation of all available data.

Diagnosis is a complicated process performed by the clinician considering signs and symptoms (5). It is a verdict which balances the need for treatment against consequences for the patient (6). In contrast, detection is an augmentation of the diagnosis in which earlier the detection, more objective assessment or quantified outcomes become possible(7) .

Diagnostic accuracy is indicated by the sensitivity and specificity of the diagnostic test. The caries diagnostic test sensitivity expresses the probability that the diagnostic method indicates caries when caries is truly present; and the test specificity expresses the probability that the test indicates no caries when caries is truly not present. (1)

The ideal caries diagnostic test method has sensitivity = specificity =1

Sensitivity = specificity =1, indicating that the test always reflects the true state of affairs. From a clinical perspective, sensitivity and specificity values are not overly interesting, because they are based on a-prior knowledge of the true state of affairs: caries presence or absence.(1)

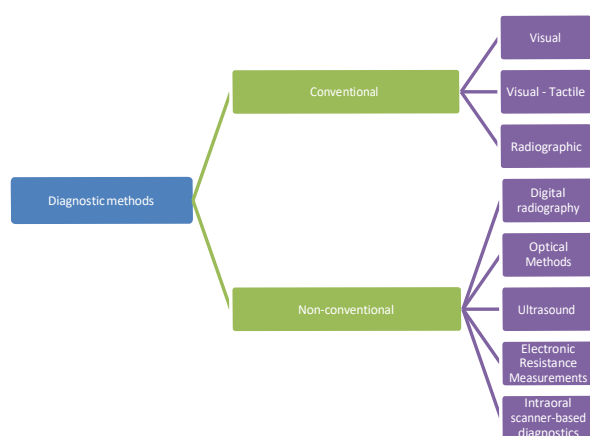
The scale of measurement of carious lesion detection differs with clinicians, researchers, techniques, and gadgets because a baseline or a gold standard is not available till date. The end result is conflicting data on the sensitivity and specificity of various aids.(8)

Ideal requisites of a diagnostic tool: (9)

Sl.no:	Requisites
1.	Accuracy
2.	Reliable
3.	Precise/simple
4.	Easy to apply
5.	Useful for all surfaces of teeth
6.	Identify caries adjacent to restorations
7.	Objectivity
8.	Sensitivity
9.	Specificity
10.	Reproducibility
11.	Validity
12.	Quantitative analysis

Detection and diagnosis at the initial (non-cavitated) and moderate (enamel cavitation) levels of caries is fundamental in achieving the promotion of oral health and prevention of oral disease (1). Several detection tools have been developed to improve the efficiency and accuracy of caries diagnosis that ranges from traditional methods of visual-tactile examination to artificial intelligence, for example, applying CNN (convolutional neural networks) and ANN (artificial neural networks) for caries diagnosis by periapical radiographs.(4)

The rationale behind detection and diagnosis of dental caries is that the course of these diseases may change for the better if they are detected and treated before they reach a stage at which they elicit symptoms or require more invasive intervention. Therefore, in dental practice, diagnosis is closely linked with the management options.(1) Diagnostic methods can be broadly categorized as conventional and non-conventional methods(10).(flowchart 1)



Flowchart 1: Classification of caries diagnostic methods

CONVENTIONAL METHODS:

Visual Examination:

This is one of the most common diagnosis methods implemented by dentists. To improve the clarity of the field of examination in the oral cavity, teeth are isolated in sextants using cotton rolls and saliva ejector along with retraction of cheeks and tongue. Air-drying of a tooth site will strengthen the difference between refractive index of enamel (1.6) and that of air (1.0)(11). Other essential requirement for the clinician for better diagnosis is a good light source.(12)

In visual examination, changes in tooth structure such as enamel dissolution, white spot lesions, discoloration, surface roughness and presence of cavitation are assessed. When illuminated, the carious tissues scatter the light and make enamel look whiter and opaque. This is due to increased porosity caused by demineralization. Similarly, when dentin undergoes demineralization, a shadow is observed under the intact enamel, thus we can evaluate the presence of lesion.(13)

Visual-Tactile Examination:

This method includes visual identification of demineralized areas (typically white spots) or suspicious pits or fissures and the use of dental explorer to determine the presence of loss of continuity or breaks in the enamel and to assess the softness or resilience of the enamel(10,14). Vigorous poking of the tooth using probe causes irreversible damage to the surface layer of non-cavitated lesion which might potentially accelerate localized lesion progression(14). Histological evaluation has shown that gentle probing does not hinder the surface integrity of non-cavitated lesions(15). For non-cavitated lesions, the reported sensitivity of visual inspection combined with probing is as low as 14% to 24%(16).

Radiographic Method:

Wilhelm Conrad Roentgen's discovery of X-rays on November 8, 1895, initiated the first dental radiographs ever taken, by Otto Walkhoff in January 1896. Dental radiographs have proven their significance in dental and maxillofacial diagnosis. For many years, two-dimensional intraoral and extraoral radiography were the only radio-

graphic options. A little more than 2 decades ago, three-dimensional imaging in dentistry (cone beam computed tomography) became more accessible(12).

Good radiologic practice include:(18)

Use of the fastest image receptor (F-speed film or digital).
Collimation of the beam to the size of the receptor whenever feasible.
Proper film exposure and processing techniques.
Use of protective aprons and thyroid collars
Limiting the number of images to the minimum necessary to obtain essential diagnostic information

Use of the fastest image receptor (F-speed film or digital).

