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Lasers in Endodontics: A Review

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ABSTRACT:

Laser generation is an evolving field. New lasers which have a numerousvariety of traitsat the moment areto be had and are being utilized innumerous fields of dentistry. Over the beyond 20 years, many technological advances were made, and we've new and advanced lasers for our use. Laser generationturned intobrought to endodontics first via way of means ofWeichman in 1971 with the purpose of enhancing the consequencesreceived with conventional procedures.Various laser structures including excimer-, argon+-, diode-, Nd:YAG-, Er:YAG- and CO2-lasers are utilized in different endodontic puposes. With the improvement of new shippingstructures - skinny and bendy fibers - for plentyexceptional wavelengths laser programs in endodontics may increase.Since laser gadgets are neverthelessexceptionally costly, get admission toto them is limited. Most of the clinical applications are laser assisted methodswhich includes the casting off of pulp remnants and particles or disinfection of inflamed root canals. The essential query is whether or not a laser can offerstepped forwardremedy over traditional care. To carry out laser remedy in endodonticsthese daysone-of-a-kind laser kinds with followed wavelengths and pulse widths are needed, everyparticular to a unique application.

The goal of this review article is to offera top level view of the existing and feasibledestinyscientificpackages of lasers in endodonticswhich include their use in pulp diagnosis, dentinal hypersensitivity, important pulp therapy, sterilization of root canals, root canal cleaning, shaping and obturation, and endodontic surgery.

I. INTRODUCTION :

A traditional endodontic remedy (RCT) entailsentire debridement of the foundation canal system from infected or necrotic pulp tissues and microorganisms.[1] Traditional endodontic remedymakes use of mechanical instruments, chemical irrigantsin addition to ultrasonic activation to shape, easy and disinfect the root canal system.[2] There are howeverdiverseboundaries to a a success root canal remedyconsisting of anatomic complexities, lateral canals, apical ramifications and the failure of the contemporary protocols to nicely disinfect these. A currentstudydiscoveredelaborate anatomical systems in 75% of the enamel analyzed. The studyadditionallydiscovered residual pulp after biomechanical practiseeachwithinside the lateral canals and withinside the apical regions in important and necrotic enamel. Hence, there may be a wantfor brand spanking new materials, techniques, and technologythat mayenhance the cleansing and decontamination of those anatomical regions.[3]

The interest in scientific use of dental laser structures for endodontic remedy is increasing. A lot of various laser structures and programs are presented to trendy practitioners and endodontists to carry out laser remedy. Questions approximately the validity of laser programs in root canal remedy as an opportunityto traditionalprocessesreceived in importance. After preliminary experiments with the ruby laser withinside the 1960s, the pioneers of endodontic laser studiescommencedthe usage of the extraordinary laser types, consisting of CO2-, Er:YAG-, Nd:YAG-, Argon+-, excimer- or semiconductor-lasers. Improved laser technology, new transportstructures and a higherexpertise of laser outcomes widened the spectrum of scientific indications. The first laser application in endodonticschanged intosaidthroughWeichmann et al. in 1971, who tried to seal the apical foramen throughaexcessivepower CO2 laser.[4]

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FUNDAMENTALS OF DENTAL LASERS :

LASER is an acronym for Light Amplification byStimulated Emission of Radiation, which describes succinctly how a laser works. Light is a shape of electromagnetic electricity, emit- ted in waves of consistent velocity (300,000 km/s). The fundamental unit of this electricity is known as a photon. Light waves are characterizedthrough their amplitude and wavelength. The amplitude refers to the fulltop of the oscillation motion of the photon, and is a sign of the electricity of the wave. The unit for energy is the joule. The wavelength is the gapbe- tween corresponding factors of a wave, ex-pressed in meters. Laser mild is a selectedshape of electromagnetic radiation, created from photons in a coherent beam. To recognize the basics of laser, the idea of 'inspired emission' must be understood.[5]

