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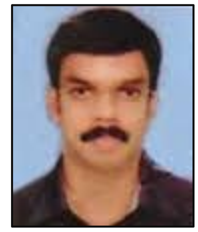
Guest Editorial

MEDICAL RESEARCH IN INDIA AT CROSS ROADS



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India has the best and the worst medical education in the world, according to a review of the world's largest database of peer-reviewed literature. Four medical colleges in India are among the top 10 global institutions that published quality research between 2004 and 2014, while around 60% of the country's 579 medical institutions have published no research in a decade. Only 25 (4.3%) institutions published more than 100 papers a year and among them accounted for 40.3% of India's total research output of a little over 100,000 papers in the decade. Unfortunately, over 57% or 332 of the medical colleges did not have a single publication during this period while over 90% of NBE-affiliated colleges in Karnataka and Kerala had none. Moreover, states that have the largest number of private medical colleges produce very little of research publication. India's total research output including original articles, reviews, case reports, and reports of conferences and symposia was 101,034 papers between 2005 and 2014, according to the Journal Current Medicine Research & Practice. All the institutions surveyed were either recognized by the Medical Council of India (MCI) or the National Board of Examinations (NBE), the two bodies that regulate medical education in our country. In comparison, the annual research output of the Massachusetts General Hospital was more than 4,600 and the Mayo Clinic was 3,700. The All India Institute of Medical Sciences with more than 1,100 annual publications ranked 3rd.

A handful of institutes, majority of them funded by Government account for the bulk of research output from medical institutions in India. At the other extreme, nearly 60% of institutes did not have a single publication over a decade. Overwhelming clinical burden leaving little time for academic activities is often cited as the reason for this state of affairs. This is belied by the fact that the most prolific Indian publications come from institutions that also deal with the largest numbers of patients. This is also true of many of the world's great hospitals, which along with providing a high standard of patient care are also leaders in publication Probably lack of guidance and absence of role models among seniors, who themselves have published little, were major factors as was inadequate institutional support in the form of funds and infrastructure. To bring medical education across states at par, India needs to incentivize quality research, which is an indicator of an institute's quality of education and clinical care. The few attempts to encourage relevant and applied research are not enough. The MCI's 2015 guidelines require at least 4 research publications for the post of an associate professor and 8 for the post of a professor.

Table 1: Ten Global Institutions that have Published Medical Research Between 2004 and 2015. (Four Medical Colleges in India are among them)

1.Massachusetts General Hospital, US	46,311
2. Mayo Clinic, Rochester, US	37,633
3. AIIMS, Delhi	11,377
4. Peking Union Medical college, Bejing, China	10,102
5. PGIMIR, Chandigarh	8,145
6. Tokyo Medical University, Jaapn	4,856
7. Christian Medical College, Vellore	3,742
8. Faculty of Medicine, University of Geneva, Switzerland	3,600
9. Sanjay Gandhi PGIMS, Lucknow	3,499
10.Aga Khan University Hospital, Karachi, Pakistan	2,332

Source: Current Medicine Research & Practice

China, which was at India's level 10 years ago, has emerged as the 5th leading nation in terms of its share of the world's scientific publications. It has done so by systematically investing a larger proportion of its GDP in R&D and by incentivizing medical universities, hospitals, and institutes through monetary awards to authors with manuscripts published in prestigious journals. The policy of increasing the number of doctors by liberally allowing the creation of new medical institutions, mainly through private funding and enhancing seats has not been an unqualified success with what is generally perceived as a fall in standards of medical education, "which has now become a business venture for many politicians and is accompanied by widespread corruption both in its entry and exit processes".

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LASERS IN ORAL AND MAXILLOFACIAL SURGERY

*Dr. Aswathi Vinod,**Dr. Manoj Kumar KP

Abstract

Lasers have been used in various treatment modalities across different specialities of Dentistry. The use of lasers within Oral and Maxillofacial Surgery along with potential benefits, drawbacks, and risks with certain procedures will be reviewed along with the discussion of some newer non traditional applications of laser therapy.

Key Words: Laser, applications, oral and maxillofacial surgery

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Introduction

Lasers are currently used to perform a variety of procedures and therapies within the practice of oral and maxilla facial surgery. The laser offers many benefits over traditional surgical procedures performed by traditional techniques of sharp dissection, and the use of the laser continues to expand in conjunction with the advancement of laser technology. The use of lasers within oral and maxillofacial surgery along with potential benefits, drawbacks, and risks with certain procedures will be reviewed along with the discussion of some newer non traditional applications of laser therapy.

Laser physics

A brief review of laser physics is essential to understand how lasers work in regard to specific applications of their use for surgical procedures. The physics of lasers is well known as energy is transferred to an electron and then emitted to produce laser energy based on Einstein's quantum theory of radiation hypothesis that atoms passing from a higher to a lower energy state will emit energy or photons, representing small units or quanta of electromagnetic waves.[1]

Electrons are usually in a low energy orbit closest to the atomic nucleus, and electrons can move to a higher energy level orbit by absorbing external energy. Conversely, when the electrons return to the original lower orbital level, the excess energy previously absorbed is released as spontaneous emission in the form of light or photons. The laser production of energy is accomplished by the transfer of energy to the electron of an atom. Normally the low energy electron is excited through a photon striking the atom and transferring energy to produce excitation of the electron to a higher energy state, causing the electron to enter another excitatory outer electron ring further away from the nucleus of the atom through the absorption of energy. The electron in the unstable higher energy state in an outer orbit returns to the lower energy orbital ring of a resting state and subsequently releases electromagnetic energy through spontaneous emission of radiation in the form of light. The stimulated emission of radiation occurs when external energy of an electrical, chemical, or optical source is used to initiate the atomic photon emission as atoms produce stimulated emission of radiation, which is used to generate laser energy.[2]

Maiman developed the acronym “laser” for light amplified by the stimulated emission of radiation.[3] Lasers are the devices that rely on the stimulated emission of radiation to produce a beam of light. Laser components include an energy source, a resonant chamber, and an active medium. The energy source is usually electrical and flows through the laser medium. The resonant chamber contains the laser medium and reflective mirrors, one of which is highly reflective and another that is only partially reflective, permitting some laser light to exit. The active medium is the atom, molecule, or ion producing the radiation. The type of medium commonly gives the laser its name. Common mediums include the Nd:YAG laser, which is a solid state laser composed of neodymium ions and crystals of yttrium-aluminum-garnet. The CO2 laser is a gas laser incorporating carbon dioxide, nitrogen, and helium. Dye lasers are liquid lasers with fluorescent organic dyes injected into a tube. The components and design of a laser permit the efficient production and emission of synchronized light. Initially, atoms within the laser chamber absorb energy from the energy source, in which atoms in the higher energy states spontaneously decay and give up energy. The released energy is absorbed by other atoms and used to enter a higher energy state as a so-called pumping phenomenon. Ultimately, a larger number of atoms exist in a higher energy state called population inversion. More and more atoms reach the higher energy state and spontaneously decay releasing more energy, which results in the emission of additional photons that travel within the laser chamber as amplification of stimulated emission of radiation. As pumping continues to maintain an ample population of inversion with the resonant chamber, a beam of coherent light is produced that is reflected and partially reflected by mirrors, resulting in the emergence of a beam of bright, monochromatic, coherent light, or a laser beam.[4]

Lasers produce energy in the form of light, which is transmitted to an object as the electron in the excited state is bombarded with irradiation by photons of light as the electron is returning to a more stable resting state. Two photons of emitted light energy are produced and transmitted. The light energy is amplified and emitted by radiation of the atom. Emitted laser light is of the same monochromatic wavelength in waves and remains collimated, or parallel, over long distances or coherent versus other light that spreads over distances.[4]

Lasers generate light in a similar manner through the excitation of atoms by photons of light in a resonator or a cavity through the use of a medium, and then the light strikes a fully reflective and a partially reflective mirror, which releases between 5% to 10% of the light. Different mediums will determine the wavelengths of light released. Gas, such as CO_2, is a common laser medium along with solid mediums, such as garnet or ruby crystals, which release energy as they are electrically charged to produce laser light energy.[2] Laser light can be characterized by wavelength. The ultraviolet range is 100 to 400 nm, visible range of 400 to 700 nm, near-infrared range of 700 to 1400 nm, mid-infrared range of 1400 to 20,000 nm, and the far-infrared range of greater than 20,000 nm. Laser light can also be defined by other unique properties. Laser light is monochromatic where all the photons in a laser beam are of the same wavelength, allowing the laser beam to attain a sufficient intensity to interact with tissues based upon wavelength and the absorption, scattering, and reflection properties of the target tissue. Laser light is also coherent with all photons in the beam synchronized in time and space, unlike the random photons of conventional light. The laser beam is collimated with the beams parallel with the ability of the beam to be focused on a small target area and also allowing all the emitted laser energy to be captured and delivered to a target site through a flexible fiber optical system or with the use of mirrors.[5]

A multitude of factors can control the interaction of lasers with tissues. Power density is the amount of power transmitted per area of a cross-section of the laser beam in watts/cm^2. It also represents the power of the laser striking the targeted tissue per unit area with the power density of a laser inversely proportional to the square diameter of the focal target. The spot size of the beam also determines the energy transmitted by the laser because the spot size reflects the ability of the laser to be focused, delivering more energy, or defocused as the distance of the lens to the tissue is increased by the operator. The vaporization threshold is the amount of energy in watts necessary to vaporize the target tissue.[5]

The wavelength of the laser beam determines factors, such as the degree of scattering, tissue penetration, and the amount of energy absorbed by the tissues. The greater the degree of scattering the less energy focused on the target tissue. Lasers with less scatter are better used as a scalpel because the energy is precisely delivered to a single spot of tissue, whereas a laser with more scatter is better for photocoagulation.[5] (Table 1).

Table 1: Temperature effect of Lasers on Tissues

Temperature °F	Tissue effect
37-60 °F	Tissue retraction and conformational protein changes
>60 °F	Protein denaturation and protein coagulation
90-100 °F	Tissue carbonization and tissue char
>100 °F	Tissue ablation

Fluence is a term that describes the amount of energy applied to a particular area of tissue. The overall delivery of energy can be determined by computer-generated patterns to maximize efficiency and minimize tissue damage.[2]Exposure time is the amount of time the laser energy is directed at the target tissue and can be varied by continuous, pulsated, or other varied modes of delivery. Continuous or non pulsated delivery provides a continuous wave of laser energy to the tissue over a time period determined by the operator.

The ability to pulsate the delivery of laser energy has the effect of modifying the delivery of higher laser energy for very short periods (e.g., 100 microseconds). The pulsation of laser energy prevents deeper tissue penetration of the laser and minimizes tissue heat build-up by allowing the thermal tissue relaxation time for heat dissipation, allowing the tissue to cool.[6] The ability to control the heat build-up of the adjacent tissue with the use of the laser provides the operator with the ability to control the interaction of the laser with the targeted tissue and, ultimately, vary the effects of the laser on the tissue. The delivery of the energy by the laser can be modified to produce optimal results depending on the desired tissue interaction.