Collimation of the beam to the size of the receptor whenever feasible.

Proper film exposure and processing techniques.

Use of protective aprons and thyroid collars

Limiting the number of images to the minimum necessary to obtain essential diagnostic information

Radiography is the most widespread lesion detection aid, particularly with respect to otherwise invisible or poorly visible approximal areas(16).Radiographs should not be taken without a prior clinical examination indicating a problem that needs further consideration before final diagnosis or treatment can be decided. Dental radiographs show differences in mineral content of the dental hard tissues. Demineralization such as carious lesions do not absorb X-ray photons to the same extent that sound enamel and dentin do.(19)

NON-CONVENTIONAL METHODS:

Digital Radiography: Digital image is an image composed of a series of sensors and pixels

distributed orderly. The advantages of digital imaging over conventional radiography is as follows: (20,21)

- ◆ The radiation dose is approximately 60-90% lower
- ◆ The image receptor is often larger
- ◆ The image is immediately available, less time consuming

- ◆ The image can be electronically transferred
- ◆ Magnification, contrast, brightness can be adjusted
- ◆ There is no need for processing solutions, protecting the environment and lowering the costs. Disadvantages: (22)
- ◆ Depending on the digital system used, a connecting wire with the intra-oral sensor might interfere with the correct positioning of the film, or the effective radiation field may be smaller.
- ◆ The printouts of digital radiography render pictures of lower quality.

There must be 40% of demineralization in the lesions, in order to be visible in the radiograph. This means that detection of deeper lesions is significantly harder when compared with superficial lesions. In an in vitro study comparing the capacity of conventional radiographic imaging with digital imaging systems in detection of proximal caries, it was concluded that these two systems provided similar results, showing no significant difference over another. It is highly recommended to use digital imaging as the radiation dose is significantly lower.(23,24)

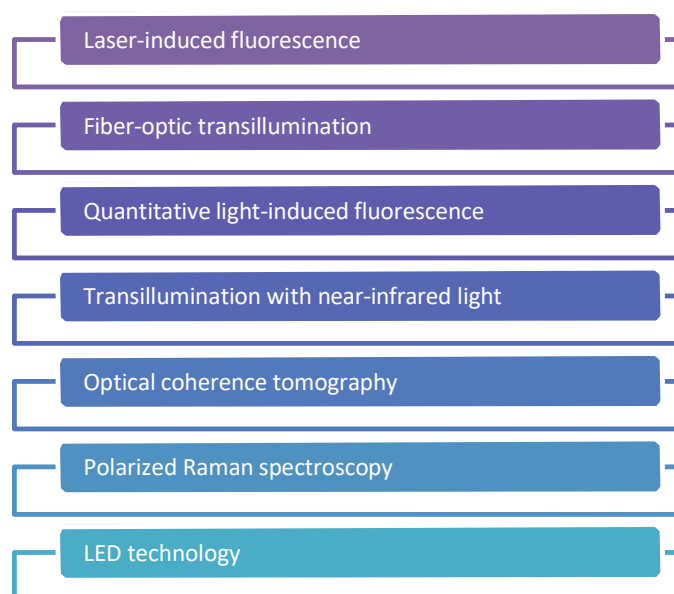
When digital radiography was compared with visual tactile examination, the sensitivity and specificity were 90% and 44% respectively. When digital radiography was compared with DIAGNOdent, the latter showed a very low specificity of only 32%, although sensitivity was still high at 91%.(25).

Optical Methods:

In a white-spot carious lesion, scattering is stronger than that in sound enamel. The penetrating photons change direction more often in carious enamel than in sound enamel and are generally back-scattered before they reach the dentin. Therefore, such a lesion appears whiter than the surrounding sound parts of the tooth. Brown lesions are due to the presence of light-absorbing material in the lesion and/or exogenous stain. A slight increase in enamel porosity leads to a change in the optical properties of enamel in such a way that light is increasingly scattered. This is mainly due to the fact that remaining small mineral particles in the lesion are embedded in water

rather than in mineral-rich sound enamel (Angmar- Mansson & ten Bosch, 1987), thereby increasing the difference in refractive index (RI) between the scattering photon and its environment. The RI of enamel apatite is 1.62, and the RIs of water and air are 1.0, respectively. Thus, when the pores of a white spot enamel lesion are filled with water, the light scattering is less than when the lesion is dry and the pores are filled with air. After dehydration of enamel it looks whiter, as a result of more scattered light. (17)

Some of the optical caries detection techniques are: (17)



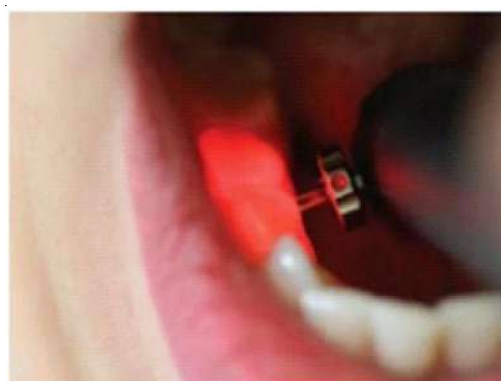
i) **LASER-INDUCED FLUORESCENCE:**

Fluorescence is the process of absorption of light of a short wavelength which results in emission of radiation at a longer wavelength. This emitted radiation is called fluorescence, as certain molecules (fluorophores) de-excite electronically from higher energy level to a lower energy level. When red light with a wavelength of 655 nm is applied, caries-induced changes in teeth lead to increased fluorescence(11).