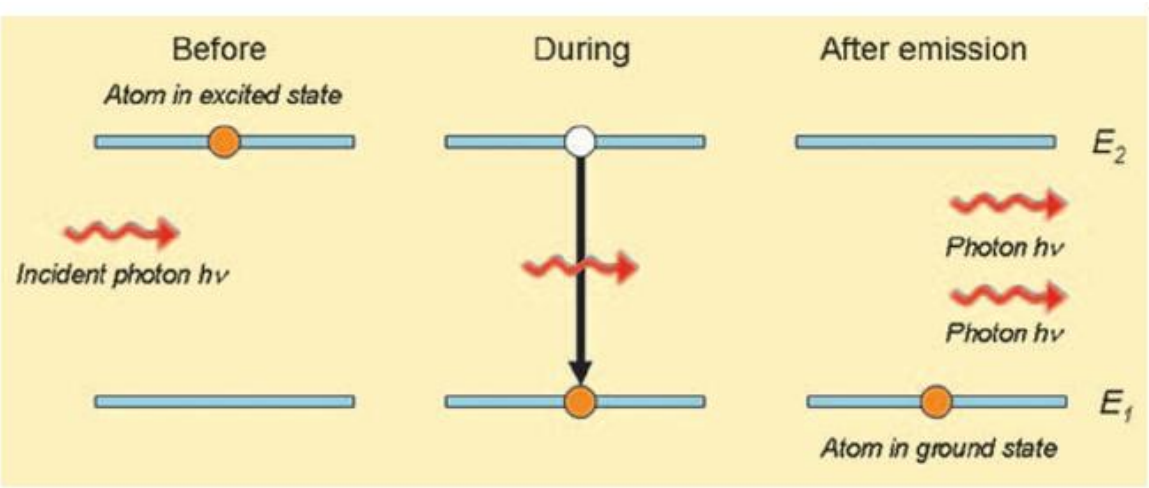

Fig 1 : Theexcited-stateatomisperturbedbytheelectricfieldofaphotonwithfrequencyν.Itmayreleasean anotherphoton of the equalfrequency, in phase with the first photon. The atom will do another decay into the ground state. This is known as stimulatedemission.

CLASSIFICATION OF LASERS :

I. According to the wavelength (nanometers)
1. UV (ultraviolet) range – one hundred forty to four hundred nm
2. VS (visible spectrum) – four hundred to seven-hundred nm
3. IR (infrared) range – greater than seven-hundred nm Most lasers performin a single or greaterof those wavelength regions.
II. Broad classification
1. Hard laser (for surgical work)
i. CO2 lasers (CO2 gas) ii. Nd:YAG lasers (Yttrium-aluminium-garnet crystals dotted with neodymium) iii. Argon laser (Argon ions)
2. Soft laser (for biostimulation and analgesia)
i. He-Ne lasers ii. Diode lasers
III. According to the transportdevice
i. Articulated arm (reflect type) ii. Hollow waveguide iii. Fiber optic cable
IV. According to sort of lasing medium E.g. Erbium: Yttrium Aluminium Garnet
V. According to sort ofenergetic medium used Gas, solid, semi-conductor or dye lasers
VI. According to operation mode
1. Continuous wave lasers 2. Pulsed lasers
VII. According to pumping scheme
1. Optically pumped laser 2. Electrically pumped laser
VIII. According to degree of risk to pores and skin or eyes following inadvertent exposure The laser classdevice is primarily based totallyat the probability of harm occurring.
Class I : (< 39mw) no threat of biologicaldamage.
Class II : (< 1 mw) The output could harm a person if they see the beam for a long period of time.
.
Class IIIA : (<500mw) Can cause injury when the beam is received by optical instruments and directed into the eye.

Class IIIB : (<500mw) Causes injury if viewed directly, even before blinking can occur.

Class IV : (> 500mw) Direct viewing and diffuse reflections can cause permanent damage of eye including blindness.[6]