The pulsation of a laser provides a non-continuous delivery of energy to the target tissue. Pulsation rates are measured in number of pulses per second and used to calculate a pulse width, representing the time necessary for the pulse to go from zero energy to maximum energy and return back to zero energy. Super pulsation is another method to minimize adjacent tissue damage by producing higher peak power per pulse at shorter pulse width to allow for the precise cutting or ablation of tissue with a laser.[7] Ultrapulsation of the laser can also be used by increasing the pulse speed, resulting in less adjacent tissue damage. It has been useful in applications, such as skin resurfacing. The use of flash scanning can also be used to produce less collateral tissue damage by limiting thermal damage. Flash scanning applies the use of a laser at continuous high energy in a circular pattern through the use of rotating mirrors, which limits the energy delivered to any specific area, allowing adequate tissue relaxation. It has been used with skin resurfacing procedures.[8]

Quality switching, or Q-switching, is another method to limit damage of adjacent tissue with the use of a laser. Q-switching provides the ability of the laser to produce high-energy pulses of nanoseconds duration

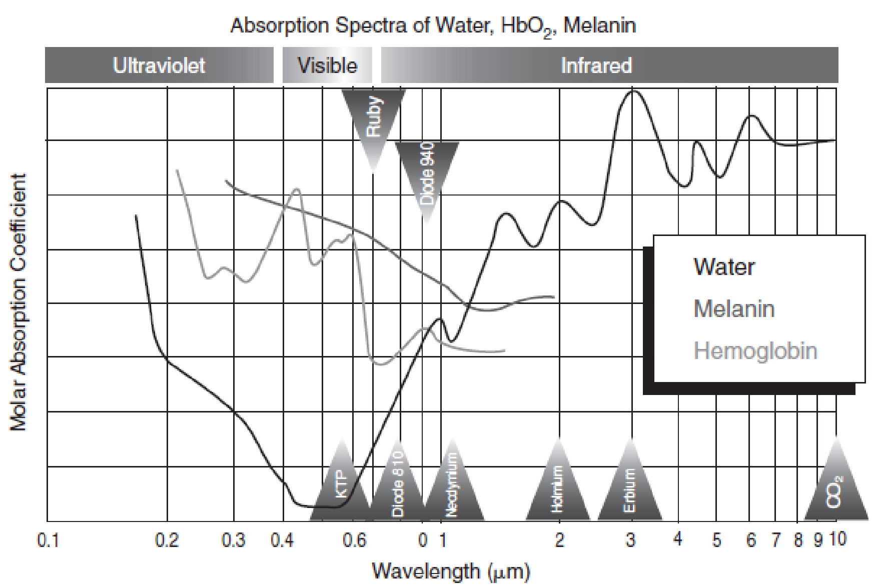

Fig 2: Laser absorption chart

through the use of an electromagnetic switch operating a shutter mechanism.[9]Applications of the Q-switched laser have included treatment of certain pigmented skin lesions and removal of tattoos. Ultimately, the laser can be used for selective tissue destruction while limiting the damage or undesirable effects to the adjacent tissue because the tissue relaxation time can be calculated for different tissues, such as skin, blood vessels, and muscle.

Lasers and tissue interactions

The effects of lasers on tissues can result in the energy of the laser being reflected, transmitted, or absorbed. Energy absorbed within the tissue can be dissipated or converted to other forms of energy, such as heat, shock waves, or chemical reactions. The conversion of laser energy into heat by the tissue is common with medical lasers interacting with molecular compounds, such as water, melanin, or hemoglobin, within the tissue called chromophores[10] (Fig 2).

Photochemical reactions can occur after lasers interact with a photosensitizer, causing tissue necrosis. Photothermal reactions result as the laser causes denaturing of enzymes, coagulation, tissue necrosis, and vaporization. Photoablation reactions of lasers can cause tissue disruption by thermal explosion or mechanical shock waves, causing tissue disruption.[5]Currently, there are multiple lasers for biomedical use, such as the CO2, Nd : YAG, erbium : YAG, argon ion, and diode lasers (Fig 3).

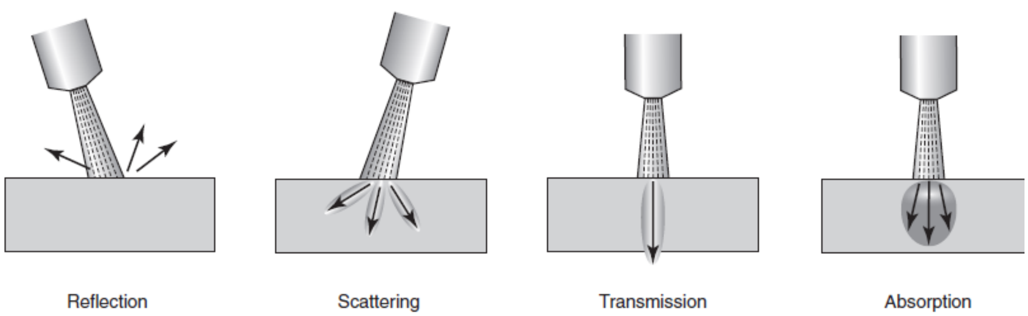

Fig 3: Tissue interactions of Laser

The CO2 laser was developed in 1964 by Patel at Bell Laboratories.[11] CO2 lasers use a gas medium composed primarily of CO2, which produces a laser beam with wavelengths in the mid-infrared region of 10,600 nm. The CO2 laser is commonly used in oral and maxillofacial surgery and otolaryngology. The benefits of the CO2 laser include minimal scatter, excellent water absorption, rapid soft tissue vaporization, and negligible surrounding tissue damage. The CO2 laser functions as an excellent scalpel and can focus precisely onto the target tissue, thus avoiding adjacent tissue damage for hemostatic cutting as vessels below 0.5 mm are coagulated.[5] The CO2 laser previously had to be delivered down an articulated arm by a series of mirrors, but is now delivered through a flexible fiber, making the delivery more versatile.

The Nd: YAG laser was also developed in 1960 at Bell Laboratories by Geusic et al.[12] The Nd: YAG laser is a solid state laser and was the first laser developed. The Nd : YAG laser produces a laser beam with wavelengths between 1064 and 1320 nm, and the beam itself is invisible requiring the use of a helium-neon guide beam.

The Nd: YAG laser is minimally absorbed, but can deeply penetrate tissue up to depths of 10 mm for deep tissue vasoconstriction of even vessels up to 2 to 3 mm in diameter.[13] There is also a greater amount of adjacent tissue damage than the CO_2 laser. Common maxillofacial applications include coagulation of angiomas, vascular tumor resections, and arthroscopic surgery of the temporomandi-bularjoint (TMJ).

The erbium : YAG laser produces a wavelength of 2940 nm and is another laser that has excellent energy absorption by water, making it an ideal laser for intraoral use and for superficial skin resurfacing as a result of the limited depth of penetration through skin with less adjacent tissue damage, resulting in decreased erythema, edema, and pain.[14]

The Erbium: YAG laser can also cut hard tissue, including both bone and enamel, which makes it an obvious choice for oral and maxillofacial surgical procedures where a combination surgery is performed on both hard and soft tissue, such as crown elongation, tooth exposure, and implant uncovering procedures. The erbium : YAG laser is used for operative dentistry and the cutting of tooth structure.[14]

The Argon ion laser is a low wavelength laser of 488 to 514 nm that produces a blue-green color beam. The argon ion laser is primarily used for photocoagulation of small vessels in dermatology and ophthalmology.[5] The Nd : YAGKTP laser is another available laser with a wavelength of 0.32 μm through the use of a frequency-doubling potassium titanyl phosphate (KTP) crystal in the green spectrum of light similar to the argon laser. The KTP crystal halves or “doubles” the wavelength.[13] Diode lasers are another development that rely on the use of non-solid state semiconductor technology. Diode lasers can attain higher power around 0.81 μm with a power of 20 W, which has applications similar to the Nd : YAG laser. Benefits of the diode laser include a reduced size, reduced cost, and greater versatility through the use of frequency-doubling crystals to allow a variety of output wavelengths for applications ranging from tissue excision, coagulation, periodontal surgery, or use at lower wavelengths for the treatment of pain or to modulate healing.[15]

Applications of lasers in oral surgery

Removal of oral mucosa lesions: A clinical study described the application of the potassium-titanyl-phosphate (KTP) laser (532 nm), used with low power parameter (1 Watt – CW) to evaluate the intra and postoperative pain. They proposed that KTP laser with low parameters permits to perform oral surgery with good pain control and good wound healing (Fornaini).

Oral leukoplakia: Oral leukoplakia is a pre-malignant lesion of the oral mucosa.[1] The curative effects of photodynamic therapy (PDT) and cryotherapy in the treatment of oral leukoplakia were compared. They found that the advantages of PDT are connected to the minimally invasive and localized characters of the treatment with no damage to collagenous tissue structures; therefore normal cells will repopulate these arrangements. PDT is more convenient for patients, less painful, and more esthetic. A prospective study evaluated clinical healing of a leukoplakia lesion after laser surgery, which was associated with a normal functional status of the new epithelium, also pathological alterations were related to the risk of local recurrence. They concluded that clinical healing of leukoplakia treated by laser surgery may be accompanied by altered cell turnover in 20% of the cases. Ki 67, as a marker of proliferative status, may be a prognostic indicator in the mucosa replacing the lesion.[2]

Lichen planus: Oral lichen planus (OLP) is a common chronic disease of uncertain aetiology. Treatment of patients with symptomatic OLP represents a therapeutic challenge. One study evaluated the efficacy of diode laser (940 nm) in the management of oral lichen planus. Their results demonstrated that diode laser therapy seemed to be an effective alternative treatment for relieving the symptoms of OLP.[3] Low-level laser and CO_2 laser were compared in the treatment of patients with oral lichen planus. They showed that low-level laser displayed better results than CO_2 laser therapy as an alternative or additional therapy.[4]

*Gingival melanin pigmentation:*A clinical and histologic study compared surgical stripping; erbium-doped:yttrium, aluminum, and garnet laser; and carbon dioxide laser techniques for gingival depigmentation. They concluded that clinical repigmentation after gingival depigmentation is an outcome of histologic changes in the melanocyte activity and density of the melanin pigments. Surgical stripping for gingival depigmentation remains the gold standard; however, Er:YAG laser and CO2 lasers can be effectively used but with distinct differences.[5]

Simsek et.al compared the use of diode and Er:YAG lasers in treating gingival melanin pigmentation (GMP) in terms of gingival depigmentation, local anesthesia requirements, postoperative pain/discomfort, depigmentation effectiveness, and total treatment duration. Their results demonstrated the total length of treatment was significantly shorter with the diode laser than with the Er:YAG laser. No melanin recurrence was detected during any follow-up session. They concluded Diode and Er:YAG lasers administered at 1 W both result in satisfactory depigmentation of GMP.[5]

*Fordyce granule excision:*A surgical lip Fordyce granule excision using a high-power diode laser in a 19-year-old male was reported. The excellent esthetic result demonstrated the effectiveness of both high-and low-intensity laser therapies on the excision of Fordyce granules .[6]

Oral dysplasia: A prospective study evaluated recurrence, residual disease malignant transformation, and overall outcome in patients undergoing such procedure. They demonstrated that recurrence and malignant transformation was mainly identified in erythroplakias and non-homogenous leukoplakias. Laser resection/ablation was recommended for oral dysplasia to prevent not only recurrence and malignant transformation but also postoperative oral dysfunction encountered by other conventional modalities.[7]

*Precancerous lesions:*A prospective study evaluated the recurrence rates resulting from different methods of CO_2 laser vaporization. Their results indicated that for CO_2 laser treatment of premalignant lesions of the oral mucosa, the best results could be achieved with the defocused technique.