The DIAGNOdent(fig.1) is based on this principle. In the 1990s, it was found that caries emits fluorescence when activated with red light at the wavelength of about 650 nm. In the late 1990s,the DIAGNOdent was developed for assessment of occlusal sites. A pen type DIAGNOdent device(fig.2) was developed for approximal sites in the early 2000.(11)



Fig 1: DIAGNOdent Fig 2: Caries detection by DIAGNOdent Pen



The device needs to be kept on clean teeth. Make sure that the prophylaxis paste or powder is completely rinsed off to avoid wrong measurements. Remnants of several prophylaxis pastes and calculus give a false positive fluorescence signal. Different tips are needed for the assessment of occlusal and approximal sites. Before using clinically, it should be noted that each tip needs to be calibrated separately against a ceramic standard. The fluorescent light is measured and its intensity is thought to be an indication of the depth of the caries lesion. The intensity of the fluorescent light is displayed as a number ranging from 0 to 99, with 0 indicating a minimum and 99 a maximum of fluorescent light. (11)

ii) **FIBER-OPTIC TRANSILLUMINATION (FOTI):**

This method of tooth transillumination with an appropriate intense light source(fig.3) is widely accepted by dental practitioners for caries detection in anterior teeth. For this purpose, transillumination is easy, fast and inexpensive. Fiber-op-

tic transillumination (FOTI) uses the principle of light scattering to increase contrast between normal and carious enamel. (16)



Fig 3: Anterior caries detection by FOTI Probe

As light is scattered more in demineralized enamel than sound enamel, a lesion appears dark on a light background (fig.4). In addition to this, carious dentin appears orange, brown or grey underneath the enamel, and this significantly aid in discrimination between enamel and dentinal lesions. (16)



Fig 4: Transilluminated central incisor with evidence of interproximal caries

FOTI provides a 3-dimensional view of the tooth and the caries within. This can provide a significant benefit in restorative dentistry enabling cavity preparation to remain minimally invasive. (16)

iii) QUANTITATIVE LIGHT-INDUCED FLUORESCENCE (QLF):

Laser light is used to induce fluorescence of enamel. The tooth is illuminated with an argon laser ($\lambda = 488 \text{ nm}$). Demineralized areas appear dark because the fluorescence of a carious lesion viewed by QLF is lower than that of sound enamel. The laser fluorescence method was developed further for in vivo quantification of mineral loss in natural enamel lesions using a color micro video charge-coupled device (CCD) camera and computed image analysis. To enable calculation of fluorescence loss in the carious lesion, the fluorescence of the lesion is subtracted from the fluorescence of the surrounding sound tissue. The difference between the actual values and the reconstructed ones gives the resulting fluorescence loss. The QLF method has been applied successfully in a few clinical studies for monitoring remineralization of incipient enamel lesions in smooth surfaces of caries-active adolescents. (1)

iv) TRANSILLUMINATION WITH NEAR-INFRARED LIGHT (TI-NIR):

Most NIR light can be transmitted across healthy enamel with marginal scattering depending on the wavelength. 1310 nm light represents an optimal imaging wavelength as it strikes a balance between enamel and water attenuation. Dental caries and demineralization scatter the transiting NIR light and appear dark (fig.5) (26-28). Cracks in the tooth are easily visualized in the NIR range of wavelengths. Stains, which absorb light and restrict the assessment of the underlying material, do not manifest at NIR wavelengths of 1200 nm and greater. (29-31)

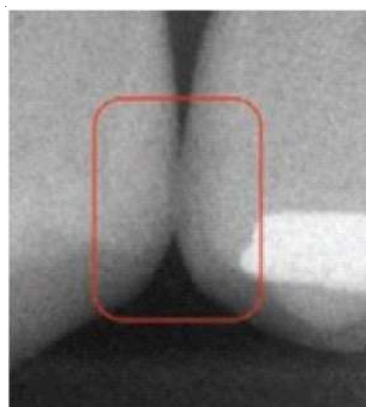


Fig 5: Proximal transillumination at 1300 nm

A device called DIAGNOcam (fig.6) emits invisible near-infrared light for transillumination (NILT) of a tooth suspected of having carious lesion. This device which is introduced in 2012, comprises elastic arms containing optical fibers, a USB connection to the computer, a specific software, and a camera system including a NIR light source. (29-31)



Fig 6: DIAGNOcam

v) OPTICAL COHERENCE TOMOGRAPHY (OCT):

This method is similar in operation to ultrasound imaging, but uses light waves rather than sound waves. OCT can only image the first several millimeters of tissues (2-4 mm, depending on the wavelength of light used). Thus, OCT is better suited for imaging near-surface structures.(32)



Fig 7: OCT images

OCT can create cross-sectional images of translucent or semi-translucent biological structures with microscopic level resolution and it is effective for the diagnosis of dental caries, tooth cracks, and age changes of tooth structures(fig.7).One of the biggest advantages of OCT is that it can be safely used in infants and pregnant women without the risk of X-ray radiation exposure.(33)

vi) POLARIZED RAMAN SPECTROSCOPY(PRS):