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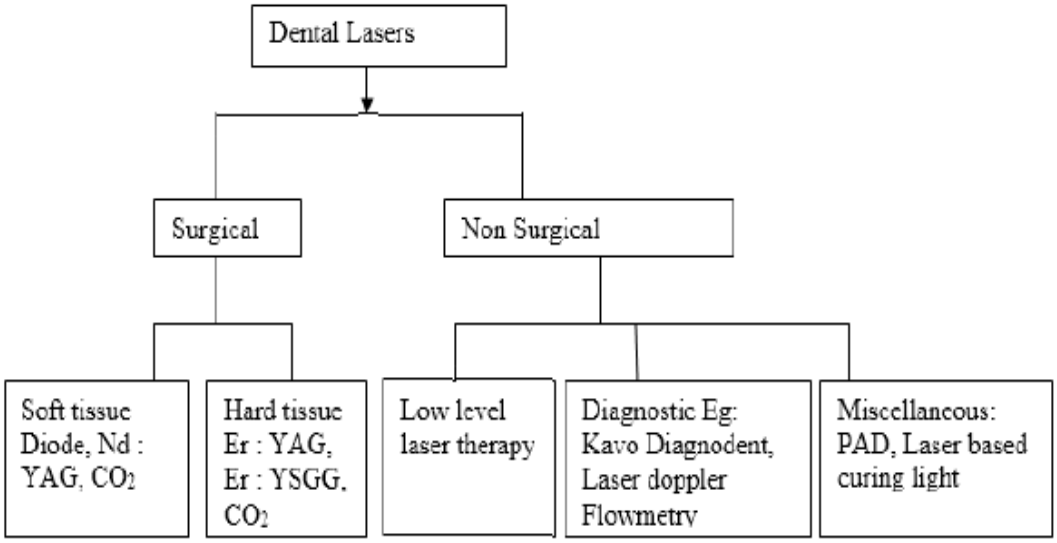

Fig 2 : Classification of lasers

APPLICATION OF LASERS IN ENDODONTICS :

1. Endodontic diagnosis.
2. Analgesia
3. Dentinal Hypersensitivity
4. Vital Pulp Therapy (Pulpotomy, Direct pulp capping, and Indirect Pulp capping)
5. Root canal treatment
• Access cavity preparation
• Orifice opening and enlargement
• Preparation of the canal walls
• Irrigation and disinfection of infected canals.
• Root canal obturation
•Gutter Percha removal andobturation material;
• Retrieval of temporary cavity filling materials, root canal filling materials, and separated instruments in root canals
6. Endodontic surgery.[3]

ENDODONTIC DIAGNOSIS :

Laser Doppler flowmetryturned intoadvancedto evaluate blood go with the drift in microvascularstructureshowever is now additionallygetting used for diagnosis of blood flowwithinside the dental pulp. Helium-neon and diode lasers at low powers of 1-2mW are used.[8]When the laser beam is directed via the crown of the tooth, it passes via the blood vessels withinside the pulp. The transferringred blood cells purpose Doppler shifts withinside the frequency of the laser beam and backscattering of a number of the light out of the tooth. Use of lasers for pulp sensibility trying outgives the gain of now no longercounting on a painful sensation for diagnosis.[9]

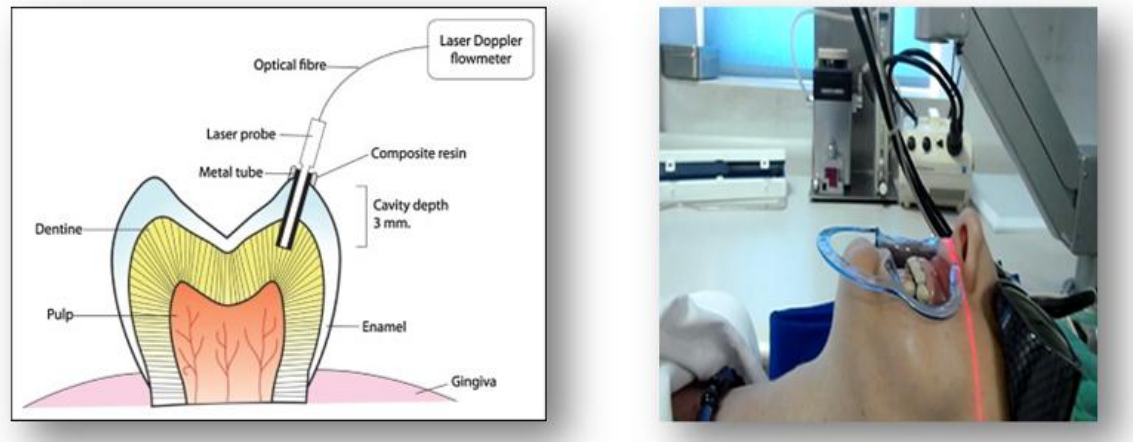

Fig 3 : Laser Doppler flowmetry

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LASER IN ANALGESIA :