It may be assumed that other methods with lesser penetration of thermal effects did not reach the deeper-lying cells and, consequently, render higher rates of recurrence.[8]

*Oral melanoma:*A retrospective study surveyed the convenience of laser surgery as optimal treatment for melanoma of the oral mucosa. In their experiment, conservative management with CO2 laser was adequate for melanomas of the oral mucosa with extraction of the dental organs and curettage of the alveoli to achieve complete surgical resection microscopically without sacrifice of the quality of life.

Management of the neck was controversial. They recommend selective therapeutic resection of the neck only if it was found to be clinically positive. Elective dissection had not shown to have an impact in overall survival.[9]

Oral benign lesions

Mucocele: Mucoceles are benign lesions of the minor salivary glands that are common in children. The most frequent localizations of these lesions include the lower lip and the cheek mucosa.Boj et.al described the case of a 4-mm extravasation mucocele located on the lower lip with an erbium laser. They showed the wound healed excellently and rapidly without sutures. No relapse was observed a year after the surgery. Lasers apply modern technology and are useful for soft tissue surgery in pediatric dentistry, as operations are rapid and wounds heal well without sutures.Oral mucocele resection with the scalpel versus the CO2 laser was compared. Their results showed that oral mucocele ablation with the CO2 laser offered more predictable results and fewer complications and recurrences than conventional resection with the scalpel.[10]

Ranula: Ranulas are mucus extravasation phenomenon formed after trauma to the sublingual gland or mucus retention from the obstruction of the sublingual ducts.Lai et.al presented a case series report on the use of carbon dioxide laser treatment for ranula and a literature review of cases treated using carbon dioxide laser. The authors' experience and reports in the literature indicated that carbon dioxide laser excision of ranula was safe with minimal or no recurrence.[11]

Pyogenic granuloma: Pyogenic granuloma (PG) may develop in the oral cavity of pregnant women. Lindenmüller et al. described CO2 laser-assisted treatment of a giant pyogenic granuloma of the gingiva. Their results showed the initial wound healing was uneventful. A 12-months follow-up revealed no recurrence of the mass and healthy periodontal tissues. [12]

Gingival hyperplastic lesions removal: Asnaashari et.al applied 810nm Diode laser to remove all of gingival hyperplastic lesions. Their results demonstrated that a perfect shaping was obtained after removal of the whole lesion in one session and no recurrence was observed in 6 months.[13]

Epulis fissuratum: Epulis fissuratum is a pseudo tumor growth located over the soft tissues of the vestibular sulcus caused by chronic irritation from poorly adapted dentures. Treatment indication for these lesions is surgical excision with appropriate prosthetic reconstruction. One study proposed treatment of epulis fissuratum with carbon dioxide laser in a patient with antithrombotic medication. The lesions were excised with CO_2 laser, and no significant complications, such as hemorrhage, pain, swelling or infection, were recorded. They proposed that use of CO_2 lasers is currently the gold standard in the excision of this type of lesion, especially in patients with hemorrhagic diathesis or under antithrombotic therapy.[14]

Treatment of epulis fissuratum with CO_2 laser and prosthetic rehabilitation of three patients with vesiculobullous diseases (VBDs) was presened with Işeri et al. The excision of fibrous tissue was performed with CO_2 laser, and the wounds formed by laser were left open to secondary epithelization. They demonstrated that the CO_2 laser might be a useful instrument in the treatment of soft tissue pathologies in VBDs patients due to minimal damage to surrounding tissue. Use of complete or partial dentures had been considered a practical, economic, and nonsurgical treatment option for patients who have been diagnosed with VBDs.[14]

Lymphangioma: Lymphangiomas are hemorrhagic, rare, benign hamartomatous tumors of lymphatic system which have a marked predilection for the head, neck and oral cavity. Lymphangiomas are congenital lesions and an often present at or around the time of birth (60%).

In A case report, treatment of lymphangioma (a red-purple vesicular appearance, nonulcerated lesion, located on the gingiva of the mandibular alveolar bone) with CO_2 laser was described. CO_2 laser application (focused CO_2 laser beam, 10,600 nm) was performed in a separate operation room at 3 watt (W), continuous wave (CW) with 90 degree angle tip under local anesthesia. They concluded that CO_2 laser therapy can be used as a primary alternative method in the treatment of lymphangiomas. It can be safely used and recurrence may be less than conventional excision with scalpel. However, long-term clinical follow-up is necessary for the recurrence of the lesion. [15]

Hemangioma: Genovese et al. reviewed the use of surgical lasers in hemangioma treatment. They described that the use of GaAs high-potency diode laser in the treatment of hemangioma reduced bleeding during surgery, with a consequent reduction in operating time, and promoted rapid postoperative hemostasis. It was safe for use on large lesions and easy to manage, and postoperative problems, including potential scarring, and discomfort are minimal.[16]

*Cancer of Oral cavity:*A retrospective study assessed the efficacy of Nd:YAG laser for stage I squamous cell carcinoma of the lip. Their results reported the use of Nd:YAG laser for treatment of Stage I squamous cell carcinoma of lip in accordance with principles of minimal invasive and morbid surgery.

A retrospective study analyzed two hundred thirty-two patients with cancer of the oral cavity were treated by oral laser microsurgery ± selective neck dissection ± postoperative (chemo) radiotherapy. They concluded that oral laser microsurgery is an efficient therapeutic option in the treatment of oral cavity cancer. Oncological and functional results are comparable to any other treatment regimen, whereas morbidity and complications tend to be lower. [17]

A retrospective analysis evaluated 296 cases of early glottic squamous cancer with and without the involvement of anterior commissure (AC) treated by trans-oral CO_2 laser microsurgery. Trans-oral laser surgery is an excellent treatment option in patients with early glottic cancer irrespective of whether or not the AC is involved. Trans-oral laser microsurgery for early glottic cancer involving AC requires adequate exposure, proper assessment, good experience, and advanced surgical skills.

*Excisional biopsy:*A prospective randomized controlled clinical trial evaluated and compared clinical and histopathologic findings of excisional biopsies performed with CO_2 laser (10.6 μm) modes in 60 patients with similar fibrous hyperplasias of the buccal plane. No significant difference was found in the widths of thermal damage zones between the CW and CF groups. The visual analogue scale (VAS) values and analgesic intake were low in the 2 groups. The 2 CO_2 laser modes were appropriate for the excision of intraoral mucosal lesions. A safety border of at least 1 mm was recommended regardless of the laser mode used .[18]

Treatment of Oral Cavity Venous Malformations: Mucosal involvement of venous malformations can cause bleeding, pain, and functional impairment. Treatment options include surgery, sclerotherapy, or laser therapy. A retrospective study surveyed 4 patients (5 subsites) with oral cavity venous malformations treated with the Nd:YAG laser using an underwater technique. Their study demonstrated that the Nd:YAG laser can be a feasible option in the treatment of venous malformations of the oral cavity. [19,20]

Frenectomy: Labial frenulums are sagittal fibrous folds of oral mucosa with a periosteal insertion that extend from the lips to the alveolar or gingival mucosa. Occasionally, they assume inadequate size or location and may lead to functional and esthetic limitations. A comparative study evaluated labial frenectomy with Nd:YAG laser and conventional surgery. Their results showed that Nd:YAG laser frenectomies reduced transoperative bleeding, avoiding the need of suturing, and promoted a significant reduction of surgical time in comparison with conventional surgery.[21]

Ankyloglossia: One study compared the tolerance of lingual frenectomy with regard to a local anesthesia requirement and comparison of postsurgical discomfort experienced by patients operated on with both diode and erbium:yttrium-aluminium-garnet (Er:YAG) lasers. Their results indicated that the Er:YAG laser is more advantageous than the diode laser in minor soft-tissue surgery because it can be performed without local anesthesia and with only topical anesthesia.[21]

Conclusion

Currently, there are multiple lasers for biomedical use, such as the CO2, Nd : YAG, erbium : YAG, argon ion, and diode lasers. The CO2 laser is commonly used in oral and maxillofacial surgery and otolaryngology. The CO2 laser functions as an excellent scalpel and can focus precisely onto the target tissue, thus avoiding adjacent tissue damage for hemostatic cutting as vessels below 0.5 mm are coagulated. The Erbium : YAG laser can also cut hard tissue, including both bone and enamel, which makes it an obvious choice for oral and maxillofacial surgical procedures where a combination surgery is performed on both hard and soft tissue, such as crown elongation, tooth exposure, and implant uncovering procedures.Adiode laser an also be beneficial, but all depends on the type of procedures to be done.

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OZONE THERAPY: TOWARDS A GREEN DENTISTRY

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Abstract

Ozone has been successfully used in medical field since many years owing to its' oxidising property making it an excellent antimicrobial agent. Moreover it's potent anti-inflammatory property along with favourable cellular and humoral immune response has made ozone an effective therapeutic agent. Also its ability to arrest and reverse carious lesions in predictable way opened up a new chapter in minimal intervention dentistry. Furthermore its efficacy in curbing resistant polymicrobial root canal flora appears very promising.

Key Words: ozone, applications, dentistry

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Introduction

Ozone is one of the most powerful antimicrobial agents available for use in medicine and dentistry. Ozone therapy is a well-established alternative and complementary therapy in most of the European countries. The ozone therapy has been more beneficial than present conventional therapeutic modalities that follow a minimally invasive and conservative application to dental treatment.

History

1839	Christian Friedrich Schonbein, first noticed the emergence of a pungent gas with an electric smell. The word Ozone (O_3) is derived from the Greek word ozein (odorant).
1857	JoachimHensler , A German physicist and Hans Wolf German physician developed first Ozone generator for medical use.
1881	Used as a therapeutic agent in treatment of diphtheria
1883	Dr. Charles Kenworthy published his experiences with ozone in Florida Medical journal
1885	Dusbaden, in Holland used Ozone in its water treatment plant .
World war I and II	Ozone was used to treat wounded soldiers in trenches.
Early 20thcentury	Ozone use got legalised in USA
1950	Dr E.A.Fiseh a German dentist used Ozone o regular basis in Dental Practice
2001	Dr.Sieg fried wrote a text on the use of Ozone in Medicine
2004	Prof. Edward lyrich published "OZONE – The Revolution in Dentistry"[1]

Chemistry of Ozone and Ozone Generation

Ozone (O_3) is a triatomic molecule, consisting of three oxygen atoms. Its molecular weight is 4798 g/mol and thermodynamically highly unstable compound that, dependent on system conditions like temperature and pressure, decompose to pure oxygen with a short half-life. Ozone is 1.6-fold denser and 10-fold more soluble in water (49.0 mL in 100 mL water at 0° C) than oxygen. Although ozone is not a radical molecule, it is the third most potent oxidant (E_ 5 12.076 V) after fluorine and per sulfate.