PRS provides details on the molecular composition (e.g., collagen in dentin) and molecular structure of cells and tissues. Like OCT, PRS measures light scattering. Although most scattered photons have the same energy and wavelength as the incoming excitation light, about 1 in 107 photons scatters at an energy different from that of the incoming light. This energy difference is proportional to the vibrational energy of the scattered molecules within the sample and is known as the Raman effect. As with other emerging optical methods, the properties of the scattered light within sound or porous carious regions are being explored to determine their use in caries detection.(32) In an ex vivo study based on 23 extracted teeth with 47 and 27 PRS measurements on sound and carious enamel, respectively, the authors could readily distinguish sound enamel from carious enamel achieving a sensitivity of 100% and a specificity of 98%.(34)

vii) LED TECHNOLOGY

Midwest Caries ID: It is a small, battery-operated technology that emits a soft LED light for detecting and quantifying caries(fig.8). A specific fiber optic signature captures the resulting reflection and refraction of the light in the tooth and it is converted to electrical signals that run through a computer-based algorithm for analyzing the presence of caries. (35,36)



Fig 8: Midwest Caries ID

Patel et al reported the sensitivity and specificity of this detection device as 0.56 and 0.84, respectively. Krause et al. reported a sensitivity of 100%, which was calculated by comparing the Midwest ID to radiographic method. (35,36)

Ultrasound:

Ultrasonic system makes the use of sound waves with frequency. They are longitudinal or pressure waves which travel through gas, liquids, and sol-

ids. Ultrasound interacts differently with different tissues. They have a frequency of more than 20,000 hertz and have all the properties of waves, in that they may be reflected, scattered, refracted, or absorbed. The relative ability of a medium to reflect the sound depends on its mechanical properties, such as elasticity, density, and wavelength of sound. Amount of sound reflected provides information about the structure of reflecting interface, whereas the time taken for sound to be reflected provides information about the position of the reflecting interface. For sound waves to reach the tooth, they have to travel through a coupling medium or an agent that has acoustic impedance (mercury, aluminum rods, water, and glycerin) (11)

An ultrasonic probe (fig.9) is used which sends and receives longitudinal waves to and from the surface of the tooth. Initial white spot lesions produce no or weak surface echoes, whereas sites with visible cavitation produce echoes with substantially higher amplitude. (11)



Fig 9: Ultrasonic probe

This method can be a realistic alternative to radiographic diagnosis of caries on approximal surfaces. It is also more sensitive than visual-tactile method(15). Ultrasonic system can distinguish an intact and demineralized enamel surface due to specific acoustic impedance caused by changes in the mineral content(11).

Electronic Resistance Measurements:

Caries can be described as a process resulting in an increase in porosity of the tissue, be it enamel or dentin. This increased porosity results in a higher fluid content than sound tissue. This dif-

ference can be detected by electrical measurement by decreased electrical resistance or impedance(13).

The low conductance of the tooth is primarily caused by the enamel. At locations where the pore volume of the enamel is larger, the electrical conductance increases considerably. Since the conductance of the tooth and the resistance are inversely proportional, the increased conductance or decreased resistance are indicative of the presence of hypo- and/or demineralization. The increased pore volume is due to the formation of microscopic cavities, which are filled with saliva to form conductive pathways for electrical transmission(21).

Pore volume \propto electrical conductance

The immature, porous enamel is more conductive than mature enamel, and dentin is more conductive than enamel. When a current is applied by placing an electrode onto a tooth surface, the electrical conductance of all material between this electrode and the contra-electrode, which is generally held in the hand, can be measured. Since all of these materials have high concentrations of electrolytes except for enamel, the measurement of the conductance is mainly that of enamel(37).

Intraoral scanner-based diagnostics:

This method helps to detect and monitor enamel caries lesions at an early stage to enable minimally invasive treatment options. This provide caries diagnostic tools for the detection of occlusal and/or proximal caries lesions integrated in their intraoral scanners. Three commercially available intraoral scanners are: (38)

- Trios 4
- iTero Element 5D
- Planmeca Emerald S.

The Trios 4(fig.10) uses fluorescence technology with blue-violet light of a wavelength of 415 nm to detect fluorescence changes between sound and demineralized tooth surfaces. Caries diagnosis can be performed with the Trios 4 using the same scan tip by performing a scan of the surface in the caries mode(38).

Summary



Fig 10: Trios 4

iTero Element 5D (fig.11) is a near-infrared trans-illumination (NIRI) based technological device. Enamel that is illuminated with light in the near-infrared range (wavelength 850 nm) appears darkly translucent, whereas dentin or carious lesions appear less translucent and brighter. Similar to Trios 4, the same scanning tip for capturing 3D images and caries diagnosis is provided. (38)



Fig. 11: iTero Element 5D

Planmeca Emerald S (fig. 12) uses near-infrared technology. It utilizes a shorter wavelength of 727 nm and requires a separate scan tip (cariosity tip) for occlusal and proximal caries diagnosis.(38)



Fig.12: Planmeca Emerald S

Dentistry has witnessed enormous advances in all its branches over the past three decades. With these advances, the need for more precise diagnostic tools, especially imaging methods, have become mandatory. There is continuous improvement in the dental caries detection technology. There were only very few advanced technologies present two decades ago, but today there are a dozen or more methods that claims the early detection of caries than visual and radiographical examination. Current technologies include laser fluorescence, electrical conductance (impedance), digital fiber-optic trans-illumination, infrared or near-infrared assessment of mineralization or biofilm activity, and several others. It has been found that the detection ability of many methods thus far is highly sensitive but yet not adequately specific(39).