The pulsed Nd: YAG laser is broadly used as an analgesic in endodontics. Its wavelengths intrude with the sodium pump mechanism, extradecell membrane permeability, modifyquickly the endings of sensory neurons, and block depolarization of C and A fibers of the nerves, inflicting analgesia.[3]

LASERS IN DENTINAL HYPERSENSITIVITY :

Dentinal hypersensitivity is generallydescribed as a short, sharp ache from uncovered dentinal tubules that takes place in because of stimuli inclusive of cold, heat, tactility, osmosis, evaporation, or chemicals. This achecan not be attributed to every other dental disorder or pathology.[10]Current medical interventions goal to lessen dentinal hypersensitivityvia way of means ofblocking off dentinal fluid flow. These techniquesinclusive ofthe usage of resins, oxalate salts, isobutyl cyanoacrylate, and fluoride-freeing resins or varnishes, and the usage ofdevices that burnish uncovered dentin had beena success in lowering the problem.

The mechanism of lasers for remedy of dentin hypersensitive reactionisn't alwaysnicely understood. Pashleycautioned that it can be because of coagulation and precipitation of plasma in dentinal fluid or via way of means of alteration of nerve fiber activity.[11]

Kimura et al. advocated laser therapy for remedy of dentin hypersensitivity. It confirmedvarious effectiveness relyingat thesort of lasers and parameters, starting from 5.2% to 100. According to the authors, lasers are extrapowerful than different treatments, besides in instances with extreme dentin hypersensitivity.[7]

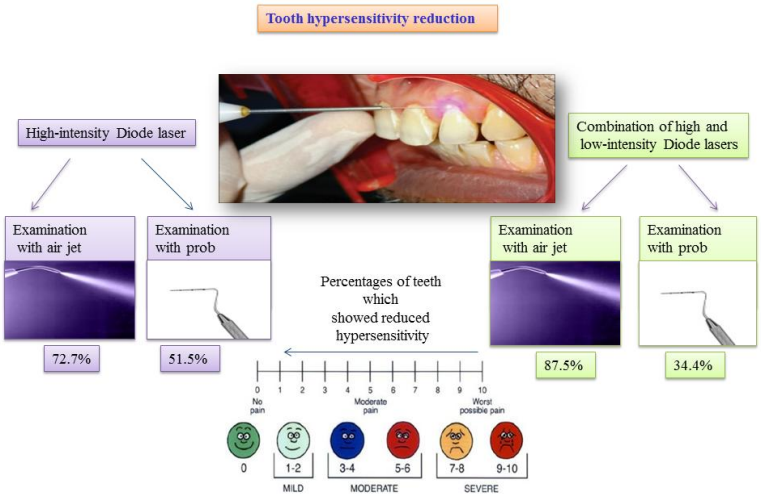

Fig 4 : Lasers used in dentinal hypersensitivity

LASERS USED IN PULPOTOMY & PULP CAPPING :

In mature grownup teeth, traditional pulp remedyalternativesencompass pulp capping or root canal remedy. The final results of pulp capping procedure, whether or not direct or indirect, is unpredictable and achievementfees ranging from 44 to 97% were reported. Pulpal extirpation and root canal remedy are finished if pulp capping tacticsaren't indicated. In immature permanent teeth, devitalization and root canal remedy are now no longerrecommendedtillcomplete apex formation and closure have occurred. Thus endodontic remedy of choice containspulpotomy and next dressing with calcium hydroxide. If a laser is used for the tactics, a bloodlessfieldcould be less difficult to obtainbecause of the capacity of the laser to vaporize tissue and coagulate and seal small blood vessels. Moreover, the handled wound floorcould be sterilized.[1]

ROOT CANAL TREATMENT :

Root canal treatmentis neededwhile, because of dental decay or traumatic injury, the necrotic or infected pulp tissues need to be eliminated to get rid ofinflamedparticles or to save you bacterial proliferation in the root canal system. Endodontic instrumentation include -get right of entry tohollow spacepreparation and growth of the foundation canal orifice,the foundation canal shaping as a precondition for root canal filling,the cleansing of the root canal to take awaydebris, the change of the root canal surface, - the root canal

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disinfection, the sealing of the apex, the root canal filling.