Ozone is an unstable gas that cannot be stored and should be used at once because it has a half-life of 40 min at 20 °C. Ozone (O_3) is naturally produced by the photo dissociation of molecular oxygen (O_2) into activated oxygen atoms, which then react with further oxygen molecules. This transient radical anion rapidly becomes protonated, generating hydrogen trioxide (HO_3), which, in turn, decomposes to an even more powerful oxidant, the hydroxyl radical (OH).

Fig 1: Ozone molecule

It is the fundamental form of oxygen that occurs naturally as a result of ultraviolet energy or lightning, causing a temporary recombination of oxygen atoms into groups of three. In the clinical setting, an oxygen/ozone generator simulates lightning via an electrical discharge field.[1,2]

Modes of ozone generation in dentistry

The most common methods of ozone production used for therapeutic purposes are given below.

1. Ultra-Violet System: Useful for purifying air but generates less concentration of ozone.
2. Cold Plasma System: Useful for purifying water and air.
3. Corona Discharge System: Most popular systems in medical field and dentistry. It has controlled production rate and easily generates high ozone concentration.

Modes of ozone administration

Ozone is administered on patients for therapeutic purposes in various forms like ozone gas, as an aqueous solution, oil or as ozonated water.

1. Ozone Gas

An Ozone generator produces ozone by passing air through high voltage in a polyurethane console. Some of the commercially available Ozone Units for medical use are:

1. HealOzone TEC 3 (Curozone, USA).

2. Prozone (W&H)

3. O3 ozicure ozone device

Fig 2:HealOzone

The generated Ozone is applied to patient through hand piece which gets adapted to teeth through a silicon cup and is exposed for a minimum period of 10 seconds. The used ozone is passed through a reducing agent to convert back to oxygen and then led back to the generator.

2. Ozone aqueous Solution

Useful for disinfection and sterilization. Displays hemostatic effect in cases of hemorrhage. Found to accelerate wound healing as it improves oxygen supply and supports metabolic processes.

3. Ozone Oil

Useful for external application. Ozone is passed through plant extracts to form a thick gel containing ozonides.

4. Ozonated water

Studies have shown that ozonated water increased metabolic activity of L29 mouse fibroblast cells and improved lipopolysaccharide induced inflammatory response. It also had strong bactericidal activity against plaque biofilm.[1,2]

Mechanisms of action

There are several potential action of ozone, which are applied in the clinical practice of dentistry, such as antimicrobial, bactericidal, viricidal and fungicidal), anti inflammatory, immunostimulating, antihypoxic and detoxicating biosynthetic, activation of the metabolism of carbohydrates, protiens, liplids. [2]

Pharmacodynamics

Ozone, a powerful biocide takes only 10sec to kill 99% of bacteria, fungi & viruses. 25 micro grams of Ozone per ml of Oxygen is the amount of ozone used in treatments and this translates into 0.25 parts of Ozone to 99.75 parts of Oxygen. The potency of one molecule of Ozone equalizes to 3000 to 10,000 molecules of chlorine and thus is 3500 times more pathogenic to microbes with no side effects of chlorine.[3]

Contraindications

Pregnancy, glucose 6 phosphate dehydrogenase deficiency, hyperthyroidism, severe anemia, ozone allergy, recent MI, haemorrhage from any organ, acute alcohol intoxications.[2]

Biological actions

Effect on Bacteria, Virus, Fungus, Protozoa

Ozone damages the bacterial cell membranes by ozonolysis and oxidates intra cellular proteins leading to loss of organelle function. This action is selective to microbial cells and thus does not affect human body cell as the later have good antioxidative ability. Ozone is very effective in antibiotic resistant strains with accelerated efficiency in acidic pH environment.[3]

Viruses

Ozone makes the infected cell intolerant to peroxides and changes the activity of reverse transcriptase thus hampering viral protein synthesis.[3]

Fungal & Protozoa

Ozone inhibits cell growth at certain stages.

Cellular and Humoral Immune system

It reactivates the immune system through macrophage activation and Cytokine release which inturn boost immune system which makes it useful in patients with low immune status and immunodeficiency.[3]

Anti-inflammatory

Ozone Stimulates release of interleukins, leukotrienes and prostaglandins thus reducing inflammation and promoting wound healing.[3]

Effect on Micro-circulation

Ozone causes secretion of nitrous oxide which is a vasodilator and hence dilates arterioles and venules. It prevents clumping of red blood corpuscles' and increases their contact area for oxygen transportation. It also activates aerobic processes like glycolysis and krebs cycle at cellular level thus stimulating circulation of blood and hence used in treatment of circulatory disorders.[4]

Applications in Dentistry

Conservative Dentistry and Endodontics

Ozone shows encouraging results in treating early dental carious lesions thus promising a painless dentistry in future. Ozone can be used along with diagnodent to assess the caries risk in the earliest stages and thus delivered according to the severity of the lesion.

However in established carious lesions, ozone therapy has to be done along with restorative therapy and patient has to be educated about the maintenance phase of caries treatment involving oral hygiene maintenance and balanced diet. Also immediately after ozone treatment it is advisable to apply a remineralising agent.[5]

Proximal Caries Lesions and root caries

Similar protocol of pit and fissure caries has to be followed and it is important to emphasize on a noninvasive protocol for non cavitated lesions which are confined to enamel. However cavitated lesions need to be restored2. Increasing exposure time of ozone from 10sec to 20sec, changed its antimicrobial effect from disinfection to sterilization. Application of ozone for 40 seconds significantly reduced S.mutans count, whereas 60sec exposure almost eliminated cariogenic species like S.mutans, L.casei and A.naeslundii in carious lesions in roots. Proximal caries lesions are generally diagnosed with Bite-Wing X-Rays unlike occlusal one. However if proximal lesion of the caries is not visible on bitewing x-ray, but gives a diagnodent reading up to 25, a minimal intervention protocol needs to be followed with 40 second ozone exposure and air abrasion or sealing the lesion. However if there is a carious lesions which can be detected on the x-ray, then ozone exposure has to be increased to 60-120 seconds and has to be followed by a restoration.[5]

Hypersensitive Teeth

Enamel and Dentine loss occurring due to multiple factors like attrition, abrasion, erosion, trauma from occlusion may cause hyper sensitivity and diagnosis of etiology is vital. After elimination of cause 40 to 60 sec application of ozone is found to instantly reduce pain in these sensitive teeth. Ozone removes the smear layer, opens the dentinal tubules and broadens their diameter. Thus when a remineralizing agent is applied, calcium & fluoride ions flow into dentinal tubules and plug them preventing fluid exchange thus terminating sensitivity.[6,7]

Effect of ozone on enamel and Dentine

Ozone does not alter the physical properties of enamel and also has no effect on its sealing ability. Thus ozone can safely be applied over intact and prepared enamel during restoration. Application of gaseous form of ozone does not affect the modulus of elasticity and vickers hardness of dentin. Thus application of ozone does not alter the micromechanical properties of substrate, nor the sealing ability of bonding system.[8]

Cracked Tooth Syndrome

After exploration of the crack, assess the prognosis and tooth is exposed to ozone for 60 – 120 sec and seal the tooth with an intermediate restoration like GIC. The tooth needs to be periodically assessed and restored.[8]

Bleaching

After root canal treatment, crown discolouration is a major aesthetic problem. Ozone has been successfully used for lightening the yellowish tinge on rat incisors. The bleaching effect with ozone is seen when the bleaching agent is placed in the access cavity & crown is exposed to ozone for a minimum of 3 to 4 minutes with marginal success.

In endodontic treatment instead of using irrigation chemicals, ozonated water can be used for irrigation. A Japanese study published in 2004 demonstrated the antimicrobial activity of ozone in root canal treatment without any tissue toxicity.[9]

Necrotic root canals & Peri-apical Lesions

Polymicrobial infections complicate cases of apical periodontitis. A study evaluated the effect of intra canal medicament comparing ozone oil, calcium hydroxide with para mono chloro phenol and glycerine (HPG) with periapical lesions. The radiological, histopathological and bacteriological studies showed no significance among groups. However Ozone showed effectiveness over most of bacteria found in cases of pulp necrosis but not when bacteria are organized in biofilm. Ozone demonstrated anti-microbial action against bacterial strains such as mycobacteria, staphylococcous, Pseudomonas, entero-coccus, e-coli, peptostreptococcus, E-fecalis & Candida albicans in invitro research models. In infected necrotic canals, ozonized oils can be used as an intra-canal dressing. Also when a root canal was disinfected by ozone water with somification, the anti-microbial efficacy was comparable to 2.5%Naocl. Hence in periapical infections, ozone therapy can increase the scope of non-surgical management of these lesions.[10,11]

Vital Root Canal Therapy

After effective biomechanical preparation, irrigation with Ozonated water significantly reduced the bacterial population in the root canal. Also intra canal gas circulation of ozone at a flow rate of 0.5-1 l/min with net volume of 5 gm/ml for 2-3 min showed encouraging results against pathogenic microbes in the root canal.[12,13]

Prosthodontics

Disinfection of dentures is necessary to prevent denture stomatitis. The exposure of dentures to ozonated water and ultrasonication had antimicrobial activity against candida albicans.[14,15,16]

Oral medicine

Soft tissue lesions like herpes, aphthae, removable denture ulcers, cuts cheilitis, candidiasis, cysts and traumatic wounds can be treated with either ozonated water or oils .Disinfectant and healing properties helps in healing of these lesions.[3.17]

Periodontics

The effect of ozonated water on oral microorganisms and dental plaque were studied. Dental plaque samples are treated with 4 ml of ozone water for 10 sec and was observed that gram positive and negative oral microorganisms and candida albicans in pure culture as well as bacteria in plaque biofilm are killed, hence, it was used to control oral microorganisms in dental plaque.[18,19]

Oral surgery

Ozone was found to accelerate wound healing. It increases the benefits of surgical and pharmacological treatments causing the lesions to heal completely.[20]

Implants

In study, gaseous ozone showed selective efficacy to reduce adherent bacteria on titanium and zirconia without affecting adhesion and proliferation of osteoblastic cells.[20]

Ozone toxicity

Therapeutic administration of ozone did not cause any deleterious effects. But the inconsistent use of ozone was reported to cause certain side effects like rhinitis, occasional nausea, vomiting, blood vessel swelling, poor circulation, heart problems, respiratory tract irritation, at times stroke. Ozone gas should not be inhaled as the bronchial pulmonary system is very sensitive to ozone. Ozone should not be administrated I.V as there would be a risk of air embolism. Other side effects include epiphora, upper respiratory irritation, rhinitis, cough, nausea, vomiting, shortness of breath, blood vessels swelling, heart problem and at times stroke. However in the event of ozone intoxication patient must be placed in supine position and treated with vitamin- E and N-acetyl cysteine.[1,2]

Conclusion

In contrast with traditional medicine modalities such as antibiotics and disinfectants, ozone therapy is quite economical; it will markedly reduce both medical cost and invalidity. Dentistry is varying with induction of modern science to practice dentistry. The ozone therapy has been more beneficial than present conventional therapeutic modalities that follow a minimally invasive and conservative application to dental treatment.