The caries diagnostic options available to the dentist are abundant and wide ranging. They fall into one of the three groups, which may be designated the 'classics', the 'newcomers' and the 'prospects'. The 'classics' comprise visual-tactile inspection, which may include fiber-optic transillumination (FOTI), and bitewing radiography, including digital radiography. The 'newcomers' encompass laser fluorescence (DIAGNOdent), quantitative laser fluorescence (QLF) and the electrical caries monitor and the 'prospects' are based on techniques such as multiphoton imaging, thermography, infrared fluorescence, optical coherence tomography, ultrasound and terahertz imaging.(7)

Conclusion:

Diagnosis acts as a mental resting point before determining the treatment options to be taken(1).Numerous technologies, including optical, radiographic, electrical, and ultrasound based methods developed with the objective of detecting lesions at various stages of the caries process. The visual assessment method remains the universal fundamental method of assessment and can be supplemented relatively simply and inexpensively to improve the validity of lesion detection. New caries detection devices can help the dental team to detect, measure, and monitor lesions over time as they respond to various interventions within the oral environment(11).

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ANTERIOR COMPOSITE RESTORATIONS

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Abstract

Aesthetic enhancement of the maxillary dentition can be accomplished using a variety of direct and indirect methods. Composite resin procedures enable the clinician to follow a predictable, conservative, and reliable chairside protocol for improving patients' smiles. Combined with advances in adhesive materials themselves, these procedures can be used successfully in the daily practice of restorative aesthetic dentistry. This case report describes the management of a patient with midline diastema using direct composite resin restoration . This patient was recalled for follow-up for 1 year , no discolouration or line of demarcation were seen . Direct composite resin restoration is considered highly aesthetic , durable and could fulfil the aesthetic need of the patient in the present case .

Introduction

Tooth size discrepancy and space in the anterior region of mouth are concerns of a majority of patients. For diastema closure , orthodontic , restorative and prosthodontic treatments can be carried out. Direct composite restoration has several advantages , conservation of tooth structure , reversibility of procedure , lower cost to patient and ease of addition or removal of materials when necessary. However , a number of clinical cases cannot be corrected or maintained by the restorative procedure only .

The appearance of teeth plays a important role as it interacts closely with facial esthetics. Since a pleasant smile is governed largely by symmetry, symmetry at the midline creates an unacceptable esthetic presentation for both patients and observers. When diastema closure is performed , dental midline as well as occlusal relationship and esthetic proportion of an individual tooth , must be considered and should coincide with the midline of face .

This clinical case reports a patient with interdental spaces in maxillary anterior region. The patients esthetic expectations were successfully met by direct resin bonding.

CaseReport

A 30 year old male reported to the clinic with complaints of space between his upper maxillary anterior teeth. Clinical examination and evaluation revealed that the esthetic problems of the patient in maxillary anterior region was the spacing between his upper central incisors. There was no notable esthetic problems in mandibular anterior region. The widest interdental space was between two central incisors , approximately 1mm.

Diagnostic Work Up

On the first visit , irreversible hydrocolloid impressions of both arches were made to fabricate a diagnostic cast . The patient showed Angle class 1 malocclusion with normal overjet (2mm) and over bite (2mm). Since a proper size relationship in anterior teeth is very important to achieve an esthetic result , mesio-distal widths of anterior teeth of both arches were recorded to calculate intermaxillary tooth size ratio .

Mock Wax Up

Based on the analysis of the patient's face , tooth size discrepancy and the diagnostic cast , diagnostic wax-ups were made . Although the space of 1.5mm or less can be successfully restored using a translucent enamel shade , a mock-up with different shades/opacities of resin composites was done to accurately match not just single shade , but also the adjacent tooth structure .

Procedure

A superfine diamond bur was used to roughen the proximal enamel surfaces for optimal adhesion , extending from the facial line angle to the lingual line angle . With cotton rolls in place to isolate the operating fields , a gingival retraction cord of size 00 was tucked in the gingival crevice to displace the tissue of interproximal gingival papilla . The adjacent tooth was separated by Teflon tape . The enamel was etched with 32% phosphoric acid for 30 seconds . After rinsing and drying , bonding agent (3M Universal SelfEtch

Bond) was applied according to manufacturer's instructions and cured for 10 seconds using a LED curing unit (Ivoclar Vivadent Blue Phase unit) . A microhybrid resin composite (3M Z350 XT Composite) was used for the composite buildups due to its ease of handling property and good shade matching . The composite was placed and polymerized using a layering technique to simulate natural tooth color and translucency . Each layer was light cured for 20 seconds from facial and lingual directions .

To begin the contouring and polishing process, the proper length was first established with a Sof-Lex™ XT Contouring Disc (3M). Second, an incisal-facial line angle was formed. Third, the mesio-facial line angle, as well as the incisal, facial and palatal embrasures were defined . Once contoured, the surface characterization of the adjacent teeth was copied onto the restoration using a fine diamond. Next Sof-Lex Diamond Polishing System a beige pre-polishing spiral is used to smoothen and remove scratches in the restoration to prepare the surface for high –gloss polishing . Next , a pink diamond polishing spiral then imparted a smooth, high-gloss polish . The patient returned one week later for a final post-operative appointment . He was still very satisfied with the final restoration.