The number oneambitions of root canal treatment - long-lasting protection of the patient's teeth, recuperation of infectedperiradicular tissues - can handiest be acquiredwhileinflamed tissues are absolutelyeliminated and the pulp cavity is obturated with an impermeable root canal filling. Due to the anatomic shape of the dentin-pulp complicated with curved canals, slenderareas and dentine tubules uniquetechniques are endorsed to attain predictable clinical results.[12]

Fig 5a Er:YAGlaserwitharticulatedarm.Thelaserlightistransmittedorreflectedalongthemirrorsinthetubeofthe articulated arm and exits through thehandpiece.

Fig5b HandpiecefortheEr:YAGlaser.Thehandpiececanbeusedincontactmodeorinnon-contactmode(thecrystalisa guide for the determination of the exact focusdistance).

Fig5c Handpieceusedforcavitypreparationincontactmode,i.e.withcrystal.Itisclearthatthisapproachisnotusefulfor root canal treatment.

Fig5d Handpieceusedforcavitypreparationinnon-contactmode,i.e.withoutcrystal.Itisclearthatthisapproachis not useful for root canal treatment.

ACCESS CAVITY PREPARATION BY LASER :

Laser systems, utilized in caries therapy, can also additionallyupdate diamonds and burs to put togetheranget admission tocavity and to increase the root canal orifice earlier thandisposing of the pulpal tissues. Angain of lasers can be the opportunityto mix them with a detecting machinewhich could distinguish amongtough and gentle tissues to manual the applicationsystem into the orifice of the root canal. Another advantagemay be the improvement of very small devices that may be inserted into the tooth when the outlet of the mouth is decreasedvia way of means of inflammation.[13]

Er, Cr: YSGG (2780nm) and Er: YAG (2940nm) are normally used for accesscavitypreparation and for the cleansing and shaping of the basis canal Er: YSGG (2780nm), Er: YAG (2940nm) and Nd: YAG(1064 nm) lasers are used for canal wall preparation.[14]

PULPECTOMY :

Access cavitypreparation is accompaniedthrough the extirpation of the pulp tissues. To use lasers exceptional optical fibers are had toattain the apical components of the basisearlier than shaping. The soft tissues may be vaporized through thermal results - e.g. CO2, Nd:YAG or diode lasers - or ablated throughmid infrared lasers - e.g. Er:YAG laser. Excellent hemostasis and antimicrobial resultshave beendonethe use of a thermal interaction. As a sideeffect carbonized particlesmight also

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additionallyarise that must beeliminatedwhilst shaping the root canal. Therefore, non thermal ablation must be preferred. One hassle that must be solved withinside thedestiny is the opportunity to lessen the diameter of applicationtipsdown to 0.2 mm to irradiate the apical portionbefore shaping.

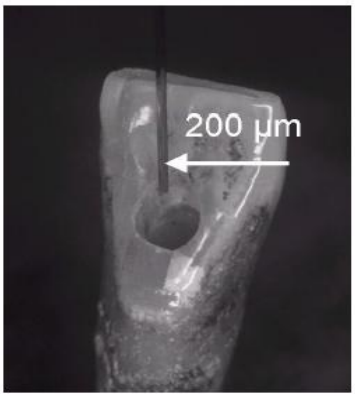

Fig 6 : 200 µm fiber for the extirpation of the pulp after access cavity preparation.

ROOT CANAL SHAPING :

Canal shaping and expansion represents ancrucial step withinside the endodontic procedure. It helps the complete elimination of soft tissue and inflamed debris; it enables irrigation and allows canal obturation. Only lasers that are succesful to cast off canal wall dentine can alternativetraditionalfiles or reamers.In the 90ies, excimer lasers have beentested to put togetherthe basis canal. Mainly XeCl lasers have been investigated due to their opportunityto apply fiber deliverysystems. The decrease thermal facetoutcomes, a terrific ablation of soft tissues and antimicrobial outcomesmay beappeared as blessingsto standard techniques.[15]