The exposition of molecular mechanisms of ozone further benefits practical function in dentistry. Treating patients with ozone therapy lessens the treatment time with an immense deal of variation and it eradicates the bacterial count more specifically. The treatment is painless and increases the patients' tolerability and fulfillment with minimal adverse effects. Contraindications of this controversial method should not be forgotten. Further research is needed to regulate indications and treatment procedures.

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HAPTICS IN PERIODONTICS

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Abstract

The simulation of clinical situations with the acquisition of fine motor skills is an essential component of the dental students' learning experience. The traditional approach to dental skills training has drawbacks in terms of cost, availability, lack of real‑world cases, with the restraints of time, clinical supervision, and the funding of raw materials such as real and plastic teeth. The introduction of dental haptics opens the door to a more realistic clinical experience which can be free from the previous constraints. The performance of the students should be reviewed invaluably by pinpointing exactly where mistakes may have been made and directed learning should be allowed. Also, haptics offers the possibility of unlimited training hours by which students can gain skills without demands on manpower and resources.

Key Words: Haptics, periodontics, simulation, virtual reality

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Introduction

Haptics is defined as the science of applying touch (tactile) sensation and control to interaction with computer applications. The word "haptics" is derived from the Greek "haptikos," meaning able to grasp or perceive. Technology is constantly evolving with time and so is its application in medical and dental fields. Simulation has long been used in the medical field, which has increased patient safety and has reduced the risk associated with human errors.

Application of haptics in other fields includes Laproscopic and Endoscopic Surgeries, Neurosurgery Simulation, Surgical Simulation System for Cleft Lip Planning and Repair, Haptic Surgical Correction of Dento-Facial Deformities, Haptic Suturing Simulator.

The field of dental simulation is at the verge of emergence. Webster's dictionary defines simulator as a training device that duplicates artificially the condition likely to be encountered in some operations.[1] Simulation can aid, improve, and advance the way dentistry is taught for future generations. This technology has significant potential to complement traditional training approaches, especially in the fields in which hands‑on training is not applicable or ethical as in dentistry.[2]

Due to the astonishing growth of computer hardware and software, virtual worlds that support the field of advanced simulation have been developed. Virtual reality creates virtual worlds using mathematical models and computer programs which allow the users to move into a created virtual world in a way very much similar to the real life. This technology is often referred to as "third dimension" or the "next generation" learning environment in medicine.[3] Virtual reality systems represent a powerful tool for training humans to perform tasks which are otherwise expensive or dangerous to duplicate in the real world. Dental students obtain their surgical skills training traditionally for decades by practicing on plastic teeth or sometimes live patients under supervision of dental experts. However, it is being challenged by the new complications in surgery such as the increasing cost of training materials, the ethical concerns for safety of patients, and the unavailability of many real‑ world challenging cases.

Hence a system which uses virtual reality and haptics technology will be a breakthrough in learning the diagnosis and treatment of periodontal diseases by visualizing a three‑ dimensional virtual human mouth and feeling real tactile sensations and allowing surgeons to touch and feel the objects such as surgical tools and human organs in the virtual environment, and to perform operations like pushing, pulling, and cutting of soft or hard tissue with realistic force feedback. It also allows objective assessment of surgical competency by providing parameters such as time taken to finish a procedure, efficiency of movements, or percentage of error.

History

Wang *et al*.[4] in 2003 worked on a simulator that allows probing and cutting a virtual tooth, but the virtual tool implementation was limited to a spherical shape for simplicity.

Kim *et al*[5] in 2005 developed a dental training system with a multi‑ modal workbench providing visual, audio, and haptic feedback. This system is a volume‑based haptic modeling which represents a tooth as a volumetric implicit surface. It allows burring and drilling on the tooth with a spherical tool.

Yau *et al*.[6] in 2006 proposed a dental training system utilizing material stiffness and spring force function. This simulation uses adaptive octree data structure for a tooth model and oriented bounding box for the boundary of the cutting tool. Different shapes of a cutting tool are introduced but details on how the forces are rendered for irregular‑shaped cutting tools is missing as well as how to handle the torque that might occur in the case of nonspherical tool.

Luciano.[7] in 2006 developed PerioSim, which allows trainee to practice diagnosing periodontal diseases that does not require deformation of tooth surface.

Background and Principles

Dental simulators not only provide an efficient way to quickly teach dental procedures to preclinical dental students but also increase their hand skills considerably. On dental simulators, proper hand and instrument usage and placement can be learned repetitively. The simulator allows students to develop the skills needed to differentiate pathological and normal conditions, as well as to diagnose and treat periodontal diseases.

Two types of dental simulators currently available are as follows:

1. Manikin‑based simulators: Consist of a physical model of the patient's head and mouth on which dental procedures can be performed using real dental instruments; and
2. Haptics‑based simulators: [Fig 1] Consist of a haptic device and virtual models of a human tooth or mouth which acts as a platform to facilitate dental practicing.

Fig 1: Simulator setup and comparison between handling the real instrument and the haptic stylus

Instead of using real dental instruments, the trainee holds the haptic device stylus to manipulate a set of virtual instruments that are shown on a monitor screen. The tactile feedback reproduces clinical sensations in the hand of the operator using dental instruments. Unlike manikin‑based, haptics‑based simulators are much more fast and cost effective as no physical models need to be replaced. In addition, as the haptic device measures the forces applied by the trainee when touching the virtual patient's mouth, it is possible to detect when the student's action is potentially aggressive.

Some of the most well‑known haptics‑based dental simulators previously developed are virtual reality dental training system, Iowa dental surgical simulator, three‑dimensional dental, haptically enabled dental simulator, and volume‑based dental simulator. All these are used for restorative purposes such as caries preparation or filling of cavities, none of them focuses on the simulation of periodontal procedures. The field of periodontics is that field of dentistry which requires dentists to depend primarily on their tactile sensations, for both diagnostic and surgical procedures. This makes haptics ideally suited for periodontal simulators.

Currently, periodontal procedures are taught by time‑consuming teaching process of instructor demonstration, use of practice manikins and finally, by actual work in the patient's mouth which requires excessive one‑on‑one instructor/student interaction. Haptics‑based dental simulators could be beneficial for the training of dental and hygiene students as they aid in diminishing the instruction time period, enhance the learning curve, and provide for unlimited practice of these treatments.[8] Haptics allows the user to feel, manipulate, and interact with the object displayed on the personal computer monitor. The user can touch, move, and feel an existing distant object indirectly through a robotic arm.

Furthermore, haptics provide force feedback to humans interacting with virtual or remote environments since the robotic arm is able to provide pre programmed guidance. Traditionally trained students neither feel what the instructor feels nor can they be physically guided by the instructor performing a procedure. At the same time, high visual acuity is required from the student. Students can learn by feeling tactile sensations as they "touch" a computer‑generated 3D model of a human upper and lower dental arches along with various oral components: Teeth (crown and roots) and gingival with a haptic device.

Haptic hardware includes the following

- High‑end computer workstation with appropriate software
- Haptic interface device (stylus)
- A stereoscopic computer monitor with stereo glasses
- Semitransparent mirrors
- Head‑ mounted display
- Monitor and speakers
- Gloves to feel the sensations.

The rendered image of a virtual object is reflected onto a semitransparent mirror so as to be aligned with the user's hand and haptic device. [2]

Applications

Differentiating between pathological and normal conditions, diagnosing and treat periodontal diseases requires skill which can be achieved by employing one of the two visuo-haptic systems: PerioSim and a periodontal simulator.[9] Periosim and periodontal simulator were developed by university of Illinois at Chicago. The application simulates three dental instruments: A periodontal probe, a scaler, and an explorer, which can be used for training students in various aspects of Periodontology. [Fig 2]

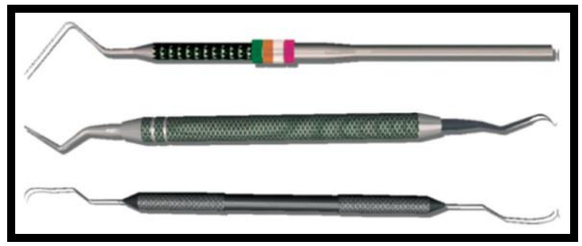

Fig 2: Virtual periodontal probe, explorer, or scaler

Diagnosis: Diagnosing the periodontal disease mainly depends on probing and measuring the clinical attachment loss. Probing depth measurement vary from examiner to examiner because of variation in angulation, pressure, force etc., and thus virtual periodontal probe could be used to teach the correct probing technique, which will help in determining the health and severity of disease of periodontal tissue and thus the correct diagnosis.

Treatment: Main etiological factors of periodontal disease are plaque and calculus, and thus the treatment of periodontal disease revolves around complete elimination of these etiological factors.

Supragingival calculus which is easily seen can be removed effectively using scalers, but the problem arises in completely removing the sub-gingival calculus, which mainly depends on tactile sensation, which can be achieved using a haptic technology while learning.

A virtual periodontal scaler with two models of gingiva, transparent and opaque, could be used for this purpose. With the opaque model where the tooth surface is covered by gingiva, the haptic device will provide the tactile sensation to evaluate virtual calculus present on the root surface, and with the transparent gingiva, calculus can be concomitantly seen under the gum line. Further virtual explorer can be used to evaluate that the calculus has been completely removed, which could be performed with both a transparent and an opaque gingiva.

Advantages

- Improved usability: Haptics improve usability by engaging touch, sight, and sound.
- Enhanced realism: Haptics injects a sense of realism into user experiences by exciting the senses and allowing the user to feel the action of the application. The inclusion of tactile feedback provides additional context that translates into a sense of realism for the user.
- Restoration of mechanical feel: By providing users with intuitive and unmistakable tactile confirmation, haptics can create a more confident user experience and can also improve safety by overcoming distractions especially during sub‑gingival calculus detection, determining bone defects without flap reflection and performing periodontal surgery.
- Cost effective: Haptics provide a new and low‑cost approach whereby dentists can practice procedures as many times as they want at no incremental cost and training can take place anywhere.
- Self‑evaluation: It has the ability to give instant, consistent, and unbiased feedback based on evaluation of the procedure in the form of felt sensations in the hand.
- Correct ergonomic positioning: Incorrect operator or patient positioning can result in blocking the camera from reading the light‑emitting diode sensors and prevents the user from continuing by warning signals which encourages the students to support and reinforce good ergonomic habits.
- Standardized evaluation: Consistency and uniformity for preclinical evaluation.
- Faster acquisition of skills: Students develop skills more efficiently in a shorter period of time as compared with the traditional simulator units (phantom heads),which can result in smoother transition for students into the clinic.
- Haptics technology along with a visual display can be used to train people for tasks requiring hand– eye coordination, such as surgery. Haptics offers an additional dimension to a virtual reality or 3D environment.