Pre op image



Post Op image

DISCUSSION

Determining the closure of diastema must be predicted upon a diagnostic evaluation of the diastema size , the length and proportion of the clinical crowns of the teeth involved , wear factors, occlusion and anterior guidance . Direct composite restoration are single visit procedures , which reduces cost of the treatment . Resin based composite are easy to repair in case of fracture . For porcelain restorations any modification required has to send to the Dental Laboratory . Disadvantages of these composite restoration are

less color stability compared to porcelain crown , less fracture toughness , compressive and shear strength . So Composite restoration are not suited for high stress bearing areas . Best quality resin materials are available to yield esthetic , functional and durable restorations . This case patient was not willing for an expensive treatment . The composite resins used for anterior restorations must have good handling and aesthetic characteristics .

A common technique of restoring diastemas is to make impression of wax-up model and fabricating a silicon putty-index . However , in this case using direct composite restoration with layering technique was decided .

CONCLUSION

The objective of cosmetic dentistry must be to provide the maximum improvement in esthetic with the minimum trauma to the dentition. Proper case selection, shade selection, contour must be taken in to consideration.

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INFORMED CONSENT : CHALLENGES AND LIMITATIONS IN MEDICAL NEGLIGENCE CASES

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ABSTRACT

Informed Consent is the permission given by a patient to a medical practitioner for treatment with full knowledge of the possible risks and benefits involved in that treatment. Purpose of Informed Consent is to give sufficient information to a patient, so as to enable him to make an informed decision about the use of a drug, or procedure in the course of the medical treatment. A medical practitioner has a duty to warn a patient of any likely harm that may result in the course of treatment. The patient can take a correct decision on whether to subject himself for a particular mode of treatment only when adequate information is made available to him. The patient has a right to accept or reject the advice of his physician. This article discusses the importance of taking Informed Written Consent especially in medical negligence cases.

Key Words : Express Consent, Implied Consent, Informed Consent, Real Consent, Valid Consent, Written Consent.

INTRODUCTION

The practice of taking Informed Written Consent from patients by healthcare professionals before undertaking any diagnostic, therapeutic or surgical procedure is zealously followed in the healthcare sector. Whether this practice shields healthcare professionals from medical negligence suits is a debatable question. It is the right of the patient to know beforehand what type of procedure he or she is being subjected to and its possible outcome. The patient has the right to know about the pros and cons of the treatment modality which he or she is being subjected to. The consent protocol followed by the healthcare professionals is that

the risks and consequences of a particular procedure is explained to the patient and his/her informed written consent is taken in the language he/she understands fully before starting any procedure by the concerned medical professional. The doctors are bound by the mandate provided by the patient to them and they are not supposed to overstep that mandate except in extraordinary circumstances if the situation so demands. In the recent years, mushroom growth of corporate hospitals have transformed healthcare sector into a profitable business sector rather than a service oriented sector. As a natural corollary to this phenomenon, patients seeking treatment from hospitals are often subjected to unnecessary diagnostic and invasive treatments and even unnecessary medications without explaining to them the possible side effects or adverse consequences of such treatments and medications. In this context, the principles of informed consent and medical ethics need a relook. When confronted with a medical negligence suit, the burden is cast upon the concerned medical professional to prove that the treatment modalities followed in that particular case is indeed necessary for the better treatment outcome for that patient.

CONSENT

Consent is an essential requirement of medical treatment. Medical treatment involves bodily contact and if it is carried out without consent, it will amount to both tort¹ and a crime. The tort of battery² can be used where the claim is that the medical professional did not have the consent of the patient. The tort of negligence would be more appropriate where it is said that the doctor did not act in accordance with the accepted body of professional opinion.³

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1 Tort is a wrongful act other than a breach of contract for which relief may be obtained in the form of damages or an injunction. MERRIAM-WEBSTER.COM; <https://www.merriam-webster.com/dictionary/tort>, (last visited May 14, 9.30 pm)

2 Battery is an offensive touching or use of force on a person without the person's consent. MERRIAM – WEBSTER.COM. <https://www.merriam-webster.com/dictionary/battery>, (last visited May 14, 9.45 pm)

3 Jonathan Herring, Medical Law, Oxford University Press (2011) P. 63.

"Consent in the context of a doctor-patient relationship, means the grant of permission by the patient for an act to be carried out by the doctor such as a diagnostic, surgical or therapeutic procedure. Consent can be implied in some circumstances from the action of the patient. For example, when a patient enters a dentist's clinic and sits in the dental chair, his/her consent is implied for examination, diagnosis and consultation. Except where consent can be clearly and obviously implied, there should be express consent. There is, however, a significant difference in the nature of express consent of the patient, known as "real consent" in U.K. and as "informed consent" in America. In U.K., the elements of consent is considered to be valid and "real" when (i) the patient gives it voluntarily without any coercion; (ii) the patient has the capacity and competence to give consent; and (iii) the patient has the minimum of adequate level of information about the nature of the procedure to which he/she is consenting to. On the other hand, the concept of "informed consent" developed by American Courts, while retaining the basic requirements of consent, shifts the emphasis on the doctor's duty to disclose the necessary information to the patient to secure his consent"⁴

CONCEPT OF INFORMED CONSENT

The basic concept behind the doctrine of informed consent is explained by Justice Benjamin Cardozo.⁵ The concept of informed consent has its roots in recognition of the patient's right to self-determination. The doctrine of informed consent means that a doctor is required to give his patient sufficient information about the proposed treatment, so as to provide him with the opportunity of making an "informed" or "rational choice as to whether to undergo the treatment." Doctrine of the informed consent is a legal concept which imposes a duty on the doctor to explain to his patient not only the nature of the proposed treatment but also damages and risks inherent therein.