However, in comparison to mechanical remedy, canal expansionbecome very restrainedresulting from the low ablation rates of the XeCl laser in dentin: The availableenergy densities of this laser kindhad beennow no longerenough to eliminate residual pulp tissues or infiltrated dentin. Mid infrared lasers additionally have the ability to formthe foundationcanal. Root canal expansion is feasiblehowever the effects are restrained. A conic shaping corresponding to mechanical remedyisn't alwaysbut possible.[16]

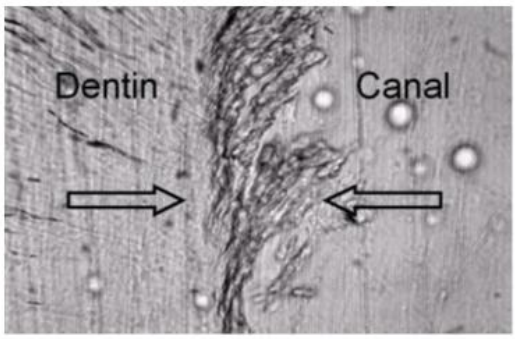

Fig 7: Canal walls were roughened by the Er:YAG laser ablation (x 400 / fiber Ø: 3.8mm, pulse energy: 50mJ (fiber window), 2Hz).

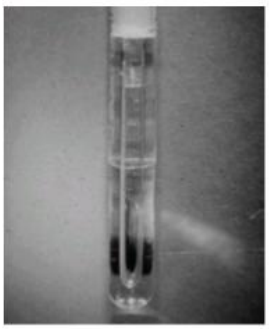

Fig 8 :Side firing fiber. At the top of the fiber the beam is diverted in a 90° angle.

CLEANING OF THE ROOT CANAL :

Pulsed Nd:YAG and diode lasers had been used for disposing of pulp remnants and debris. Er:YAG laser radiation is also successful to ablate particles after shaping. To enhance the cleansingresultsirrigantsconsisting ofNaOCl or EDTA are recommended. Some pulsed laser structuresappearto provide cavitation resultswith inside the root canal in a waycomparable to ultrasonic irrigations or might also additionallydecorate the chemical pastime of the irrigants. Conventional shaping of the basis canal as much as a length of ISO 30 is the precondition to location the rinsing solutions and the laser fiber tipsas much as the apical part of the root. Laser assisted root canal cleansing exceed traditional techniques. However, complete cleansing of the basis canal isn't always predictable.[17]

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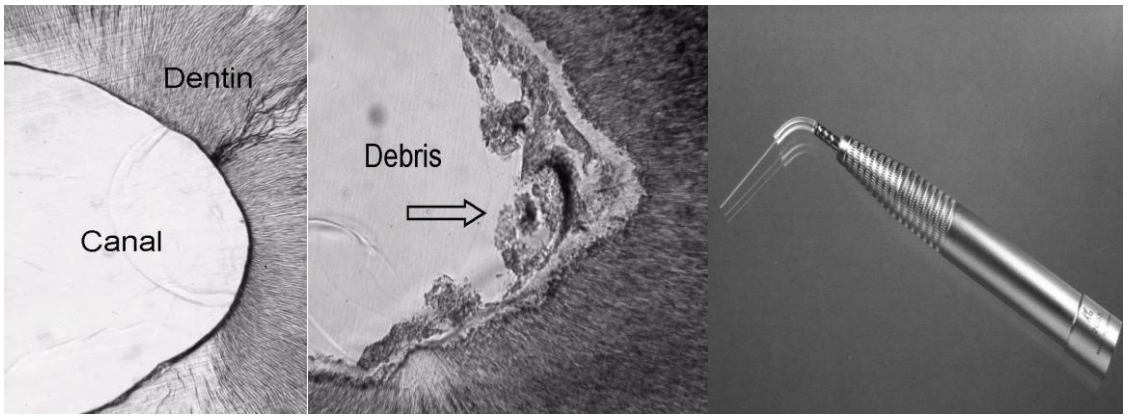

Figure 6 :left: no residual pulp tissue after Nd:YAG laser assisted root canal
cleaning using NaOCl (5%), (x250 / fiber Ø: 0.2mm, 1.5W, 15pps, 15s).
right: residual pulp tissue after Nd:YAG laser assisted root canal cleaning without using NaOCl (5%), (x250 / fiber Ø: 0.2mm, 1.5W, 15pps, 15s).