Disadvantages

- The tactile perception for gingiva is not very real.
- The feel of working on dental chair is lacking as it uses desktop system.
- Single-hand held haptic arm does not provide the feel of using mouth mirror and working instrument together.
- The initial cost of this advanced technology simulation can be substantial.
- Difficult equipment to maintain and repair:
- Technology-based systems require faculty/engineering staff to be available for training and supervision of the laboratory.

Conclusion

Advanced simulation technology simulators offer an exciting opportunity to dramatically improve student learning. Haptic technology is a powerful educational methodology which improves the level of perception, sense of touch and feel and reduces the distance between the virtual and the real world. Haptics offer an excellent complementary means of training and could be a replacement for the existing ones.

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BIOMIMETICS IN CONSERVATIVE DENTISTRY AND ENDODONTICS

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Abstract

Biomimetics is the study of the form, structure or function of biologically produced substances and materials, and biological mechanisms and processes, especially for the purpose of synthesising similar products by artificial mechanisms to mimic natural ones. Biomimetic Dentistry is based on the philosophy that the intact tooth in its ideal hues and shades and, more importantly, its intra coronal anatomy, mechanics and location in the arch, is the guide to reconstruction. Biomaterials used in the medical field lack the ability to integrate with biological systems through a cellular pathway. Conversely, biomimetic materials transcend the regular biomaterial in utility and will suitably perform the functions of the biological molecule that needs to be replaced. This review will attempt to provide a better understanding of the relative position of the Biomimetic materials in the context of the past and present dental materials.

Key Words: biomimetics, dental materials, biologic systems, conservative dentistry, endodontics

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Introduction

The advancement in science and technology has a positive impact on the present day world. It has contributed immensely to every aspect of our lives, including medical and dental care.

Biomimetics is defined as the study of the formation, structure, or function of biologically produced substances and materials and biological mechanisms and processes especially for the purpose of synthesizing similar products by artificial mechanisms which mimic natural ones. A material fabricated by Biomimetic technique based on natural process found in biological systems is called a Biomimetic material.[1] The goal of Biomimetics in restorative dentistry is to return all of the prepared dental tissues to full function by the creation of a hard tissue bond that allows functional stresses to pass through the tooth, making the entire crown into the final functional biologic and esthetic unit. Using the intact tooth as the guide to reconstruction that determines the success.[2] Biomimetics is known by several names such as Bionics, Biognosis etc. The concept is very old but the implementation is gathering momentum only recently.[3]

In dentistry there is no one biomaterial that has the same, mechanical, physical and optical properties as dental hard tissue. By using biomimetic therapeutic approaches, dental professionals aim to improve and come closer to natural biological structures and their function. There are two major perspectives to which the term "biomimetic" is applied: a purist perspective that focuses on recreating biological tissues and a descriptive perspective that focuses on using materials that result in a mimicked biological effect. Although different, both share a common goal of mimicking biology in restoration. A biomimetic material should match the part of the tooth that it is replacing in several ways, including the modulus of elasticity and function of the respective areas (e.g., pulp, dentin, enamel, dentoenamel junction).

History

The name biomimeitcs was coined by Ottoschmit in the 1950s while studying the nerves in a squid. He tried to copy and design an artificial device that could replicate the same process of synaptic impulse.

The term bionics was coined by Jack E.Steele in 1960 at Dayton. It literally means to mimic life. It is the study of natural structural processes to try to mimic or replicate it artificially in an attempt to restore the same aesthetics or function.[3]

The foundation of this broad new field has ancient roots. Replacing body parts goes back at least 2,500 years when bridges were made by artificial teeth carved from the bones of oxen. Evidence of crude dental implants dates back to Roman population of the first or second century AD and to Pre-Columbian cultures of central and South America.

Application of Biomimetics in Dentistry

Biomimetics in Restorative Dentistry: The goal of biomimetics in restorative dentistry is to return all of the prepared dental tissues to full function by the creation of a hard-tissue bond that allows functional stresses to pass through the tooth, drawing the entire crown into the final functional biologic and esthetic results.[2]

Glass-Ionomer cement is often known as a Biomimetic material, because of its similar mechanical properties to dentin. This, together with the important benefits of adhesion and release of fluoride, render it an ideal material in many restorative situations.[4]

Biodentin is a new material that may replace GIC as a liner in deep fillings, but further research is needed. GIC is currently the main material advocated in minimum invasive dentistry which is under the umbrella of Biomimetic Restorative Dentistry.[5]

Fig 1: Biomimetic Restoration

Biomimetic mineralization: A recently introduced technique of guided formation of an enamel-like fluorapatite layer on a mineral substrate has the potential to enable remineralization of superficial enamel defects and/or exposed dentin. The technique, BIMIN, utilizes the diffusion of calcium ions from solution into a glycerine enriched gelatin gel that contains phosphate and fluoride ions. When the conditioned gel is in direct contact with the exposed tooth surface, within 8 hours, a firmly adhering mineral layer is formed on the tooth surface . Applying BIMIN in a clinical study demonstrated a deposition of fluorapatite mineral on dental enamel.[6]

Dentin is a mineralized tissue consisting of apatite (the mineral phase), collagen and other proteins, and water . Remineralization of dentin can occur either by simple precipitation of calcium phosphates into the demineralized dentin matrix between collagen fibrils , or by the chemical bonding of mineral to the dentin matrix structure, with BIMIN.

Biomimetic remineralization of dentin has been investigated with different methods using ion-containing solutions or ion leaching silicon-containing materials. Gandolfi et al. recently reported the use of bioactive "smart" composites containing reactive calcium-silicate. Ning et al. in 2011, experimented on a novel method for biomimetic mineralization of hydroxyl-apatite. They used Agarose gel containing Na_2HPO_4 that covered an acid-etched dentin sample. Comparable to a sandwich-technique, the gel was then covered by a layer of Agarose without phosphate ions, masked by a $CaCl_2$ solution.

The system was immersed in a water bath at 37 0C, replenished on multiple occasions, and resulted in densely packed hydroxyapatite crystals that covered the dentin surface and occluded the dentinal tubules after 10 days of biomimetic mineralization.[7]

Biomimetic Principles in Ceramics: It is used in dental applications and are being examined for bone tissue engineering application. Two common ceramics used in Dentistry are alumina and hydroxyapatite. Alumina has excellent corrosion resistance, high strength, high wear resistance. Hydroxyapatite is a calcium phosphate based ceramic and it is a major component of inorganic compartment of bone.[8]

Biomimetic self-assembling peptides: P11-4 is a rationally-designed self-assembling peptide. Self-assembling peptides undergo well-characterized hierarchical self-assembly into three-dimensional fibrillar scaffolds in response to specific environmental triggers, offering a new generation of well-defined biopolymers with a range of potential applications.

P11-4 switches from a low viscosity isotropic liquid to an elastomeric pneumatic gel at pH <7.4 and in the presence of cations, conditions assumed to be found within a caries lesion. In a number of in vivo and in vitro experiments, the assembled P11-4 fibers were shown to be highly biocompatible with low immunogenicity. Following P11- 4 self-assembly, the anionic groups of the P11-4 side chains would attract Ca++ ions, inducing de novo precipitation of hydroxyapatite.

The earliest clinical sign of enamel caries is the appearance of a 'white spot' lesion on the tooth surface. At this stage, clinicians generally elect to monitor lesion appearance, possibly after the use of topical fluorides, to determine whether the lesion will progress or not, in which case a restoration would then be placed. Infiltration of early carious lesions using low viscosity monomeric P11-4 would result in triggered self-assembly within the lesion, generating a subsurface bioactive scaffold capable of recapitulating normal histogenesis by inducing mineral deposition in situ.

Biomimetics in Endodontics

Current biomimetic approaches for regeneration of tooth and its associated structures.

a. Root canal revascularization

Treatment of the young permanent tooth with a necrotic root canal system and an incompletely developed root is often difficult. Not only is the root canal system often difficult to fully debride, but the thin dentinal walls increase the risk of a subsequent fracture. Other than the procedure like maturogenesis or apexo-genesis, root canal revascularization is a procedure to establish the vitality in a non vital tooth to allow repair and regeneration of tissues. The typical revascularization protocol advocates that the immature tooth, diagnosed with apical periodontitis, should be accessed and irrigated with either 5% NaOCl or 3% H_2O_2.[9] An antimicrobial agent (either an antibiotic such as metronidazole, ciprofloxacin or minocycline or Ca (OH) should be then applied into the root canal system, and the access cavity is sealed. After an average of 3 weeks, in the absence of symptoms, the tooth is re-entered, the tissue is irritated until bleeding is started and a blood clot produced, and then MTA is placed over the blood clot, and the access is sealed. Within the next 2 years a gradual increase in root development can be observed.[10]

b. Stem cell therapy

The simplest method to administer cells of appropriate regenerative potential is to inject the postnatal stem cells into the disinfected root canal system. Autologous dental stem cells are the most accessible stem cells for this therapy. Among the eight different post natal dental stem cells, Dental pulp stem cells (DPSCs), Stem cells from human exfoliated deciduous teeth (SHED), and Stem cells from the apical papilla (SCAP) were more commonly used in the field of regenerative endodontics.[10]

DPSCs are the stem cells isolated from human dental pulp. The most striking feature of DPSCs is their ability to regenerate a dentin-pulp-like complex that is composed of mineralized matrix with tubules lined with odontoblasts, and fibrous tissue containing blood vessels in an arrangement similar to the dentin-pulp complex found in normal human teeth.[11]

Stem cells from human exfoliated deciduous teeth (SHED) have become an attractive alternative for dental tissue engineering. The use of SHED might bring advantages for tissue engineering over the use of stem cells from adult human teeth as follows:

(a) SHED were reported to have higher proliferation rate compared with stem cells from permanent teeth, which might facilitate the expansion of these cells in vitro before replantation. (b) SHED cells are retrieved from a tissue that is "disposable" and readily accessible in young patients. ie, exfoliated deciduous teeth. It also has an added advantage of abundant cell supply, and painless stem cell collection with minimal invasion.

A recent finding is the presence of a new population of a mesenchymal stem cells residing in the apical papilla of incompletely developed teeth. They are termed stem cells from the apical papilla (SCAP). It is hypothesised that SCAP appear to be the source of primary odontoblast that are responsible for the formation of root dentine, whereas DPSCs are likely the source of replacement odontoblast. Since these stem cells are in the apical papilla, they are benefited by its collateral circulation, which enables it to survive during the process of pulp necrosis.[12]

There are several advantages to an approach using postnatal stem cells. First, autogenous stem cells are relatively easy to harvest and to deliver by syringe, and the cells have the potential to induce new pulp regeneration.

Second, this approach is already used in regenerative medical applications, including bone marrow replacement, and a recent review has described several potential endodontic applications.

However, there are several disadvantages to a delivery method of injecting cells. First, the cells may have low survival rates. Second, the cells might migrate to different locations within the body, possibly leading to aberrant patterns of mineralization.

c. Pulp implantation

In pulp implantation, replacement pulp tissue is produced by tissue engineering triad (stem cell, scaffold and morphogens). and is transplanted into cleaned and shaped root canal systems.