⁴ Samira Kohli V. Dr. Prabha Manchanda, (2008) 2SCC1

⁵ Scholendroff V. Society of NY Hosp 105 NE92, 93 (NY 1919) Cardozo J. Every human being of adult years and sound mind has a right to determine what shall be done with his own body.

⁶ B,S, Venugopal, "Informed Consent to Medical Treatment" 46 JILI (2004) p. 393 – 417.

⁷ Laurel R Hanson, "Informed Consent and the Scope of a Physician's duty of Disclosure" (2001) 77 – North Dakota Law Review p.17

⁸ Peter. H. Schuck, "Rethinking Informed Consent" (1994) 103 Yale Law Journal 919, 899-959.

Exceptions to the doctrine of Informed Consent

The duty of disclosure is subject to certain exceptions :

1. Therapeutic privilege : This exception means that a physician may be entitled to withhold from his patient information concerning the risk of proposed treatment if it can be established, by means of medical evidence, that disclosure of this information would have posed a serious threat of psychological detriment to the patient. This relates to the more general issue of whether a doctor is entitled to withhold information from his patient if he considers this to be in the "best interest of his patient."
2. Waive the right not to know : A patient may intentionally relinquish his right to know.
3. Emergency : It implies a situation of great urgency warranting immediate treatment to save the life of the patient.⁶ Jurisdictions use either a physician based, patient based or hybrid standard of disclosure to determine what information a physician need to disclose to his or her patients.⁷ Under the physician based standard, the court looks to what risks the reasonable physician would disclose to the patient. Under the patient-based standard, a physician must disclose those risks to patient that a reasonable patient would consider material to decisions about medical treatment. The hybrid standard of disclosure comprises of those jurisdictions who have clearly articulated a standard or who use a combination of physician and patient disclosure standards and therefore can't be categorized as one or the other.⁸

ESSENTIAL ELEMENTS OF A VALID CONSENT TO TREATMENT

The essential elements to a valid consent to treatment are as follows:-

- a) **CAPACITY** : The patient must have sufficient understanding, ie; mental capacity or mental competence to make the decision;
- b) **VOLUNTARINESS** : The next essential ingredient of a valid consent is that it should have been given voluntarily. Coercion, under influence and mistake may vitiate consent to medical treatment. A medical practitioner should ensure that patient is expressing his views and was not under any influence. In the other words, the patient must consent to (or refuse) the treatment of his own free will, with no duress or under influence;
- c) **SUFFICIENT INFORMATION** : The patient must have been given sufficient information about the proposed treatment.⁹ A patient who had not been adequately informed may bring an action for medical negligence stating that there was a breach of duty of care.
- d) **BEST INTEREST RULE** : In cases where a patient does not have capacity, to give consent, then decisions are made on that patient's behalf based on what is in his/her best interest. For example, consent for the treatment of a child below eighteen years of age, or a person having mental incapacity.

For consent to be legally valid, it must fulfill the following conditions:-

1. Person giving the consent should be of sound mind.
2. The consent should not be obtained by fraud or misrepresentation.
3. The consent given should be based on correct and adequate information.
4. The consent can be either implied or express.
5. In cases of medical emergencies, consent to save life is implied.
6. Consent is also implied, where a person of unsound mind requires emergency treatment and his/her guardian is not available, or in cases where a comatose patient requires immediate treatment, or in cases where an intoxicated person cannot exercise it and also in cases where a person allows treatment to proceed without objection.

KINDS OF CONSENT :

The consent for medical treatment may be either implied or express. Consent can be even tacit, anticipatory or conditional.

Implied Consent : In implied consent, the demeanor, behaviour and action of a patient his consent. In situations where a patient voluntarily submits to treatment in a manner indicating awareness of the treatment being administered, his consent is implied. Consent to a routine clinical examination is implied, where a patient comes to a physician for treatment. In such cases, examination would mean, inspection, palpation, percussion or auscultation in a standard professional manner.

Express Consent : In express consent, the patient specifically grants permission to a physician to undertake diagnosis and treatment of a specific problem. The consent may be given either verbally or in writing. Written consent is admissible as proof of consent in a court of law. Verbal consent is also legally valid in a court of law. However, it may face problems of credibility in cases where the patient has died.

Tacit Consent : In case of tacit consent, the patient who is not agreeing to undergo a medical procedure has to take some active action to refuse, if he does not want the procedure to be done on him. However, tacit consent like all other consent procedure must fulfill three basic features, namely: (i) the patient must have the capacity to understand the information, retain and consider the available choices before him and then make a decision, (ii) adequate information must be given to the patient to make his decision. (iii) consent must be given by the patient out of his free will and not under any duress or coercion.