Figure7: Er:YAGhandpiece with an endodontic tip (Ø: 0.28mm / KaVo).

MODIFICATION OF ROOT CANAL SPACE :

Using lasers, the floor of the root canal wall can both be melted to lessen dentin permeability or the smear layer of the canal wall may be removed. Weichman& Johnson first carried outaexcessivestrength CO2 laser to seal the canal in vitro. Complete sealing with outfacetoutcomescouldn't be achieved. However, the effectsadvocatedsimilarly studies. After CO2 laser irradiation, dentine permeability is extensively reduced. However, a hugevariety of morphological changes will be observed.[18]Themost importanttrouble of CO2 lasers is the scale of utilityguidelines that can't be located in slender or curved root canals.

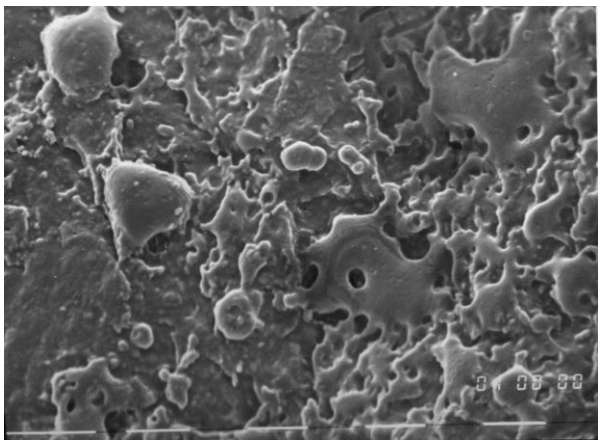

Fig 8 : Melting effects at the canal wall afterNd:YAG laser application (fiber Ø: 0.2mm, 1.5W,15pps, 15s) following absorber application and NaOCl (5%) irrigation (SEM, x1250).

Many research on Nd:YAG laser sealing of the canal surface werepublished. Fine bendy optical fibers can be used to attain the apical region. Absorption of the Nd:YAG laser radiation have to be bettervia way of means of black ink to avoid damaging thermal aspectoutcomeswithinside the periodontium34. Dentine permeability is decreasedthe usage ofsuitable laser parameters. However, observingoutcomesaren't predictable. Ar+, excimer and Er:YAG lasers had been investigated to remove the smear layer. Ar+ and excimer lasers inducedaelimination of the smear layer followedvia way of means of melting outcomeswhilst high fluenceshad been used.[19]

ROOT CANAL DISINFECTION :

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Many researchwereaccomplished to look at laser consequences in inflamed root canals. The Nd:YAG, Ar+ and diode lasers are the maximumfamous ones, due to the factskinny fiber optic transportstructures are available.[20] Thermal destruction can be mixed with photodynamic consequences. Er:YAG and excimer lasers have additionally been used for this purpose. They might also additionally have bactericidal disruptive effects. All examined lasers decreased the quantity of germswithinside the canal extra or much less powerful depending on the used fluency and irradiation time. Sterilization of root canals handiest via way of means of lasers is problematical, considering the fact that thermal harm to the periodontal ligament is possible. It is essential to pick suitable laser parameters. Attention should be taken to steam and smoke because of the laser utility which could reason bacterial dissemination.[21]To growth antimicrobial consequences, laser utility might be mixed with traditional irrigants (e.g. NaOCl, EDTA). In the future, sterilization via way of means of antimicrobial photodynamic remedy can be accomplished with certain drugs.

IRRIGATION OF ROOT CANALS :

One of the primarytroubles in endodontics is the non-turbulent fluid dynamics of irrigantswithinside therestrained and complicated canal space, which hinders deep penetration of the irrigant. Many System like endoactivator and endovac are to be hadhoweverextrapowerfulgear like superior Laser endodontic remedy has been brought for powerful irrigation.