One of the potential problems associated with the implantation of cultured pulp tissue is that specialized procedures may be required to ensure that the cells properly adhere to root canal walls. When implanting pulp into the root canals that have blood supply only from the apical end, enhanced vascularization is needed in order to support its vitality. As a result, micro scale technologies that provide open channels or the ability to guide vascular ingress from the apex through the pulp may be of particular benefit. Recent efforts in developing scaffold systems for tissue engineering have been focusing on creating a system that promotes angiogenesis for the formation of a vascular network. These scaffolds are impregnated with growth factors such as VEGF (vascular endothelial growth factor) and/or platelet derived growth factor or further, with the addition of endothelial cells.[13]

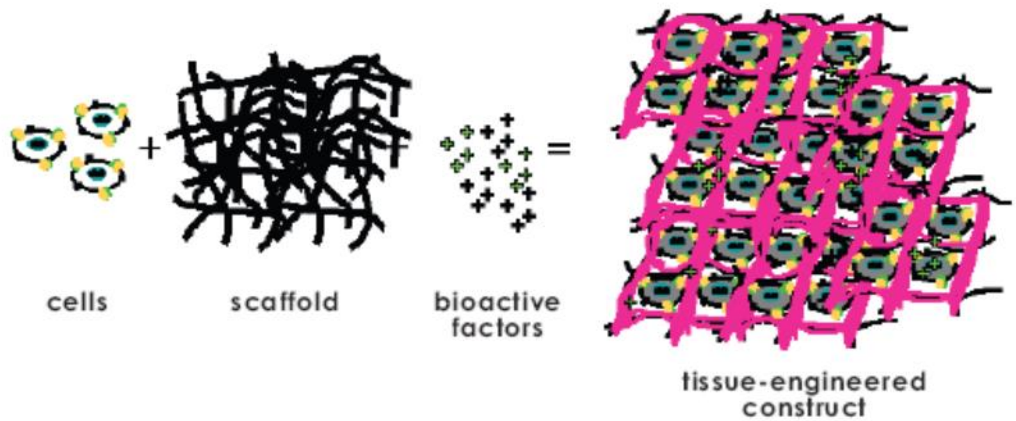

Fig 2:Biomimetic stem cell therapy

d. Injectable scaffold delivery

Rigid tissue engineered scaffold structures provide excellent support for cells used in bone and other body areas where the engineered tissue is required to provide physical support. However, in root canal systems a tissue engineered pulp is not required to provide structural support of the tooth. This will allow tissue engineered pulp tissue to be administered in a soft three-dimensional scaffold matrix. Among the injectable biomaterials investigated so far, hydrogels are more and more attractive in the field of tissue engineering. Hydrogels are injectable scaffolds that can be delivered by syringe and have the potential to be noninvasive and easy to deliver into root canal systems. In theory, the hydrogel may promote pulp regeneration by providing a substrate for cell proliferation and differentiation into an organized tissue structure. [14]

Despite these advances, hydrogels at are at an early stage of research, and this type of delivery system, although promising, has yet to be proven to be functional in vivo. To make hydrogels more practical, research is focusing on making them photopoly-merizable to form rigid structures once they are implanted into the tissue site.

e. Three-dimensional cell printing

One of the most promising approaches in tissue engineering is the application of 3D scaffolds, which provide cell support and guidance in the initial tissue formation stage. The porosity of the scaffold and internal pore organization influence cell migration and play a major role in its biodegradation dynamics, nutrient diffusion and mechanical stability. The three-dimensional cell printing technique can be used to precisely position cells, and this method has the potential to create tissue constructs that mimic the natural tooth pulp tissue structure. This may involve positioning of odontoblasts around the periphery, with fibroblasts in the core. The major challenge involved is the precise orientation of cellular suspensions according to the apical and coronal asymmetry of pulp. The disadvantage of using the three dimensional cell printing technique is that careful orientation of the pulp tissue construct according to its apical and coronal asymmetry would be required during placement into cleaned and shaped root canal systems.[15]

f. Gene Therapy

Gene therapy is a method of delivering genes with the help of viral or non-viral vectors. The gene delivery in endodontics would be to deliver mineralizing genes into pulp tissue to promote tissue mineralization. Viral vectors are genetically altered to eliminate ability of causing disease, without losing infectious capacity to the cell. At present adenoviral, retroviral, adeno associated virus, herpes simplex virus, lentivirus are being developed. Nonviral delivery systems uses plasmids, peptides, cationic liposomes, DNA-ligand complex, gene guns, electroporation, and sonoporation to address safety concerns such as immunogenicity and mutagenesis. Widespread clinical application still awaits the development of vectors that are safe, affordable, efficient, simple for application, and that have ability to express the required level of transgene for the sufficient long term.[16]The main challenges for gene therapy in the next decade will be the requirements to demonstrate that gene therapy can provide cost-effective and safe long-term treatments for conditions that would otherwise lead to significant pulp necrosis. This indicates the potential of adding growth factors before pulp capping, or incorporating them into Technology - to stimulate dentin and pulp regeneration.[17]

g. Bioengineered tooth

The ultimate goal of regenerative therapy is to develop fully functioning bioengineered organs that can replace lost or damaged organs following disease, injury, or aging.

Tissue engineering builds a tissue such as skin, bone and cartilage, by seeding cells into a scaffold. Research on the fabrication of teeth from dissociated cells was first performed using tooth germ cells. When explanted, seeded with porcine third impacted tooth bud cells, were implanted for 20-30 weeks into omentum, bioengineered teeth were visible within the explants. However, the regenerated teeth were not identical to their naturally formed counterparts. Tooth regeneration is an important stepping stone in the establishment of engineered organ transplantation, which is one of the ultimate goals of regenerative therapies.

Conclusion

Replacement of diseased or lost tooth structure with biocompatible restorative materials is currently the technique of today but each of these procedures has its own limitations and drawbacks. Regeneration of the lost tooth structure rather than replacement will ensure better prognosis and high success rate. Hence the future dentistry would involve the use of Biomimetic materials which could successfully replace lost enamel, dentin, cementum and even the pulp tissue.

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SMEAR LAYER IN ENDODONTICS:A REVIEW

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Abstract

When the root canals are instrumented during endodontic therapy, a layer of material composed of dentine, remnants of pulp tissue and odontoblastic processes, and sometimes bacteria, is always formed on the canal walls. This layer has been called the Smear layer. It can prevent the penetration of intracanal medicaments into dentinal tubules and influence the adaptation of filling materials to canal walls.Data obtained suggests that smear layer removal should enhance canal disinfection. Current methods of smear removal include chemical, ultrasonic and laser techniques – none of which are totally effective throughout the length of all canals or are universally accepted. If smear is to be removed, the method of choice seems to be the alternate use of ethylenediaminetetraacetic acid and sodium hypochlorite solutions. Conflict remains regarding the removal of the smear layer before filling root canals, with investigations required to determine the role of the smear layer in the outcomes of root canal treatment.

Key Words: dentine, ethylene diaminetetraacetic acid, endodontic treatment, smear layer

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Introduction

The term 'smear layer' is used most often to describe the grinding debris left on dentin by cavity preparation. However, the term applies to any debris produced iatrogenically by the cutting, not only of dentin, but also of enamel, cementum, and even the dentin of the root canal.

Endodontic smear layer has been reported as being a layer of material which covers the prepared canal walls.[1] It is always produced when dentine surface is cut or drilled. Identification of the smear layer was made possible using the electron microprobe with scanning electron microscope (SEM) attachment, and first reported by Eick et al. (1970). These workers showed that the smear layer was made of particles ranging in size from less than 0.5–15 μm.[2] Scanning electron microscope studies of cavity preparations by Bra¨nnstro¨m & Johnson (1974) demonstrated a thin layer of grinding debris. They estimated it to be 2–5 lm thick, extending a few micrometres into the dentinal tubules.[3]

Cameron16 (1983) and Madder et al(1984) described the formation of two kinds of smear layer: the first one consisted of a superficial layer loosely attached to the dentinal walls(fig.1)and the second one of a smear material packed in the dentinal tubule openings. The depth to which this material was packed into tubules varied. In some places, it appeared densely packed up to 40 µm into the tubules. According to the hypothesis proposed by Cengiz et al. (1990), penetration of smear material into dentinal tubules might be caused by capillary action as a result of adhesives forces between tubules and smear material. Typically the texture of the smear material in the tubules is granular or particulate.[1]

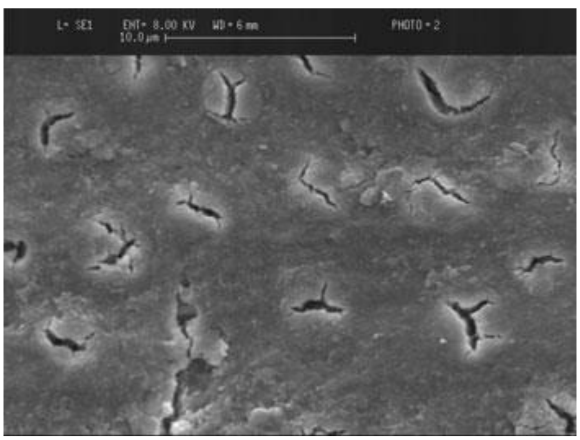

Fig 1: Scanning electron micrograph of smeared surface of dentine. The crack shapes are processing artefacts overlying dentinal tubules.

The main argument of the greater number of scientists recommending removal of the smear layer is the fact that this layer obturates dentinal tubules in root canal and effects of canal medication are blocked, as well as the efficacy of disinfecting during endodontic treatment. In addition, smear layer is containing significant amount of organic material (including bacteria and their products), which can act as a reservoir to irritation factors in canals' system and influence further disorders in periapical structures of the tooth. When smear layer is removed from root canal walls prior to canal obturation, adhesion of the sealing material to the walls is increased and adaptation improved, thus preventing microleakage and communication path between oral cavity and periapical structures.

Not many authors claim that existence of the smear layer on root canal walls may present a barrier against bacterial penetration into dentinal tubules [2,4] and vice versa, a barrier against microorganisms that already have penetrated dentine before endodontic instrumentation, to flow back into inadequately obturated canal and express their pathogenicity. Even though success of endodontic treatment is based on adequate diagnosis, successfully completed instrumentation and canal obturation, it is generally accepted in endodontics that a thorough debridement is the most important aspect of endodontic treatment.[5]

Composition and structure of smear layer

The smear layer has an amorphous, irregular and granular appearance when viewed under the SEM.[4] (Bra¨nnstro¨m et al. 1980, Yamada et al. 1983, Pashley et al. 1988) (Fig. 3). The appearance is thought to be formed by translocating and burnishing the superficial components of the dentine walls during treatment (Baumgartner & Mader 1987).When root canal is prepared, manually or mechanically, a specific structure is formed on dentine surface, which is covering dentine texture and is often closing openings of the tubules. This layer that is consequenting from instrumentation contains organic and inorganic particles of cut dentine, necrotic or vital pulp fragments, odontoblasts endings, microorganisms and blood cells.