Anticipatory Consent : Anticipatory consent is the consent taken where additional problem or situations may arise and the patient may not be able to consent as he/she may temporarily lack the capacity. In situations where the surgeon has to perform an important or crucial surgical manoeuvre based on operative findings intra operatively and the patient is not able to give consent as he is under anaesthesia. Therefore, it is important to obtain anticipatory consent by

⁹ Marc Stauch and Kay Wheat with John Tingle, "Text, Cases & Materials on Medical Law (2006) p. 115.

discussing with the patient all foreseeable situations and what kind of action may need to be undertaken before proceeding with a major surgery.

Conditional Consent : Consent of a limited scope or with condition is known as conditional consent. For example, Sometimes patients may agree for procedures like lumpectomy and not mastectomy or myomectomy and not hysterectomy.

JUDICIAL PRONOUNCEMENTS RELATING TO CONSENT

One of the leading decisions of the Hon'ble Supreme Court of India relating to consent is discussed below:

In *Samira Kholi V. Dr. Prabha Manchanda*¹⁰, the doctor performed abdominal hysterectomy (removal of uterus) and bilateral-salpingo-oophorectomy (removal of ovaries and fallopian tubes) after taking consent of the mother of the patient while the patient was under general anaesthesia for diagnostic laparoscopy. Appellant contended that as she was admitted only for a diagnostic procedure, namely, a laparoscopy test, and as her mother's consent for conducting hysterectomy had been obtained by misrepresentation, there was no valid consent for the surgery. The following questions arose for the consideration of the court:

- (i) Whether informed consent of a patient is necessary for surgical procedure involving removal of reproductive organs? If so, what is the nature of such consent?
- (ii) When a patient consults a medical practitioner, whether consent given for diagnostic surgery can be construed as consent for performing additional or further surgical procedure - either as conservative treatment or as radical treatment - without the specific consent for such additional or further surgery?
- (iii) Whether there was consent by the appellant for the abdominal hysterectomy and bilateral salpingo - oophorectomy performed by the respondent?
- (iv) Whether the respondent had falsely invented a case that the appellant was suffering from

endometriosis to explain the unauthorized and unwarranted removal of uterus and ovaries, and whether such radical surgery was either to cover-up negligence in conducting diagnostic laparoscopy or to claim a higher fee?

- (v) Even if the appellant was suffering from endometrioses, the respondent ought to have resorted to conservative treatment/surgery instead of performing radical surgery.
- (vi) Whether the respondent is guilty of the tortuous act of negligence/battery amounting to deficiency in service, and consequently liable to pay damages to the appellant?

The Supreme Court summarised the principles relating to consent in the following manner:

- (i) A doctor has to seek and secure the consent of the patient before commencing a "treatment" (the term "treatment" includes surgery also). The consent so obtained should be real and valid, which means that : the patient should have the capacity and competence to consent; his consent should be voluntary and his consent should be on the basis of adequate information concerning the nature of the treatment procedure, so that he knows that he is consenting to.
- (ii) The "adequate information" to be furnished by the doctor (or a member of his team) who treats the patient, should enable the patient to make a balanced judgment as to whether he should submit himself to the particular treatment or not. This means that the doctor should disclose - (a) nature and procedure of the treatment and its purpose, benefits and effect; (b) alternatives if any available; (c) outline of the substantial risks; and (d) adverse consequences of refusing treatment.

But there is no need to explain remote or theoretical risks involved, which may persuade a patient to undergo a fanciful or unnecessary treatment. A balance should be achieved between the need for disclosing necessary and adequate information and at the same time, avoid the possibility of the patient being deterred from agreeing to a necessary

¹⁰ (2008) 2 SCC 1

treatment or offering to undergo an unnecessary treatment.

- (iii) Consent given only for a diagnostic procedure, cannot be considered as consent for therapeutic treatment. Consent given for a specific treatment procedure will not be valid for conducting some other treatment procedure. The fact that the unauthorized additional surgery is beneficial to the patient, or would relieve the patient from pain and suffering in future, are not grounds of defence in an action in tort for the additional procedure though unauthorized, is necessary in order to save the life or preserve the health of the patient and it would be unreasonable to delay such unauthorized procedure until patient regains consciousness and takes a decision.
- (iv) There can be a common consent for diagnostic and operative procedures where they are contemplated. There can also be a common consent for a particular surgical procedure and an additional or further procedure that may become necessary during the course of surgery.
- (v) The nature and extent of information to be furnished by the doctor to the patient to secure the consent need not be stringent and of a high degree, but should be of the extent which is accepted as normal and proper by a body of medical men skilled and experienced in the particular field. It will depend upon the physical and mental condition of the patient, the nature of treatment and the risk and consequences attached to the treatment.

In this case, the Supreme Court came to the conclusion that for a vast majority of people in our country, the concept of informed consent, or any form of consent and choice in treatment have no meaning or relevance to them.

CONCLUSION :

In India, informed consent was practically nonexistent till the Consumer Protection Act was made applicable to the medical profession. Now both the doctors and patients are increasingly becoming more aware about this concept of informed consent. The patients are now aware of their rights. As a result of this, obtaining a valid written consent from the patient has become an

important ingredient of our medical practice today. Therefore, it is important and also necessary that doctors should obtain a valid written consent from the patient before starting examination of a patient for diagnosis and surgery in order to protect themselves from future medical negligence litigations.

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