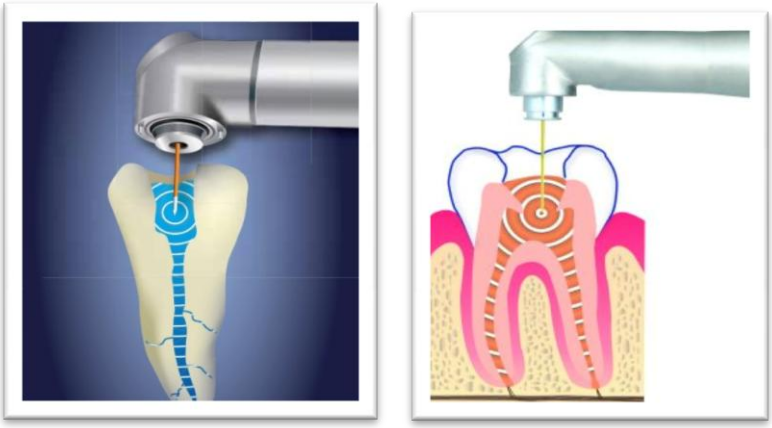

Fig 9 : Laser activated irrigation

APICAL SEALING OF ROOT CANALS :

Atraumatic apical apex closure of the foramina could be anvitalbenefit in root canal therapy. In the 70ies, triesto soften the apical dentin brought on necrosis withinside the periodontal ligament and a disintegration of the apical dentin/cementum complex. Improved strategies used dentin chips on the apical stop. However, the consequenceshad beenadditionally not predictable. As an alternative, mild curable composite resins in mixture with an Ar+ laser or thermoplasticized gutta-percha primarily based totally filling strategieshad been investigated. However, whilstaaccurate conic shaping may be performed, the scientific relevance of apical closure strategies is low, because of the reality that traditional gutta-percha factorprimarily based totallyobturationstrategies are keep and clean to handle.

ROOT CANAL FILLING :

The use of lasers in root canal obturation is limited to only a few laser techniques, e.g. thermoplasticized gutta-percha primarily based totally filling and light-curable resin obturation. Up to now, the usage of lasers to heat gutta-percha in vertical condensation strategies is viablehowever time consuming and now no longer practical.[19]

LASERS IN ENDODONTIC SURGERY :

The important contribution of laser to endodontic surgical treatment is that it converts apical dentin and cementum to a uniform glazed area .This dosentpermit the mircoorganisms to penetrate via the dentinal tubules and differentsystemson the apical area. Apart from that laser application in endodontic surgical proceduresgivesbenefitsjust likethe ones it gives for different surgical procedures. Soft tissue lasers just like theNd: YAG; Diode or CO2 offersmooth incisions with little bleeding for gaining access to

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the periradicular area. The use of lasers in preference to the to be had hand portions for periapicalsurgriessignificantly reduces aerosol production, loweringinfection of the surgical area and unfold of infections.TheEr: YAG or the Er, Cr: YSGG may be used for slicing the bone, sectioning of the apical a part ofthe basis and additionally for the retrograde prepraionfothe basis end. Laser whilst used for endodontic surgical procedureshad beenproven to lessenput up operative ache and edema and decrease scarring.[3]

Fig 10 : Lasers in endodontic surgery

Fig 11a :Er,Cr:YSGGlaserwithfibre.Thelaserlightistransmittedthroughthe fibreandconductedtothehandpiece.

Figs11bto11d Specialflexiblewaveguides(fibres)forendodonticpurposesinassociationwiththeEr,Cr:YSGGlaser.

Fig 12 : Nd:YAGlaser (a) with fibre and handpiece (b) for endodontic purposes.

II. CONCLUSION :

With the improvement of thin, bendyand durable fiber tips and advanced laser structures, laser programs in endodontics will boom. Side firing fibers can behad todecoratepower densities on the canal walls. They are a precondition to get extra predictable resultswhilstcleansing or enhancing the canal surface. New components of sterilizing the inflamed root canal can berelated to the similarlyimprovement of antimicrobial photodynamic therapy. Laser fluorescence primarily based totally analytic structures, these daysutilized in caries detection, may be used for lookingslender canal orifices or to decidethe appropriaterunning length. This methodmay also be used for bestevaluation to evidence whether canal shaping is sufficient. Mid infrared laser with followedutilitystructurescan also additionallyalternative mechanical root canal shaping. However, given that laser system is especially costly, get entry toto them can be limited. New laser gadgets with a large number of

wavelength and laser parameters, everyunique to a selectedutility, can behad toboomthe that means of lasers in endodontics.

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