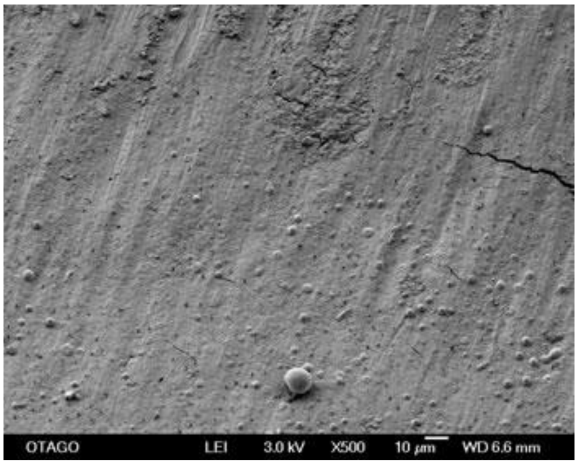

Fig 2: Scanning electron micrograph of dentine surface with typical amorphous smear layer with granular appearance and moderate debris present (Courtesy: Dr Artika Soma).

It is commonly built from two separate sub- layers: (a) superficial, which is thin and adhering to dentine walls delicately and (b) underlying, which is firmly attached to dentine capping openings of the tubules.

From the chemical point, smear layer has two components, organic and inorganic. Organic part of the smear layer contains dentine collagen fibres and glycosamine-glycans, originating from extracellular matrix. This part presents the base for the other, dominant inorganic. It, sometimes, contains bacteria (canals contaminated with non-sterile instruments and more by inadequate temporary filling). The smear layer on the wall of root canal could have a relatively high organic content in early stages of instrumentation because of necrotic and/or viable pulp tissue in the root canal.

Variations in thickness and composition of the smear layer on root canal walls are caused by the anatomy of root canals, dentine tissue properties (patient's age, necrotic or vital dentine), preparation techniques applied (manual, mechanical), quantity and type of irrigating agents, i.e. irrigation techniques (standard needle, blunt perforated needle). Most researchers agree that extensive instrumentation of root canal subsequently is leading to formation of smear layer, which means that thickness of the layer depends on instrumentation.

Common depth of superficial sublayer is 1-2 µm, while the depth of the sublayer impressed into dentinal tubules may be up to 40 µm.

Different bacterial species (anaerobes) can be detected in smear layer existing on root canal walls. Considering the complexity of root canals morphology and surfaces unreachable for endodontic instruments, significant number of microorganisms is left on hidden sites of root canal wall. That means that bacteria can be detected in all surfaces of canals system, and more exactly in dentine tubules of infected canals.

Dentine tubules in radicular part are linear, directed from the pulp toward peripheral parts (opposite to S-shaped tubules in crown's dentine), which is enabling microorganisms to penetrate deep into the tubules, almost the half-distance between canal wall and cement-dentine junction. Factors, like type of the tooth, age, number and bacterial types, and root canals exposure, significantly influence the depth of bacterial leakage into dentinal tubules. SEM analysis of human teeth with necrotic pulp, undertaken by Sen and co-workers, has shown that depth of bacterial penetration into dentinal tubules was up to 150 µm in apical two-thirds of the root. Perez et al. has found that mean value of penetration was 479 µm to 737 µm max.

Methods to remove the smear layer

Chemical removal

A number of chemicals have been investigated as irrigants to remove the smear layer. According to Kaufman & Greenberg (1986), a working solution is the one which is used to clean the canal, and an irrigation solution the one which is essential to remove the debris and smear layer created by the instrumentation process.[6]

Sodium hypochlorite

The conclusion reached by many authors is that the use of NaOCl during or after instrumentation produces superficially clean canal walls with the smear layer present [6,7] (Baker et al. 1975, Goldman et al. 1981, Berg et al. 1986, Baumgartner & Mader 1987).

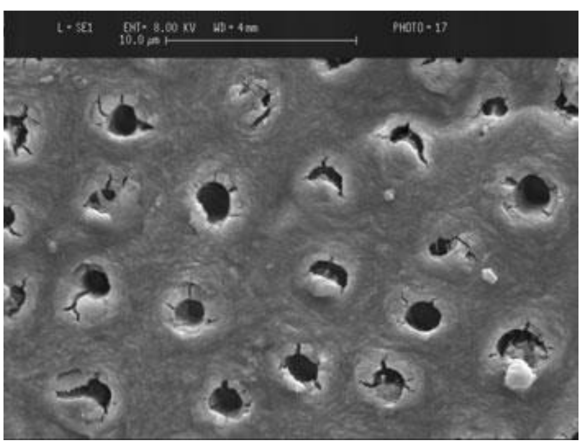

Fig 3: Scanning electron micrograph of dentine following 60 s exposure to 18% ethylene diaminetetraacetic acid solution (Ultradent Products Inc., South Jordan, UT, USA).

Chelating agents

The most common chelating solutions are based on EDTA which reacts with the calcium ions in dentine and forms soluble calcium chelates[6] (Fig.3).

Many studies have shown that paste-type chelating agents, whilst having a lubricating effect, do not remove the smear layer effectively when compared to liquid EDTA. A recent experiment examining the addition of two surfactants to liquid EDTA did not result in better smear layer removal (Lui et al. 2007). A quaternary ammonium bromide (cetrimide) has been added to EDTA solutions to reduce surface tension and increase penetrability of the solution (von der Fehr & Nygaard-O¨ stby 1963). McComb & Smith (1975) reported that when this combination (REDTA) was used during instrumentation, there was no smear layer remaining except in the apical part of the canal.[6]

It was also shown that the use of EDTA with any surface active agents removed the smear layer without opening many dentinal tubules or removing peritubular dentine. Another root canal chelating irrigant is Salvizol which is based on aminoquiinaldinum diacetate. It has surface-acting properties similar to material of the quaternary ammonium group and posseses the combined actions of chelation and organic debridement. Kaufman et al. applied oxine derivatives (bis- dequalinium-acetate, BDA). BDA effect was confirmed in removal of the smear layer even in the apical part for its low surface potential and penetration ability to reach hidden regions in canals' system.

Organic acids: Citric acid appeared to be an effective root canal irrigant and was more effective than NaOCl alone in removing the smear layer. This acid removed smear layer better than many acids such as polyacrylic acid, lactic acid, and phosphoric acid except EDTA. Best results were obtained when sequential use of 10% citric acid and 2.5% NaOCl solution, then again followed by 10% solution of citric acid. However this combination was not as effective as the combination of EDTA and NaOCl [6]. The disadvantage of citric acid is that it left precipitated crystals in the root canal which might be disadvantageous on root canal obturation. The polyacrylic acid did not remove the smear layer completely because of its high viscosity.

Sodium hypochlorite and EDTA: The purpose of irrigation is twofold: to remove gross debris originating from the pulp tissue, and possible bacteria; the organic component, and to remove smear layer; the mostly inorganic component. Because there is no single solution which has the ability to dissolve organic tissues and to demineralize the smear layer, a sequential use of organic and inorganic solvents have been recommended.[8,9]

The ability of the tetracycline family of antibiotics to remove smear layers has also been studied. They have been used to demineralize dentin surfaces, uncover and widen the orifices of dentinal tubules, and expose the dentin collagen matrix. These effects provide a matrix that stimulates fibroblast attachment and growth. Barkhordar et al showed that doxycycline HCl (100 mg/ mL) is effective in removing the smear layer from the surfaces of instrumented canals and root-end cavity preparations. They speculated that a reservoir of active antibacterial agents might be created because doxycycline readily attaches to dentin and can be subsequently released.

Ultrasonic removal of the smear layer

Preparation of root canal with ultrasonic device is providing good canal cleaning because mechanical and chemical effects in removing smear layer are joined by this technique. Ultrasonic vibrations and maximal effect of irrigating agent, which is directed toward instrument's tip, are providing significant removal of the smear layer.

Cameron produced a debris-free canal with the use of a 3% NaOCl solution combined with ultrasonic instrumentation for 3-5 minutes after conventional canal instrumentation. The mechanism of action for debris removal was described as acoustic streaming. Acoustic streaming is maximized when the tips of the smaller instruments operate at high power and vibrate freely in a solution. It is recommended that only size 15 files be used to maximize the microstreaming for removal of debris.

Laser technique in removal of the smear layer

During the last decade, laser technique has won important place in endodontic therapy. Among other, it can be used for smear layer removal and elimination of tissue fragments in the apical part of root canal. The main problem in removal of the smear layer by laser is a complicated approach to narrow space with considerably large tips when laser beam is directed. With the use of neodymium-yttrium-aluminum-garnet laser some authors have re- ported a range of findings from no change or disruption of the smear layer to actual melting and recrystallization of the dentin.. This pattern of dentin disruption was observed in other studies with various lasers, including the carbon dioxide laser, the argon fluoride excimer laser, and the argon laser. However when Erbium-yttrium- aluminium-garnet (Er: YAG) laser was used it showed an optimal removal of smear layer but without consequent dentine.

Conclusion

Manual and mechanical shaping produces smear layer and debris that contains organic and inorganic components. This layer might interfere with the adaptation of filling materials on root canal walls and has been related to microleakage.

Clinical implications of the smear layer are still not fully understood, conflicting results have been obtained from studies regarding significance of smear layer presence and its deleterious effects. As several new sealer and core materials have recently been introduced, further investigations are required to determine the role of the smear layer in the outcome of treatment.

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AWARDS & ACHIEVEMENTS

CDE PROGRAMME: DEPARTMENT OF PERIODONTICS

Department of Periodontics, KMCT Dental College in association with IDA Malabar Branch organized a one day CDE programme on LASER Dentistry.

The event "Opening your door to Laser Dentistry" was conducted on 27th August 2017. Dr. Harish Kumar V V (*Organizing Chairman*) welcomed the gathering. Dr. Santhosh V C (*Organizing Secretary*) delivered the welcome address. Dr. Ayisha Nazreen (*Director, KMCT Dental College*) inaugurated the CDE programme. Dr. Manoj Kumar K P wished the programme all success. Dr. Haris P S (*IDA Malabar Branch-CDE Chairman*) congratulated the team. Dr. Sreekanth Puthalath (*Organizing Committee Member*) introduced the faculty, Dr. M S Saravanakumar. The CDE was attended by around 200 delegates. There was lecture class followed by live demonstration of more than 5 laser assisted procedures. Dr. Sameera G Nath (*Organizing Committee Member*) co-ordinated the symposium. Dr. Shabeer Mohammed Madani (*Organizing Committee Member*) delivered the vote of Thanks.

KUHS RANK HOLDERS - MDS PART II

Kerala University of Health Sciences MDS Part II Ranks were secured by Dr. Fazeela Beegum (2^{nd} Rank, Periodontics), Dr Renjith KP (3^{rd} Rank, Periodontics), and Dr. Sajeela Ismail (2^{nd} Rank, Pedodontics).

Dr. Fazeela Beegum

Dr. Renjith K. P.

Dr. Sajeela Ismail

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